The contents of this document will be discussed at the Commission Meeting (Briefing) scheduled for October 8, 2014.

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
BETHESDA, MD 20814

This document has been electronically approved and signed.

DATE: September 24, 2014

THIS MATTER IS NOT SCHEDULED FOR A BALLOT VOTE.
A DECISIONAL MEETING FOR THIS MATTER IS SCHEDULED ON: October 22, 2014

TO: The Commission
Todd A. Stevenson, Secretary

THROUGH: Stephanie Tsacoumis, General Counsel
DeWane Ray, Deputy Executive Director

FROM: Patricia M. Pollitzer, Assistant General Counsel
Barbara E. Little, Attorney, OGC

SUBJECT: Proposed Rule: Recreational Off-Highway Vehicles (ROVs)

Staff is forwarding a briefing package recommending that the Commission issue a proposed rule pursuant to the Consumer Product Safety Act (CPSA) to address the risk of injury associated with ROVs. The Office of the General Counsel is providing for the Commission's consideration a draft proposed rule that would establish requirements for ROVs.

Please indicate your vote on the following options:

I. Approve publication of the attached document in the *Federal Register*, as drafted.

________________________________ ______________
(Signature) (Date)

II. Approve publication of the attached document in the *Federal Register,* with changes. (Please specify.)

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________________________________ ______________
(Signature) (Date)

III. Do not approve publication of the attached document in the *Federal Register*.

________________________________ ______________
(Signature) (Date)

IV. Take other action. (Please specify.)

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________________________________ ______________
(Signature) (Date)

Attachment: Draft *Federal Register* Notice: Proposed Rule to Establish a Safety Standard for Recreational Off-Highway Vehicles.

Billing Code 6355-01-P

CONSUMER PRODUCT SAFETY COMMISSION

16 CFR Part 1422

RIN 3041-AC78

Docket No. CPSC-2009-0087

Safety Standard for Recreational Off-Highway Vehicles (ROVs)

AGENCY: Consumer Product Safety Commission.

ACTION: Notice of Proposed Rulemaking.

SUMMARY: The U.S. Consumer Product Safety Commission has determined preliminarily that there may be an unreasonable risk of injury and death associated with recreational off-highway vehicles (ROVs). To address these risks, the Commission proposes a rule that includes: (1) lateral stability and vehicle handling requirements that specify a minimum level of rollover resistance for ROVs and require that ROVs exhibit sublimit understeer characteristics; (2) occupant retention requirements that would limit the maximum speed of an ROV to no more than 15 miles per hour (mph), unless the seat belts of both the driver and front passengers, if any, are fastened, and would require ROVs to have a passive means, such as a barrier or structure, to limit further the ejection of a belted occupant in the event of a rollover; and (3) information requirements.

DATES: Submit comments by [INSERT DATE 75 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER].

ADDRESSES: You may submit comments, identified by Docket No. CPSC-2009-0087, by any of the following methods:

Electronic Submissions: Submit electronic comments to the Federal eRulemaking Portal at: http://www.regulations.gov. Follow the instructions for submitting comments. The Commission does not accept comments submitted by electronic mail (e-mail), except through www.regulations.gov. The Commission encourages you to submit electronic comments by using the Federal eRulemaking Portal, as described above.

Written Submissions: Submit written submissions by mail/hand delivery/courier to: Office of the Secretary, Consumer Product Safety Commission, Room 820, 4330 East West Highway, Bethesda, MD 20814; telephone (301) 504-7923.

Instructions: All submissions received must include the agency name and docket number for this notice. All comments received may be posted without change, including any personal identifiers, contact information, or other personal information provided, to: http://www.regulations.gov. Do not submit confidential business information, trade secret information, or other sensitive or protected information that you do not want to be available to the public. If furnished at all, such information should be submitted in writing.

Docket: For access to the docket to read background documents or comments received, go to: http://www.regulations.gov, and insert the docket number CPSC-2009-0087, into the "Search" box, and follow the prompts.

Submit comments related to the Paperwork Reduction Act (PRA) aspects of the proposed rule to the Office of Information and Regulatory Affairs, Attn: OMB Desk Officer for the CPSC or by email: OIRA_submission@omb.eop.gov or fax: 202-395-6881. In addition, comments that are sent to OMB also should be submitted electronically at http://www.regulations.gov, under Docket No. CPSC-2009-0087.

FOR FURTHER INFORMATION CONTACT: Caroleene Paul, Project Manager, Directorate for Engineering Sciences, Consumer Product Safety Commission, 5 Research Place, Rockville, MD 20850; telephone: 301-987-2225; e-mail: cpaul@cpsc.gov.

SUPPLEMENTARY INFORMATION:

I. Background

Recreational off-highway vehicles (ROVs) are motorized vehicles that combine off-road capability with utility and recreational use. Reports of ROV-related fatalities and injuries prompted the U.S. Consumer Product Safety Commission (Commission or CPSC) to publish an advance notice of proposed rulemaking (ANPR) in October 2009 to consider whether there may be unreasonable risks of injury and death associated with ROVs. (74 FR 55495 (October 28, 2009)). The ANPR began a rulemaking proceeding under the Consumer Product Safety Act (CPSA). The Commission received 116 comments in response to the ANPR. The Commission is now issuing a notice of proposed rulemaking (NPR) that would establish requirements for lateral stability, vehicle handling, and occupant protection performance, as well as information requirements. The information discussed in this preamble comes from CPSC staff's briefing package for the NPR, which is available on CPSC's website at [INSERT CITE to WEBSITE].

II. The Product

A. Products Covered

ROVs are motorized vehicles designed for off-highway use with the following features: four or more pneumatic tires designed for off-highway use; bench or bucket seats for two or more occupants; automotive-type controls for steering, throttle, and braking; and a maximum vehicle speed greater than 30 miles per hour (mph). ROVs are also equipped with rollover protective structures (ROPS), seat belts, and other restraints (such as doors, nets, and shoulder barriers) for the protection of occupants.

ROVs and All-Terrain Vehicles (ATVs) are similar in that both are motorized vehicles designed for off-highway use, and both are used for utility and recreational purposes. However, ROVs differ significantly from ATVs in vehicle design. ROVs have a steering wheel instead of a handle bar for steering; foot pedals instead of hand levers for throttle and brake control; and bench or bucket seats rather than straddle seating for the occupant(s). Most importantly, ROVs only require steering wheel input from the driver to steer the vehicle, and the motion of the occupants has little or no effect on vehicle control or stability. In contrast, ATVs require riders to steer with their hands and to maneuver their body front to back and side to side to augment the ATV's pitch and lateral stability.

Early ROV models emphasized the utility aspects of the vehicles, but the recreational aspects of the vehicles have become very popular. Currently, there are two varieties of ROVs: utility and recreational. Models emphasizing utility have larger cargo beds, higher cargo capacities, and lower top speeds. Models emphasizing recreation have smaller cargo beds, lower cargo capacities, and higher top speeds. Both utility and recreational ROVs with maximum speed greater than 30 mph are covered by the scope of this NPR.

B. Similar or Substitute Products

There are several types of off-road vehicles that have some characteristics that are similar to those of ROVs and may be considered substitutes for some purposes.

***Low-Speed Utility vehicles (UTVs)* –** Although ROVs can be considered to be a type of utility vehicle, their maximum speeds of greater than 30 mph distinguish them from low-speed utility vehicles, which have maximum speeds of 25 mph or less. Like ROVs, low-speed utility vehicles have steering wheels and bucket or bench seating capable of carrying two or more riders. All utility vehicles have both work and recreational uses. However, low-speed utility vehicles might not be good substitutes for ROVs in recreational uses where speeds higher than 30 mph are important.

All-terrain vehicles (ATVs) – Unlike ROVs, ATVs make use of handlebars for steering and hand controls for operating the throttle and brakes. The seats on ATVs are intended to be straddled, unlike the bucket or bench seats on ROVs. Some ATVs are intended for work or utility applications, as well as for recreational uses; others are intended primarily for recreational purposes. ATVs are usually narrower than ROVs. This means that ATVs can navigate some trails or terrain that some ROVs might not be able to navigate.

Unlike ROVs, ATVs are rider interactive. When riding an ATV, the driver must shift his or her weight from side to side while turning, or forward or backward when ascending or descending a hill or crossing an obstacle. Most ATVs are designed for one rider (the driver). On ATVs that are designed for more than one rider, the passenger sits behind the driver and not beside the driver as on ROVs.

Go-Karts – Go-karts (sometimes called "off-road buggies") are another type of recreational vehicle that has some similarities to ROVs. Go-karts are usually intended solely for recreational purposes. Some go-karts with smaller engines are intended to be driven by children 12 and younger. Some go-karts are intended to be driven primarily on prepared surfaces. These go-karts would not be substitutes for ROVs. Other go-karts have larger engines, full suspensions, can reach maximum speeds in excess of 30 mph, and can be used on more surfaces. These go-karts could be close substitutes for ROVs in some recreational applications.

III. Risk of Injury

A. Incident Data

As of April 5, 2013, CPSC staff is aware of 550 reported ROV-related incidents that occurred between January 1, 2003 and April 5, 2013; there were 335 reported fatalities and 506 reported injuries related to these incidents. To analyze hazard patterns related to ROVs, a multidisciplinary team of CPSC staff reviewed incident reports that CPSC received by December 31, 2011 concerning incidents that occurred between January 1, 2003 and December 31, 2011. CPSC received 428 reports of ROV-related incidents that occurred between January 1, 2003 and December 31, 2011, from the Injury and Potential Injury Incident (IPII) and In-Depth Investigation (INDP) databases.

ROV-related incidents can involve more than one injury or fatality because the incidents often involve both a driver and passengers. There were a total of 826 victims involved in the 428 incidents. Of the 428 ROV-related incidents, there were a total of 231 reported fatalities and 388 reported injuries. Seventy-five of the 388 injuries (19 percent) could be classified as severe; that is, based on the information available, the victim has lasting repercussions from the injuries received in the incident. The remaining 207 victims were either not injured or their injury information was not known.

Of the 428 ROV-related incidents, 76 incidents involved drivers under 16 years of age (18 percent); 227 involved drivers 16 years of age or older (53 percent); and 125 involved drivers of unknown age (29 percent). Of the 227 incidents involving adult drivers, 86 (38 percent) are known to have involved the driver consuming at least one alcoholic beverage before the incident; 52 (23 percent) did not involve alcohol; and 89 (39 percent) have an unknown alcohol status of the driver.

Of the 619 victims who were injured or killed, most (66 percent) were in a front seat of the ROV, either as a driver or passenger, when the incidents occurred. The remaining victims were in the rear of the ROV or in an unspecified location of the ROV.

In many of the ROV-related incidents resulting in at least one death, the Commission was able to obtain more detailed information on the events surrounding the incident through an In-Depth Investigation (IDI). Of the 428 ROV-related incidents, 224 involved at least one death. This includes 218 incidents resulting in one fatality, five incidents resulting in two fatalities, and one incident resulting in three fatalities, for a total of 231 fatalities. Of the 224 fatal incidents, 145 (65 percent) occurred on an unpaved surface; 38 (17 percent) occurred on a paved surface; and 41 (18 percent) occurred on unknown terrain.

B. Hazard Characteristics

After CPSC staff determined that a reported incident resulting in at least one death or injury was ROV-related, a multidisciplinary team reviewed all the documents associated with the incident. The multidisciplinary team was made up of a human factors engineer, an economist, a health scientist, and a statistician. As part of the review process, each member of the review team considered every incident and coded victim characteristics, the characteristics of the vehicle involved, the environment, and the events of the incident.[1] Below, we discuss the key hazard characteristics that the review identified.

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[1] The data collected for the Commission's study are based on information reported to the Commission through various sources. The reports are not a complete set of all incidents that have occurred, nor do they constitute a statistical sample representing all ROV-related incidents with at least one death or injury resulting. Additionally, reporting is ongoing for ROV-related incidents that occurred in the specified time frame. The Commission is expecting additional reports and information on ROV-related incidents that resulted in a death or injury and that occurred in the given time frame.

1. <u>Rollover</u>

Of the 428 reported ROV-related incidents, 291 (68 percent) involved rollover of the vehicle, more than half of which occurred while the vehicle was in a turn (52 percent). Of the 224 fatal incidents, 147 (66 percent) involved rollover of the vehicle, and 56 of those incidents (38 percent) occurred on flat terrain. The slope of the terrain is unknown in 39 fatal incidents.

A total of 826 victims were involved in the 428 reported incidents, including 231 fatalities and 388 injuries. Of the 231 reported fatalities, 150 (65 percent) died in an incident involving lateral rollover of the ROV. Of the 388 injured victims, 75 (19 percent) were classified as being severely injured; 67 of these victims (89 percent) were injured in incidents that involved lateral rollover of the ROV.

2. <u>Occupant Ejection and Seat Belt Use</u>

From the 428 ROV-related incidents reviewed by CPSC, 817 victims were reported to be in or on the ROV during the incident, and 610 (75 percent) were known to have been injured or killed. Seatbelt use is known for 477 of the 817 victims; of these, 348 (73 percent) were not wearing a seatbelt at the time of the incident.

Of the 610 fatally and nonfatally injured victims who were in or on the ROV, 433 (71 percent) were partially or fully ejected from the ROV; and 269 (62 percent) of these victims were struck by a part of the vehicle, such as the roll cage or side of the ROV, after ejection. Seat belt use is known for 374 of the 610 victims; of these, 282 (75 percent) were not wearing a seat belt.

Of the 225 fatal victims who were in or on the ROV at the time of the incident, 194 (86 percent) were ejected partially or fully from the vehicle, and 146 (75 percent) were struck by a part of the vehicle after ejection. Seat belt use is known for 155 of the 194 ejected victims; of these, 141 (91 percent) were not wearing a seat belt.

C. NEISS Data

To estimate the number of nonfatal injuries associated with ROVs that were treated in a hospital emergency department, CPSC undertook a special study to identify cases that involved ROVs that were reported through the National Electronic Injury Surveillance System (NEISS) from January 1, 2010 to August 31, 2010.[2]

NEISS does not contain a separate category or product code for ROVs. Injuries associated with ROVs are usually assigned to an ATV product category (NEISS product codes 3286 – 3287) or to the utility vehicle (UTV) category (NEISS product code 5044). A total of 2,018 injuries that were related to ATVs or UTVs were recorded in NEISS between January 1, 2010 and August 31, 2010. The Commission attempted follow-up interviews with each victim (or a relative of the victim) to gather more information about the incidents and the vehicles involved. CPSC determined whether the vehicle involved was an ROV based on the make and model of the vehicle reported in the interviews. If the make and model of the vehicle was not reported, staff did not count the case as involving an ROV.

A total of 688 surveys were completed, resulting in a 33 percent response rate for this survey. Of the 688 completed surveys, 16 were identified as involving an ROV based on the make and model of the vehicle involved. It is possible that more cases involved an ROV, but it was not possible to identify them due to lack of information on the vehicle make and model.

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[2] NEISS is a stratified national probability sample of hospital emergency departments that allows the Commission to make national estimates of product-related injuries. The sample consists of about 100 of the approximately 5,400 U.S. hospitals that have at least six beds and provide 24-hour emergency service. Consumer product-related injuries treated in emergency departments of the NEISS-member hospitals are coded from the medical record. As such, information about the injury is extracted, but specifics about the product and its use are often not available.

The estimated number of emergency department-treated ROV-related injuries occurring in the United States between January 1, 2010 and August 31, 2010, is 2,200 injuries. Extrapolating for the year 2010, the estimated number of emergency department-treated, ROV-related injuries is 3,000, with a corresponding 95 percent confidence interval of 1,100 to 4,900.

D. Yamaha Rhino Repair Program

CPSC staff began investigating ROVs following reports of serious injuries and fatalities associated with the Yamaha Rhino. In March 2009, CPSC staff negotiated a repair program on the Yamaha Rhino 450, 660, and 700 model ROVs to address stability and handling issues with the vehicles.[3] CPSC staff investigated more than 50 incidents, including 46 driver and passenger deaths related to the Yamaha Rhino. The manufacturer voluntarily agreed to design changes through a repair program that would increase the vehicle's lateral stability and change the vehicle's handling characteristic from oversteer to understeer. The repair consisted of the following: (1) addition of 50-mm spacers on the vehicle's rear wheels to increase the track width, and (2) the removal of the rear stabilizer bar to effect understeer characteristics.

CPSC staff reviewed reports of ROV-related incidents reported to the CPSC between January 1, 2003 and May 31, 2012, involving Yamaha Rhino model vehicles. (The data are only those reported to CPSC staff and are not representative of all incidents.) The number of incidents that occurred by quarters of a year are shown below in Figure 1.

[3] CPSC Release #09-172, March 31, 2009, Yamaha Motor Corp. Offers Free Repair for 450, 660, and 700 Model Rhino Vehicles.

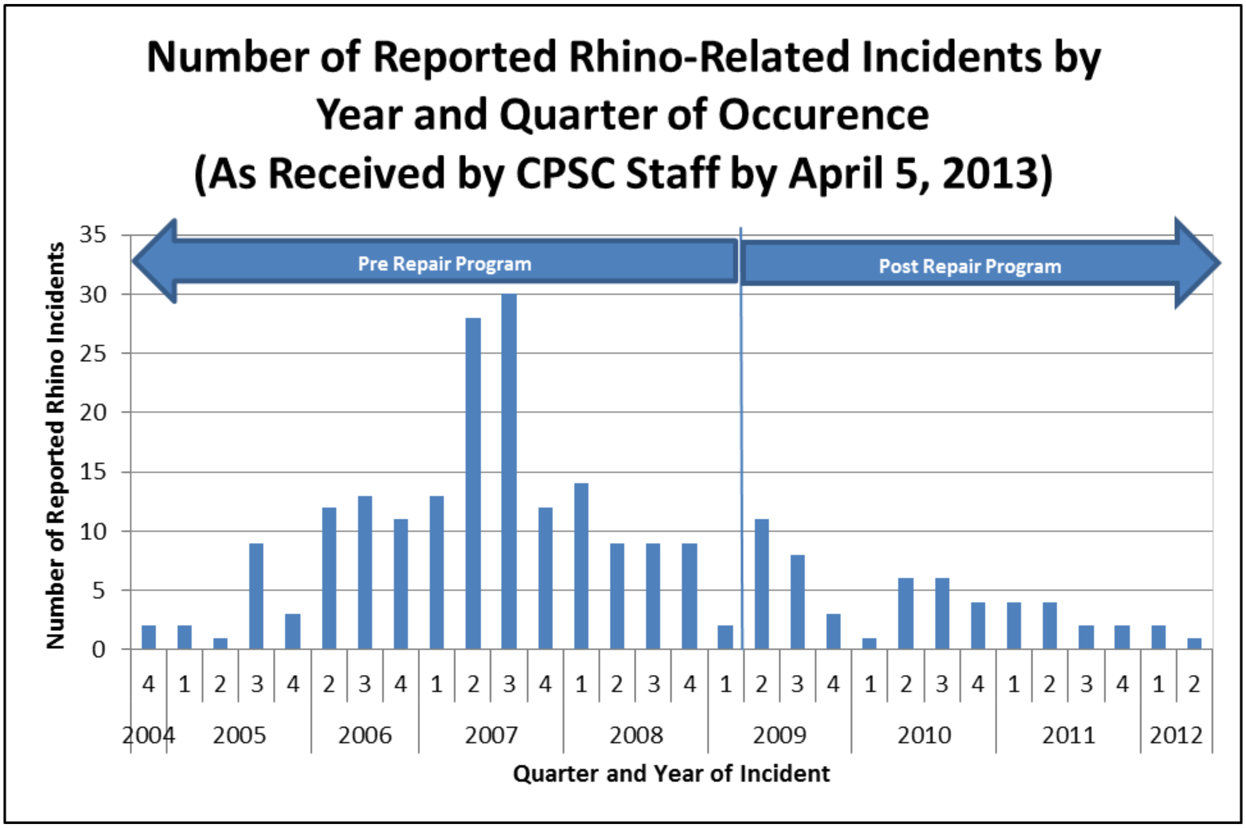

Figure 1. Number of Reported Yamaha Rhino Incidents from January 2003 to May 2012.

After the repair program was initiated in March 2009, the number of reported incidents involving a Yamaha Rhino ROV decreased noticeably.

CPSC staff also analyzed the 242 Yamaha Rhino-related incidents reported to CPSC and identified 46 incidents in which a Yamaha Rhino vehicle rolled over during a turn on flat or gentle terrain. Staff identified forty-one of the 46 incidents as involving an unrepaired Rhino vehicle. In comparison, staff identified only two of the 46 incidents in which a repaired Rhino vehicle rolled during a turn, and each of these incidents occurred on terrain with a 5 to 10 degree slope. Among these 41 reported incidents, there were no incidents involving repaired Rhinos rolling over on flat terrain during a turn.

The Commission believes the decrease in Rhino-related incidents after the repair program was initiated can be attributed to the vehicle modifications made by the repair program. Specifically, correction of oversteer and improved lateral stability can reduce rollover incidents by reducing the risk of sudden and unexpected increases in lateral acceleration during a turn, and increasing the amount of force required to roll the vehicle over. CPSC believes that lateral stability and vehicle handling have the most effect on rollovers during a turn on level terrain because the rollover is caused primarily by lateral acceleration generated by friction during the turn. Staff's review of rollover incidents during a turn on level ground indicates that repaired Rhino vehicles are less likely than unrepaired vehicles to roll over. CPSC believes this is further evidence that increasing lateral stability and correcting oversteer to understeer contributed to the decrease in Yamaha Rhino incidents.

IV. Statutory Authority

ROVs are "consumer products" that can be regulated by the Commission under the authority of the CPSA. *See* 15 U.S.C. 2052(a). Section 7 of the CPSA authorizes the Commission to promulgate a mandatory consumer product safety standard that sets forth certain performance requirements for a consumer product or that sets forth certain requirements that a product be marked or accompanied by clear and adequate warnings or instructions. A performance, warning, or instruction standard must be reasonably necessary to prevent or reduce an unreasonable risk or injury. *Id.*

Section 9 of the CPSA specifies the procedure the Commission must follow to issue a consumer product safety standard under section 7. In accordance with section 9, the Commission may commence rulemaking by issuing an ANPR; as noted previously, the Commission issued an ANPR on ROVs in October 2009. Section 9 authorizes the Commission to issue an NPR including the proposed rule and a preliminary regulatory analysis in accordance with section 9(c) of the CPSA and request comments regarding the risk of injury identified by the Commission, the regulatory alternatives being considered, and other possible alternatives for addressing the risk. *Id*. 2058(c). Next, the Commission will consider the comments received in response to the proposed rule and decide whether to issue a final rule along with a final regulatory analysis. *Id.* 2058(c)-(f). The Commission also will provide an opportunity for interested persons to make oral presentations of the data, views, or arguments, in accordance with section 9(d)(2) of the CPSA. *Id.* 2058(d)(2).

According to section 9(f)(1) of the CPSA, before promulgating a consumer product safety rule, the Commission must consider, and make appropriate findings to be included in the rule, concerning the following issues: (1) the degree and nature of the risk of injury that the rule is designed to eliminate or reduce; (2) the approximate number of consumer products subject to the rule; (3) the need of the public for the products subject to the rule and the probable effect the rule will have on utility, cost, or availability of such products; and (4) the means to achieve the objective of the rule while minimizing adverse effects on competition, manufacturing, and commercial practices. *Id.* 2058(f)(1).

According to section 9(f)(3) of the CPSA, to issue a final rule, the Commission must find that the rule is “reasonably necessary to eliminate or reduce an unreasonable risk of injury associated with such product” and that issuing the rule is in the public interest. *Id.* 2058(f)(3)(A)&(B). In addition, if a voluntary standard addressing the risk of injury has been adopted and implemented, the Commission must find that: (1) the voluntary standard is not likely to eliminate or adequately reduce the risk of injury, or that (2) substantial compliance with the voluntary standard is unlikely. *Id.* 2058(f)(3(D). The Commission also must find that expected benefits of the rule bear a reasonable relationship to its costs and that the rule imposes the least burdensome requirements that would adequately reduce the risk of injury. *Id.* 2058(f)(3)(E)&(F).

Other provisions of the CPSA also authorize this rulemaking. Section 27(e) provides the Commission with authority to issue a rule requiring consumer product manufacturers to provide the Commission with such performance and technical data related to performance and safety as may be required to carry out the CPSA and to give such performance and technical data to prospective and first purchasers. *Id.* 2076(e). This provision bolsters the Commission's authority under section 7 to require provision of safety-related information, such as hang tags.

V. Overview of Proposed Requirements

Based on incident data, vehicle testing, and experience with the Yamaha Rhino repair program, the Commission believes that improving lateral stability (by increasing rollover resistance) and improving vehicle handling (by correcting oversteer to understeer) are the most effective approaches to reducing the occurrence of ROV rollover incidents. ROVs with higher lateral stability are less likely to roll over because more lateral force is necessary to cause rollover than an ROV with lower lateral stability. ROVs exhibiting understeer during a turn are less likely to rollover because steering control is stable and the potential for the driver to lose control is low.

The Commission believes that when rollovers do occur, improving occupant protection performance (by increasing seat belt use) will mitigate injury severity. CPSC's analysis of ROV incidents indicates that 91 percent of fatally ejected victims were not wearing a seat belt at the time of the incident. Increasing seat belt use, in conjunction with better shoulder retention performance, will significantly reduce injuries and deaths associated with an ROV rollover event.

To address these hazards, the Commission is proposing requirements for:

- A minimum level of rollover resistance of the ROV when tested using the J-turn test procedure;
- A hang tag providing information about the vehicle's rollover resistance on a progressive scale;
- Understeer performance of the ROV when tested using the constant radius test procedure;
- Limited maximum speed of the ROV when tested with occupied front seat belts unbuckled; and
- A minimum level of passive shoulder protection when using a probe test.

VI. CPSC Technical Analysis and Basis for Proposed Requirements

A. Overview of Technical Work

In February 2010, the Commission contracted SEA, Limited (SEA) to conduct an in-depth study of vehicle dynamic performance and static rollover measures for ROVs. SEA evaluated a sample of 10 ROVs that represented the recreational and utility oriented ROVs available in the U.S. market that year. SEA tested and measured several characteristics and features that relate to the rollover performance of the vehicles and to the vehicle's handling characteristics.

In 2011, SEA designed and built a roll simulator to measure and analyze occupant response during quarter-turn roll events of a wide range of machines, including ROVs. The Commission contracted with SEA to conduct occupant protection performance evaluations of seven ROVs with differing occupant protection designs.[4]

B. Lateral Stability

1. Definitions. Following are definitions of basic terms used in this section.

- **Lateral acceleration**: acceleration that generates the force that pushes the vehicle sideways. During a turn, lateral acceleration is generated by friction between the tires and surface. Lateral acceleration is expressed as a multiple of free-fall gravity (g).
- **Two-wheel lift:** point at which the inside wheels of a turning vehicle lift off the ground, or when the uphill wheels of a vehicle on a tilt table lift off the table. Two-wheel lift is a precursor to a rollover event. We use the term "two-wheel lift" interchangeably with "tip-up."
- **Threshold lateral acceleration**: minimum lateral acceleration of the vehicle at two-wheel lift.
- **Untripped rollover**: rollover that occurs during a turn due solely to the lateral acceleration generated by friction between the tires and the road surface.
- **Tripped rollover**: rollover that occurs when the vehicle slides and strikes an object that provides a pivot point for the vehicle to roll over.

2. Static Measures to Evaluate ROV Lateral Stability

CPSC and SEA evaluated the static measurements of the static stability factor (SSF) and tilt table ratio (TTR) to compare lateral stability of a group of 10 ROVS.

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[4] SEA's reports are available on CPSC's website at: http://www.cpsc.gov/en/Research--Statistics/Sports--Recreation/ATVs/Technical-Reports/.

a. *Static Stability Factor (SSF)*

SSF approximates the lateral acceleration in units of gravitational acceleration (g) at which rollover begins in a simplified vehicle that is assumed to be a rigid body without suspension movement or tire deflections. NHTSA uses rollover risk as determined by dynamic test results and SSF values to evaluate passenger vehicle rollover resistance for the New Car Assessment Program (NCAP).[5] SSF relates the track width of the vehicle to the height of the vehicle center of gravity (CG), as shown in Figure 2. Loading condition is important because CG height and track width vary, depending on the vehicle load condition. Mathematically, the relationship is track width (T) divided by two times the CG height (H), or SSF=T/2H. Higher values for SSF indicate higher lateral stability, and lower SSF values indicate lower lateral stability.

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[5] NHTSA, 68 FR 59250, "Consumer Information; New Car Assessment Program; Rollover Resistance," (Oct. 14, 2003).

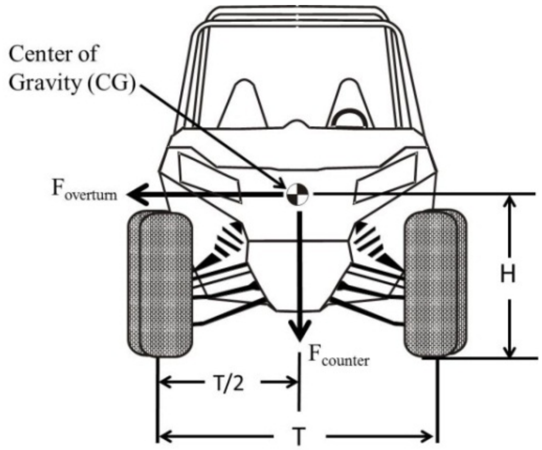

Figure 2. Components of SSF

SEA measured track width and CG height values for the sample group of 10 ROVs. SEA used their Vehicle Inertia Measurement Facility (VIMF), which incorporates the results of five different tests to determine the CG height. SEA has demonstrated that VIMF CG height measurements are repeatable within ±0.5 percent of the measured values.[6] Using the CG height and track width measurement, SEA calculated SSF values for several different load conditions. (See Table 1).

[6] Christoffersen, Steven R., et al. (1995) Deceleration Factors on Off-Road Surfaces Applicable for Accident Reconstruction. SAE 950139.

Table 1—SSF Values

Vehicle Rank (SSF)	SSF
F	0.881
A	0.887
H	0.918
B	0.932
D	0.942
J	0.962
E	0.965
C	0.991
G	1.031
I	1.045

b. *Tilt Table Ratio* (*TTR)*

SEA conducted tilt table tests on the ROV sample group. In this test, the vehicles in various loaded conditions were placed on a rigid platform, and the angle of platform tilt was increased (see Figure 3) until both upper wheels of the vehicle lifted off the platform. The platform angle at two-wheel lift is the Tilt Table Angle (TTA). The trigonometric tangent of the TTA is the Tilt Table Ratio (TTR). TTA and TTR are used to evaluate the stability of the vehicle. Larger TTA and TTR generally correspond to better lateral stability, except these measures do not account for dynamic tire deflections or dynamic suspension compliances. Tilt testing is a quick and simple static test that does not require sophisticated instrumentation. Tilt testing is used as a rollover metric in the voluntary standards created by the Recreational Off-

Highway Vehicle Association (ROHVA) and the Outdoor Power Equipment Institute (OPEI).

TTA and TTR values measured by SEA are shown in Table 2.[7]

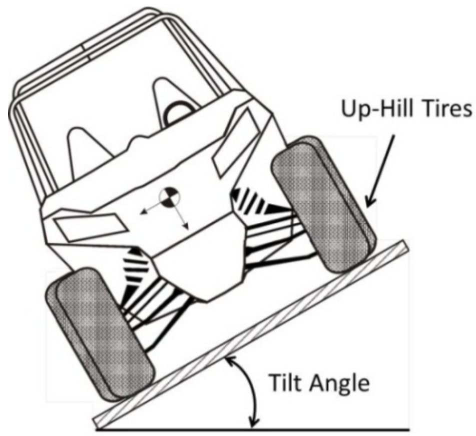

Figure 3. Tilt Table Ratio (TTR) = Tan (Tilt Angle)

[7] ROHVA developed ANSI/ROHVA 1 for recreation-oriented ROVs and OPEI developed ANSI/OPEI B71.0 for utility-oriented ROVs.

Table 2—TTA and TTR Values

Vehicle Rank (TTA)	TTA (deg.)		Vehicle Rank (TTR)	TTR
A	33.0		A	0.650
B	33.6		B	0.664
D	33.7		D	0.667
I	35.4		I	0.712
H	35.9		H	0.724
J	36.1		J	0.730
F	36.4		F	0.739
E	38.1		E	0.784
C	38.8		C	0.803
G	39.0		G	0.810

Because ROVs are designed with long suspension travel and soft tires for off-road performance, staff was concerned that SSF and TTR would not accurately characterize the *dynamic* lateral stability of the vehicle. Therefore, CPSC's contractor, SEA, conducted dynamic J-turn tests to determine whether SSF or TTR measurement corresponded with actual dynamic measures for lateral stability.

3. Dynamic Test to Measure ROV Lateral Stability—the J-Turn Test

In 2001, NHTSA evaluated the J-turn test (also called drop-throttle J-turn testing and step-steer testing) as a method to measure rollover resistance of automobiles. NHTSA found the J-turn test to be the most objective and repeatable method for vehicles with low rollover resistance. Specifically, the J-turn test is objective because a programmable steering machine turns the steering wheel during the test, and the test results show that the vehicle speed, lateral acceleration, and roll angle data observed during J-turn tests were highly repeatable.[8] However, NHTSA determined that although the J-turn test is the most objective and repeatable method for vehicles with low rollover resistance, the J-turn test is unable to measure the high rollover resistance of most passenger automobiles.[9] On pavement where a high-friction surface creates high lateral accelerations, vehicles with high rollover resistance (such as passenger automobiles) will lose tire traction and slide in a severe turn rather than roll over. The threshold lateral acceleration cannot be measured because rollover does not occur. In contrast, vehicles with low rollover resistance exhibit untripped rollover on a pavement during a J-turn test, and the lateral acceleration at rollover threshold can be measured. Thus, the J-turn test is the most appropriate method to measure the rollover resistance of ROVs because ROVs exhibit untripped rollover during the test.

J-turn tests are conducted by driving the test vehicle in a straight path, releasing (dropping) the throttle, and rapidly turning the steering wheel to a specified angle once the vehicle slows to a specified speed. The steering wheel angle and vehicle speed are selected to produce two-wheel lift of the vehicle. Outriggers, which are beams that extend to either side of a vehicle, allow the vehicle to roll but prevent full rollover. The sequence of events in the test procedure is shown in Figure 4. SEA conducted drop-throttle J-turn tests to measure the minimum lateral accelerations

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[8] Forkenbrock, G. and Garrott, W. (2002). A Comprehensive Experimental Evaluation of Test Maneuvers That May Induce On-Road, Untripped, Light Vehicle Rollover Phase IV of NHTSA's Light Vehicle Rollover Research Program. DOT HS 809 513.

[9] Forkenbrock, G. and Garrott, W. (2002). A Comprehensive Experimental Evaluation of Test Maneuvers That May Induce On-Road, Untripped, Light Vehicle Rollover Phase IV of NHTSA's Light Vehicle Rollover Research Program. DOT HS 809 513.

necessary to cause two-wheel lift (shown in Step 3 of Figure 4) for each vehicle. Side loading of the vehicle occurs naturally as a result of the lateral acceleration that is created in the J-turn and this lateral acceleration can be measured and recorded. The lateral acceleration produced in the turn is directly proportional to the side loading force acting to overturn the vehicle according to the equation $F= (m) (A_y)$, where F is force, m is the mass of the vehicle, and A_y is lateral acceleration.

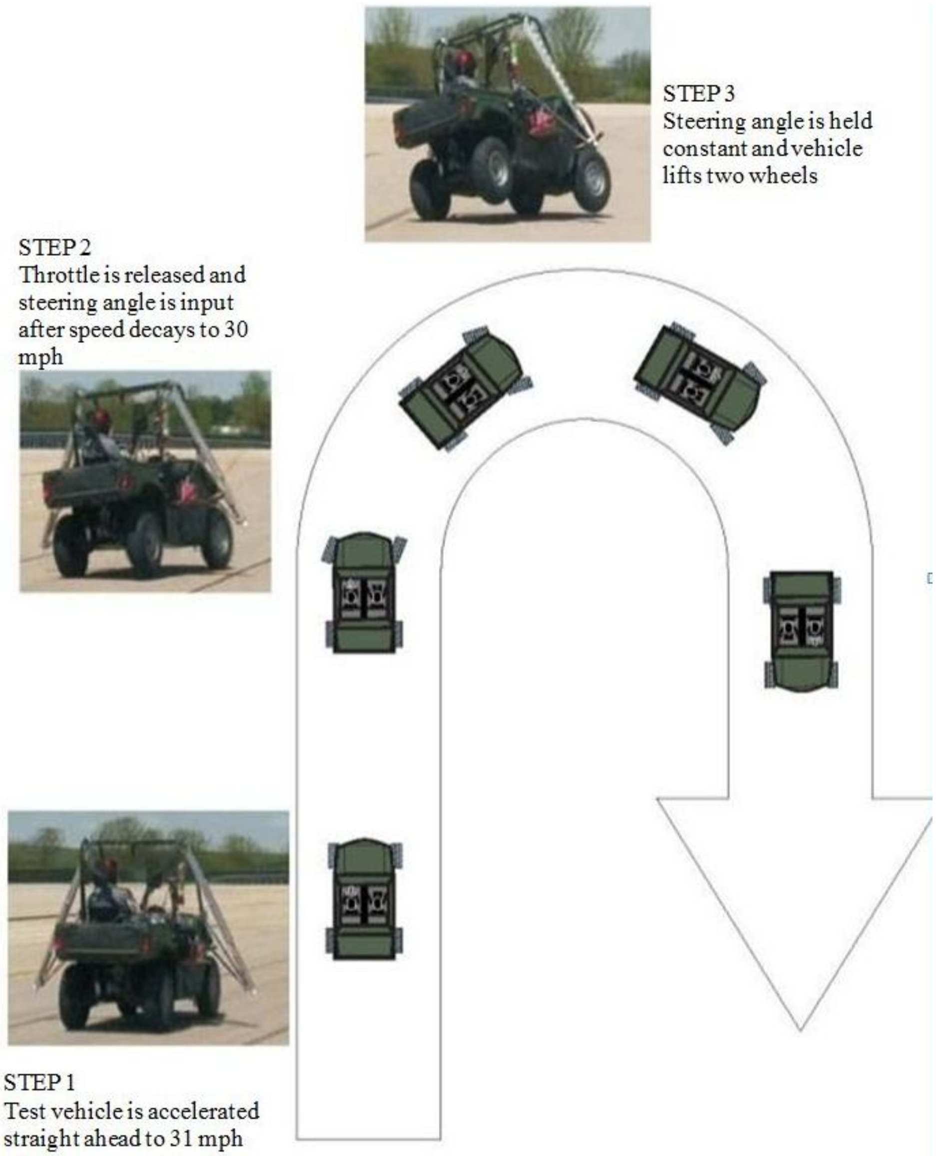


Figure 4. J-Turn Test Sequence of Events

SEA conducted the J-turn testing at 30 mph. A programmable steering controller input the desired steering angles at a steering rate of 500 degrees per second for all vehicles. The chosen steering rate of 500 degrees per second is high enough to approximate a step input, but still within the capabilities of a driver. (A step input is one that happens instantly and requires no time to complete. For steering input, time is required to complete the desired steering angle, so a steering step input is approximated by a high angular rate of steering input.) SEA conducted preliminary tests by starting with a relatively low steering angle of 80 to 90 degrees and incrementally increasing the steering angle until two-wheel lift was achieved. When SEA determined the steering angle that produced a two-wheel lift, SEA conducted the test run for that vehicle load condition. For each test run, SEA recorded the speed, steering angle, roll rate, and acceleration in three directions (longitudinal, lateral, and vertical). SEA processed and plotted the data to determine the minimum lateral acceleration required for two-wheel lift of the vehicle.

The J-turn test is a direct measure of the minimum or threshold lateral acceleration required to initiate a rollover event, or tip-up of the test vehicle when turning. ROVs that exhibit higher threshold lateral acceleration have a higher rollover resistance or are more stable than ROVs with lower threshold lateral accelerations. Each of the 10 ROVs tested in the study by SEA exhibited untripped rollover in the J-turn tests at steering wheel angles ranging from 93.8 to 205 degrees and lateral accelerations ranging from 0.625 to 0.785 g. Table 3 shows the vehicles arranged in ascending order for threshold lateral acceleration (A_y) at tip up, SSF, TTA, and TTR. Table 3 illustrates the lack of correlation of the static metrics (SSF, TTA, or TTR) with the direct dynamic measure of threshold lateral acceleration (A_y) at tip up.

Table 3

Vehicle Rank (A_y)	A_y (g)	SSF	TTR
D	0.625	0.942	0.667
B	0.655	0.932	0.664
A	0.670	0.887	0.650
J	0.670	0.962	0.730
I	0.675	1.045	0.712
F	0.690	0.881	0.739
E	0.700	0.965	0.784
H	0.705	0.918	0.724
C	0.740	0.991	0.803
G	0.785	1.031	0.810

Adapted from: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles – Additional Results for Vehicle J. Retrieved from http://www.cpsc.gov/PageFiles/93928/rovj.pdf.

SEA also conducted J-turn tests on four ROVs to measure the repeatability of the lateral acceleration measurements and found the tests to be very repeatable. [10] The results of the repeatability tests indicate the standard deviation for sets of 10 test runs (conducted in opposite directions and left/right turn directions) ranged from 0.002 g to 0.013 g.

Comparison of the SSF, TTR, and A_y values for each ROV indicate that there is a lack of correspondence between the static metrics (SSF and TTR) and the direct measurement of threshold lateral acceleration at rollover. Static metrics cannot be used to evaluate ROV rollover resistance because static tests are unable to account fully for the dynamic tire deflections and suspension compliance exhibited by the ROVs during a J-turn maneuver. Therefore, the

[10] Heydinger, G. (2013). Repeatability of J-Turn Testing of Four Recreational Off-Highway Vehicles. Retrieved from http://www.cpsc.gov//Global/Research-and-Statistics/Injury-Statistics/Sports-and-Recreation/ATVs/SEAReporttoCPSCRepeatabilityTestingSeptember%202013.pdf.

Commission believes that the lateral acceleration threshold at rollover is the most appropriate metric to use when measuring and comparing rollover resistance for ROVs.

C. Vehicle Handling

1. Basic Terms

- Understeer: path of vehicle during a turn in which the vehicle steers less into a turn than the steering wheel angle input by the driver. If the driver does not correct for the understeer path of the vehicle, the vehicle continues on a straighter path than intended (see Figure 5).
- Oversteer: path of vehicle during a turn in which the vehicle steers more into a turn than the steering wheel angle input by the driver. If the driver does not correct for the oversteer path of the vehicle, the vehicle spirals into the turn more than intended (see Figure 5).
- Sub-limit understeer or sub-limit oversteer: steering condition that occurs while the tires have traction on the driving surface.
- Limit understeer or limit oversteer: steering condition that occurs when the traction limits of the tires have been reached and the vehicle begins to slide.

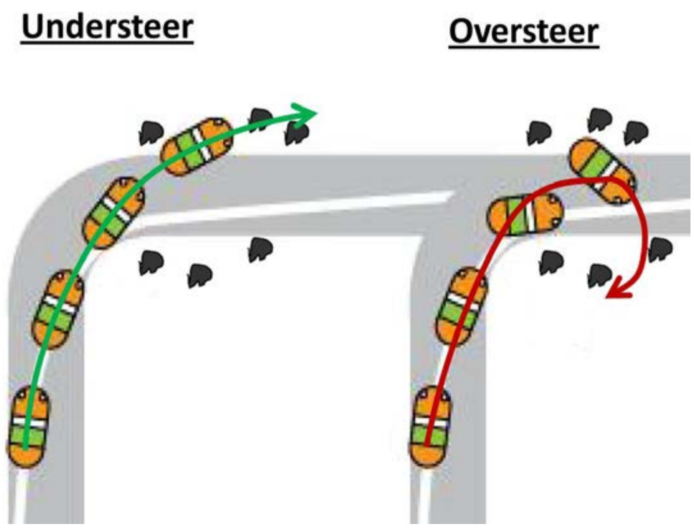


Figure 5. Understeer and Oversteer Path

2. Staff's Technical Work

a. Constant Radius Test

SAE International (formerly Society of Automotive Engineers) standard, SAE J266, Surface Vehicle Recommended Practice, *Steady-State Directional Control Test Procedures for Passenger Cars and Light Trucks*, establishes test procedures to measure the vehicle handling properties of passenger cars and light trucks. ROVs obey the same principles of motion as automobiles because ROVs and automobiles share key characteristics, such as pneumatic tires, a steering wheel, and spring-damper suspension that contribute to the dynamic response of the vehicle.[11] Thus, the test procedures to measure the vehicle handling properties of passenger cars and light trucks are also applicable to ROVs.

[11] See Tab A of the CPSC staff's briefing package.

SEA used the constant radius test method, described in SAE J266, to evaluate the sample ROVs' handling characteristics. The test consists of driving each vehicle on a 100 ft. radius circular path from very low speeds, up to the speed where the vehicle experiences two-wheel lift or cannot be maintained on the path of the circle. The test vehicles were driven in the clockwise and counterclockwise directions. For a constant radius test, "understeer" is defined as the condition when the steering wheel angle required to maintain the circular path increases as the vehicle speed increases because the vehicle is turning less than intended. "Neutral steer" is defined as the condition when the steering wheel angle required to maintain the circular path is unchanged as the vehicle speed increases. "Oversteer" is defined as the condition when the average steering wheel input required to maintain the circular path decreases as the vehicle speed increases because the vehicle is turning more than intended.

SEA tested 10 ROVs; five of those vehicles (A, D, F, I, and J) exhibited sub-limit transitions to oversteer when tested on asphalt (see Figure 6). The five remaining vehicles (B, C, E, G, and H) exhibited a sub-limit understeer condition for the full range of the test.

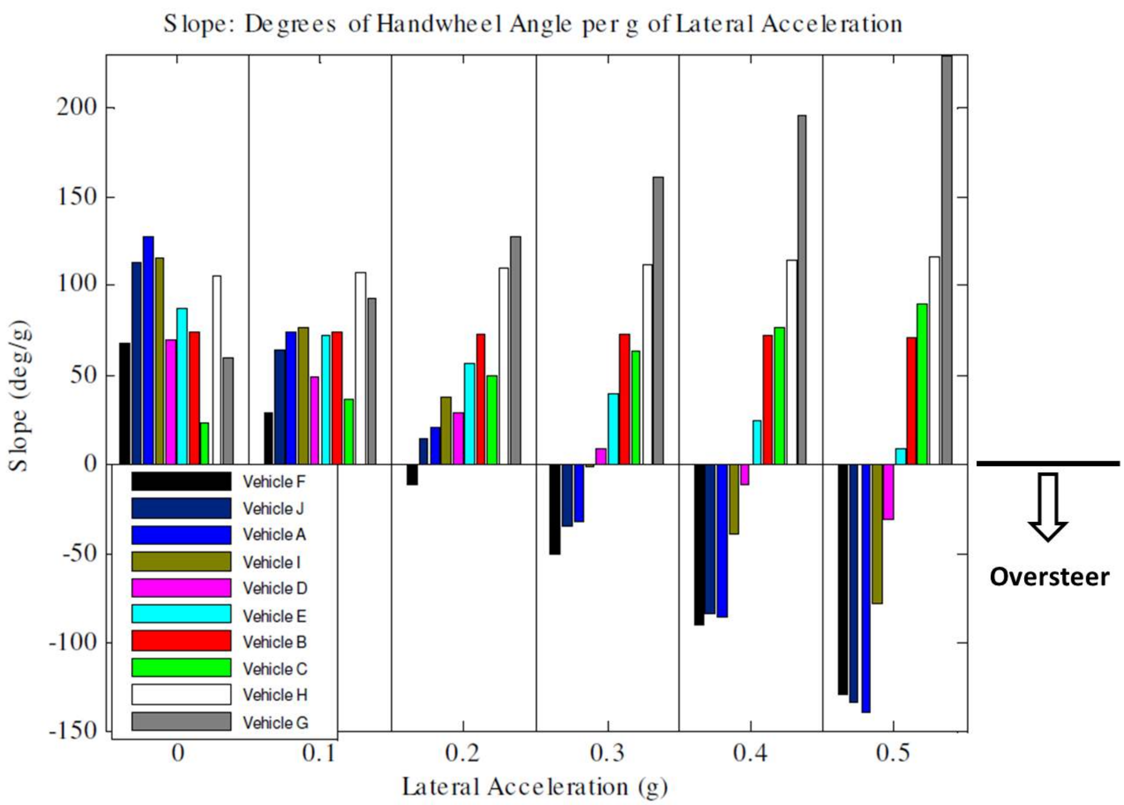


Figure 6. Steering Gradient Slopes at Selected Values of Lateral Acceleration for Tested ROVs

Source: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles – Additional Results for Vehicle J. Retrieved from http://www.cpsc.gov/PageFiles/93928/rovj.pdf.

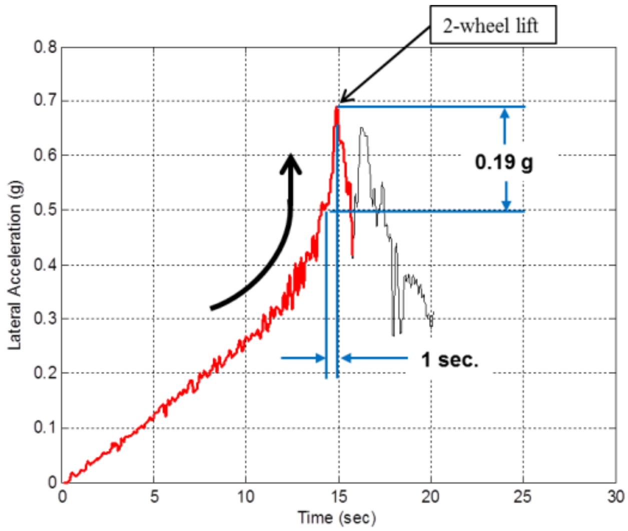
b. Slowly Increasing Steer (SIS) Test

SAE J266, Surface Vehicle Recommended Practice, *Steady-State Directional Control Test Procedures for Passenger Cars and Light Trucks*, also establishes test procedures for the Constant Speed Variable Steer Angle Test. SEA calls this test the "constant speed slowly increasing steer (SIS) test." During the SIS test, the ROV driver maintains a constant speed of 30 mph, and the vehicle's steering wheel angle is slowly increased at a rate of 5 degrees per second until the ROV reaches a speed limiting condition or tip-up. A programmable steering controller (PSC) was used to increase the steering angle at a constant rate of 5 degrees per second. During the test, instrumentation for speed, steering angle, lateral acceleration, roll angle, and yaw rate were recorded. SEA conducted SIS tests on the sample of 10 ROVs.

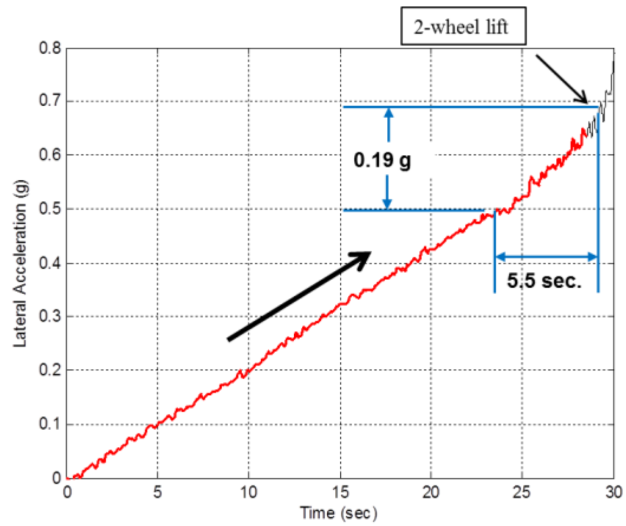
Figure 7 shows SIS test data plotted of lateral acceleration versus time for Vehicle A and Vehicle H. Vehicle H is the same model vehicle as Vehicle A, but Vehicle H is a later model year, where the sub-limit oversteer has been corrected to understeer.

Plots from the ROV SIS tests in Figure 7 illustrate a sudden increase in lateral acceleration that is found only in vehicles that exhibit sub-limit oversteer. The sudden increase in lateral acceleration is exponential and represents a dynamically unstable condition.[12] This condition is undesirable because it can cause a vehicle with high lateral stability (such as a passenger car) to spin out of control, or it can cause a vehicle with low lateral stability (such as an ROV) to roll over suddenly.

[12] (Gillespie, T. (1992). Fundamentals of Vehicle Dynamics. Society of Automotive Engineers, Inc. p. 204-205.)



Vehicle A (Oversteer)



Vehicle H (Understeer)

Figure 7. SIS Plots of Lateral Acceleration Gain Over Time

Source: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles . Retrieved from http://www.cpsc.gov/PageFiles/96037/rov.pdf. Appendix D.

When Vehicle A reached its dynamically unstable condition, the lateral acceleration suddenly increased from 0.50 g to 0.69 g (difference of 0.19 g) in less than 1 second, and the vehicle rolled over. (Outriggers on the vehicle prevented full rollover of the vehicle.) In contrast, Vehicle H never reached a point where the lateral acceleration increases exponentially because the condition does not develop in understeering vehicles.[13] The increase in Vehicle H's lateral acceleration remains linear, and the lateral acceleration increase from 0.50 g to 0.69 g (same difference of 0.19 g) occurs in 5.5 seconds.

[13] Gillespie, T. (1992). Fundamentals of Vehicle Dynamics. Society of Automotive Engineers.

SEA test results indicate that ROVs that exhibited sub-limit oversteer also exhibited a sudden increase in lateral acceleration that caused the vehicle to roll over. An ROV that exhibits this sudden increase in lateral acceleration is directionally unstable and uncontrollable.[14]

Plots of the vehicle path during SIS tests illustrate further how an oversteering ROV (Vehicle A) will roll over earlier in a turn than an understeering ROV (Vehicle H), when the vehicles are operated at the same speed and steering rate (see Figure 8). Vehicle A and Vehicle H follow the same path until Vehicle A begins to oversteer and its turn radius becomes smaller. Vehicle A becomes dynamically unstable, its lateral acceleration increases exponentially, and the vehicle rolls over suddenly. In contrast, Vehicle H continues to travel 300 more feet in the turn before the vehicle reaches its threshold lateral acceleration and rolls over. A driver in Vehicle H has more margin (in time and distance) to correct the steering to prevent rollover than a driver in Vehicle A because Vehicle H remains in understeer during the turn, while Vehicle A transitions to oversteer and becomes dynamically unstable.

[14] Gillespie, T. (1992). Fundamentals of Vehicle Dynamics. Society of Automotive Engineers, Inc. p. 204-205; Bundorf, R. T. (1967). The Influence of Vehicle Design Parameters on Characteristic Speed and Understeer. SAE 670078; Segel, L. (1957). Research in the Fundamentals of Automobile Control and Stability. SAE 570044.

Slowly Increasing Steer (SIS) Test for

Vehicle A (----oversteer) and Vehicle H (— understeer)

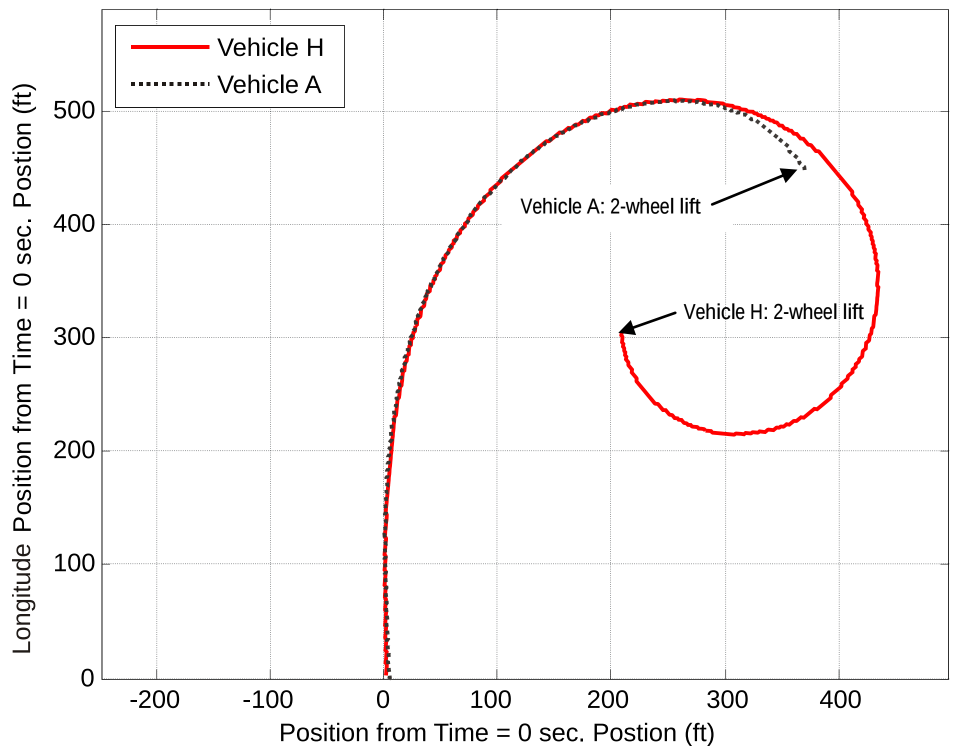


Figure 8. Path of Vehicle A and H During SIS Test (Superimposed in the Right Turn Direction)

The Commission believes that tests conducted by SEA provide strong evidence that sub-limit oversteer in ROVs is an unstable condition that can lead to a rollover incident, especially given the low rollover resistance of ROVs. All ROVs that exhibited sub-limit oversteer reached a dynamically unstable condition during a turn where the increase in lateral acceleration suddenly became exponential. The CPSC believes this condition can contribute to ROV rollover on level ground, and especially on pavement.

D. Occupant Protection

1. Overview and Basic Terms

The open compartment configuration of ROVs is intentional and allows for easy ingress and egress, but the configuration also increases the likelihood of complete or partial ejection of the occupants in a rollover event. ROVs are equipped with a ROPS, seat belts, and other restraints for the protection of occupants (see Figure 9). Occupants who remain in the ROV and surrounded by the ROPS, an area known as the protective zone, are generally protected from being crushed by the vehicle during a quarter-turn rollover. Seat belts are the primary restraint for keeping occupants within the protective zone of the ROPS.

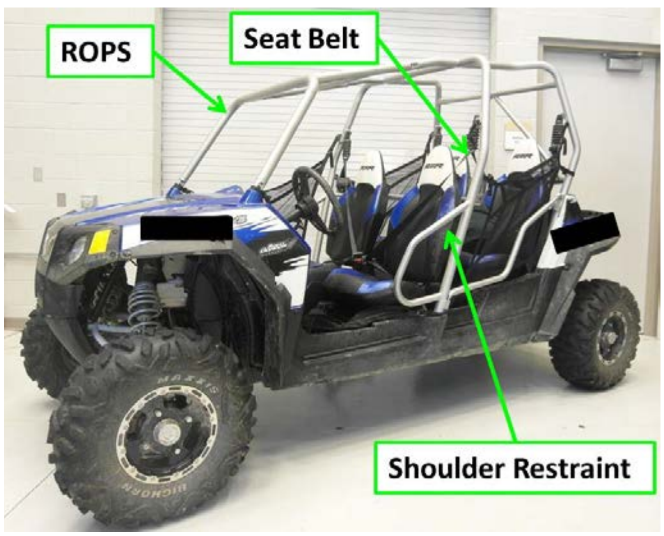


Figure 9. Occupant Protection Components on ROVs

NHTSA evaluates the occupant protection performance of passenger vehicles with tests that simulate vehicle collisions and tests that simulate vehicle rollover.[15] The NHTSA tests use anthropometric test devices (ATDs), or crash test dummies, to evaluate occupant excursion and

[15] Federal Motor Vehicle Safety Standard (1971) 49 CFR 571.208.

injury severity during the simulation tests. The occupant movement during these tests is called occupant kinematics. Occupant kinematics is defined as the occupant's motion during a crash event, including the relative motion between various body parts. Occupant kinematics is an important element of dynamic tests because forces act on an occupant from many different directions during a collision or rollover.

There are no standardized tests to evaluate the occupant protection performance of ROVs. However, a test to evaluate occupant protection performance in ROVs should be based on simulations of real vehicle rollover. In a rollover event, the vehicle experiences lateral acceleration and lateral roll. A valid simulation of an ROV rollover will reproduce the lateral acceleration and the roll rate experienced by an ROV during a real rollover event.

2. <u>Seat belts</u>

a. Seat Belt Use in Incidents

From the 428 ROV-related incidents reviewed by the Commission, 817 victims were reported to be in or on the ROV at the time of the incident, and 610 (75 percent) were known to have been injured or killed. Seatbelt use is known for 477 of the 817 victims; of these, 348 (73 percent) were not wearing a seatbelt at the time of the incident.

Of the 610 fatal and nonfatal victims who were in or on the ROV at the time of the incident, 433 (71 percent) were ejected partially or fully from the ROV, and 269 (62 percent) of these victims were struck by a part of the vehicle, such as the roll cage or side of the ROV, after ejection. Seat belt use is also known for 374 of the 610 victims; of these, 282 (75 percent) were not wearing a seat belt.

Of the 225 fatal victims who were in or on the ROV at the time of the incident, 194 (86 percent) were ejected partially or fully from the vehicle, and 146 (75 percent) were struck by a part of the vehicle after ejection. Seat belt use is known for 155 of the 194 ejected victim; of these, 141 (91 percent) were not wearing a seat belt.

A total of 826 victims were involved in the 428 ROV-related incidents reviewed the Commission's multidisciplinary team. Of these victims, 353 (43 percent) were known to be driving the ROV, and 203 (24 percent) were known to be a passenger in the front seat of the ROV. Of the 231 reported fatalities, 141 (61 percent) were the driver of the ROV, and 49 (21 percent) were the right front passenger in an ROV.

ROHVA also performed an analysis of hazard and risk issues associated with ROV-related incidents and determined that lack of seat belt use is the top incident factor.[16] ROHVA has stated: "Based on the engineering judgment of its members and its review of ROV incident data provided by the CPSC, ROHVA concludes that the vast majority of hazard patterns associated with ROV rollover would be eliminated through proper seat belt use alone." [17]

a. Literature Review (Automotive)

CPSC staff reviewed the substantial body of literature on seat belt use in automobiles. (See Tab I of staff's briefing package.) Although seat belts are one of the most effective strategies for avoiding death and injury in motor vehicle crashes, seat belts are only effective if they are used.

Strategies for increasing seat belt use in passenger vehicles date to January 1, 1972, when NHTSA required all new cars to be equipped with passive restraints or with a seat belt reminder

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[16] Heiden, E. (2009). Summary of Recreational Off-Highway Vehicle (ROV) Hazard Analysis. Memorandum from E. Heiden to P. Vitrano. Docket No. CPSC-2009-0087. Regulations.gov.

[17] Yager, T. (2011) Letter to Caroleene Paul. 18 Apr. 2011. Recreational Off-Highway Vehicle Association (ROHVA) written response to CPSC staff's ballot on proposed American National Standard ANSI/ROHVA 1-201X.

system that used a visual flashing light and audible buzzer that activated continuously for one minute if the vehicle was placed in gear with occupied front seat belts not belted. In 1973, NHTSA required that all new cars be equipped with an ignition interlock that allowed the vehicle to start only if the driver was belted. The ignition interlock was meant to be an interim measure until passive airbag technology matured, but public opposition to the technology led Congress to rescind the legislation and to prohibit NHTSA from requiring either ignition interlocks or continuous audible warnings that last more than 8 seconds. NHTSA then revised the Federal Motor Vehicle Safety Standard (FMVSS) to require a seat belt reminder with warning light and audible buzzer that lasts 4 seconds to 8 seconds when front seat belts are not fastened at the time of ignition. This standard still applies today (15 U.S.C. 1410 (b)).

Work by NHTSA indicates seat belt users can be separated loosely into three categories: full-time users, part-time users, and nonusers. Part-time users and nonusers give different reasons for not wearing seat belts. Part-time seat belt users consistently cite forgetfulness and perceived low risk, such as driving short distances or on familiar roads, as reasons for not using seat belts.[18]

One approach to increasing vehicle occupant seat belt use is to provide in-vehicle reminders to encourage occupants to fasten their seat belts. However, possible systems vary considerably in design, intrusiveness, and, most importantly, effectiveness.

Observational studies of cars equipped with the original NHTSA-required seat belt reminders found no significant difference in seat belt use among vehicles equipped with the

[18] Block, 1998; Bradbard et al., 1998; Harrison and Senserrick, 2000; Bentley et al., 2003; Boyle and Vanderwolf, 2003; Eby et al., 2005; Boyle and Lampkin, 2008.

continuous one minute visual-audio system and vehicles not equipped with the reminder system.[19] After NHTSA adopted the less stringent 4-second to 8-second visual and audio reminder system requirements, NHTSA conducted observational and phone interview studies and concluded that the less intrusive reminder system was also not effective in increasing seat belt use.[20]

A national research project by the University of Michigan Transportation Research Institute endeavored to promote safety belt use in the United States by developing an effective in-vehicle safety belt reminder system.[21] The project authors performed literature reviews and conducted surveys and focus groups to design an optimal safety belt reminder system. The authors concluded that principles for an optimal safety belt reminder system include the following:

1. The full-time safety belt user should not notice the system.
2. It should be more difficult to cheat on the system than to use the safety belt.
3. Permanent disconnection of the system should be difficult.
4. The system should be reliable and have a long life.
5. Crash and injury risk should not be increased as a result of the system.

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[19] Robertson, L.S. and Haddon, W. (1974). The Buzzer-Light Reminder System and Safety Belt Use. *American Journal of Public Health*, Vol. 64, No. 8, pp. 814-815.; Robertson, L. S. (1975). Safety Belt Use in Automobiles with Starter-Interlock and Buzzer-Light Reminder Systems. American Journal of Public Health, Vol. 65, No. 12, pp. 1319-1325.

[20] Westefeld, A. and Phillips, B.M. (1976). Effectiveness of Various Safety Belt Warning Systems. (DOT HS 801 953). Washington, D.C.: National Highway Traffic Safety Administration, U.S. Department of Transportation.

[21] Eby, D. W., Molnar, L. J., Kostyniuk, L. P., and Shope, J. T. (2005). Developing an Effective and Acceptable Safety Belt Reminder System. 19th International Technical Conference on the Enhanced Safety of Vehicles, Washington, D.C., June 6-9, 2005. **http://www-nrd.nhtsa.dot....01/esv/esv19/05-0171-O.pdf**.

6. System design should be based on what is known about the effectiveness and acceptability of system types and elements.
7. System design should be compatible with the manufacturer's intended purpose/goals for the system.

NHTSA conducted a study of enhanced seatbelt reminder (ESBR) effectiveness that compared results of controlled experiments with field observations of actual seat belt use. Among the findings of the ESBR effectiveness report are: (1) systems with only visual reminders are not effective; (2) ESBR systems, in general, promote greater seat belt use by 3 to 4 percentage points; (3) more annoying systems are more effective, but that creates the challenge of designing an effective system that is acceptable; (4) potential gains in seat belt use not only come from simply reminding users, but also from motivating users, such as equating seat belt use with elimination of an annoyance; and (5) the positive effects of ESBRs on belt use were more pronounced for the low belt-use propensity groups.[22]

c. Innovative Technologies

Automobiles. Researchers developed more innovative in-vehicle technology, beyond visual and audible warnings, to study the effectiveness of systems that hindered a vehicle function if the driver's seat belt was not buckled. One system allowed drivers to start the vehicle

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[22] Lerner, N., Singer, J., Huey, R., Jenness, J. (2007). Acceptability and Potential Effectiveness of Enhanced Seat Belt Reminder System Features. (DOT HS 810 848). Washington, D.C.: National Highway Traffic Safety Administration, U.S. Department of Transportation. Freedman, M., Lerner, N., Zador, P., Singer, J., and Levi, S. (2009). Effectiveness and Acceptance of Enhanced Seat Belt Reminder Systems: Characteristics of Optimal Reminder Systems. (DOT HS 811 097). Washington, D.C.: National Highway Traffic Safety Administration, U.S. Department of Transportation.

but delayed the driver's ability to place the vehicle in gear if the seat belt was not buckled.[23] Follow-up systems made it more difficult for the driver to depress the gas pedal when the vehicle exceeded 20–25 mph if the driver's seat belt was not buckled. Study participants were more receptive to the latter system, which was a consistent and forceful motivator to buckle the seat belt without affecting the general operation of the vehicle.[24]

ROVs. In 2010, Bombardier Recreation Products (BRP) introduced the Can-Am Commander 1000 ROV with a seat belt speed limiter system that restricts the vehicle speed to 9 mph if the driver's seat belt is not buckled. CPSC staff performed dynamic tests to verify that the vehicle's speed was limited when the driver's seat belt was not buckled. On level ground, the vehicle's speed was limited to 6 to 9 mph when the driver was unbelted, depending on the ignition key and transmission mode selected.

In 2013, BRP introduced the Can-Am Maverick vehicle as a sport-oriented ROV that also includes a seat belt speed limiter system. CPSC staff did not test the Maverick vehicle because a sample vehicle was not available for testing.

In 2014, Polaris Industries (Polaris) announced that model year 2015 Ranger and RZR ROVs will include a seatbelt system that limits the speed of the vehicle to 15 mph if the seatbelt is not engaged. (Retrieved at: http://www.weeklytimesnow.com.au/machine/sidebyside-

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[23] Van Houten, R., Malenfant, J.E.L., Reagan, I., Sifrit, K., Compton, R., & Tenenbaum, J. (2010). Increasing Seat Belt Use in Service Vehicle Drivers with a Gearshift Delay. *Journal of Applied Behavior Analysis, 43,* 369-380.

[24] Van Houten, R., Hilton, B., Schulman, R., and Reagan, I. (2011). Using Haptic Feedback to Increase Seat Belt Use of Service Vehicle Drivers. (DOT HS 811 434). Washington, D.C.: National Highway Traffic Safety Administration, U.S. Department of Transportation.

vehicles-soon-to-get-safety-improvements/story-fnkerd6b-1227023275396.) The Commission has not tested these vehicles because they are not yet available on the market.

d. User Acceptance of Innovative Technologies in ROVs

Studies of seat belt reminder systems on automobiles are an appropriate foundation for ROV analysis because ROVs are typically driven by licensed drivers and the seating environment is similar to an automobile. Staff decided to obtain data on ROV users' experience and acceptance of seat belt reminders to validate the analysis.

CPSC staff was not aware of any studies that provide data on the effectiveness of seat belt reminder systems on ROVs or user acceptance of such technologies. Therefore, the CPSC contracted Westat, Inc. (Westat), to conduct focus groups with ROV users to explore their opinions of seat belt speed-limitation systems on ROVs. Phase 1 of the effort involved conducting focus groups of ROV users and asking questions about ROV use and user opinions of the Can-Am speed-limitation system that were shown in a video to the participants. Results from Phase 1 were used to develop the protocol for Phase 2. Phase 2 of the effort conducts focus groups of ROV users who provide feedback after driving and interacting with an ROV equipped with a speed-limitation system.

Results of Phase 1 of the Westat study indicate that participants:

- admit to being part-time seat belt users;
- cite familiarity and low-risk perception as reasons for not wearing seat belts;
- value easy ROV ingress and egress over seat belt use;
- generally travel around 5 mph when driving on their own property, and overall, drive 15 to 30 mph for typical use;
- had a mixed reaction to the speed-limitation technology at 10 mph;

- were more accepting of the speed-limitation technology if the speed was raised to 15 mph or if the system was tied to a key control.

Phase 2 of the Westat study is ongoing, and a report of the results is expected by December 2015. The results will provide data on ROV users' acceptance of a seat belt speed limitation technology with a threshold speed of 10 mph, 15 mph, and 20 mph. CPSC believes the results will provide additional rationale for determining a threshold speed for a seat belt speed limitation technology that balances users acceptance (as high a speed as possible) with safe operation of the ROV without seat belt use (as low a speed as possible).

3. CPSC's Technical Work

To explore occupant protection performance testing for a product for which no standard test protocol exists, CPSC staff contracted Active Safety Engineering (ASE) to conduct two exploratory pilot studies to evaluate potential test methods. After completion of the pilot studies, CPSC staff contracted SEA, Limited (SEA) to conduct occupant protection performance evaluation tests, based on a more advanced test device designed by SEA.[25]

a. Pilot Study 1

ASE used a HYGE™ accelerator sled to conduct dynamic rollover simulations on sample ROVs, occupied by a Hybrid III 50th percentile male anthropomorphic test device (ATD). The HYGE™ system causes a stationary vehicle, resting on the test sled, to roll over by imparting a short-duration lateral acceleration to the test sled. The torso of an unbelted ATD ejected partially from the ROV during a simulated rollover. In comparison, the torso of a belted ATD remained

[25] The ASE and SEA reports are available on CPSC's website at: http://www.cpsc.gov/en/Research--Statistics/Sports--Recreation/ATVs/Technical-Reports/.

in the ROV during a simulated rollover. The tests demonstrated that use of a seat belt prevented full ejection of the ATD’s torso.

b. Pilot Study 2

In a follow-up pilot study, ASE used a deceleration platform sled rather than a HYGE™ accelerator sled to impart the lateral acceleration to the test vehicle. The deceleration sled is more accurate than the HYGETM sled in re-creating the lower energy rollovers associated with ROVs.

An unbelted ATD ejected fully from the vehicle during tests conducted at the rollover threshold of the ROV. In comparison, a belted ATD partially ejected from the vehicle during tests conducted at the same lateral acceleration. These exploratory tests with belted and unbelted occupants indicate the importance of using seat belts to prevent full ejection of the occupant during a rollover event.

c. SEA Roll Simulator

SEA designed and built a roll simulator to measure and analyze occupant response during quarter-turn roll events of a wide range of machines, including ROVs. The SEA roll simulator produces lateral accelerations using a deceleration sled and produces roll rates using a motor to rotate the test sled (see Figure 10).

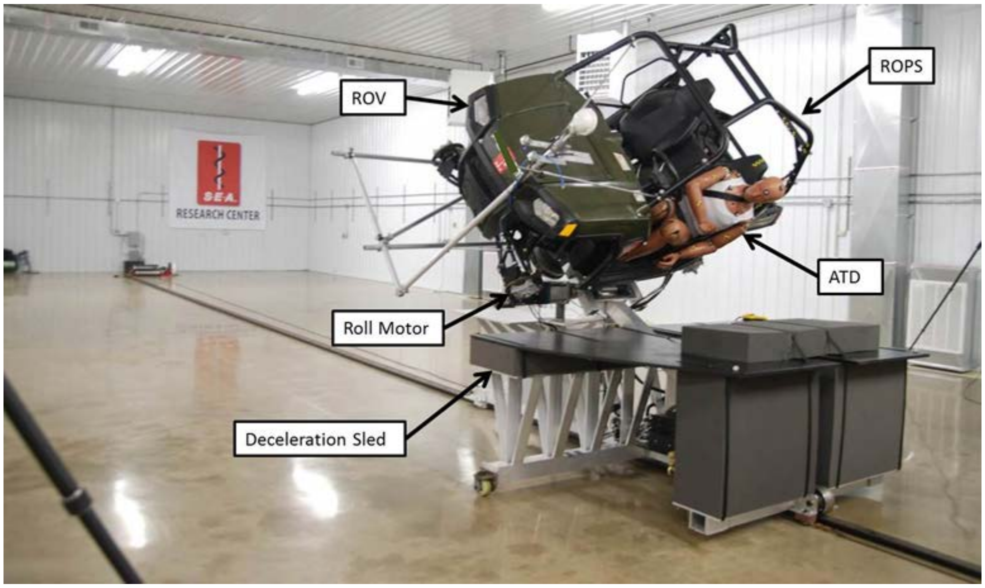

Figure 10. SEA Roll Simulator

Source: Zagorski, S. B., Heydinger, G. J., Sidhu, A., Guenther, D.A., and Andreatta, D. A. (2011). Modeling and Validation of a Roll Simulator for Recreational Off-Highway Vehicles. IMECE 2011-6203.

SEA validated the roll simulator as an accurate simulation of ROV rollover and occupant kinematics by comparing roll rates, lateral accelerations, and ATD ejections that were created by the simulator with actual values measured during autonomous rollover. Results show that the roll simulator accurately re-creates the conditions of an ROV rollover. CPSC believes that the vehicle kinematics on the SEA rollover simulator accurately represent real-world events because SEA validated the sled kinematics against full-vehicle, real-world rollover events.

SEA simulated tripped and untripped rollovers of seven sample ROVs using belted and unbelted ATD occupants. Plots of the head excursion data indicate how well the vehicle's occupant protection features retain the occupant inside the protective zone of the ROPS during a roll simulation (see Figure 11). Head displacement plots above the ROPS Plane indicate the occupant's head stayed inside the ROPS zone, and plots below the ROPS Plane indicate that the occupant's head moved outside the ROPS zone.

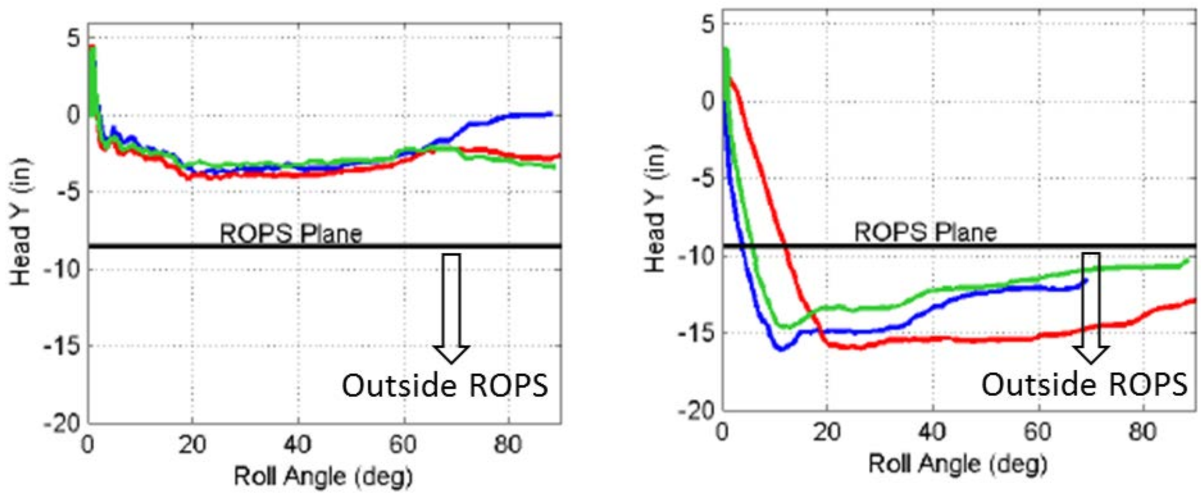

Figure 11. Exemplar Plots of Head Excursion During ROV Roll Simulation

Source: Morr, D. (2012) Test and Evaluation of Recreational Off-Highway Vehicles (ROVs) Dynamic Occupant Protection Performance Tests. Retrieved from http://www.cpsc.gov/Global/Research-and-Statistics/Technical-Reports/Sports-and-Recreation/ATV-ROV/ROVOccupantProtectionPerformanceTests.pdf.

The SEA roll simulator test results indicate that five of the seven ROVs tested allowed a belted occupant's head to eject outside the ROPS of the vehicle during a quarter-turn rollover simulation. The occupant protection performance of belted occupants varied from vehicle to vehicle, depending on seat belt design, passive hip and shoulder coverage, whether the rollover was tripped or untripped, and ROPS dimensions and geometry.

CPSC staff analysis of the SEA roll simulator test results indicates that vehicles with the best occupant protection performance restricted movement of the occupant with combinations of quick-locking seat belts, passive coverage in the hip and shoulder areas of the occupant, and large ROPS zones around the occupant's head. Rollover tests indicate that a seat belt is effective at preventing full occupant ejection, but in some cases where the seat belt does not lock quickly, partial occupant ejection still occurs. However, when a seat belt is used in conjunction with a passive shoulder barrier restraint, testing indicates that the occupant remains within the protective zone of the vehicle's ROPS during quarter-turn rollover events.

The SEA roll simulator test results also indicate that unbelted occupants are partially or fully ejected from all vehicles, regardless of the presence of other passive restraints, such as hip restraints or shoulder restraints. Although passive shoulder barriers may not provide substantial benefit for occupant protection in unbelted rollovers, the roll simulator test results indicate that shoulder restraints significantly improved occupant containment when used in conjunction with a seat belt.

Although the SEA roll simulator is the most advanced test equipment viewed by the Commission, to date, and the test results provide clear evidence of occupant head excursion, not enough test data have been generated to base dynamic occupant protection performance test requirements on a device like the roll simulator. Therefore, the Commission is using the roll simulator test results to focus on occupant protection requirements that maximize occupant retention through seat belt use with passive shoulder restraint.

d. ANSI/ROHVA 1-2011 Occupant Protection Tests

CPSC staff tested 10 sample ROVs to the occupant retention system (ORS) zone requirements specified in ANSI/ROHVA 1-2011. Requirements are specified for Zone 1 – Leg/Foot, Zone 2 – Shoulder/Hip, Zone 3 – Arm/Hand, and Zone 4 – Head/Neck. CPSC focused on the requirements for Zone 2 because occupant ejection occurs in this zone.[26]

ANSI/ROHVA Zone 2 – Shoulder/Hip requirements allow the vehicle to pass one of two different test methods to meet that zone's requirement. Under the first option, a construction-based method defines an area near the occupant's side that must be covered by a passive barrier. The test involves applying a 163-lbf. load at a point in the defined test area without failure or

[26] See Tab H of the briefing package.

deformation of the barrier. Under the second option, a performance-based method specifies a tilt table test with a vehicle occupied by a belted test dummy. When the vehicle is tilted to 45 degrees on the tilt table, the ejection of the dummy must not exceed 5 inches beyond the vehicle width.

Results of CPSC tests indicate that only four of 10 vehicles passed the construction-based test requirements, and eight of 10 vehicles passed the performance-based test requirements.[27] CPSC analysis identified a primary weakness with the performance-based tilt table tests. The performance-based test criteria measure the torso excursion outside the vehicle width, not the excursion outside the protective zone of the ROPS. An occupant must remain inside the envelope of the ROPS to be protected; therefore, the requirement allows an inherently unsafe condition where the occupant moves outside the protective zone of the vehicle's ROPS.

CPSC measured the difference between the outermost point of the ROV and the outermost point on the ROPS near the occupant's head (see Figure 12). On one vehicle, the vehicle's maximum width was 6.75 inches outside the maximum ROPS width near the occupant's head. Because the requirement is based on a 5-inch limitation beyond the vehicle width, the occupant's torso could be 11.75 inches (6.75 inches plus 5 inches) outside of the vehicle ROPS and still meet the performance-based requirement.

[27] See Tab H of the briefing package.

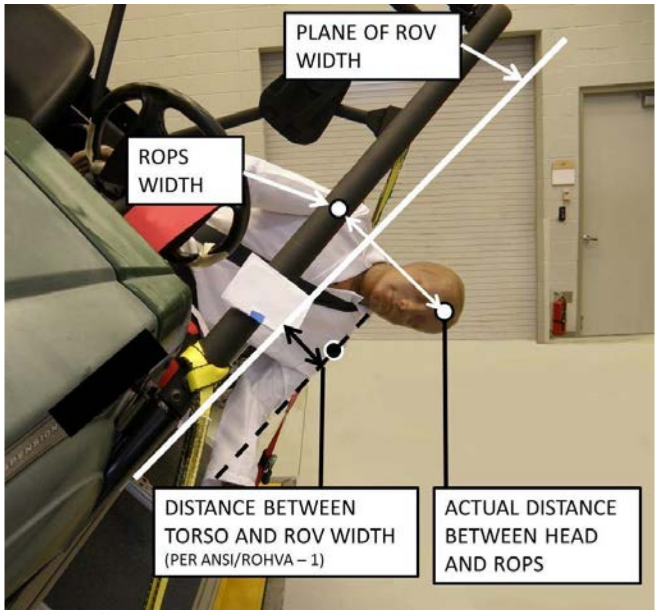

Figure 12. Difference Between Torso and Head Excursion During Tilt Table Test

CPSC also compared the occupant head excursion relative to the torso excursion during the tilt table tests. Due to occupant rotation during the tests, the maximum head displacement exceeded the torso displacement by up to 3 inches. The discrepancy between head and torso displacement and between the vehicle width and ROPS' width can result in occupant head ejection that is 14.75 inches (11.75 inches plus 3 inches) outside the protective zone of the ROPS and still meet the performance-based requirement.

VII. Relevant Existing Standards

A. Background

Two different organizations developed separate voluntary standards for ROVs. The Recreational Off-Highway Vehicle Association (ROHVA) developed ANSI/ROHVA 1, *American National Standard for Recreational Off-Highway Vehicles,* and the Outdoor Power Equipment Institute (OPEI) developed ANSI/OPEI B71.9, *American National Standard for Multipurpose Off-Highway Utility Vehicles*.

ROHVA member companies include: Arctic Cat, BRP, Honda, John Deere, Kawasaki, Polaris, and Yamaha. Work on ANSI/ROHVA 1 started in 2008, and work completed with the publication of ANSI/ROHVA 1-2010. The standard was immediately opened for revision, and a revised standard, ANSI/ROHVA 1-2011, was published in July 2011.

OPEI member companies include: Honda, John Deere, Kawasaki, and Yamaha. Work on ANSI/OPEI B71.9 was started in 2008, and work was completed with the publication of ANSI/OPEI B71.9-2012 in March 2012.

Both voluntary standards address design, configuration, and performance aspects of ROVs, including requirements for accelerator and brake controls; service and parking brake/parking mechanism performance; lateral and pitch stability; lighting; tires; handholds; occupant protection; labels; and owner’s manuals.

CPSC staff participated in the canvass process used to develop consensus for ANSI/ROHVA 1 and ANSI/OPEI B71.9. From June 2009 to the present, CPSC staff has engaged actively with ROHVA and OPEI through actions that include the following:

- Sending correspondence to ROHVA and OPEI with comments on voluntary standard ballots that outlined CPSC staff’s concerns that the voluntary standard requirements for lateral stability are too low, that requirements for vehicle handling are lacking, and that requirements for occupant protection are not robust;
- Participating in public meetings with ROHVA and OPEI to discuss development of the voluntary standard and to discuss static and dynamic tests performed by contractors on behalf of CPSC staff;
- Sharing all CPSC contractor reports with test results of static and dynamic tests performed on ROVs by making all reports available on the CPSC website;
- Requesting copies of test reports on dynamic tests performed on ROVs by ROHVA for CPSC staff to review;

- Demonstrating dynamic test procedures and data collection to ROHVA and OPEI at a public meeting at an outdoor test facility in East Liberty, OH; and
- Submitting suggested changes and additions to the ANSI/ROHVA 1-2011 voluntary standard to improve lateral stability, vehicle handling, and occupant protection (OPEI was copied).

ANSI/ROHVA 1-2011 was published in July 2011, without addressing CPSC staff's concerns. CPSC staff requested, but has not received reports or test results of static or dynamic tests conducted by contractors on behalf of ROHVA.

ANSI/OPEI B71.9 - 2012 was published in March 2012, without addressing CPSC staff's concerns.

On August 29, 2013, CPSC staff sent a letter to ROHVA with suggested modifications to the voluntary standard requirements to address staff's concerns. CPSC staff sent a courtesy copy of the August 29, 2013 recommendation letter to OPEI. On November 27, 2013, ROHVA responded that ROHVA plans to adopt less stringent versions of CPSC staff's suggested requirements to improve the lateral stability and occupant protection performance of ROVs. On March 13, 2014, ROHVA sent CPSC staff the Canvass Draft of proposed revisions to ANSI/ROHVA 1-2011. Staff responded to the Canvass Draft on May 23, 2014, and summarized why staff believes ROHVA's proposed requirements will not reduce the number of deaths and injuries from ROVs. The discussion below also provides that explanation.

On February 21, 2014, OPEI sent a letter to CPSC staff requesting that the CPSC exclude from CPSC's rulemaking efforts multipurpose off-highway utility vehicles (MOHUVs) that meet the ANSI/OPEI B71.9-12 standard requirements. We address this request in the response to comments section of this preamble (Section VIII).

B. Voluntary Standards Provisions Related to the Proposed Rule

In this section, we summarize the provisions of the voluntary standards that are related to the specific requirements the Commission is proposing and we assess the adequacy of these voluntary standard provisions.

1. Lateral Stability

ANSI/ROHVA 1-2011 and ANSI/OPEI B71.9 include similar provisions to address static lateral stability and differing provisions to address dynamic lateral stability:

Voluntary Standard Requirement: **ANSI/ROHVA 1-2011 Section 8.2 Stability Coefficient (K_{st}) and ANSI/OPEI B71.9-2012 Section 8.6 Stability Coefficient (K_{st})** specify a stability coefficient, K_{st}, which is calculated from the vehicle's center of gravity location and track-width dimensions. The value of K_{st} for a vehicle at curb weight (without occupants) is required to be no less than 1.0.

Adequacy: The Commission believes the stability coefficient requirement does not adequately address lateral stability in ROVs because static tests are unable to account fully for the dynamic tire deflections and suspension compliance exhibited by ROVs in a dynamic maneuver. For practical purposes, K_{st} and SSF values provide the same information for ROVs because the difference in front and rear track widths are averaged in the SSF calculation. Table 4 shows the results of SSF measurements made by SEA for driver-plus-passenger load condition. A comparison of how the vehicles would rank if the SSF (or K_{st}) were used instead of the threshold lateral acceleration at rollover (A_y) illustrates how poorly a stability coefficient correlates to the actual rollover resistance of the vehicle. The stability coefficient does not account for dynamic effects of tire compliance, suspension compliance, or vehicle handling, which are important factors in the vehicle's lateral stability.

Table 4. Vehicle Ascending Rank Order A_y vs. SSF (Operator Plus Passenger Load)					
Vehicle Rank (A_y)	A_y (g)		Vehicle Rank (SSF)	SSF
D	0.625		F	0.881
B	0.655		A	0.887
A	0.670		H	0.918
J	0.670		B	0.932
I	0.675		D	0.942
F	0.690		J	0.962
E	0.700		E	0.965
H	0.705		C	0.991
C	0.740		G	1.031
G	0.785		I	1.045

Adapted from: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles – Additional Results for Vehicle J. Retrieved from http://www.cpsc.gov/PageFiles/93928/rovj.pdf.

Furthermore, all of the ROVs tested pass the K_{st} minimum of 1.0 for an unoccupied vehicle, as specified by ANSI/ROHVA 1-2011 and ANSI/OPEI B71.9-12. The K_{st} value of an ROV with no occupants is of limited value because an ROV in use has at least one occupant. The Commission believes the ANSI/ROHVA and ANSI/OPEI stability coefficient requirement is a requirement that all ROVs can pass, does not reflect the actual use of ROVs, does not promote 0improvement in lateral stability, and does not correspond to the actual rollover resistance of ROVs. The Commission believes that the threshold lateral acceleration at rollover is a direct measure for rollover resistance, and its use would eliminate the need for a stability coefficient requirement.

Voluntary Standard Requirement: **ANSI/ROHVA 1-2011 Section 8.1 Tilt Table Test and ANSI/OPEI Section 8.7 Tilt Table Stability** specify tilt table tests in the driver-plus-passenger load condition and the gross vehicle weight rating (GVWR) load condition. The minimum tilt table angle (TTA) requirement for an ROV with a driver-plus-passenger load condition is 30 degrees, and the minimum TTA for GVWR load condition is 24 degrees.

Adequacy: The CPSC believes the tilt table requirement does not adequately address lateral stability in ROVs because static tests are unable to account fully for the dynamic tire deflections and suspension compliance exhibited by ROVs in a dynamic maneuver. Table 5 shows the results of tilt table measurements made by SEA for driver-plus-passenger load condition. A comparison of how the vehicles would rank if the TTA were used instead of the direct measurement of threshold lateral acceleration at rollover (A_y) illustrates how poorly the TTA corresponds to the actual rollover resistance of the vehicle. The tilt table test does not account for dynamic effects of tire compliance, suspension compliance, or vehicle handling, which are important factors in the vehicle's lateral stability.

Furthermore, all of the ROVs tested passed the minimum 30 degree TTA requirement specified by ANSI/ROHVA 1-2011. The ROV with the lowest rollover resistance, as directly measured by threshold lateral acceleration at rollover (Vehicle D, A_y = 0.625 g, TTA = 33.7 degrees), exceeds the voluntary standard TTA requirement by 3.7 degrees, or 12 percent above the 30 degree minimum. The ROV that was part of a repair program to increase its roll resistance, Vehicle A, exceeds the TTA requirement by 3.0 degrees, or 10 percent above the 30 degree minimum.

Table 5**. Vehicle Ascending Rank Order**

Ay vs. TTA

(Operator Plus Passenger Load)

Vehicle Rank (A_y)	A_y (g)	Vehicle Rank (TTA)	TTA (deg.)
D	0.625	A	33.0
B	0.655	B	33.6
A	0.670	D	33.7
J	0.670	I	35.4
I	0.675	H	35.9
F	0.690	J	36.1
E	0.700	F	36.4
H	0.705	E	38.1
C	0.740	C	38.8
G	0.785	G	39.0

Source: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles – Additional Results for Vehicle J. Retrieved from http://www.cpsc.gov/PageFiles/93928/rovj.pdf.

The CPSC believes the ANSI/ROHVA and ANSI/OPEI tilt table requirement does not detect inadequate rollover resistance. The TTA requirement in the voluntary standard does not correlate to the actual rollover resistance of ROVs, allows a vehicle that was part of repair program to pass the test without having undergone the repair, and provides no incentive for manufacturers to improve the lateral stability of ROVs. The CPSC believes the threshold lateral acceleration at rollover is a direct measure of rollover resistance, and its use would eliminate the need for a tilt table test requirement.

Voluntary Standard Requirement: **ANSI/ROHVA 1-2011 Section 8.3 Dynamic Stability** specifies a dynamic stability test based on a constant steer angle test performed on pavement. The standard describes the method for driving the vehicle around a 25-foot radius circle and slowly increasing the speed until 0.6 g of lateral acceleration is achieved; or 0.6 g lateral acceleration cannot be achieved because the vehicle experiences two-wheel lift of the inside wheels, or the vehicle speed is limited and will not increase with further throttle input. The vehicle passes the dynamic test if at least eight out of 10 test runs do not result in two-wheel lift.

Adequacy: The CPSC does not believe the ANSI/ROHVA requirement accurately characterizes the lateral stability of an ROV because it does not measure the threshold lateral acceleration at rollover. The Commission is not aware of any standards, recognized test protocols, or real-world significance that supports using a constant steer angle test to assess dynamic lateral stability.

CPSC staff contracted SEA to conduct constant steer angle testing, as specified by the ROHVA standard, on vehicles A, F, and J of the ROV study.[28] Table 6 shows the results of the tests.

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[28] Heydinger, G. J. (2011) Results from Proposed ROHVA and OPEI Dynamic Maneuvers - Vehicles A, F, and J. Retrieved from: http://www.cpsc.gov/Global/Research-and-Statistics/Technical-Reports/Sports-and-Recreation/ATV-ROV/ProposedROHVAandOPEIDynamicManeuvers.pdf.)

Table 6. Summary of Constant Steer Angle Test for 25 ft. Radius Path

Vehicle	Turn Direction (CW = clockwise CCW = counter-clockwise)	Test End Condition/Limit Response	ROHVA Test Pass/Fail Outcome
Vehicle A	Right (CW)	Two-wheel lift	Fail
	Left (CCW)	Two-wheel lift	Fail
Vehicle F	Right (CW)	Maximum Speed*	Pass**
	Left (CCW)	Maximum Speed*	Pass**
Vehicle J	Right (CW)	Two-wheel lift	Fail
	Left (CCW)	Maximum Speed/Spinout	Pass

* Maximum speed occurred very near 0.6 g of corrected lateral acceleration for Vehicle F.

** Two-wheel lift occurred for Vehicle F after the driver slowed from maximum speed at the end of the test.

Source: Heydinger, G. (2011) Results from Proposed ROHVA and OPEI Dynamic Maneuvers - Vehicles A, F, and J. Retrieved from http://www.cpsc.gov/Global/Research-and-Statistics/Technical-Reports/Sports-and-Recreation/ATV-ROV/ProposedROHVAandOPEIDynamicManeuvers.pdf.

The Commission is concerned that ROVs with low lateral stability can pass ROHVA's dynamic stability requirement because the small turn radius limits the ROV's speed and prevents generation of the lateral accelerations necessary to assess rollover resistance (as shown by the results for Vehicle F). The Commission is also concerned that the effects of oversteer can allow an ROV to pass the test because maximum speed is reached by vehicle spinout (as shown by the results for Vehicle J).

NHTSA evaluated the J-turn test protocol as a method to measure the rollover resistance of automobiles.[29] NHTSA determined that the J-turn test is the most objective and repeatable method for vehicles with low rollover resistance. Vehicles with low rollover resistance exhibit untripped rollover on pavement during a J-turn test and the lateral acceleration at the rollover threshold can be measured. Lateral acceleration is the accepted measure by vehicle engineers for assessing lateral stability or rollover resistance.[30] This value is commonly used by engineers to compare rollover resistance from one vehicle to another. The ANSI/ROHVA test protocol does not measure the lateral acceleration at two-wheel lift, and the parameters of the test appear tuned to allow most vehicles to pass. Based on CPSC's testing and review, the Commission does not believe the ANSI/ROHVA dynamic stability requirement is a true measure of rollover resistance, and the CPSC does not believe the requirement will improve the lateral stability of ROVs.

Voluntary Standard Requirement: **ANSI/OPEI B71.9-2012 Section 8.8 Dynamic Stability** specifies a dynamic stability test based on a 20 mph J-turn maneuver performed on pavement. At a steering input of 180 degrees in the right and left directions, the vehicle shall not exhibit two-wheel lift.

Adequacy: The Commission does not believe the ANSI/OPEI requirement accurately characterizes the lateral stability of an ROV because the ANSI/OPEI requirement does not measure the threshold lateral acceleration at rollover. The Commission is not aware of any

[29] Forkenbrock, G. and Garrott, W. (2002). A Comprehensive Experimental Evaluation of Test Maneuvers That May Induce On-Road, Untripped, Light Vehicle Rollover Phase IV of NHTSA's Light Vehicle Rollover Research Program. DOT HS 809 513.

[30] Gillespie, T. (1992). Fundamentals of Vehicle Dynamics. Society of Automotive Engineers, Inc. p. 309-319.

standards or recognized test protocols that support using a J-turn maneuver with 180 degrees of steering wheel input to assess dynamic lateral stability of an ROV.

OPEI's use of the J-turn maneuver does not measure the lateral acceleration at two-wheel lift that produces ROV rollover. There is no correspondence between the proposed ANSI/OPEI dynamic stability requirement and ROV lateral stability because the 180-degree steering wheel input does not correspond to a turning radius. For example, an ROV with a low steering ratio will make a sharper turn at 180 degrees of steering wheel input than an ROV with a high steering ratio. (The steering ratio relates the amount that the steering wheel is turned to the amount that the wheels of the vehicle turns. A higher steering ratio means the driver turns the steering wheel more to get the vehicle wheels to turn, and a lower steering ratio means the driver turns the steering wheel less to get the vehicle wheels to turn.) In the proposed ANSI/ROHVA J-turn test, a vehicle with a larger steering ratio will make a wider turn and generate less lateral acceleration than a vehicle with a smaller steering ratio.

The steering ratio is set by the ROV manufacturer and varies depending on make and model. SEA measured the steering ratios of the 10 sample ROVs that were tested (see Figure 13). If the dynamic lateral stability requirement is defined by a steering wheel angle input, a manufacturer could increase the steering ratio of a vehicle to meet the requirement rather than improve the vehicle's stability.

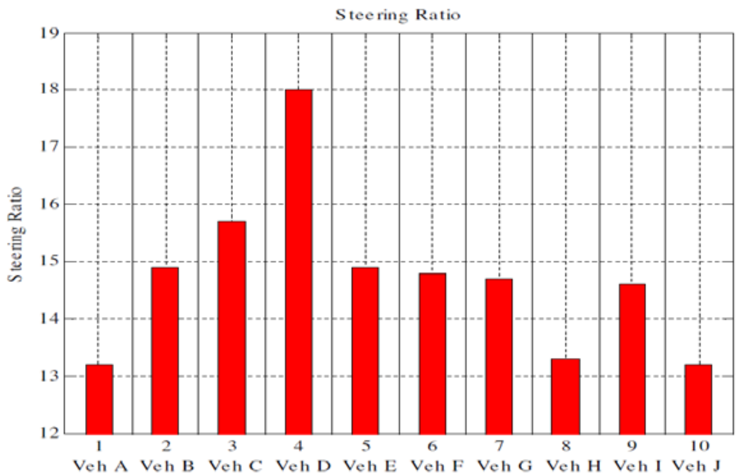

Figure 13. Steering Ratio = steering wheel input (degrees)/change in front wheel angle (degrees)

Source: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles – Additional Results for Vehicle J. Retrieved from http://www.cpsc.gov/PageFiles/93928/rovj.pdf.

CPSC staff contracted SEA to conduct J-turn testing, as specified by the ANSI/OPEI standard, on vehicles A, F, and J (see Table 7).

Table 7. Summary of J-Turn Test Results

(20 mph with 180 degrees steering wheel angle input)

Vehicle	Turn Direction	Speed Required for 2-wheel	OPEI 20 mph test Pass/Fail Outcome
Vehicle A	Right	22 mph	Pass
	Left	21 mph	Pass
Vehicle F	Right	21 mph	Pass
	Left	22 mph	Pass
Vehicle J	Right	21 mph	Pass
	Left	23 mph	Pass

Source: Heydinger, G. (2011) Results from Proposed ROHVA and OPEI Dynamic Maneuvers - Vehicles A, F, and J. Retrieved from http://www.cpsc.gov/Global/Research-and-Statistics/Technical-Reports/Sports-and-Recreation/ATV-ROV/ProposedROHVAandOPEIDynamicManeuvers.pdf.

CPSC is concerned that ROVs with low lateral stability can pass OPEI's dynamic stability requirement because an ROV that was part of a repair program (Vehicle A) to increase its roll resistance passed the ANSI/OPEI stability test. When the ANSI/OPEI J-turn maneuver was conducted just one mile above the requirement at 21 mph, Vehicle A failed. Similarly, when the maneuver was conducted at 22 mph, Vehicle F and Vehicle J failed. These results indicate that the parameters of the test protocol allow most ROVs to pass.

NHTSA evaluated the J-turn test protocol as a method to measure rollover resistance of automobiles and determined that the J-turn test is the most objective and repeatable method for vehicles with low rollover resistance.[31] Vehicles with low rollover resistance exhibit untripped rollover on pavement during a J-turn test and the lateral acceleration at the rollover threshold can be measured. Lateral acceleration is the accepted measure by vehicle engineers for assessing lateral stability or rollover resistance.[32] This value is commonly used by engineers to compare rollover resistance from one vehicle to another. The ANSI/OPEI test protocol does not measure the lateral acceleration at two-wheel lift, and the parameters of the test appear tuned to allow most vehicles to pass. Based on CPSC's testing and review, the CPSC does not believe the ANSI/OPEI dynamic stability requirement is a true measure of rollover resistance, and the CPSC does not believe the requirement will improve the lateral stability of ROVs.

2. Vehicle Handling

ANSI/ROHVA 1-2011and ANSI/OPEI B71.9 both lack provisions to address vehicle handling:

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[31] Forkenbrock, G. and Garrott, W. (2002). A Comprehensive Experimental Evaluation of Test Maneuvers That May Induce On-Road, Untripped, Light Vehicle Rollover Phase IV of NHTSA's Light Vehicle Rollover Research Program. DOT HS 809 513.

[32] Gillespie, T. (1992). Fundamentals of Vehicle Dynamics. Society of Automotive Engineers, Inc. p. 309-319.

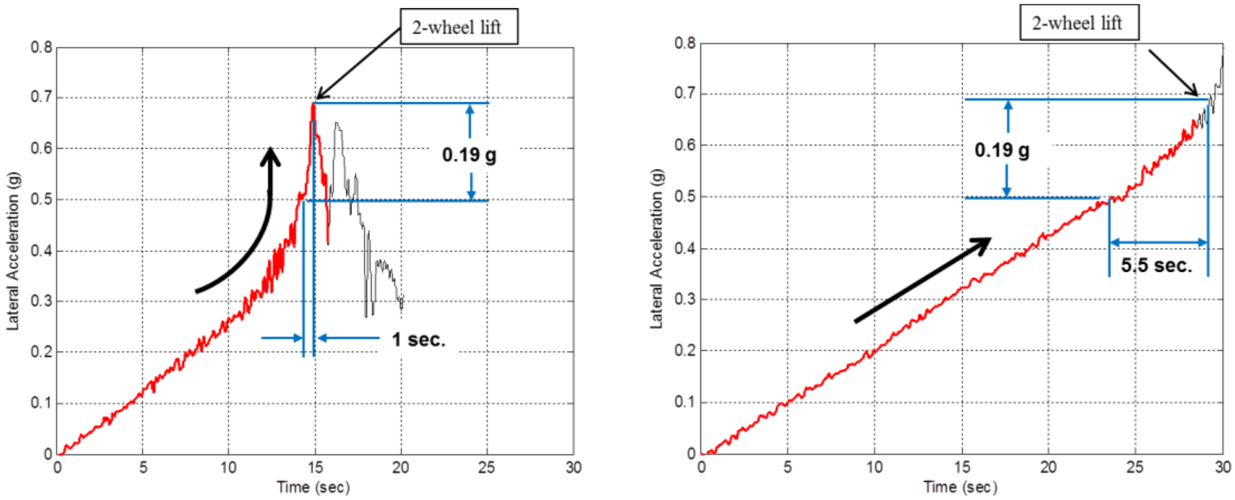
Voluntary Standard Requirement: ANSI/ROHVA 1-2011 ANSI/OPEI B71.9-2012 do not specify a vehicle handling requirement.

Adequacy: CPSC's testing and review indicate that a requirement for sub-limit understeer is necessary to reduce ROV rollovers that may be produced by sub-limit oversteer in ROVs. Tests conducted by SEA show that ROVs in sub-limit oversteer transition to a condition where the lateral acceleration increases suddenly and exponentially. The CPSC believes this condition can lead to untripped ROV rollovers or cause ROVs to slide into limit oversteer and experience tripped rollover.

ROVs that understeer in sub-limit conditions do not exhibit a sudden increase in lateral acceleration. Therefore, the CPSC concludes that ROVs should be required to operate in understeer at sub-limit conditions based on the associated inherent dynamic stability of understeering ROVs and the smaller burden of steering correction it places on the average driver who is familiar with driving a passenger vehicle that operates in sub-limit understeer.

SIS tests conducted by SEA that illustrate the sudden increase in lateral acceleration that is found only in vehicles that exhibit sub-limit oversteer. The sudden increase in lateral acceleration is exponential and represents a dynamically unstable condition. This condition is undesirable because it can cause a vehicle with low lateral stability (such as an ROV) to roll over suddenly.

In Figure 14, Vehicle A is an ROV that transitions to oversteer; Vehicle H is the same model ROV, but a later model year in which the oversteer has been corrected to understeer.



Vehicle A (Oversteer) Vehicle H (Understeer)

Figure 14. SIS Plots of Lateral Acceleration Gain Over Time

Source: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles . Retrieved from http://www.cpsc.gov/PageFiles/96037/rov.pdf.

When Vehicle A reached its dynamically unstable condition, the lateral acceleration suddenly increased in less than 1 second, and the vehicle rolled over. In contrast, Vehicle H never reaches a dynamically unstable condition because the condition does not develop in understeering vehicles. The increase in Vehicle H's lateral acceleration remains linear, and Vehicle H rolls over more than 5 seconds later than Vehicle A.

3. Occupant Protection

ANSI/ROHVA 1-2011and ANSI/OPEI B71.9 include similar provisions to address occupant retention during a rollover event.

Voluntary Standard Requirement: **ANSI/ROHVA 1-2011 Section 11.2 Seat Belt Reminder and ANSI/OPEI B71.9-2012 Section 5.1.3.2 Seat Belt Reminder System** specify that ROVs shall be equipped with a seat belt reminder system that activates a continuous or flashing warning light visible to the operator for at least 8 seconds after the vehicle is started.

Adequacy: The CPSC believes the requirement for an 8-second reminder light is not adequate to increase meaningfully seat belt use rates in ROVs because the system is not intrusive enough to motivate drivers and passengers to wear their seat belts. Results from past studies on automotive seat belt reminders conclude that visual reminders are ineffective. Numerous studies also conclude that reminder systems must be intrusive enough to motivate users to buckle their seat belts. The more intrusive reminders are more effective at changing user behavior, as long as the reminder is not so intrusive that users bypass the system.

The Commission's analysis of ROV-related incidents indicates that 91 percent of fatal victims, and 73 percent of all victims (fatal and nonfatal), were not wearing a seat belt at the time of the incident. Without seat belt use, occupants experience partial to full ejection from the ROV, and many occupants are struck by the ROV after ejection. Based on review of ROV incident data and CPSC's testing described above, the Commission believes that many ROV deaths and injuries can be eliminated if occupants are wearing seat belts.

Automotive researchers have developed technology that motivates drivers to buckle seat belts by making it more difficult to drive faster than 20−25 mph if the driver's seat belt is not buckled.[33] This concept shows promise in increasing seat belt use because the technology was acceptable to users and was 100 percent effective in motivating drivers to buckle their seat belts. One ROV manufacturer has also introduced a technology that limits the vehicle speed if the driver's seat belt is not buckled. ROVs with the speed-limitation technology have been in the market since 2010.

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33 Van Houten, R., Hilton, B., Schulman, R., and Reagan, I. (2011). Using Haptic Feedback to Increase Seat Belt Use of Service Vehicle Drivers. (DOT HS 811 434). Washington, D.C.: National Highway Traffic Safety Administration, U.S. Department of Transportation. Hilton, Bryan W. (2012). The Effect of Innovative Technology on Seatbelt Use. Masters Theses. Paper 103.

Given the low seat belt use rate in ROV-related incidents, as well as the substantial potential reduction in injuries and deaths if seat belt use were higher, the CPSC believes that the requirement for seat belt reminders should be more stringent and should incorporate the most recent advances in technology developed in the automotive and ROV market.

Voluntary Standard Requirement: **ANSI/ROHVA 1-2011 Section 11.3 ORS Zones** specifies construction and performance requirements for four zones that cover the leg/foot, shoulder/hip, arm/hand, and head/neck areas of an occupant. (Occupant retention system (ORS) is defined in ANSI/ROHVA 1-2011 as a system, including three-point seat belts, for retaining the occupant(s) of a vehicle to reduce the probability of injury in the event of an accident.) The construction requirements specify a force application test to set minimum guidelines for the design of doors, nets, and other barriers that are intended to keep occupants within the protection zone of the ROPS. The performance requirements use a tilt table and a Hybrid III 50^{th} percentile male anthropomorphic test device (ATD) to determine occupant excursion when the vehicle is tilted 45 degrees laterally.

Adequacy: The CPSC believes the tilt table performance requirements for Zone 2 – Shoulder/Hip are not adequate to ensure that occupants remain within the protective zone of the vehicle's ROPS during a rollover event. The tilt table test method measures the torso ejection outside the vehicle width, not the ejection outside the protective zone of the ROPS. The CPSC's test results indicate the tilt table test allows unacceptable occupant head excursion beyond the protective zone of the vehicle ROPS. The Commission also believes the tilt table test method is not an accurate simulation of an ROV rollover event because the test method does not reproduce the lateral acceleration and roll experienced by the vehicle, and by extension, the occupants, during a rollover.

CPSC staff also believes the construction-based test method for Zone 2 is inadequate because the specified point of application (a single point) and 3-inch diameter test probe do not accurately represent contact between an occupant and the vehicle during a rollover event. Specifying a single point does not ensure adequate coverage because a vehicle with a passive barrier at only that point would pass the test. Similarly, a 3 inch diameter probe does not represent the upper arm of an occupant and therefore does not ensure adequate coverage.

Voluntary Standard Requirement: **ANSI/OPEI B71.9-2012 Section 5.1.4 Occupant Side Retention Devices** specifies ROVs shall be equipped with occupant side retention devices that reduce the probability of entrapment of a properly belted occupant's head, upper torso, and limbs between the vehicle and the terrain, in the event of a lateral rollover. Physical barriers or design features of the vehicle may be used to comply with the requirement, but no performance tests are specified to determine compliance with the requirement.

Adequacy: The Commission believes the occupant side retention requirements are not adequate because they lack performance requirements to gauge occupant protection performance. Performance requirements, based on occupant protection performance tests of ROV rollovers, are needed to ensure that occupants remain within the protective zone of the vehicle's ROPS during a rollover event.

VIII. Response to Comments

In this section, we describe and respond to comments to the ANPR for ROVs. We present a summary of each of the commenter's topics, followed by the Commission's response. The Commission received 116 comments. The comments can be viewed on: *www.regulations.gov*, by searching under the docket number of the ANPR, CPSC-2009-0087. Letters with multiple and detailed comments were submitted by the following:

- Joint comments submitted on behalf of Arctic Cat Inc., Bombardier Recreational Products Inc., Polaris Industries Inc., and Yamaha Motor Corporation, U.S.A. (Companies);
- Carr Engineering, Inc. (CEI);
- The OPEI/ANSI B 71.9 Committee (Committee); and
- ROHVA.

The respondents were ROV manufacturers and their associations, consultants to ROV manufacturers, and more than 110 consumers. Eighteen commenters supported developing regulatory standards for ROVs. The other commenters opposed rulemaking action. The commenters raised issues in five areas:

- Voluntary standard activities,
- Static stability metrics,
- Vehicle handling,
- Occupant protection, and
- Consumer behavior.

The comment topics are separated by category.

<u>Voluntary Standard Activities</u>

1. *Comment*: Comments from the Companies, ROHVA, and several individuals state that the CPSC should work with ROHVA to develop a consensus voluntary standard for ROVs.

Response: As described in detail in the previous section of this preamble, CPSC staff has been engaged actively with ROHVA since 2009, to express staff's concerns about the voluntary standard and to provide specific recommendations for the voluntary standard and supply ROHVA with CPSC's test results and data supporting the staff's recommendations.

CPSC believes the history of engagement with ROHVA, as detailed above, shows that CPSC staff has tried to work with ROHVA to improve the voluntary standard requirements to address low lateral stability, lack of vehicle handling requirements, and inadequate occupant protection requirements. The Commission does not believe deferring to ROHVA will address those areas of concern because, although ROHVA has made changes to the voluntary standard, the requirements still do not improve the lateral stability of ROVs, do not eliminate sub-limit oversteer handling, and do not improve occupant protection in a rollover event.

2. *Comment*: Comments from the Committee and ROHVA state that the Commission should defer to the current voluntary standards for ROVs. Several comments state that the current voluntary standards are adequate.

Response: In the previous section of this preamble, we explain in detail why the requirements in ANSI/ROHVA 1-2011 and ANSI/OPEI B71.9-2012 do not adequately address the risk of injury and death associated with ROVs. We summarize that explanation below.

Lateral Stability. The Commission believes the static stability requirements and the dynamic lateral stability requirements specified in both voluntary standards do not measure the vehicle's resistance to rollover. Static and dynamic tests conducted by SEA on a sample of ROVs available in the U.S. market indicate that the tests specified in ANSI/ROHVA 1-2011 and the ANSI/OPEI B71.9 will not promote improvement in the rollover resistance of ROVs.

Vehicle Handling. In addition, ANSI/ROHVA 1-2011 and ANSI/OPEI B71.9 - 2012 do not have requirements for vehicle handling. The Commission believes that a requirement for sub-limit understeer is necessary to reduce ROV rollovers that may be produced by sub-limit oversteer in ROVs. Tests conducted by SEA show that ROVs in sub-limit oversteer transition to a condition where the lateral acceleration increases suddenly and exponentially. The

Commission believes this runaway increase in lateral acceleration can lead to untripped ROV rollovers or cause ROVs to slide into limit oversteer and experience tripped rollover.

Occupant Protection. ANSI/ROHVA 1-2011 and ANSI/OPEI B71.9 - 2012 require only an 8-second reminder light to motivate users to buckle seat belts. This requirement is similar to the Federal Motor Vehicle Safety Standard (FMVSS) seat belt reminder requirements for automobiles. Manufacturers in the automotive industry have long since exceeded such minimal seat belt reminder requirements because numerous studies have proven that the FMVSS requirements, and indeed visual-only reminders, are not effective.[34]

Lastly, the occupant protection requirements in ANSI/ROHVA 1-2011 and ANSI/OPEI B71.9 - 2012 are not based on valid occupant protection performance tests that simulate conditions of vehicle rollover. ANSI/OPEI B71.9 -2012 does not include any performance requirements for occupant protection. ANSI/ROHVA 1-2011 includes performance requirements based on static tilt tests that allow unacceptable occupant head ejection beyond the protective zone of the vehicle ROPS.

3. *Comment*: On February 21, 2014, OPEI sent a letter to CPSC staff requesting that the CPSC exclude multipurpose off-highway utility vehicles (MOHUVs) from CPSC's rulemaking efforts. OPEI states that there are key differences between work-utility vehicles and recreational vehicles. The differences include: maximum vehicle speed, engine and powertrain design, cargo box configuration and capacity, towing provisions, and vehicle usage.

Response: The Commission's proposed requirements for lateral stability, vehicle handling, and occupant protection are intended to reduce deaths and injuries caused by ROV rollover and

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[34] Westefeld, A. and Phillips, B.M. (1976). Effectiveness of Various Safety Belt Warning Systems. (DOT HS 801 953). Washington, D.C.: National Highway Traffic Safety Administration, U.S. Department of Transportation.

occupant ejection. ROVs are motorized vehicles that are designed for off-highway use and have four or more tires, steering wheel, non-straddle seating, accelerator and brake pedals, ROPS, restraint system, and maximum vehicle speed greater than 30 mph.

"MOHUVs," as defined by ANSI/OPEI B71.9-2012, are vehicles with four or more wheels, a steering wheel, non-straddle seating, and maximum speed between 25 and 50 mph. Therefore, the Commission believes that an MOHUV that exceeds 30 mph is an ROV that is subject to the scope of the proposed rulemaking. The differences cited by OPEI between work-utility vehicles and recreational vehicles, *e.g.*, the cargo capacity or the powertrain of a vehicle, do not exclude these ROVs from the hazard of rollover and occupant ejection.

<u>Static Stability Metrics</u>

1. *Comment*: Comments from CEI state that the Static Stability Factor (SSF), defined as T/2H, is not an appropriate metric for stability because there is no correlation between SSF values and ROV rollovers.

Response: The Commission agrees that the SSF is not an appropriate metric for ROV lateral stability because CPSC staff compared the actual lateral acceleration at rollover threshold of several ROVs, as measured by the J-turn test, and found that static measures (whether K_{st}, SSF, or TTA) are not accurate predictors of the vehicle's rollover resistance. The static tests are unable to account fully for the dynamic tire deflections and suspension compliance exhibited by ROVs. The Commission believes that the threshold lateral acceleration at rollover (Ay) is the most appropriate metric to use because it is a direct measure of the vehicle's resistance to rollover.

2. *Comment*: Comments from the Companies and the Committee state that NHTSA decided not to implement a minimum SSF standard for on-road vehicles because it would have forced the radical redesign of the characteristics of many, and in some cases, all vehicles of certain classes, which would have raised issues of public acceptance and possibly even the elimination of certain classes of vehicles.

Response: Contrary to the comment's implication that setting a minimum lateral stability (in this case SSF) is detrimental to vehicle design, and that NHTSA abandoned the use of SSF, NHTSA concluded that there is a causal relationship between SSF and rollover, and NHTSA has incorporated the SSF in its New Car Assessment Program (NCAP) rating of vehicles. In June 1994, NHTSA terminated rulemaking to establish a minimum standard for rollover resistance because it would be difficult to develop a minimum stability standard that would not disqualify whole classes of passenger vehicles (light trucks and sport utility vehicles) that consumers demand. Instead, by January 2001, NHTSA concluded that consumer information on the rollover risk of passenger cars would influence consumers to purchase vehicles with a lower rollover risk and inspire manufacturers to produce vehicles with a lower rollover risk.[35] NHTSA found consistently that given a single-vehicle crash, the SSF is a good statistical predictor of the likelihood that the vehicle will roll over.[36] The number of single-vehicle crashes was used as an index of exposure to rollover because this method eliminates the additional complexity of multi-vehicle impacts and because about 82 percent of light vehicle rollovers occur in single-vehicle crashes. NHTSA decided to use the SSF to indicate the risk of rollover in single-vehicle crashes and to incorporate the new rating into NHTSA's New Car Assessment Program (NCAP). Based on NHTSA's statistical analysis of single-vehicle crash data and

[35] Walz, M. C. (2005). Trends in the Static Stability Factor of Passenger Cars, Light Trucks, and Vans. DOT HS 809 868. Retrieved from http://www.nhtsa.gov/cars/rules/regrev/evaluate/809868/pages/index.html

[36] Rollover Prevention Docket No. NHTSA-2000-6859 RIN 2127-AC64. Retrieved from http://www.nhtsa.gov/cars/rules/rulings/rollover/Chapt05.html.

vehicle SSF value, the NCAP provides a 5-star rating system. One star represents a 40 percent or higher risk of rollover in a single vehicle crash; two stars represent a risk of rollover between 30 percent and 40 percent; three stars represent a risk of rollover between 20 percent and 29 percent; four stars represent a risk of rollover between 10 percent and 19 percent; and five stars represent a risk of rollover of less than 10 percent.

A subsequent study of SSF trends in automobiles found that SSF values increased for all vehicles after 2001, particularly SUVs, and SUVs tended to have the worst SSF values in the earlier years. NHTSA's intention that manufacturers improve the lateral stability of passenger vehicles was achieved through the NCAP rating, a rating based predominantly on the SSF value of the vehicle.

Based on dynamic stability tests conducted by SEA and improvements in the Yamaha Rhino after the repair program was initiated, the Commission believes that setting a minimum rollover resistance value for ROVs can improve the lateral stability of the current market of ROVs, without forcing radical designs or elimination of any models. The Commission also believes continued increase in ROV lateral stability can be achieved by making the value of each model vehicle's threshold lateral acceleration at rollover available to consumers. Publication of an ROV model's rollover resistance value on a hang tag will allow consumers to make informed purchasing decisions regarding the comparative lateral stability of ROVs. In addition, publication of rollover resistance will provide a competitive incentive for manufacturers to improve the rollover resistance of their ROVs.

3. *Comment*: Comments from the Companies and the Committee state that K_{st} is the more appropriate stability factor than SSF because it accounts for differences in the rear and track width, as well as differences in the fore and aft location of the vehicle's center of gravity.

Response: K_{st} is a three-dimensional calculation of the two-dimensional SSF, and when the front and rear track widths are equal, K_{st} equals SSF. For practical purposes, K_{st} and SSF provide the same information on ROVs. Occupant-loaded values of K_{st} and SSF are informative to the design process of ROVs; however, K_{st} and SSF values do not account for all the dynamic factors that affect actual rollover resistance. Therefore, they do not represent the best stability metric for ROVs.

The Commission compared the actual lateral acceleration at rollover threshold of several ROVs, as measured by the J-turn test, and found that the static measures (whether K_{st}, SSF, or TTA) are not accurate predictors of the vehicle's actual lateral stability. Direct dynamic measurement of the vehicle's resistance to rollover is possible with ROVs. Therefore, the Commission believes that J-turn testing to determine the threshold lateral acceleration at rollover should be used as the standard requirement to determine lateral stability.

4. *Comment*: Comments from CEI and the Companies state that tilt table angle or tilt table ratio should be used as a measure of lateral stability.

Response: As stated above, the staff compared the actual lateral acceleration at rollover threshold of several ROVs, as measured by the J-turn test, and found that the static measures (whether it is K_{st} or SSF or TTA) are not accurate predictors of the vehicle's actual lateral stability.

The Commission believes that the tilt table requirement in ANSI/ROHVA 1-2011 does not adequately address lateral stability in ROVs. A comparison of how the vehicles would rank if the TTA were used instead of the direct measurement of lateral acceleration at rollover (A_y) illustrates how poorly the TTA correlates to the actual rollover resistance of the vehicle. The tilt table test does not account for dynamic effects of tire compliance, suspension compliance, and vehicle handling, which are important factors in the vehicle's lateral stability.

Direct dynamic measurement of the vehicle's resistance to rollover is possible with ROVs. Therefore, the Commission believes that J-turn testing to determine the threshold lateral acceleration at rollover should be used as the standard requirement to determine lateral stability.

5. *Comment*: Comments from the Companies state that the ANSI/ROHVA 1, *American National Standard for Recreational Off-Highway Vehicles,* lateral stability requirement of K_{st}=1 and TTA=30 degrees is adequate and should be adopted by CPSC.

Response: SEA tested 10 representative ROV samples to the tilt table requirements in ANSI/ROHVA 1-2011. All of the ROVs tested pass the minimum 30-degree TTA, which indicates that the tilt table requirement is a status quo test. Vehicle D, the vehicle with the lowest rollover resistance (A_y = 0.625 g, TTA = 33.7 degrees), exceeds the TTA requirement by 3.7 degrees, or 12 percent above the 30-degree minimum requirement. Vehicle A, the ROV that was part of a repair program to increase its roll resistance, exceeds the TTA requirement by 3.0 degrees, or 10 percent above the 30-degree minimum.

CPSC believes the ANSI/ROHVA and ANSI/OPEI tilt table requirement is a requirement that all ROVs can pass and will not promote improvement among vehicles that have lower rollover resistance. The TTA requirement in the voluntary standard does not correlate to the actual rollover resistance of ROVs; the requirement allows the Yamaha Rhino to pass the test without having undergone the repair; and the requirement provides no incentive for manufacturers to improve the lateral stability of ROVs. The Commission believes that the threshold lateral acceleration at rollover value is a direct measure for rollover resistance, and its use would eliminate the need for tilt table testing as a requirement.

6. *Comment*: Comments from the Companies, the Committee, and several individuals state that the SSF values recommended by CPSC staff for ROVs would make the vehicles unusable for off-road use and would eliminate this class of vehicle.

Response: Based on the testing and data discussed in this preamble, CPSC staff no longer recommends using the SSF value as a measure of an ROV's rollover resistance. The SSF value of a vehicle represents the best theoretical lateral stability that the vehicle can achieve. CPSC staff compared the actual lateral acceleration at rollover threshold of several ROVs, as measured by the J-turn test, and found that the static measures (whether it is $K_{st,}$ or SSF, or TTA) are not accurate predictors of the vehicle's actual lateral stability due to the extreme compliance in the vehicle's suspension and tires. Therefore, the Commission believes that neither the $K_{st,}$ nor the SSF is an accurate measure of an ROV's lateral stability. Rather, the vehicle's actual lateral acceleration at rollover threshold is the appropriate measure of the vehicle's lateral stability.

Vehicle Handling

1. *Comment*: Comments from CEI and the Companies state that measurements of understeer/oversteer made on pavement are not applicable to non-pavement surfaces. ROVs are intended for off-highway use and any pavement use is product misuse, they assert.

Response: Both the ANSI/ROHVA and ANSI/OPEI standards specify dynamic testing on a paved surface. This indicates that ROHVA and OPEI agree that testing of ROVs on pavement is appropriate because pavement has a uniform high-friction surface. Tests conducted on pavement show how the vehicle responds at lateral accelerations that range from low lateral accelerations (associated with low friction surfaces like sand) up to the highest lateral acceleration that can be generated by friction at the vehicle's tires. This provides a complete picture of how the vehicle handles on all level surfaces. The amount of friction at the tires, and thus, the lateral accelerations generated, varies on non-paved surfaces. However, the vehicle's handling at each lateral acceleration does not change when the driving surface changes.

2. *Comment*: Comments from CEI state that CEI has performed various tests and analyses on ROVs that demonstrate that ROVs that exhibit oversteer are not unstable.

Response: The Commission disagrees with the statement that ROVs that exhibit oversteer are stable. Vehicles that exhibit sub-limit oversteer have a unique and undesirable characteristic, marked by a sudden increase in lateral acceleration during a turn. This dynamic instability is called critical speed and is described by Thomas D. Gillespie in the *Fundamentals of Vehicle Dynamics* as the speed "above which the vehicle will be unstable." [37] Gillespie further explains that an oversteer vehicle "becomes directionally unstable at and above the critical speed" because the lateral acceleration gain approaches infinity.

CEI states that their tests demonstrate that ROVs that exhibit oversteer are not unstable. However, testing performed by SEA shows that oversteering ROVs can exhibit a sudden increase in lateral acceleration resulting in a roll over. Plots from SIS tests illustrate this sudden increase in lateral acceleration, which is found only in vehicles that exhibit sub-limit oversteer (see Figure 15). Vehicle A is an ROV that transitions to oversteer; Vehicle H is the same model ROV, but a later model year in which the oversteer has been corrected to understeer.

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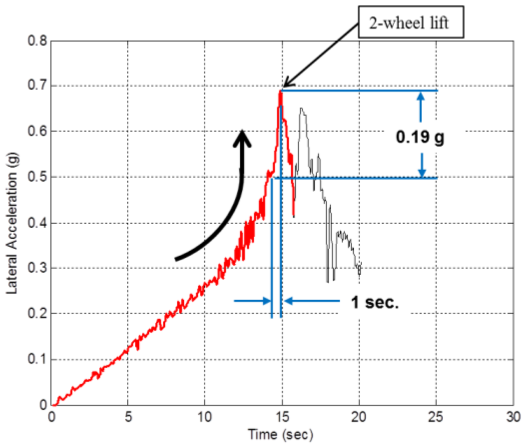
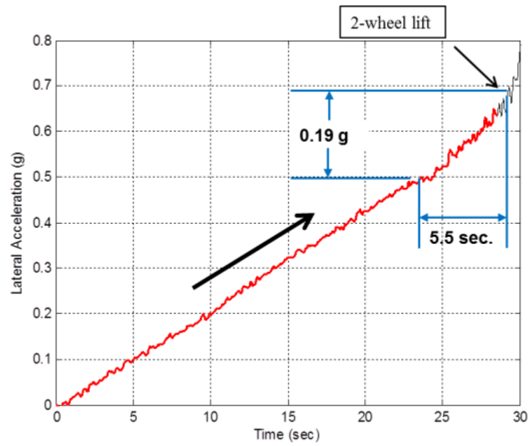
[37] Gillespie, T. (1992). Fundamentals of Vehicle Dynamics. Society of Automotive Engineers, Inc. p.204-205.



Vehicle A (Oversteer)



Vehicle H (Understeer)

Figure 15. SIS Plot of Lateral Acceleration Gain Over Time

Source: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles . Retrieved from http://www.cpsc.gov/PageFiles/96037/rov.pdf.

When Vehicle A reached its dynamically unstable condition, the lateral acceleration suddenly increased from 0.50 g to 0.69 g (difference of 0.19 g) in less than 1 second, and the vehicle rolled over. (Outriggers on the vehicle prevented full rollover of the vehicle.) In contrast, Vehicle H never reached a dynamically unstable condition because the condition does not develop in understeering vehicles. The increase in Vehicle H's lateral acceleration remains linear, and the lateral acceleration increase from 0.50 g to 0.69 g (same difference of 0.19 g) occurs in 5.5 seconds. A driver in Vehicle H has more margin to correct the steering to prevent rollover than a driver in Vehicle A because Vehicle H remains in understeer during the turn, while Vehicle A transitions to oversteer and becomes dynamically unstable.

SEA test results indicate that ROVs that exhibited sub-limit oversteer also exhibited a sudden increase in lateral acceleration that caused the vehicle to roll over. An ROV that exhibits this sudden increase in lateral acceleration is directionally unstable and uncontrollable.[38] Tests conducted by SEA provide strong evidence that sub-limit oversteer in ROVs is an unstable condition that can lead to a rollover incident, especially given the low rollover resistance of ROVs.

3. *Comment*: Comments from CEI and the Companies state that all vehicles, whether they understeer or oversteer, can be driven to limit conditions and can spin or plough. Any vehicle can exhibit "limit oversteer" through manipulation by the driver.

Response: The Commission does not dispute that operator input and road conditions can affect limit oversteer or understeer in a vehicle. The vehicle handling requirements proposed by the Commission specify that vehicles exhibit sub-limit understeer. The Commission believes that sub-limit oversteer is an unstable condition that can lead to a rollover incident. Ten sample ROVs were tested by SEA; five of the 10 vehicles exhibited a desirable sub-limit understeer condition, and five exhibited a transition to undesirable sub-limit oversteer condition. CPSC's evaluation indicates that ROVs can be designed to understeer with minimal cost and without diminishing the utility or recreational value of this class of vehicle.

4. *Comment*: Comments from the Companies state that oversteer is desirable for path-following capability. Specifically, vehicles in oversteer will generally follow the path and allow directional control of the vehicle. High rear tire slip angles and tire longitudinal slip are needed for traction on off-highway surfaces, such as loose soil.

Response: The Commission is not aware of any studies that define "path-following capability" and its relation to the sub-limit understeer or oversteer design of the vehicle. Of the 10 sample

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[38] Bundorf, R. T. (1967). The Influence of Vehicle Design Parameters on Characteristic Speed and Understeer. SAE 670078; Segel, L. (1957). Research in the Fundamentals of Automobile Control and Stability. SAE 570044.

ROVs tested by SEA, five vehicles exhibited a desirable sub-limit understeer condition. The Commission is not aware of any reports of the steering of sub-limit understeering vehicles causing loss of control or preventing the driver from navigating off-road terrain.

A significant body of research has been developed over many years regarding the science of vehicle dynamic handling and control. The Commission has reviewed technical papers regarding vehicle handling research and finds no agreement with the statement that "a vehicle in an oversteer condition will generally follow the path and allow directional control of the vehicle to be maintained longer." In fact, the Commission's research finds universal characterization of sub-limit oversteer as directionally unstable, highly undesirable, and dynamically unstable at or above the critical speed.[39] The Commission's review of 80 years of automotive research did not find support for the suggestion that sub-limit oversteer provides superior precision in handling and control.

Likewise, limit oversteer is described by the Companies as the result of the driver "operating the vehicle in a turn at a speed beyond what is safe and reasonable for that turn or applying excessive power in a turn." A vehicle in limit oversteer is essentially sliding with the rear of the vehicle rotating about the yaw axis. A vehicle in a slide is susceptible to a tripped rollover. ROVs have low rollover resistance and are at high risk of a violent, tripped rollover. Autonomous vehicle testing by SEA has duplicated these limit oversteer conditions and found that tripped rollovers can create in excess of 2 g to 3 g of instantaneous lateral acceleration,

[39] Olley, M. (1934). Independent Wheel Suspension - Its Whys and Wherefores. SAE 340080.; Stonex, K. A. (1941). Car Control Factors and Their Measurement. SAE 410092.; Segel, L. (1957). Research in the Fundamentals of Automobile Control and Stability. SAE 570044.; Bergman, W. (1965). The Basic Nature of Vehicle Understeer – Oversteer. SAE 650085.; Bundorf, R. T. and Leffert, R. L. (1976). The Cornering Compliance Concept for Description of Vehicle Directional Control Properties. SAE 760713.; and Milliken, William F., Jr., et al. (1976). The Static Directional Stability and Control of the Automobile. SAE 760712.

which produces a violent rollover event. CPSC's evaluation indicates that eliminating sub-limit oversteer will reduce unintentional transitions to limit oversteer.

The Commission does not agree that producing power oversteer by spinning the rear wheels is a necessity for negotiating low-friction, off-highway surfaces. Drifting or power oversteering is a risky practice that presents tripped rollover hazards and does not improve the vehicle's controllability. However, the practice of power oversteering is the result of driver choices that are not under the control of the manufacturer or the CPSC, and will not be significantly affected by the elimination of sub-limit oversteer.

5. *Comment*: Comments from the Companies state that requiring ROVs to exhibit understeer characteristics could create unintended and adverse risk, such as gross loss of mobility. These commenters assert that CPSC would be trading one set of purported safety issues for another, equally challenging set of safety issues, and running against 100 years of experience in off-highway vehicle design and driving practice, which suggests that for off-highway conditions, limit oversteer is at least sometimes, if not most often, preferable to limit understeer.

Response: ROVs that exhibit sub-limit understeering are currently in the U.S. market in substantial numbers. The Commission is not aware of any reports of the steering of sub-limit understeering vehicles causing loss of control or preventing the driver from navigating off-road terrain. The CPSC is not aware of any reports of sub-limit understeering vehicles that exhibit the unintended consequences described by the Companies.

The Commission believes that sub-limit oversteer is an unstable condition that can lead to a rollover incident. Based on the Yamaha Rhino repair program and the SEA test results indicating that half of the sample ROVs tested already exhibit sub-limit understeer, the CPSC believes that ROVs can be designed to understeer with minimum cost and without diminishing the utility or recreational value of this class of vehicle.

6. *Comment*: Comments from CEI, the Companies, and the Committee state that no correlation can be shown between understeer/oversteer and ROV crashes or rollovers.

Response: From a design and engineering perspective, the physics of vehicle rollover inherently support the fact that increasing a vehicle's resistance to rollover will make the vehicle more stable. In addition, eliminating a vehicle characteristic that exhibits a sudden increase in lateral acceleration during a turn will reduce the risk of rollover. The constant radius tests and SIS tests conducted by SEA provide strong evidence that sub-limit oversteer is an unstable condition that can lead to a rollover incident.

Of the 428 ROV-related incidents reviewed by the CPSC, 291 (68 percent) involved lateral rollover of the vehicle, and more than half of these (52 percent) occurred while the vehicle was turning. Of the 147 fatal incidents that involved rollover, 26 (18 percent) occurred on a paved surface. A vehicle exhibiting oversteer is most susceptible to rollover in a turn where the undesirable sudden increase in lateral acceleration can cause rollover to occur quickly, especially on paved surfaces, where an ROV can exhibit an untripped rollover.

The Commission believes that improving the rollover resistance and vehicle steering characteristics of ROVs is a practical strategy for reducing the occurrence of ROV rollover events.

<u>Occupant Protection</u>

1. *Comment*: Comments from CEI, the Companies, and the Committee state that seat belt use is critically important. Increasing seat belt use is the most productive and effective way to

reduce ROV-related injuries and deaths because seat belt use is so low among those injured in ROV incidents. A major challenge is clearly how to get occupants to use the seat belt properly.

Response: The Commission agrees that the use of seat belts is important in restraining occupants in the event of a rollover or other accident. Results of the Commission's testing of belted and unbelted occupants in simulated ROV rollover events indicate that seat belt use is required to retain occupants within the vehicle. Without seat belt use, occupants experience partial to full ejection from the vehicle. This scenario has been identified as an injury hazard in the CPSC's review of ROV-related incidents. Of those incidents that involved occupant ejection, many occupants suffered crushing injuries caused by the vehicle.

After reviewing the literature regarding automotive seat belts, the Commission believes that an 8-second reminder light, as required in ANSI/ROHVA 1-2011 and ANSI/OPEI B71.9-2012, is not adequate to increase meaningfully seat belt use rates in ROVs because the system is not intrusive enough to motivate drivers and passengers to wear their seat belts. Results from past studies on automotive seat belt reminders conclude that visual reminders are ineffective. Numerous studies conclude further that effective reminder systems have to be intrusive enough to motivate users to buckle their seat belts. The more intrusive reminders are more effective at changing user behavior, as long as the reminder is not so intrusive that users bypass the system.

Based on literature and results from the Westat study, the Commission believes that a seat belt speed limiting system that restricts the maximum speed of the vehicle to 15 mph, if the driver seat and any occupied front seats are not buckled, is the most effective method to increase meaningfully seat belt use rates in ROVs. The system is transparent to users at speeds of 15 mph and below, and the system consistently motivates occupants to buckle their seat belts to achieve speeds above 15 mph.

2. *Comment*: Comments from CEI state that four-point and five-point seat belts are not appropriate for ROVs. In contrast, several individual comments state that five-point seat belts should be required on ROVs.

Response: The Commission identified lack of seat belt use as an injury hazard in the CPSC's review of ROV-related incidents. The majority of safety restraints in the ROV incidents were three-point restraints, and to some extent, two-point seat belts. Although four-point seat belts might be superior to three-point seat belts in retaining occupants in a vehicle, three-point seat belts have been shown to be effective in reducing the risk of death and serious injury in automotive applications. The Commission believes that it is unlikely that users who already do not use three-point seat belts will use the more cumbersome four-point and five-point seat belts.

A more robust seat belt reminder system than the current voluntary standard requirement for a visual reminder light is necessary to motivate users to wear their seat belts because automotive studies of seat belt reminders indicate that visual reminders do not increase seat belt use. Dynamic rollover tests of ROVs indicate that a three-point seat belt, in conjunction with a passive shoulder restraint, is effective in restraining an occupant inside the protective zone of the vehicle's ROPS during a quarter-turn rollover.

3. *Comment*: Comments from CEI state that occupant protection requirements should be based on meaningful tests.

Response: The Commission agrees that ROV occupant protection performance evaluations should be based on actual ROV rollovers or simulations of real-world rollovers. Occupant protection performance requirements for ROVs in the voluntary standard developed by ROHVA (ANSI/ROHVA 1-2011) and the voluntary standard developed by OPEI (ANSI/OPEI B71.9 - 2012) are not supported by data from rollover tests.

The SEA roll simulator is the most accurate simulation of an ROV rollover event because it has been validated by measurements taken during actual ROV rollovers. Rollover tests indicate that a seat belt, used in conjunction with a passive shoulder barrier, is effective at restraining occupants within the protective zone of the vehicle's ROPS during quarter-turn rollover events.

ROV Incident Analysis

1. *Comment*: Comments from CEI state that ROV rollover incidents are caused by a small minority of drivers who intentionally drive at the limits of the vehicle and the driver's abilities, and intentionally drive in extreme environments.

Response: Of the 224 reported ROV incidents that involved at least one fatality, 147 incidents involved lateral rollover of the vehicle. Of the 147 lateral rollover fatalities, it is reported that the ROV was on flat terrain in 56 incidents (38 percent) and on a gentle incline in 18 incidents (12 percent). Of the 224 fatal ROV incidents, the vehicle speed is unknown in 164 incidents (73 percent); 32 incidents (14 percent) occurred at speeds of 20 miles per hour (mph) or less; and 28 incidents (13 percent) occurred at speeds more than 20 mph. (Vehicle speeds were reported (*i.e.*, not measured by instrumentation); so these speeds can be used qualitatively only and not as accurate values of speed at which incidents occurred.) Of the 224 fatal ROV incidents, the age of the driver was less than 16 years old in 61 incidents (27 percent). Of the 231 fatalities, 77 victims (33 percent) were children less than 16 years of age.

A review of the incident data shows no indication that the majority of rollover incidents are caused by drivers who "purposely push the vehicle to and beyond its limits by engaging in stunts, racing, and intentional use of extreme environments." An analysis of the reported ROV incidents indicates that many of the details of the circumstances of the event, such as vehicle speed or terrain slope, are not known. In cases in which details of the event are known, roughly 50 percent of the fatal lateral rollover incidents occurred on flat or gentle slope terrain; and 14 percent occurred at speeds below 20 miles per hour. Twenty-seven percent of the drivers in fatal rollover incidents are children under 16 years of age; and 33 percent of all ROV-related fatalities are children under 16 years of age.

2. *Comment*: Comments from the Companies state that the CPSC failed to use data from the NEISS in its analysis of ROV hazards. The comments suggest further that analysis of the NEISS data on utility-terrain vehicles (UTVs) indicate that UTVs, and therefore, ROVs, have a low hospitalization rate.

Response: The joint comment's conclusions based on the commenters' analyses of the NEISS UTV data are not technically sound because the NEISS results do not specifically identify ROVs. NEISS has a product code for UTVs and several product codes for ATVs, but there is no separate product code for ROVs. ATVs have a straddle seat for the operator and handlebars for steering. UTVs have bucket or bench seats for the operator/passengers, a steering wheel for steering, and UTVs may or may not have a ROPS. ROVs are a subset of UTVs and are distinguished by having a ROPS, seat belts, and a maximum speed above 30 mph. However, many official entities, news media, and consumers refer to ROVs as ATVs. Injuries associated with ROVs are usually assigned to either an ATV product category or to the UTV product category in NEISS. At a minimum, ROVs can be thought of as a subset of UTVs and/or ATVs, and cannot be identified on a consistent basis through the NEISS case records because NEISS requires knowledge of the make/model of the vehicle (which is not coded in the NEISS for any product). Occasionally, the NEISS narrative contains make/model identification, but this cannot be used to identify ROVs accurately and consistently.

CPSC conducted a special study in 2010, in which all cases coded as ATVs or UTVs were selected for telephone interviews to gather information about the product involved. Sixteen of the 668 completed surveys had responses that identified the vehicle as an ROV. Staff's analysis shows that many ROVs are coded as ATVs; many UTVs are also coded as ATVs; and identification of ROVs and UTVs is difficult because the NEISS narratives often do not include enough information to identify the product. The miscoding rate for UTVs and ROVs is high, and most likely, the miscoding is due to consumer-reported information in the emergency department.

The CPSC added the UTV product code 5044 to the NEISS in 2005. In the years 2005 to 2008 (the years cited in the joint comment document), the UTV product code had mostly out-of-scope records, with a large number of utility trailers and similar records. After these out-of-scope records are removed, the only viable estimate is obtained by aggregating the cases across 2005 to 2008, to get an estimated 1,300 emergency department-treated injuries related to UTVs(see Tab K, Table 1). This estimate is considerably less than the estimate reported by Heiden in the joint comment. This estimate also does not include the UTV-related injuries that were miscoded as ATVs in the ATV product codes.

As the years have passed and the UTV product code is being used more as intended, a completely different picture is seen for UTVs. From 2009 to 2012, there are an estimated 6,200 emergency department-treated, UTV-related injuries (which can be attributed to an increase in the number of UTV-related injuries, a larger portion of injuries being identified in NEISS as UTVs, or a combination of all of these and other factors not identified). Of these estimated 6,200 injuries, only 80.2 percent are treated and released. The proportion of treated and released injuries for UTVs is significantly below the proportion of treated and released for all consumer products (92.0 percent of estimated consumer product-related, emergency department-treated injuries were treated and released from 2009 to 2012). This illustrates a hazard of more severe injuries associated with UTVs.

In conclusion, data are insufficient to support the argument that UTV injuries are not as severe as those associated with other products. As more data have become available in recent years, it appears that about 80 percent of the injuries associated with UTVs have been treated and released as compared to about 92 percent of the injuries associated with all consumer products.

3. *Comment*: The Companies provided their own analysis of ROV-related reports that were used in the CPSC's ANPR analysis. In particular, the Companies criticize Commission staff's analysis because asserting that staff's analysis did not include factors related to incident conditions and user behavior.

Response: Commission staff's analysis of incidents for the ANPR was a preliminary review of reported incidents to understand the overall hazard patterns. For the NPR, Commission staff conducted an extensive, multidisciplinary review of 428 reported ROV-related incidents resulting in at least one death or injury. The results of this study are summarized in two reports in the NPR briefing package, along with analyses of victim characteristics, hazard patterns, environmental characteristics, and make and model characteristics. (The approach taken in the comments from the Companies, to remove reports from the analysis because there is unknown information, is not the Commission's approach in analyzing ROV-related incidents.) Unknowns from all reports are included with the knowns to ensure that the full picture is seen because every report will have at least one piece of unknown information, and every report will have at least one piece of known information. The unknowns are reported in all tables, if unknowns were recorded for the variables used.

The analysis of IDIs summarized in the comments from the Companies does not define "excessive speed," "dangerous maneuver," or "sharp turn." In fact, in other places in the comments, the companies mention: "There is also no evidence suggesting that speed is an important factor in preventing accidents." The companies also state: "Tight steering turn capability is an important feature in certain ROVs, particularly those for trail use, because of the need to respond quickly to avoid obstacles and trail-edge drop-offs, and otherwise navigate in these off-highway terrains" Thus, there is ambiguity in what the definitions could mean in the analysis of the IDIs (When is the vehicle at an excessive speed? When is a turn too sharp? When is a maneuver dangerous?). The Commission's approach to analyzing the 428 incidents summarized in the reports available in the NPR briefing package is to consider the sequence of events, the vehicle, the driver, any passenger, and environment characteristics across all incidents. All definitions are set and used consistently by the multidisciplinary review team to understand the hazard patterns and incident characteristics across all incidents, not to set responsibility in one place or another.

4. *Comment*: Comments from CEI state that the CPSC should begin to address human factors that pertain to risk-taking behavior of the small minority of ROV users who operate the vehicles at their limits without crash-worthiness concerns. In particular, CEI proposes that the CPSC focus primarily on changing consumer behavior to wearing seat belts, wearing helmets, and refraining from driving ROVs irresponsibly.

Response: The Commission agrees that human factors and behavior affect the risk of death and injury for ROV users. However, the CPSC believes that establishing minimum requirements for ROVs can also reduce the hazards associated with ROVs. As explained in this preamble, the ANSI/ROHVA voluntary standard does not adequately addresses the risk of injury and death associated with lateral rollovers of ROVs because the standards do not have robust lateral stability requirements, do not have vehicle handling requirement to ensure understeer, and do not have robust occupant restraint requirements to protect occupants from vehicle rollover.

An analysis of the reported ROV incidents indicates that many of the details of an event, such as vehicle speed or terrain slope, are not known. Where details of the event are known, roughly 50 percent of the fatal lateral rollover incidents occurred on flat or gentle slope terrain, and 14 percent occurred at speeds below 20 miles per hour. Twenty-seven percent of the drivers in fatal rollover incidents are children under 16 years of age; and 33 percent of all ROV-related fatalities are children under 16 years of age. There is no indication that the majority of rollover incidents are caused by drivers who intentionally drive under extreme conditions.

Regarding seat belt use, results from past studies on automotive seat belt reminders conclude that visual seat belt reminders are ineffective. Numerous studies further conclude that effective reminder systems have to be intrusive enough to motivate users to buckle their seat belts. The more intrusive reminders are more effective at changing user behavior, as long as the reminder is not so intrusive that users bypass the system.

The Commission believes that a seat belt speed-limiting system that restricts the maximum speed of the vehicle to 15 mph if the driver seat and any occupied front seats are not buckled is the most effective method to increase meaningfully seat belt use rates in ROVs. The system is transparent to users at speeds of 15 mph and below, and the system consistently motivates occupants to buckle their seat belts to achieve speeds above 15 mph.

IX. Description of the Proposed Rule

A. Scope, Purpose, and Compliance Dates - § 1422.1

The proposed standard would apply to "recreational off-highway vehicles" (ROVs), as defined, which would limit the scope to vehicles with a maximum speed greater than 30 mph. The proposed standard would include requirements relating to lateral acceleration, vehicle handling, and occupant protection. The requirements are intended to reduce or eliminate an unreasonable risk of injury associated with ROVs. The proposed standard would specifically exclude "golf cars," "all-terrain vehicles," "fun karts," "go karts," and "light utility vehicles," as defined by the relevant voluntary standards. The Commission proposes two compliance dates: ROVs would be required to comply with the lateral stability and vehicle handling requirements (§§ 1422.3 and 1422.4) 180 days after publication of the final rule in the *Federal Register*. ROVs would be required to comply with the occupant protection requirements (§ 1422.5) 12 months after publication of the final rule in the *Federal Register*. The Commission recognizes that some ROV manufacturers will need to redesign and test new prototype vehicles to meet the occupant protection requirements. This design and test process is similar to the process that manufacturers use when introducing new model year vehicles. As described more fully in Section X, staff estimates that it will take approximately 9 person-months per ROV model to design, test, implement, and begin manufacturing vehicles to meet the occupant protection performance requirements. Therefore, the Commission believes that 12 months is a reasonable time period for manufacturers to comply with all of new mandatory requirements.

B. Definitions - § 1422.2

The proposed standard would provide that the definitions in section 3 of the Consumer Product Safety Act (15 U.S.C. 2051) apply. In addition, the proposed standard would include the following definitions:

- "recreational off-highway vehicle" - a motorized vehicle designed for off-highway use with the following features: four or more wheels with pneumatic tires; bench or bucket seating for two or more occupants; automotive-type controls for steering, throttle, and braking; rollover protective structures (ROPS); occupant restraint; and maximum speed capability greater than 30 mph.
- "two-wheel lift" - point at which the inside wheels of a turning vehicle lift off the ground, or when the uphill wheels of a vehicle on a tilt table lift off the table. Two-wheel lift is a precursor to a rollover event. We use the term "two-wheel lift" interchangeably with "tip-up."
- "threshold lateral acceleration" – minimum lateral acceleration of the vehicle at two-wheel lift.

C. Requirements for dynamic lateral stability. - § 1422.3

1. <u>Proposed Performance Requirement</u>

a. Description of Requirement

The proposed rule would require that all ROVs meet a minimum requirement for lateral stability. The dynamic lateral stability requirement would set a minimum value for the lateral acceleration at rollover of 0.70 g, as determined by a 30 mph drop-throttle J-turn test. The 30 mph drop-throttle J-turn test uses a programmable steering controller to turn the test vehicle traveling at 30 mph at prescribed steering angles and rates to determine the minimum steering angle at which two-wheel lift is observed. These are the conditions and procedures that were used in testing with SEA. Under the proposed requirements, the data collected during these tests are analyzed to compute and verify the lateral acceleration at rollover for the vehicle. The greater the lateral acceleration value, the greater is the resistance of the ROV to tip or roll over.

b. *Rationale*

The J-turn test is the most appropriate method to measure the rollover resistance of ROVs because the J-turn test has been evaluated by NHTSA as the most objective and repeatable method for vehicles with low rollover resistance. As discussed previously, static metrics, such as SSF and TTR, cannot be used to evaluate accurately ROV rollover resistance because static tests are unable to account fully for the dynamic tire deflections and suspension compliance exhibited by ROVs during a J-turn maneuver. The Commission also verified that the J-turn test is objective and repeatable for ROVs by conducting numerous J-turn tests on several ROVs.

As explained above, testing conducted by CPSC staff and SEA supports the proposed requirement that ROVs demonstrate a minimum threshold lateral acceleration at rollover of 0.70 g or greater in a J-turn. Results of J-turn tests performed on a sample of 10 ROVs available in the U.S. market indicate that six of the 10 ROVs tested measured threshold lateral accelerations below 0.70 g (values ranged from 0.625 g to 0.690 g). The Commission believes that minor changes to vehicle suspension and/or track width spacing, similar to the changes in the Yamaha Rhino repair program, can increase the threshold lateral acceleration of these vehicles to 0.70 g or greater. The Yamaha repair program improved the rollover resistance of the Yamaha Rhino from 0.670 g (unrepaired Yamaha Rhino) to 0.705 g (repaired Yamaha Rhino).

Based on CPSC's evaluation of ROV testing and the decrease in injuries and deaths associated with Yamaha Rhino vehicles after the repair program was implemented, the

Commission believes that improving the rollover resistance of all ROVs can reduce injuries and deaths associated with ROV rollover events.

2. Proposed Requirements for Hang tag

a. *Description of Requirement*

The Commission is proposing a requirement that ROV manufacturers provide technical information for consumers on a hangtag at the point of purchase.

As discussed previously, the Commission is proposing a requirement that ROVs meet a minimum lateral acceleration of 0.70 g at rollover, as identified by J-turn testing. The Commission proposes requiring a hangtag on each ROV that would state the actual measured lateral acceleration at rollover (as identified by the J-turn testing) of each ROV model. The Commission believes that the hang tag will allow consumers to make informed decisions on the comparative lateral stability of ROVs when making a purchase and will provide a competitive incentive for manufacturers to improve the rollover resistance of ROVs.

The proposed rule specifies the content and format for the hang tag, and includes an example hang tag. Under the proposal, the hang tag must conform in content, form, and sequence as specified in the proposed rule.

The Commission proposes the following ROV hangtag requirements:

- Content. Every ROV shall be offered for sale with a hangtag that graphically illustrates and textually states the lateral acceleration threshold at rollover for that ROV model. The hangtag shall be attached to the ROV and may be removed only by the first purchaser.
- Size. Every hangtag shall be at least 15.24 cm (6 inches) wide by 10.16 cm (4 inches) tall.

- Attachment. Every hangtag shall be attached to the ROV and be conspicuous to a person sitting in the driver's seat; and the hangtag shall be removable only with deliberate effort.
- Format. The hang tag shall provide all of the elements shown in the example hangtag (see Figure 16).

b. Rationale

Section 27(e) of the CPSA authorizes the Commission to require, by rule, that manufacturers of consumer products provide to the Commission performance and technical data related to performance and safety as may be required to carry out the purposes of the CPSA, and to give notification of such performance and technical data at the time of original purchase to prospective purchasers and to the first purchaser of the product. 15 U.S.C. 2076(e)). Section 2 of the CPSA provides that one purpose of the CPSA is to "assist consumers in evaluating the comparative safety of consumer products." 15 U.S.C. 2051(b)(2).

Other federal government agencies currently require on-product labels with information to help consumers in making purchasing decisions. For example, NHTSA requires automobiles to come with comparative information on vehicles regarding rollover resistance. 49 CFR 575.105. NHTSA believes that consumer information on the rollover risk of passenger cars would influence consumers to purchase vehicles with a lower rollover risk and inspire manufacturers to produce vehicles with a lower rollover risk.[40] A subsequent study of SSF trends in automobiles

[40] Walz, M. C. (2005). Trends in the Static Stability Factor of Passenger Cars, Light Trucks, and Vans. DOT HS 809 868. Retrieved from http://www.nhtsa.gov/cars/rules/regrev/evaluate/809868/pages/index.html.

found that SSF values increased for all vehicles after 2001, particularly SUVs, which tended to have the worst SSF values in the earlier years.[41]

EnergyGuide labels, required on most appliances, are another example of federally-mandated labels to assist consumers in making purchase decisions. 16 CFR part 305. Detailed operating cost and energy consumption information on these labels allows consumers to compare competing models and identify higher efficiency products. The EnergyGuide label design was developed based on extensive consumer research and following a two-year rulemaking process.

Like NHTSA rollover resistance information and EnergyGuide labels, the proposed ROV hang tags are intended to provide important information to consumers at the time of purchase. Providing the value of each ROV model vehicle's threshold lateral acceleration to consumers will assist consumers with evaluating the comparative safety of the vehicles in terms of resistance to rollover. Requiring that ROV lateral acceleration test results be stated on a hangtag may motivate manufacturers to increase the performance of their ROV to achieve a higher reportable lateral acceleration, similar to incentives created as a result of NHTSA's NCAP program.

The proposed hangtag is based, in part, on the point-of-purchase hangtag requirements for ATVs. ATVs must have hangtags that include general warning information regarding operation and operator and passenger requirements, as well as behavior that is warned against. Most ROV manufacturers are also manufacturers of ATVs. Accordingly, ROV manufacturers are likely to be familiar with the hangtag requirements for ATVs. The ANSI/SVIA 1-2010 voluntary

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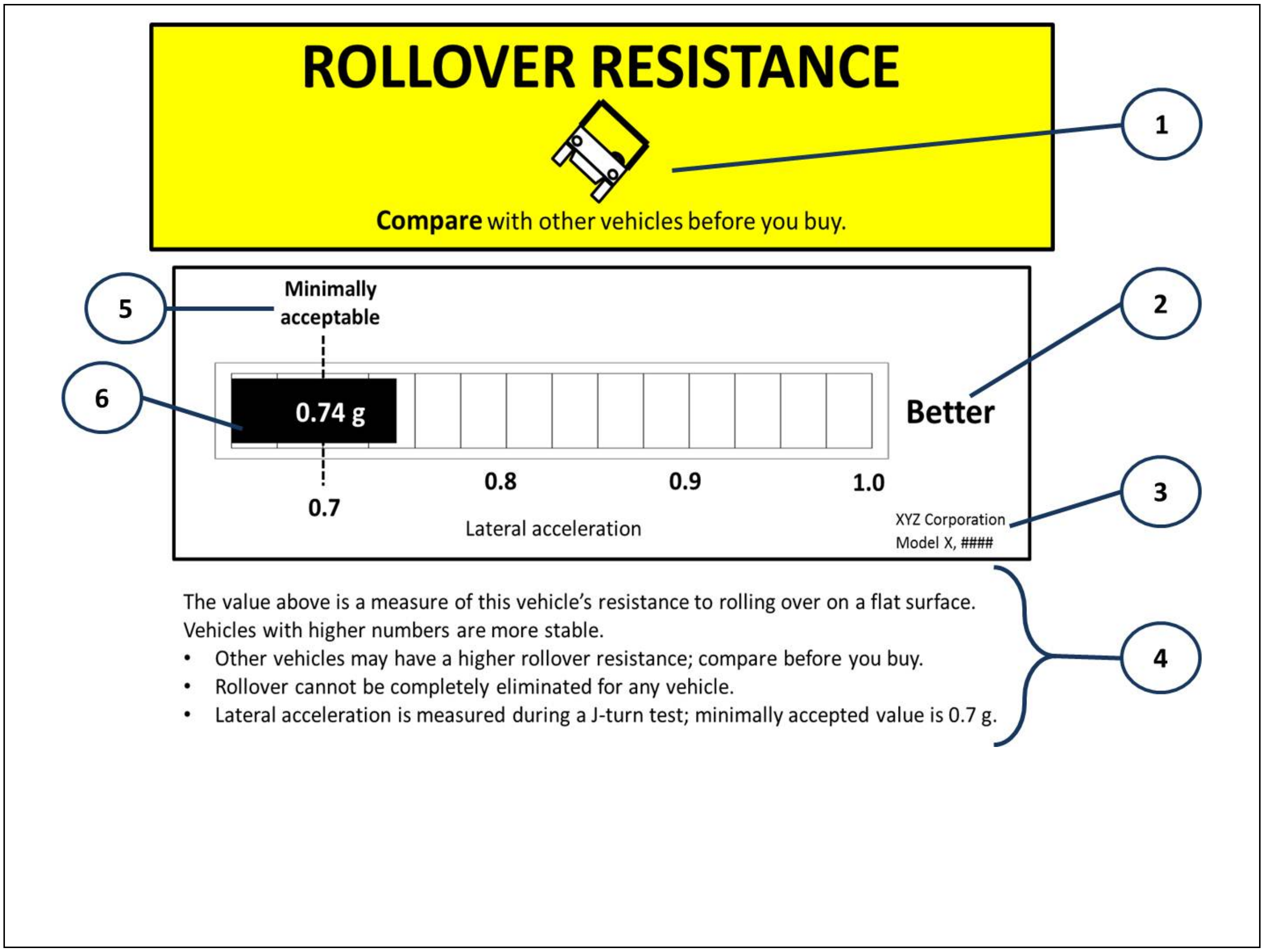
[41] Walz, M.C. (2005). Trends in the Static Stability Factor of Passenger Cars, Light Trucks, and Vans. DOT HS 809868. Retrieved from http://www.nhtsa.gov/cars/rules/regrev/evaluate/809868/pages/index.html.

standard that applies to ATVs requires ATVs to be sold with a hangtag that is to be removed only by the purchaser and requires ATV hangtags to be 6-inches tall x 4-inches wide. Because ROV manufacturers are likely to be familiar with the hangtag requirements for ATVs, the Commission is proposing the same size requirements for ROV hang tags.

The hang tag graph draws its format from well-recognized principles in effective warnings. When presenting graphical information, it is important to include labels so that the data can be understood. Graphs should have a unique title, and the axes should be fully labeled with the units of measurement. Graphs should also be distinguished from the text, by adding white space, or enclosing the graphs in a box.[42]

[42] Markel, M. (2001). Technical Communication. Boston, MA: Bedford/St. Martin's.

Figure 16—Hang tag[43]



1) The ROV icon helps identify the product. The icon is presented at a slight angle to help consumers readily identify the label as addressing ROV rollover characteristics. Research has shown that pictorial symbols and icons make warnings more noticeable and easier to detect than warnings without such symbols and icons.[44]

[43] Hang tag not shown to scale.
[44] Wogalter, M., Dejoy, D., and Laughery, K. (1999). Warnings and Risk Communication. Philadelphia, PA: Taylor & Francis, Inc.

2) Graph label, “Better,” indicates that the higher the value (as shading increases to the right), the higher the ROV’s resistance to rolling over during a turn on a flat surface.

3) The Manufacturer, Model, Model number, Model year help the consumer identify the exact ROV described by the label. Likewise, the EnergyGuide label provides information on the manufacturer, model, and size of the product so that consumers can identify exactly what appliance the label describes.[45] The Commission is proposing a similar identification of the ROV model on the hangtag so that consumers can compare values among different model ROVs.

4) Textual information. Technical communication that includes graphs should also include text to paraphrase the importance of the graphic and explain how to interpret the information presented.[46] Additionally, including a graphic before introducing text may serve as a valuable reference for consumers, by maintaining attention and encouraging further reading.[47] The textual informational in the hangtag provides consumers with more definition of the values given in the graph.

5) Linear scale, and anchor showing minimally acceptable value on the scale. Currently, the EnergyGuide label uses a linear scale with the lowest and highest operating costs for similar models so that consumers can compare products; the yearly operating cost for the specific model is identified on the linear scale.[48] The Commission is proposing a linear scale format for the ROV hangtag, as well. The text identifies the minimally accepted lateral acceleration at rollover

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[45] Guide to EnergyGuide label retrieved at http://www.consumer.ftc.gov/articles/0072-shopping-home-appliances-use-energyguide-label.
[46] Markel, M. 2001.
[47] Smith, T. P. (2003). Developing consumer product instructions. Washington, DC: U. S. Consumer Product Safety Commission.

[48] FTC. Retrieved from: https://www.consumer.ftc.gov/articles/0072-shopping-home-appliances-use-energyguide-label.

as being 0.7 g. When providing this on the scale, people are able to determine visually how a specific model compares to the minimal value.

6) Scale starts at 0.65 g to allow a shaded bar for those ROVs meeting only the minimally acceptable lateral acceleration value.

D. Vehicle Handling. - § 1422.4

1. Description of Requirement

The proposed rule would require that all ROVs meet a vehicle handling requirement, which requires that ROVs exhibit understeer characteristics. The understeer requirement would mandate that ROVs exhibit understeer characteristics in the sublimit range of the turn circle test. The test for vehicle handling or understeer performance involves driving the vehicle around a 100-foot radius circle at increasing speeds, with the driver making every effort to maintain compliance of the vehicle path relative to the circle. SEA testing was based on a 100-foot radius circle. Data collected during these tests are analyzed to determine whether the vehicle understeers through the required range. The proposed rule would require that all ROVs exhibit understeer for values of ground plane lateral acceleration from 0.10 to 0.50 g.

2. Rationale

The CPSC believes that the constant radius test is the most appropriate method to measure an ROV's steering gradient because SAE J266, Surface Vehicle Recommended Practice, Steady-State Directional Control Test Procedures for Passenger Cars and Light Trucks, establishes the constant radius test as a method to measure understeer/oversteer in passenger cars. The test procedures are also applicable to ROVs because ROVs are similar to cars, have four steerable wheels and a suspension system, and thus, ROVs obey the same principles of motion as automobiles.

The Commission believes that the appropriate lateral acceleration range to measure steering gradient is from 0.10 g to 0.50 g because SEA test results indicate that spurious data occur at the beginning and end of a constant radius test conducted up to vehicle rollover. Data collected in the range of 0.10 g to 0.50 g of lateral acceleration provide the most accurate plots of the vehicle's steering characteristic.[49]

Tests conducted by SEA show that ROVs in sub-limit oversteer transition to a condition where the lateral acceleration increases suddenly and exponentially. Based on testing and relevant literature, the CPSC believes that this condition can lead to untripped ROV rollovers or may cause ROVs to slide into limit oversteer and experience tripped rollover. Ensuring sub-limit understeer eliminates the potential for sudden and exponential increase in lateral acceleration that can cause ROV rollovers.

[49] Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles. Retrieved from http://www.cpsc.gov/PageFiles/96037/rov.pdf. Page 18.

The decrease in Rhino-related incidents after the repair program was initiated and the low number of vehicle rollover incidents associated with repaired Rhino vehicles are evidence that increasing the lateral stability of an ROV and correcting oversteer characteristics to understeer reduces the occurrence of ROV rollover on level terrain. In particular, the Commission believes the elimination of runaway lateral acceleration associated with oversteer contributed to a decrease in Rhino-related rollover incidents.

As mentioned previously, ROVs can be designed to understeer in sub-limit operation with minimum cost and without diminishing the utility or recreational value of this class of vehicle. Half of the vehicles CPSC tested already exhibit sub-limit understeer condition for the full range of the test, and this includes both utility and recreational model ROVs.

E. Occupant retention system. - § 1422.5

The proposed rule includes two requirements that are intended to keep the occupant within the vehicle or the ROPs. First, each ROV would be required to have a means to restrict occupant egress and excursion in the shoulder/hip zone defined by the proposed rule. This requirement could be met by a fixed barrier structure or structure on the ROV or by a barrier or structure that can be put into place by the occupant using one hand in one operation, such as a door. Second, the proposed rule would require that the speed of an ROV be limited to a maximum of 15 mph, unless the seat belts for both the driver and any front seat passengers are fastened. The purpose of these requirements is to prevent deaths and injury incidents, especially incidents that involve full or partial ejection of the rider from the vehicle.

1. Speed Limitation

a. Requirement

The Commission proposes a performance requirement that limits the maximum speed that an ROV can attain to 15 mph or less when tested with unbuckled front seat belts during the maximum speed test. Section 5 of ANSI/ROHVA 1-2011, “Maximum Speed,” establishes test protocols to measure maximum speed on level ground. Because ROV manufacturers are already familiar with these test procedures and the proposed test would add elements to a test procedure manufacturers already conduct to meet the voluntary standard, the CPSC believes that the maximum speed test from ANSI/ROHVA 1-2011 is the most appropriate method to measure the limited speed of an ROV.

b. *Rationale*

i. Importance of Seat Belts

As discussed in section V of this preamble, results of the CPSC’s exploratory testing of belted and unbelted occupants in simulated ROV rollover events indicate that seat belt use is required to retain occupants within the vehicle. This conclusion corresponds with the incident data for ROV rollovers, in which 91 percent of the fatal victims who were partially or fully ejected from the vehicle were not wearing seat belts. Of the incidents that involved occupant ejection, many occupants were injured when struck by the vehicle after ejection. The Commission believes that many of the ROV occupant ejection deaths and injuries can be eliminated if occupants wear seat belts.

Studies have shown that automobile seat belt reminders do not increase seat belt use, unless the reminders are aggressive enough to motivate users to buckle seat belts without alienating the user into bypassing or rejecting the system. Based on the Commission’s testing and literature review and the low seat belt use rates in ROV-related incidents, the Commission believes that a seat belt speed limiting system that restricts the maximum speed of the vehicle to 15 mph if any occupied front seats are not buckled, is the most effective method to increase seat belt use rates in ROVs.

ii. Likely Acceptance of Speed-Limitation Technology

The Commission believes that in-vehicle technology that limits the speed of the ROV if the front occupied seats are not buckled will be accepted by ROV users because the technology does not interfere with the operation of the ROV below the threshold speed, and users will be motivated to wear seat belts if they wish to exceed the threshold speed. This conclusion is based on automotive studies that show drivers accepted a system that reduced vehicle function (*i.e.*, requiring more effort to depress the accelerator pedal) after a threshold speed, if the driver's seat belt was not buckled. The system did not interfere with the operation of the vehicle below the threshold speed, and drivers were willing to buckle their seat belts to access unhindered speed capability of the vehicle.

The Commission also believes that speed-limitation technology will be accepted by ROV users because the technology is already included on the BRP Can-Am Commander and Can-Am Maverick model ROVs, and the manufacturer with the largest ROV market share, Polaris, announced that it will introduce the technology on model year 2015 Ranger and RZR ROVs.

The Commission's literature review concludes that intrusive reminders are effective at changing user behavior, as long as the reminder is not so intrusive that users bypass the system. Limitation of vehicle speed is the intrusive reminder for ROV users to buckle their seat belt; therefore, the Commission believes that the threshold speed for a seat belt speed-limitation system should be as high as possible to gain user acceptance (and reduce bypass of the system), but low enough to allow relatively safe operation of the vehicle.

iii. Choice of 15 MPH

The Commission believes 15 mph is the appropriate speed threshold for a seat belt speed-limitation system. Based on information about ROVs and vehicles similar to ROVs, the Commission concludes that ROVs can be operated relatively safely at 15 mph. For example:

- ANSI/NGCMA Z130.1 – 2004, American National Standard for Golf Carts – Safety and Performance Specifications, specifies the maximum speed for golf carts at 15 mph. This standard establishes 15 mph as the maximum acceptable speed for unbelted drivers and passengers (golf carts do not have seat belts or ROPS) in vehicles that are often driven in off-road conditions.

- SAE J2258, Surface Vehicle Standard for Light Utility Vehicles, specifies a speed of 15 mph as acceptable for a vehicle, with a lateral stability of at least 25 degrees on a tilt table test, without seat belts or ROPS. This standard also establishes 15 mph as the maximum acceptable speed for unbelted drivers and passengers in vehicles that are driven in off-road conditions.

- Polaris Ranger and RZR model year 2015 ROVs will be equipped with a seat belt speed limiter that limits the vehicle speed to 15 mph if the driver's seat belt is not buckled. The decision by the largest manufacturer of ROVs establishes 15 mph as the maximum acceptable speed for unbelted ROV drivers.

Additionally, the principles of physics support this conclusion. The fundamental relationship between speed and lateral acceleration is:

$A = V^2/R$ where A = lateral acceleration

V = velocity

R = radius of turn

The minimum proposed lateral acceleration threshold at rollover for ROVs is 0.70 g, and the typical turn radius of an ROV is 16 feet.[50] Therefore, without any additional effects of tire friction, the speed at which rollover would occur during a turn on level ground is 13 mph. (The CPSC recognizes that on a slope, the lateral acceleration due to gravity can cause ROV rollover at speeds below 15 mph. However, the CPSC believes that it is appropriate to use level ground as a baseline.) In reality, friction at the tires would increase the speed at which rollover occurs to above 13 mph.

iv. User Acceptance of 15 mph

Based on CPSC's study and the experience of some ROVs that have speed limitations, the Commission believes that ROV users are likely to accept a 15 mph threshold speed limitation. The following reasons support this conclusion:

- Results of Westat's Phase 1 focus group study of ROV users indicate that ROV users value easy ingress and egress from an ROV and generally drive around 15 mph to 30 mph during typical use of the ROV. Users had mixed reactions to a speed threshold of 10 mph and were more accepting of a speed-limitation technology if the threshold speed was 15 mph.

- There are many situations in which an ROV is used at slow speeds, such as mowing or plowing, carrying tools to jobsites, and checking property. The Commission believes that a speed-limitation threshold of 15 mph allows the most latitude for ROV users to perform utility tasks where seat belt use is often undesired.

[50] Turn radius values retrieved at: http://www.atv.com/features/choosing-a-work-vehicle-atv-vs-utv-2120.html and http://www.utvunderground.com/2014-kawasaki-teryx-4-le-6346.html.

- The Commission believes that ROV user acceptance of a seat belt speed-limitation system will be higher at 15 mph than the speed threshold of 9 mph on the Commander ROV. Although BRP continues to sell the Can-Am Commander and Can-Am Maverick ROVs with speed limitations set at around 10 mph, focus group responses indicate that many ROV users believe that 10 mph is too low a speed limit to be acceptable, and therefore, these users will bypass the system. The 15 mph threshold is 50 percent higher than a 10 mph threshold, and staff believes that the difference in the speed threshold will increase user acceptance of the system. Polaris's decision to include seat belt speed limiters with a 15 mph threshold speed in model year 2015 Ranger and RZR ROVs supports the Commission's belief that user acceptance of a speed-limitation system will be higher at 15 mph than 10 mph.

2. Shoulder Probe Test

a. *Requirement*

CPSC is proposing a performance requirement that ROVs pass a probe test at a defined area near the ROV occupants' shoulder. The probe test is the most appropriate method to measure the occupant protection performance in the shoulder area of the ROV because various forms of the probe test are already used in the voluntary standard for ROVs and ATVs to determine occupant protection performance.

The test applies a probe with a force of 163 lbs., to a defined area of the vehicle's ROPS near the ROV occupants' shoulder. The vertical and forward locations for the point of application of the probe are based upon anthropometric data. The probe dimensions are based on the upper arm of a 5th percentile adult female, and the dimensions of a 5^{th} percentile adult female represent the smallest size occupant that may be driving or riding an ROV. The 163 lb. force application represents a 50th percentile adult male occupant pushing against the barrier during a rollover event. The probe is applied for 10 seconds and the vehicle structure must absorb the force without bending more than 1 inch.

b. Rationale

After exploring several methods to test occupant protection performance of ROVs during a rollover event, CPSC believes the SEA roll simulator is the most accurate simulation of a rollover because the roll simulator is able to reproduce the lateral acceleration and roll rate experienced by ROVs in rollover events. SEA conducted simulations of tripped and untripped rollovers on ROVs with belted and unbelted ATD occupants. CPSC's analysis of SEA's test results indicate that the best occupant retention performance results, where occupants remain within the protective zone of the vehicle's ROPS, occurred when a seat belt is used in conjunction with a passive shoulder barrier restraint.

F. Findings. - § 1422.6

In accordance with the requirements of the CPSA, we are proposing to make the findings stated in section 9 of the CPSA. The proposed findings are discussed in section XVI of this preamble.

X. Preliminary Regulatory Analysis

The Commission is proposing to issue a rule under sections 7 and 9 of the CPSA. The CPSA requires that the Commission prepare a preliminary regulatory analysis and that the preliminary regulatory analysis be published with the text of the proposed rule. 15 U.S.C. 2058(c). The following discussion is extracted from staff's memorandum, "Draft Proposed Rule Establishing Safety Standard for Recreational Off-Road Vehicles: Preliminary Regulatory Analysis."

A. Introduction

The CPSC is issuing a proposed rule for ROVs. This rulemaking proceeding was initiated by an ANPR published in the *Federal Register* on October 28, 2009. The proposed rule includes: (1) lateral stability and vehicle handling requirements that specify a minimum level of rollover resistance for ROVs and requires that ROVs exhibit sublimit understeer characteristics, and (2) occupant retention requirements that would limit the maximum speed of an ROV to no more than 15 miles per hour (mph), unless the seat belts of both the driver and front passengers, if any, are fastened; and in addition, would require ROVs to have a passive means, such as a barrier or structure, to limit further the ejection of a belted occupant in the event of a rollover.

Following is a preliminary regulatory analysis of the proposed rule, including a description of the potential costs and potential benefits. Each element of the proposed rule is discussed separately. For some elements, the benefits and costs cannot be quantified in monetary terms. Where this is the case, the potential costs and benefits are described and discussed conceptually.

B. Market Information

1. Manufacturers and Market Shares

The number of manufacturers marketing ROVs in the United States has increased substantially in recent years. The first utility vehicle that exceeded 30 mph, thus putting the utility vehicle in the ROV category, was introduced in the late 1990s. No other manufacturer offered an ROV until 2003. In 2013, there were 20 manufacturers known to CPSC to be supplying ROVs to the U.S. market. One manufacturer accounted for about 60 percent of the ROVs sold in the United States in 2013. Another seven manufacturers, including one based in China, accounted for about 36 percent of the ROVs sold in the same year. None of these seven manufacturers accounted for more than 10 percent of the market. The rest of the market was divided among about 12 other manufacturers, most of which were based in China or Taiwan.[51] Commission staff's analysis attempted to exclude vehicles that had mostly industrial or commercial applications and were not likely to be purchased by consumers. The Commission has identified more than 150 individual ROV models from among these manufacturers. However, this count includes some models that appear to be very similar to other models produced by the same manufacturer but sold through different distributors in the United States.

About 92 percent of ROVs sold in in the United States are manufactured in North America. About 7 percent of the ROVs sold in the United States are manufactured in China (by nine different manufacturers). Less than 1 percent of ROVs are produced in other countries other than the United States or China.[52]

Seven recreational vehicle manufacturers, which together account for more than 90 percent of the ROV market, established ROHVA. The stated purpose of ROHVA is "to promote the safe and responsible use of recreational off-highway vehicles (ROVs) manufactured or distributed in North America." ROHVA is accredited by the American National Standards Institute (ANSI) to develop voluntary standards for ROVs. ROHVA members have developed a voluntary standard (ANSI/ROHVA 1-2011) that sets some mechanical and performance requirements for ROVs. Some ROV manufacturers that emphasize the utility applications of their vehicles have worked with the Outdoor Power Equipment Institute (OPEI) to develop another ANSI voluntary standard that is applicable to ROVs (ANSI/OPEI B71.9-2012). This

[51] Market share is based upon Commission analysis of sales data provided by Power Products Marketing, Eden Prairie, MN (2014).
[52] This information is based upon a Commission analysis of sales data provided by Power Products Marketing, Eden Prairie, MN (2012).

voluntary standard also sets mechanical and performance requirements for ROVs. The requirements of both voluntary standards are similar, but not identical.

2. Retail Prices

The average manufacturer's suggested retail price (MSRP) of ROVs in 2013 was approximately $13,100, with a range of about $3,600 to $20,100. The average MSRP for the eight largest manufacturers (in terms of market share) was about $13,300. The average MSRP of ROVs sold by the smaller, mostly Chinese manufacturers was about $7,900.[53]

The retail prices of ROVs tend to be somewhat higher than the retail prices of other recreational and utility vehicles. The MSRPs of ROVs are about 10 percent higher, on average, than the MSRPs of low-speed utility vehicles. A comparison of MSRPs for the major manufacturers of ATVs and ROVs indicates that ROVs are priced about 10 percent to 35 percent higher than ATVs offered by the same manufacturer.[54] Another source indicates that the price of one ROV or other utility vehicle is about two-thirds the price of two ATVs.[55] Go-karts usually retail for between $2,500 and $8,000.[56]

3. Sales and Number in Use

Sales of ROVs have increased substantially since their introduction. In 1998, only one firm manufactured ROVs, and fewer than 2,000 units were sold. By 2003, when a second major

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[53] MSRPs for ROVs were reported by Power Products Marketing, Eden Prairie, MN (2014)

[54] This information is based upon a Commission analysis of data provided by Power Products Marketing, Eden Prairie, MN, (2014), and an examination of the suggested retail prices on several manufacturers' Internet sites.

[55] "2009 Utility Vehicle Review," Southern Sporting Journal, October 2008, Vol. 14, Issue 5, pp. 58-70, accessed through: http://web.ebscohost.com on March 17. 2011.

[56] Tom Behrens, "Kart Racing: Fast times out on the prairie," The Houston Chronicle, November 27, 2008, p. 4. (accessed from http://www.chron.com on January 17, 2014).

manufacturer entered the market, almost 20,000 ROVs were sold. The only dip in sales occurred around 2008, which coincided with the worst period of the credit crisis and a recession that also started about the same time. In 2013, an estimated 234,000 ROVs were sold by 20 different manufacturers.[57] The chart below shows ROV sales from 1998 through 2013.

The number of ROVs available for use has also increased substantially. Because ROVs are a relatively new product, we do not have specific information on the expected useful life of ROVs. However, using the same operability rates that CPSC uses for ATVs, we estimate that there were about 570,000 ROVs available for use in 2010.[58] By the end of 2013, there were an estimated 1.2 million ROVs in use. (See Figure 17).

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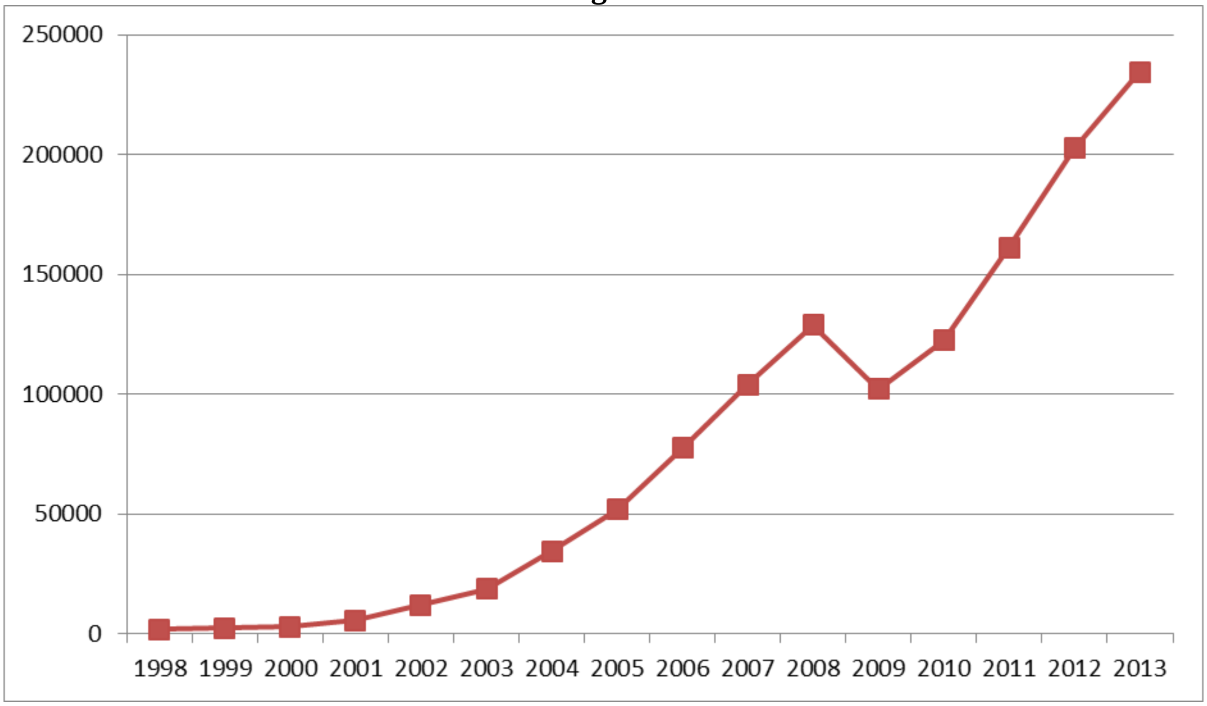
[57] This information is based upon a Commission analysis of sales data provided by Power Products Marketing, Eden Prairie, MN.

[58] CPSC Memorandum from Mark S. Levenson, Division of Hazard Analysis, to Susan Ahmed, Associate Executive Director, Directorate for Epidemiology, "2001 ATV Operability Rate Analysis," U.S. Consumer Product Safety Commission, Bethesda Maryland (19 August 2003). "Operability rate" refers to the probability that an ATV will remain in operation each year after the initial year of production.

ROV Sales (units), 1998–2013
Figure 17



Source: CPSC analysis of data compiled by Power Products Marketing.

Most ROVs are sold through retail dealers. Generally, dealers that offer ROVs also offer other products, such as motorcycles, scooters, ATVs, and similar vehicles. ROVs are also sold through dealers that carry farm equipment or commercial turf management supplies.

While sales of ROVs have increased over the last several years, sales of competing vehicles have leveled off, or declined. Low-speed utility vehicles have been on the market since the early 1980s. Their sales increased from about 50,000 vehicles in 1998, to about 150,000 vehicles in 2007. In 2011, however, sales fell to about 110,000 vehicles. A substantial portion of these sales were for commercial applications rather than consumer applications.[59]

[59] This information is based upon a Commission analysis of information provided by Power Products Marketing of Eden Prairie, MN.

After several years of rapid growth, U.S. sales of ATVs peaked in 2006, when more than 1.1 million ATVs were sold.[60] Sales have declined substantially since then. In 2012, less than 320,000 ATVs were sold, including those intended for adults, as well as those intended for children under the age of 16 years.[61]

One factor that could account for part of the decline in ATV sales is that after many years of increasing sales, the market may be saturated. Consequently, a greater proportion of future sales will likely be replacement vehicles or vehicles sold due to population growth. Another factor could be the increase in sales of ROVs. Some riders find that ROVs offer a more comfortable or easier ride, and ROVs are more likely to appeal to people who prefer the bench or bucket seating on ROVs over the straddle seating of ATVs. It is also easier to carry passengers on ROVs. Most ATVs are not intended to carry passengers, and the side-by-side seating offered by ROVs appears to be preferred over the tandem seating on the few ATVs intended to carry passengers.[62] A disadvantage of an ROV compared to an ATV is that many ROVs are too wide to travel on some trail systems intended for ATVs. However, some of the more narrow ROVs are capable of negotiating many ATV trails.[63]

Of the several types of vehicles that could be substitutes for ROVs, go-karts appear to be the smallest market segment. After increasing sales for several years, go-kart sales peaked at about 109,000 vehicles in 2004. Sales of go-karts have since declined significantly. In 2013,

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[60] Mathew Camp, "Nontraditional Quad Sales Hit 465,000," Dealer News, April 28, 2008. Available at: http://www.dealernews.com/dealernews/article/nontraditional-quad-sales-hit-465000?page=0,0, accessed June 19, 2013.
[61] Estimates of ATV sales are based on information provided by the Specialty Vehicle Manufacturers Association and on confidential data purchased from Power Products Marketing of Minneapolis, MN.
[62] "UTV Sales Flatten Out in 2008," Dealer News, August 2009, p. 40(4). "2009 Kawasaki Teryx 750 FI 4x4 Sport RUV Test Ride Review," article posted on: http://www.atvriders.com, accessed 20 August 2009 and Tom Kaiser, "Slowing sales: It's now a trend," Powersports Business, 12 February 2007, p. 44(1).
[63] Chris Vogtman, "Ranger shifts into recreation mode," Powersports Business, 12 February 2007, p., 46(2).

fewer than 20,000 units were sold. However, many of these are aimed at young riders or intended for use on tracks or other prepared surfaces and would not be reasonable substitutes for ROVs for some purposes.[64] The decline in go-kart sales may be due to the influx of inexpensive ATVs imported from China, which may have led some consumers to purchase an ATV rather than a go-kart.[65]

C. Societal Costs of Deaths and Injuries Associated with ROVs

The intent of the proposed rule is to reduce the risk of injury and death associated with incidents involving ROVs. Therefore, any benefits of the proposed rule could be measured as a reduction in the societal costs of injuries and deaths associated with ROVs. This section discusses the societal costs of injuries and deaths.

1. ROV Injuries

a. Nonfatal Injuries

To estimate the number of nonfatal injuries associated with ROVs that were treated in hospital emergency departments, CPSC undertook a special study to identify cases that involved ROVs that were reported through the National Electronic Injury Surveillance System (NEISS) from January 1, 2010 to August 31, 2010. NEISS is a stratified national probability sample of hospital emergency departments that allows the Commission to make national estimates of product-related injuries. The sample consists of about 100 of the approximately 5,400 U.S. hospitals that have at least six beds and provide 24-hour emergency service.[66]

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[64] "U.S. Go-Kart Market in Serious Decline," Dealer News, October, 2009, p. 38.
[65] ("Karts Feel the Chinese Crunch," Dealer News, November 2007, p. 44(2).

[66] Schroeder T, Ault K. The NEISS Sample (Design and Implementation): 1999 to Present. Bethesda, MD: U.S. Consumer Product Safety Commission; 2001. Available at: http://www.cpsc.gov/neiss/2001d011-6b6.pdf.

NEISS does not contain a separate product code for ROVs. Injuries associated with ROVs are usually assigned to either an ATV product code (NEISS product codes 3286–3287) or to the utility vehicle category (NEISS product code 5044). Therefore, the Commission reviewed all NEISS cases that were coded as involving an ATV or a UTV that occurred during the first 8 months of 2010 and attempted follow-up interviews with each victim (or a relative of the victim) to gather more information about the incidents and the vehicles involved. The Commission determined whether the vehicle involved was an ROV based on the make and model of the vehicle reported in the interviews. If the make and model of the vehicle was not reported, the case was not counted as an ROV. Out of 2,018 NEISS cases involving an ATV or UTV during the study period, a total of 668 interviews were completed for a response rate of about 33 percent. Sixteen of the completed interviews were determined to involve an ROV. To estimate the number of ROV-related injuries initially treated in an emergency department in 2010, the NEISS weights were adjusted to account for both non-response and the fact that the survey only covered incidents that occurred during the first 8 months of the year. Variances were calculated based on the adjusted weights. Based on this work, the Directorate for Epidemiology estimated that there were about 3,000 injuries (95 percent confidence interval of 1,100 to 4,900) involving ROVs in 2010 that were initially treated in hospital emergency departments.[67]

NEISS injury estimates are limited to injuries initially treated in hospital emergency departments. NEISS does not provide estimates of the number of medically attended injuries that were treated in other settings, such as physicians' offices, ambulatory care centers, or injury

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[67] Sarah Garland, Directorate for Hazard Analysis, "NEISS Injury Estimates for Recreational Off-Highway Vehicles (ROVs)," U.S. Consumer Product Safety Commission (September 2011).

victims who bypassed the emergency departments and were directly admitted to a hospital. However, the Injury Cost Model (ICM), developed by CPSC for estimating the societal cost of injuries, uses empirical relationships between cases initially treated in hospital emergency departments and cases initially treated in other medical settings to estimate the number of medically attended injuries that were treated outside of a hospital emergency department.[68] According to ICM estimates, based on the 16 NEISS cases that were identified in the 2010 study, injuries treated in hospital emergency departments accounted for about 27 percent of all medically treated injuries involving ROVs. Using this percentage, the estimate of 3,000 emergency department-treated injuries involving ROVs suggests that there were about 11,100 medically treated injuries involving ROVs in 2010 (*i.e.*, 3,000 injuries initially treated in emergency departments and 8,100 other medically attended injuries) or 194 medically attended injuries per 10,000 ROVs in use (11,100 ÷ 570,000 x 10,000).[69]

b. *Fatal Injuries*

In addition to the nonfatal injuries, there are fatal injuries involving ROVs each year. As of April 5, 2013, the Commission had identified 49 fatalities involving ROVs that occurred in 2010, or about 0.9 deaths per 10,000 ROVs in use ((49 ÷ 570,000) x 10,000). The actual number of deaths in 2010 could be higher because reporting is ongoing for 2010. Overall, CPSC has

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[68] For a more complete discussion of the Injury Cost Model see Ted R. Miller, et al., The Consumer Product Safety Commission's Revised Injury Cost Model, (December 2000). Available at:
http://www.cpsc.gov/PageFiles/100269/costmodept1.PDF.
http://www.cpsc.gov/PageFiles/100304/costmodept2.PDF.

[69] Using the ICM estimates for all cases involving ATVs and UTVs, injuries that were initially treated in a hospital emergency department accounted for about 35 percent of all medically-attended injuries. If this estimated ratio, which is based on a larger sample, but that includes vehicles that are not ROVs, was used instead of the ratio based strictly on the 16 known ROV NEISS cases in 2010, the estimated number of medically-attended injuries would be 8,600.

counted 335 ROV deaths that occurred from January 1, 2003 to April 5, 2013. There were no reported deaths in 2003, when relatively few ROVs were in use. As of April 5, 2013, there had been 76 deaths reported to CPSC that occurred in 2012.[70]

2. Societal Cost of Injuries and Deaths Associated with ROVs

a. Societal Cost of Nonfatal Injuries

The CPSC's ICM provides comprehensive estimates of the societal costs of nonfatal injuries. The ICM is fully integrated with NEISS and provides estimates of the societal costs of injuries reported through NEISS. The major aggregated components of the ICM include: medical costs; work losses; and the intangible costs associated with lost quality of life or pain and suffering.[71]

Medical costs include three categories of expenditure: (1) medical and hospital costs associated with treating the injury victim during the initial recovery period and in the long run, the costs associated with corrective surgery, the treatment of chronic injuries, and rehabilitation services; (2) ancillary costs, such as costs for prescriptions, medical equipment, and ambulance transport; and (3) costs of health insurance claims processing. Cost estimates for these expenditure categories were derived from a number of national and state databases, including the National Healthcare Cost and Utilization Project – National Inpatient Sample and the Medical Expenditure Panel Survey, both sponsored by the Agency for Healthcare Research and Quality.

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[70] Memorandum from Sarah Garland, Division of Hazard Analysis, "Additional ROV-related incidents reported from January 1, 2012 through April 5, 2013," U.S. Consumer Product Safety Commission, Bethesda, MD (8 April 2013).

[71] A detailed description of the cost components, and the general methodology and data sources used to develop the CPSC's Injury Cost Model, can be found in Miller et al. (2000), available at http://www.cpsc.gov//PageFiles/100269/costmodept1.PDF and http://www.cpsc.gov//PageFiles/100304/costmodept2.PDF.

Work loss estimates, based on information from the National Health Interview Survey and the U.S. Bureau of Labor Statistics, as well as a number of published wage studies, include: (1) the forgone earnings of parents and visitors, including lost wage work and household work, (2) imputed long term work losses of the victim that would be associated with permanent impairment, and (3) employer productivity losses, such as the costs incurred when employers spend time juggling schedules or training replacement workers. The earnings estimates were updated most recently with weekly earnings data from the Current Population Survey conducted by the Bureau of the Census in conjunction with the Bureau of Labor Statistics.

Intangible, or non-economic, costs of injury reflect the physical and emotional trauma of injury as well as the mental anguish of victims and caregivers. Intangible costs are difficult to quantify because they do not represent products or resources traded in the marketplace. Nevertheless, they typically represent the largest component of injury cost and need to be accounted for in any benefit-cost analysis involving health outcomes.[72] The Injury Cost Model develops a monetary estimate of these intangible costs from jury awards for pain and suffering. While these awards can vary widely on a case-by-case basis, studies have shown them to be systematically related to a number of factors, including economic losses, the type and severity of injury, and the age of the victim.[73] Estimates for the Injury Cost Model were derived from a regression analysis of about 2,000 jury awards in nonfatal product liability cases involving consumer products compiled by Jury Verdicts Research, Inc.

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[72] Rice, D.P. & MacKenzie, E.J. (1989). Cost of injury in the United States: A report to Congress, Institute for Health and Aging. San Francisco, CA: University of California and The Johns Hopkins University.
[73] Viscusi, W.K. (1988). Pain and suffering in product liability cases: systematic compensation or capricious awards? *Int. Rev. Law Econ. 8*, 203-220 and Rodgers, G.B. (1993). Estimating jury compensation for pain and suffering in product liability cases involving nonfatal personal injury. *J. For. Econ.* 6(3), 251-262.

In addition to estimating the costs of injuries treated in U.S. hospital emergency departments and reported through NEISS, the Injury Cost Model uses empirical relationships between emergency department injuries and those treated in other settings (*e.g.*, physicians' offices, clinics, ambulatory surgery centers, and direct hospital admissions) to estimate the number, types, and costs of injuries treated outside of hospital emergency departments. Thus, the ICM allows us to expand on NEISS by combining (1) the number and costs of emergency department injuries with (2) the number and costs of medically attended injuries treated in other settings to estimate the total number of medically attended injuries and their costs across all treatment levels.

In this analysis, we use injury data from 2010, as a baseline from which to estimate the societal cost of injuries associated with ROVs. We use the year 2010 because 2010 is the year for which we have the most comprehensive estimates of both fatal and nonfatal injuries associated with ROVs. According to ICM, the average societal cost of a medically attended injury associated with ROVs in 2010 was $29,383 in 2012 dollars. Based on this estimate, the total societal costs of the medically attended injuries involving ROVs in 2010 was about $326.2 million in 2012 dollars (11,100 injuries x $29,383). About 75 percent of the cost was related to the pain and suffering. About 9 percent of the cost was related to medical treatment, and about 16 percent was related to work and productivity losses victim, caregivers, visitors, and employers. Less than 1 percent of the cost was associated with the costs of the legal and liability system.

These cost estimates are based on a small sample of only 16 NEISS cases. This sample is too small to reflect the full range of injury patterns (*i.e.*, the different combinations of injury diagnoses, body parts, and injury dispositions) and rider characteristics (*i.e.*, age and sex) associated with ROV injuries. In fact, because the 16 NEISS cases did not include any case in which the victim required admission to a hospital, the cost estimates are probably low. Nevertheless, this estimate will be used in this analysis with the knowledge that the estimate's use probably leads to an underestimate of the societal costs associated with ROVs and underestimates of the potential benefits of the proposed rule intended to reduce the risk of injury associated with ROVs. [74]

b. Societal Cost of Fatal Injuries

As discussed above, there were at least 49 fatal injuries involving ROVs in 2010. If we assign a cost of $8.4 million for each death, then the societal costs associated with these deaths would amount to about $411.6 million (49 deaths x $8.4 million). The estimate of $8.4 million is the estimate of $7.4 million (in 2006 dollars) developed by the U.S. Environmental Protection Agency (EPA) updated to 2012 dollars and is consistent with willingness-to-pay estimates of the value of a statistical life (VSL). According to OMB's *2013 Draft Report to Congress on the Benefits and Costs of Federal Regulations and Agency Compliance with the Unfunded Mandates Reform Act,* willingness-to-pay-estimates of the VSL generally vary from about $1.3 million to $12.2 million in 2010 dollars. In 2012 dollars, the range would be $1.3 million to 13.0 million.[75]

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[74] An alternative method for estimating the injury costs would be to assume that the patterns of injury associated with ROVs are similar to the injury patterns associated with all ATVs and UTVs. According to ICM estimates for all ATVs and UTVs (NEISS Product Codes 3285–3287 and 5044), injuries treated in hospital emergency departments accounted for about 35 percent of the medically attended injuries. This would suggest that the number of medically attended injuries involving an ROV was about 8,600. The average cost of a medically attended injury involving an ATV or UTV was $42,737. Therefore, the total societal cost of medically attended injuries would be $367.5 million.

[75] The estimate of the VSL developed by the EPA is explained EPA's *Guidelines* for Preparing Economic Analysis, Appendix B: Mortality Risk Valuation Estimates (Environmental Protection Agency, 2014) and is available at http://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0568-50.pdf/$file/EE-0568-50.pdf. The OMB's 2013 Draft Report to Congress is available at:
http://www.whitehouse.gov/sites/default/files/omb/inforeg/2013_cb/draft_2013_cost_benefit_report.pdf. Both reports were accessed on August 6, 2014.

c. Societal Cost of Injuries per ROV in Use

Based on the previous discussion, the total estimated societal costs of deaths and injuries associated with ROVs were $737.8 million in 2010 (expressed in 2012 dollars). The estimate does not include the costs associated with any property damage, such as property damage to the ROVs involved or other property, such as another vehicle or object that might have been involved in an incident.

Given the earlier estimate that about 570,000 ROVs were in use at the end of 2010, the estimated societal costs of deaths and medically attended injuries was about $1,294 per ROV in use ($737.8 million ÷ 570,000) in 2010. However, because the typical ROV is expected to be in use for 15 to 20 years, the expected societal cost of fatalities or deaths per ROV over the vehicle's useful life is the present value of the annual societal costs summed over the ROV's expected useful life. CPSC has not estimated the operability rates of ROVs as they age. However, CPSC has estimated the operability rates for ATVs as they age, based on the results of exposure surveys.[76] ROVs and ATVs are similar vehicles in that they are both off-road recreational vehicles generally produced by the same manufacturers. If ROVs have the same operability rates as they age as ATVs, the present value of the societal cost of injuries over the expected useful life of an ROV (at a 3 percent discount rate) is $17,784.[77]

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[76] CPSC Memorandum from Mark S. Levenson, Division of Hazard Analysis, to Susan Ahmed, Associate Executive Director, Directorate for Epidemiology, "2001 ATV Operability Rate Analysis," U.S. Consumer Product Safety Commission, Bethesda MD (19 August 2003).

[77] The choice of discount rate is consistent with research suggesting that a real rate of 3 percent is an appropriate discount rate for interventions involving public health (see Gold, Marthe R, Joanna E. Siegel, Louise B. Russell and Milton C. Weinstein, 1996, *Cost-Effectiveness in Health and Medicine*, New York: Oxford University Press).

D. Requirements of the Proposed Rule: Costs and Benefits

The proposed rule would establish a mandatory safety standard for ROVs. The requirements of the proposed rule can be divided into two general categories: (1) lateral stability and vehicle handling requirements, and (2) occupant-retention requirements. Following is a discussion of the costs and benefits that are expected to be associated with the requirements of the proposed rule. As discussed earlier, we use 2010 as the base year for this analysis because it is the only year for which we have estimates of both fatal and nonfatal injuries associated with ROVs. However, where quantified, the costs and benefits are expressed in 2012 dollars.

In general, the cost estimates were developed in consultation with the Directorate for Engineering Sciences (ES staff). Estimates are based on ES staff's interactions with manufacturers and knowledge related to ROV design and manufacturing process as well as direct experience with testing ROVs and similar products. In many cases, we relied on ES staff's expert judgment. Consequently, we note that these estimates are preliminary and welcome comments on their accuracy and the assumptions underlying their constructions. We are especially interested in data that would help us to refine our estimates to more accurately reflect the expected costs of the draft proposed rule as well as any alternative estimates that interested parties can provide.

1. <u>Lateral Stability and Vehicle Handling Requirements</u>

The lateral stability and vehicle handling requirements of the proposed rule would require that all ROVs meet a minimum level of rollover resistance and that ROVs exhibit sub-limit understeer characteristics. The dynamic lateral stability requirement would set a minimum value for the lateral acceleration at roll-over of 0.70 g (unit of standard gravity), as determined by a 30 mph drop-throttle J-turn test. The greater the lateral acceleration value, the greater the resistance of the ROV is to tipping or rolling over. The understeer requirement would mandate that ROVs exhibit understeer characteristics in the sublimit range of the turn circle test described in the proposed rule.

The proposed rule would also require manufacturers to place a hangtag on all new vehicles that provides the lateral acceleration at rollover value for the model and provides information to the consumer about how to interpret this value. The intent of the hangtag is to provide the potential consumer with information about the rollover propensity of the model to aid in the comparison of ROV models before purchase. The content and format of the hangtag are described in Section IX.C.2.

The proposed rule describes the test procedures required to measure the dynamic rollover resistance and the understeering performance of the ROV, including the requirements for the test surface, the loading of test vehicles, and the instrumentation required for conducting the tests and for data-acquisition during the tests. The test for rollover resistance would use a 30 mph drop-throttle J-turn test. This test uses a programmable steering controller to turn the test vehicle traveling at 30 mph at prescribed steering angles and rates to determine the minimum steering angle at which two-wheel lift is observed. The data collected during these tests are analyzed to compute and verify the lateral acceleration at rollover for the vehicle.

The test for vehicle handling or understeer performance involves driving the vehicle around a 100-foot radius circle at increasing speeds, with the driver making every effort to maintain compliance of the vehicle path relative to the circle. Data collected during the tests are analyzed to determine whether the vehicle understeers through the required range. The proposed rule would require that all ROVs exhibit understeer for values of ground plane lateral acceleration from 0.10 to 0.50 g.

a. Cost of Lateral Stability and Vehicle Handling Requirements

All manufacturers would have to conduct the tests prescribed in the proposed rule to determine whether their models meet the requirements and to obtain the information on dynamic lateral stability that must be reported to consumers on the hangtag. If any model fails to meet one or both of the requirements, the manufacturer would have to make adjustments or modifications to the design of the model. After the model has been modified, the manufacturer would have to conduct tests on the modified models to check that the model meets the requirements.

There is substantial overlap in the conditions under which the tests for dynamic lateral stability and vehicle handling must be performed. The test surfaces are the same, and the vehicle condition, loading, and instrumentation required for both tests are virtually the same. The one difference is that the test for dynamic lateral stability also requires that the test vehicle be equipped with a programmable steering controller. Because there is substantial overlap in the conditions under which the tests must be conducted, manufacturers likely will conduct both sets of tests on the same day. This would save manufacturers the cost of loading and instrumenting the test vehicle twice and renting a test facility for more than one day.

We estimate that the cost of conducting the dynamic lateral stability tests and the vehicle handling tests will be about $24,000 per model.[78] This includes the cost of conducting both sets of tests, measuring the center of gravity of the test vehicle, which is required for the dynamic lateral stability test, transporting the test vehicle to and from the test site, outfitting the test

[78] This estimate is based on the rates that CPSC has most recently paid a contractor for conducting these tests. For example, see contract CPSC-D-11-0003, which provides the following costs estimates: $3,000 for static measurement to determine center of gravity location, $19,000 to perform dynamic test, and $2,000 to ship vehicles. This amounts to approximately $24,000.

vehicles with the needed equipment and instruments, and the cost of renting the test facility. This estimate also assumes that both tests are being conducted on the same day and that the manufacturer only needs to rent the test facility for one day and pay for loading and instrumenting the test vehicles once.

If the model meets the requirements of both tests, the manufacturer would have no additional costs associated with these requirements. The tests would not have to be conducted again, unless the manufacturer makes changes to the model that could affect the vehicle's performance in these tests.

If the model does not meet the requirements of one or both of the tests, the manufacturer will incur costs to adjust the vehicle's design. Engineers specializing in the design of utility and recreational vehicles are likely to have a good understanding of vehicle characteristics that influence vehicle stability and handling. Therefore, these engineers should be able to modify easily the design of a vehicle to meet the stability and handling requirements. The Yamaha Rhino repair program demonstrated that an ROV that did not meet the lateral stability and vehicle handling requirements was successfully modified to meet the requirements by increasing the track width and reducing the rear suspension stiffness (by removing the sway bar) of the ROV. Based on experience with automotive manufacturing, ES staff believes that less than 1 or 2 person-months would be required to modify an ROV model that did not comply with the requirements. A high estimate would be that a manufacturer might require as many as 4 person-months (or about 700 hours) to modify. Assuming an hourly rate of $61.75, which is the estimated total hourly compensation for management, professional, and related workers, the cost to modify the design of an ROV model to meet the stability and handling requirements, using the high estimate, would be about $43,000.

The Commission believes that most modifications that might be required to meet the lateral stability and vehicle handling requirements will have minimal, if any, impact on the production or manufacturing costs because the assembly of an ROV already includes installation of a wheel axle and installing a longer wheel axle or wheel spacer would not change the current assembly procedure; likewise, the assembly of an ROV already includes installation of sway bars and shock absorbers and installing different variations of these suspension components would not affect the current assembly procedure.

Once an ROV model has been modified to comply with the requirements, the manufacturer will have to retest the vehicle to check that the model does comply with the requirements. Both the dynamic stability and vehicle handling tests will have to be conducted on the redesigned model, even if the original model failed only one of the tests. This is because the design changes could have impacted the ROVs ability to comply with either requirement. Therefore, the full cost of the proposed lateral stability and vehicle handling requirements could range from a low of about $24,000 for a model that already met the requirements, up to $91,000, for a scenario in which the model was tested, the manufacturer required 4 person-months to modify the vehicle, and the vehicle was retested to check that the modified vehicle complied with the requirements.[79]

Although the plausible range for the cost of the lateral stability and vehicle handling requirement is $24,000 to $91,000 per model, the Commission believes that the average cost per model will be toward the low end of this range because CPSC tested 10 ROVs that represented

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[79] If the ROV already met the lateral stability and vehicle handling requirements, the low estimate of $24,000 could overstate the incremental cost of meeting the requirements if the manufacturer was already performing the tests prescribed in the proposed rule.

the recreational and utility oriented ROVs available in 2010, and found that four out of 10 ROVs met the lateral stability requirement and five out of 10 ROVs met the vehicle handling requirements. As discussed previously, for models that already meet the requirements, the manufacturer will incur no additional costs other than the cost of the testing. Based upon CPSC examination of models that do not meet the requirements, CPSC believes in most cases the manufacturers should be able to bring the model into compliance with the requirements by making simple changes to the track width, or to the suspension of the vehicle. These are relatively modest modifications that probably can be accomplished in less time than the high estimate of 4 months. However, the Commission welcomes comments on our underlying rationale for the estimates as well as the estimates themselves.

It is frequently useful to compare the benefits and costs of a rule on a per-unit basis. Based on 2011 sales data, the average unit sales price per ROV model was about 1,800. [80] ROVs are a relatively new product and the average number of years a ROV model will be produced before being redesigned is uncertain. It is often observed that automobile models are redesigned every 4 to 6 years. If a ROV model is produced for about 5 years before being redesigned, then the cost of testing the model for compliance with the dynamic lateral stability and vehicle handling requirements, and, if necessary, modifying the design of the vehicle to comply with the requirements and retesting the vehicle would apply to about 9,000 units. (The Commission welcomes comments on this assumption.) Therefore, the average per-unit cost of the proposed dynamic lateral stability and vehicle handling requirements would be about $3 per

[80] In 2011, the average number of units sold per model was about 1,800. Depending on the particular model, the units sold ranged from less than 10 for some models, to more than 10,000 for others (based on an analysis by CPSC staff of a database obtained from Power Products Marketing of Eden Prairie, MN).

unit ($24,000 ÷ 9,000), if the model already complies with the requirements. Using the high estimate of the time that it could take to modify a model that fails or one or both of the tests, the per-unit cost would be about $10 per unit ($91,000 ÷ 9,000).[81]

The proposed rule requires that the manufacturer attach a hangtag on each new ROV that provides the ROV's lateral acceleration at rollover value, which can be used by the consumer to compare the rollover resistance of different ROVs. We estimate that the cost of the hangtag, including the designing and printing of the hangtag, and attaching the hang tag to the vehicle, will be less than $0.25 per vehicle. Our estimates are based on the following assumptions: (1) the cost of printing the hang tag and the wire for attaching the hang tag is about 8 cents per vehicle, (2) placing the hang tag on each vehicle will require about 20 seconds at an hourly rate of $26.11[82] and (3) designing and laying out the hang tag for each model will require about 30 minutes at an hourly rate of $61.75. [83] The estimate of 30 minutes for the hang tag design reflects that the proposed rule provides a sample of the required hang tag and guidance regarding the layout of the hang tag for manufacturers to follow. Also, if the manufacturer has multiple models, the same template could be used across models; the manufacturer would simply need to change the lateral acceleration number and model identification. In light of these considerations,

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[81]These per-unit cost estimates are an attempt to estimate the average per-unit costs across all ROV models. The actual per-unit cost for any ROV model would depend upon the sales volume for that model. If the sales were substantially more than 1,800 units annually, then the per-unit cost would be substantially lower than the estimate above. If sales were substantially less than 1,800 units annually, then the per-unit cost of the proposed requirements would be substantially higher.

[82] U.S. Bureau of Labor Statistics, Table 9 (Employer Costs for Employee Compensation (ECEC), total compensation for production, transportation, and material moving for all workers in private industry), June 2012. U.S. Department of Labor. Accessed on January 9, 2014. Available at: http://www.bls.gov/news.release/archives/ecec_09112012.pdf

[83] U.S. Bureau of Labor Statistics, Table 9 (Employer Costs for Employee Compensation (ECEC), total compensation for all management, professional, and related for all workers in private industry), June 2012. U.S. Department of Labor. Accessed on January 9, 2014. Available at: http://www.bls.gov/news.release/archives/ecec_09112012.pdf.

CPSC believes that 30 minutes per model represents a reasonable estimate of the effort involved, but we welcome comments on this estimate, especially comments that will assist us in refining the estimate.

According to several ROV manufacturers, some ROV users "might prefer limit oversteer in the off-highway environment." This assertion appeared in a public comment on the ANPR for ROVs (Docket No. CPSC-2009-0087), submitted jointly on behalf of Arctic Cat, Inc., Bombardier Recreational Products, Inc., Polaris Industries, Inc., and Yamaha Motor Corporation, USA. To the extent that the requirements in the proposed rule would reduce the ability of these users to reach limit oversteer intentionally, the proposed rule could have some adverse impact on the utility or enjoyment that these users receive from ROVs. These impacts would probably be limited to a small number of recreational users who enjoy activities or stunts that involve power oversteering or limit oversteer.

Although the impact on consumers who prefer limit oversteer cannot be quantified, the Commission expects that the impact will be low. Any impact would be limited to those consumers who wish to engage intentionally in activities involving the loss of traction or power oversteer. The practice of power oversteer, such as the speed at which a user takes a turn, results from driver choice. The proposed rule would not prevent ROVs from reaching limit oversteer under all conditions; nor would the rule prevent consumers from engaging in these activities. At most, the proposed rule might make reaching limit oversteer in an ROV to be somewhat more difficult for users to achieve.

b. Benefits of the Lateral Stability and Vehicle Handling Requirements

The benefit of the dynamic lateral stability and vehicle handling or understeer requirements would be the reduction of injuries and deaths attributable to these requirements.

The intent of the dynamic lateral stability requirement is to reduce rollover incidents that involve ROVs. A CPSC analysis of 428 ROV incidents showed that at least 68 percent involved the vehicle rolling sideways. More than half of the overturning incidents (or 35 percent of the total incidents) occurred during a turn. There were other incidents (24 percent of the total incidents) in which the vehicle rolled sideways, but it is not known whether the incident occurred during a turn.[84] The dynamic lateral stability requirement is intended to ensure that all ROVs on the market have at least a minimum level of resistance to rollover during turns, as determined by the test in the proposed rule. Additionally, by requiring through the use of hang tags that consumers be informed of the rollover resistance of ROV models, the proposed rule would make it easier for consumers to compare the rollover resistance of ROV models before making a purchase. Manufacturers might be encouraged to develop ROV models with greater resistance to rollover if consumers show a clear preference for ROVs with the higher values for lateral acceleration threshold at rollover when they purchase new ROVs. As a similar example, in 2001, NHTSA began including rollover resistance information in its new car assessment program (NCAP).[85] NHTSA believed that consumer information on the rollover risk of passenger cars would influence consumers to purchase vehicles with a lower rollover risk and inspire manufacturers to produce vehicles with a lower rollover risk.[86] A subsequent study of static stability factor (SSF) trends in automobiles found that SSF values increased for all vehicles after 2001, particularly SUVs, which tended to have the worst SSF values in the earlier years.[86]

[84] Sarah Garland, Ph.D., Analysis of Reported Incidents Involving Deaths or Injuries Associated with Recreational Off-Highway Vehicles (ROVs), U.S. Consumer Product Safety Commission, Bethesda, MD (May 2012).

[85] 65 FR 34988 (June 1, 2000).

[86] Walz, M. C. (2005). Trends in the Static Stability Factor of Passenger Cars, Light Trucks, and Vans. DOT HS 809 868. Retrieved from http://www.nhtsa.gov/cars/rules/regrev/evaluate/809868/pages/index.html.

The understeer requirement is intended to reduce the likelihood of a driver losing control of an ROV during a turn, which can lead to the vehicle rollover, striking another vehicle, or striking a fixed object. Oversteer is an undesirable trait because it is a directionally unstable steering response that leads to dynamic instability and loss of control. For this reason, automobiles are designed to exhibit understeer characteristics up to the traction limits of the tires. Sub-limit oversteer is also undesirable for off-highway vehicles due to the numerous trip hazards that exist in the off-highway environment and can cause the vehicles to roll over.

Although the Commission believes that the dynamic lateral stability and vehicle handling requirements will reduce the number of deaths and injuries involving ROVs, it is not possible to quantify this benefit because we do not have sufficient data to estimate the injury rates of models that already meet the requirements and models that do not meet the requirements. Thus, we cannot estimate the potential effectiveness of the dynamic lateral stability and vehicle handling requirements in preventing injuries. However, these requirements are intended to reduce the risk of an ROV rolling sideways when making a turn. Because the estimated societal cost of deaths and injuries associated with ROVs is $17,784 over the useful life of an ROV, and because at least 35 percent of the injuries occurred when an ROV rolled sideways when making a turn, these requirements would address approximately $6,224 in societal costs per ROV ($17,784 x .35). Consequently, given that the estimated cost of the lateral stability and handling requirements is less than $10 per ROV, the requirements would have to prevent less than about 0.2 percent of these incidents ($10 ÷ $6,224) for the benefits of the requirements to exceed the costs.

2. Occupant Retention Requirements

The occupant retention requirements of the proposed rule are intended to keep the occupant within the vehicle or within the rollover protective structure (ROPs). First, each ROV would be required to have a means to restrict occupant egress and excursion in the shoulder/hip zone, as defined by the proposed rule. This requirement could be met by a fixed barrier or structure on the ROV or by a barrier or structure that can be put into place by the occupant using one hand in one operation, such as a door. Second, the proposed rule would require that the speed of an ROV be limited to a maximum of 15 mph, unless the seat belts for both the driver and any front seat passengers are fastened. The purpose of these requirements is to prevent deaths and injuries, especially incidents involving full or partial ejection of the rider from the vehicle.

a. Costs of Occupant Retention Requirements

i. Means to Restrict Occupant Egress or Excursion

Most ROVs already have some occupant protection barriers or structures. In some cases, these structures might already meet the requirements of the proposed rule. In other cases, they could be modified or repositioned to meet the requirements of the proposed rule. A simple barrier that would meet the requirements of the proposed rule could be fabricated out of a length of metal tubing that is bent and bolted or welded to the ROPs or other suitable structure of the vehicle in the shoulder/hip zone of the vehicle, as defined in the proposed rule. ES staff believes that any additional metal tubing required to form such a barrier could be obtained for a cost of about $2 per barrier. ES also believes that the additional time that would be required to bolt or weld the barrier to the vehicle would be less than 1 minute. Assuming an hourly labor cost of $26.11, the labor time required would be less than $0.50. ES staff also believes that it would take manufacturers only a few hours to determine how an existing ROV model would need to be modified to comply with the requirement and to make the necessary drawings to implement the change. When spread over the production of the model, this cost would only amount to a few cents per vehicle. Therefore, the estimated cost is expected to be less than $3 per barrier.

Based on a cost of less than $3 per barrier, the cost per vehicle would be less than $6 for ROVs that do not have rear seats and $12 for ROVs with rear seats. One exposure study found that about 20 percent of ROVs had a seating capacity of 4 or more, which indicates that these ROVs have rear seats. Therefore, if all ROV models required modification to meet the standard, the weighted average cost per ROV would be about $7 ($6 x 0.8 + $12 x 0.2). However, CPSC tested 10 ROVs that represented the recreational and utility oriented ROVs available in 2010, and found that four out 10 ROVs had a passive shoulder barrier that passed a probe test specified in ANSI/ROHVA 1-2011. Therefore, this estimate of the average cost is high because there would be no additional cost for models that already meet the proposed requirement. We welcome comments on these costs and the assumptions underlying their constructions. We are especially interested in data that would help us to refine our estimates to more accurately reflect the expected costs of this proposed requirement as well as any alternative estimates that interested parties can provide.

ii. Requirement to Limit Speed if the Driver's Seat Belt Is not Fastened

The requirement that the speed of the vehicle be limited if the driver's seat belt is unfastened does not mandate any specific technology. Therefore, manufacturers would have some flexibility in implementing this requirement. Nevertheless, based on staff's examination of and experience with speed-limiting technology, including examination of current ROV models with this feature, most systems to meet this requirement will probably include the following components:

1. a seat belt use sensor in the seat belt latch, which detects when the seat belt is fastened;

2. a means to limit the speed of the vehicle when the seat belt is not fastened;

3. a means to provide a visual signal to the driver of the vehicle when the speed of the vehicle is limited because the seat belt is not fastened;

4. wiring or other means for the sensor in the seat belt latch to send signals to the vehicle components used to limit the speed of the vehicle and provide feedback to the driver.

Before implementing any changes to their vehicles to meet the requirement, manufacturers would have to analyze their options for meeting the requirement. This process would include developing prototypes of system designs, testing the prototypes, and refining the design of the systems based on this testing. Once the manufacturer has settled upon a system for meeting the requirement, the system will have to be incorporated into the manufacturing process of the vehicle. This will involve producing the engineering specifications and drawings of the system, parts, assemblies, and subassemblies that are required. Manufacturers will need to obtain the needed parts from their suppliers and incorporate the steps needed to install the system on the vehicles in the assembly line.

ES staff believes that it will take about nine person-months per ROV model to design, test, implement, and begin manufacturing vehicles that meet the requirements. The total compensation for management, professional, and related occupations as of 2012, is about $61.75 per hour.[87] Therefore, if designing and implementing a system to meet the requirement entails about nine person months (or 1,560 hours), the cost to the company would be about $100,000 per ROV model.[88]

Manufacturers would be expected to perform certification tests, following the procedure described in the proposed rule, at least once for each model the manufacturer produces, to ensure that the model, as manufactured, meets the rule's requirements. Additionally, manufacturers would be expected to perform the certification testing again if they make any changes to the design or components used in a vehicle that could impact the ROV's compliance with this requirement. We estimate that the cost of this testing would be about $4,000 per model. This estimate assumes that the testing will require three professional employees 4 hours to conduct the testing at $61.75 per hour, per person. Additionally, the rental of the test facility will cost $1,000; rental of the radar gun will cost $400; and transportation to the test facility will cost $1,400, and that the test vehicle can be sold after the testing is completed.

In addition to the cost of developing and implementing the system, manufacturers will incur costs to acquire any parts required for the system and to install the parts on the vehicles. We estimate the cost of adding a seat belt-use sensor to detect when the seat belt is fastened to be about $7 per seat belt. This estimate is based on figures used by the National Highway Traffic Safety Administration (NHTSA) in its preliminary economic assessment of an advanced air bag

[87] U.S. Bureau of Labor Statistics, Table 9 (Employer Costs for Employee Compensation (ECEC), total compensation for all management, professional, and related for all workers in private industry), June 2012. U.S. Department of Labor. Accessed on January 9, 2014. Available at: http://www.bls.gov/news.release/archives/ecec_09112012.pdf.

[88] The estimate has been rounded to the nearest $10,000.

rule.[89] This is a widely used technology; virtually all passenger cars have such sensors in their driver side seat belt latches to signal the seat belt reminder system in the car. The sensors and seat belt latches that would be expected to be used to meet this requirement in ROVs are virtually the same as the sensors used in passenger cars.

There is more than one method manufacturers could use to limit the maximum speed of the vehicle when the driver's seat belt is unfastened. One method would be to use a device, such as a solenoid, that limits mechanically the throttle opening. Based on observed retail prices for solenoid valves used in automotive applications, the cost to manufacturers of such a solenoid should be no more than about $25 per vehicle. One retailer had 24 different solenoids available at retail prices ranging from about $24 to $102. We expect that a manufacturer would be able to obtain similar solenoids for substantially less than the retail price. Thus, using the low end of the observed retail prices suggests that manufacturers would probably be able to acquire acceptable solenoids for about $25 each.

Manufacturers of ROVs equipped with electronic throttle control (ETC or "throttle by wire") would have at least one other option for limiting the maximum speed of the vehicle. Instead of using a mechanical means to limit the throttle opening, the engine control unit (ECU) of the vehicle, which controls the throttle, could be reprogrammed or "mapped" in a way that would limit the speed of the vehicle if the seat belt was not fastened. If the ECU can be used to limit the maximum speed of the ROV, the only cost would be the cost of reprogramming or mapping the ECU, which would be completed in the implementation stage of development, discussed previously. There would be no additional manufacturing costs involved.

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[89] NHTSA estimated the cost of a seat belt use sensor to be $2 to $5 in 1997 dollars. The cost has been adjusted to 2012 dollars using the CPI Inflation Calculator at: http://www.bls.gov/data/inflation_calculator.htm.

There would be at least two options for providing a visual signal to the driver that the speed of the vehicle is limited because seat belts are not fastened. One option would be to use an LCD display. Most ROV models already have an LCD display in the dashboard that could be used for this purpose. If an LCD display is present, the only cost would be the cost of the programming required for the display to show this message. This cost would be included in the estimated cost of the research and development, and there would be no additional manufacturing cost.

Another option for providing a visual signal to the driver that the speed of the vehicle is limited would be to use a lighted message or icon on the dashboard or control panel of the vehicle. Both voluntary standards already require a "lighted seat belt reminder." To comply with this proposed requirement, the current visual reminder would have to be modified. For example, the wording or icons of the reminder would change, and the reminder would probably require a somewhat larger area on the dashboard or control panel. There could be some additional cost for an extra bulb or lamp to illuminate the larger area or icon. Based on its experience, ES staff believes that the cost of an additional bulb or lamp would be about $1 or less per vehicle.

There will be some labor costs involved in installing the components needed to meet this requirement, including installing and connecting the wires. We expect that the components would be installed at the stage of assembly that would minimize the amount of labor required. If the amount of additional labor per vehicle was about 5 minutes, and assuming a total labor compensation rate of $26.11 an hour, [90] the labor cost is estimated to amount to approximately $2 per vehicle.

In addition to the certification testing discussed previously, most manufacturers would be expected to conduct some quality assurance testing on vehicles as the vehicles come off the assembly line. Virtually all manufacturers already perform some quality control or quality assurance tests on their vehicles. The tests are intended to ensure, among other things, that the vehicle starts properly, that the throttle and brakes function properly, and that any lights function properly. Testing of the system limiting the maximum speed when the driver's seat belt is not fastened would likely be incorporated into this testing to ensure that the system is working as intended. These tests could simply involve running the vehicle once with the seat belt unfastened to determine whether speed was limited and running the vehicle again with the seat belt fastened to determine whether the maximum speed was no longer limited. If this testing added an additional 10 minutes to the amount of time it takes to test each vehicle, the cost would be about $4 per vehicle, assuming a total hourly compensation rate of $26.11.

The manufacturing costs that would be associated with meeting the seat belt reminder and speed limitation requirement of the proposed rule are summarized in Table 8. These costs include the cost of one seat belt-use sensor, the throttle or engine control, the visual feedback to the driver, and about 5 minutes of labor time and about 10 minutes for testing.

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[90] U.S. Bureau of Labor Statistics, Table 9 (Employer Costs for Employee Compensation (ECEC), total compensation for production, transportation, and material moving for all workers in private industry), June 2012. U.S. Department of Labor. Accessed on January 9, 2014. Available at: http://www.bls.gov/news.release/archives/ecec_09112012.pdf

Table 8. Estimated Manufacturing Costs of Requirement, per ROV

Component	Cost
Seat Belt-Use Sensor	$7
Throttle or Engine Control	$0 to $25
Visual Signal to Driver	$1
Labor	$2
Quality Control Testing	$4
Total	***$14 to $39***

As discussed previously, we estimate the upfront research, design, and implementation costs to be about $100,000 per model, and the certification testing costs are estimated to be about $4,000 per model. Assuming, as before, that the average annual sales per model are 1,800 units, and assuming that the typical model is produced for 5 years, then the research, design, and certification testing costs would average about $12 per vehicle. The average cost for models produced at lower volumes would be higher, and the average cost for models produced at higher-than-average volumes would be lower. Given the average cost of the design and development and the costs of the parts and manufacturing, we estimate that this requirement would cost between $26 ($14 + $12) and $51 ($39 + 12) per vehicle.

Unquantifiable Costs to Users – The requirement could impose some unquantifiable costs on certain users who would prefer not to use seat belts. The cost to these users would be the time required to buckle and unbuckle their seat belts and any disutility cost, such as discomfort caused by wearing the seat belt. We cannot quantify these costs because we do not know how many ROV users choose not to wear their seat belts. Nor do we have the ability to quantify any discomfort or disutility that ROV users would experience from wearing seat belts. However, the proposed rule does not require that the seat belts be fastened, unless the vehicle is traveling 15 mph or faster. This requirement should serve to mitigate these costs because many people who would be inconvenienced or discomforted by the requirement, such as people using the vehicle for work or utility purposes, or people who must get on and off the vehicle frequently, are likely to be traveling at lower speeds.

iii. Requirement to Limit Speed if Seat Belts for Front Passengers Are not Fastened

The proposed rule would also require that the speed of the ROV be limited to no more than 15 mph if the seat belt of any front passenger, who is seated in a location intended by the manufacturer as a seat, is not fastened. Based on conversations with ES staff , designing a system that also limits the speed of the vehicle if the seat belt of a passenger is not fastened would require only minor adjustments to the system limiting the speed if the driver's seat belt is not fastened. The speed-limiting system uses sensor switches (seat belt latch sensors and/or occupant presence sensors) to determine if seat belts are in use, and the speed-limiting system controls the vehicle's speed based on whether the switch is activated or not. ES staff believes adding requirements for front passenger seat belt use will not add significant time to the research and design effort for a speed-limitation system because the system would only have to incorporate additional switches to the side of the system that determines whether vehicle speed should be limited.

However, incorporating the front passenger seats into the requirement would require additional switches or sensors. A seat belt-use sensor like the one used on the driver's side seat belt latch, would be required for each passenger seat belt. The cost of a seat belt-use sensor was estimated to be about $7. Additionally, there would likely be a sensor switch in each front passenger seat to detect the presence of a passenger. This switch could be similar to the seat switches in riding lawn mowers that shut off the engine if a rider is not detected. Similarly, in a ROV, if the presence of a passenger is not detected, the switch would not include the passenger seat belt sensor in circuit for determining whether the speed of the ROV should be limited. We estimate that the cost of this switch is $13 per seat, based on the retail price of a replacement switch for the seat switch in a riding lawn mower.

There will be labor costs involved in installing the components needed to meet this requirement. The components would probably be installed at the stage of assembly that would minimize the amount of labor required and would probably not require more than about 5 minutes. Additionally, manufacturers will need to conduct tests of the system to ensure that the system functions as required. These tests could take an additional 5 minutes per vehicle. Assuming a total labor compensation rate of $26.11 an hour,[91] the labor cost would probably amount to about $4 per vehicle. Therefore, the full cost of meeting this requirement would be about $24 per passenger seat ($7 for seat belt latch sensor + $13 for seat switch + $4 for labor). Therefore, the quantifiable cost of extending the seat belt/speed limitation requirement to include the front passenger seat belts would be $24 for ROVs with only two seating positions in the front, (*i.e.*, the driver and right front passenger) and $48 for ROVs that have three seating positions in the front. According to a survey by Heiden Associates, about 9 percent of ROVs

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[91] U.S. Bureau of Labor Statistics, Table 9 (Employer Costs for Employee Compensation (ECEC), total compensation for production, transportation, and material moving for all workers in private industry), June 2012. U.S. Department of Labor. Accessed on January 9, 2014. Available at: http://www.bls.gov/news.release/archives/ecec_09112012.pdf

were reported to have a seating capacity of three.[92] Therefore, the average cost of extending the seat belt/speed limitation requirement per ROV would be $26 ($24 + 0.09 x $24).

An additional cost that is unquantifiable but should be considered nevertheless, is the impact that the failure of a component of the system could have on consumers. The more components that a system has, or the more complicated that a system is, the more likely it is that there will be a failure of a component somewhere in the system. A system that limits the speed of an ROV if a front passenger's seat belt is unbuckled would consist of more components and the system would be more complicated than a system that only limited the speed of the vehicle if the driver's seat belt is unfastened. Failure in one or more of the components would impose some costs on the consumer, and this failure could possibly affect consumer acceptance of the requirement. For example, if the sensor in a passenger's seat belt failed to detect that the seat belt was latched, the speed of the vehicle could be limited, even though the seat belts were fastened. The consumer would incur the costs of repairing the vehicle and the loss in utility because the speed was limited until the repairs were made.

b. Benefits of the Occupant Retention Requirements

The benefit of the occupant-retention requirement is the reduction in the societal cost of fatal and nonfatal injuries that could be attributable to the requirements. In passenger cars, NHTSA assumes that a belted driver has a 45 percent reduction in the risk of death.[93] Research

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[92] Heiden Associates et al. provided results from a 2009 ROV Survey, which is included in Appendix 2 of Docket No. CPSC – 2009-0087).

[93] Charles J. Kahane, "Fatality Reduction by Safety Belts for Front-Seat Occupants of Cars and Light Trucks: Updated and Expanded Estimates Based on 1986–99 FARS Data," U.S. Department of Transportation, Report No. DOT HS 809 199, (December 2000).

confirms the validity of that estimate.[94] The effectiveness of seat belts in reducing the number or severity of nonfatal injuries is less certain than in the cases resulting in deaths. Nevertheless, there is evidence that the use of seat belts is associated with a reduction in injury severity. A study by Robert Rutledge and others found statistically significant decreases in the severity of injuries in belted patients versus unbelted patients admitted to trauma center hospitals in North Carolina for variables such as the trauma scores, the Glasgow coma scale, days on a ventilator, days in an intensive care unit, days in a hospital, and hospital charges.[95] This study found, for example, that the mean stay in the hospital for belted patients was about 20 percent shorter than for unbelted patients: 10.5 days for belted patients as opposed to 13.2 days for unbelted patients. The hospital charges for belted patients were 31 percent less than the charges incurred by unbelted patients: $10,500 versus $15,250.[96]

In this analysis, we assume that the effectiveness estimate that NHTSA uses for seat belts in automobiles is a reasonable approximation of the effectiveness of seat belts at reducing fatalities in ROVs. However, according to Kahane (2000), the effectiveness of seat belts was significantly higher in accidents involving rollover and other incidents where the potential for ejection was high.[97] A significant portion of the fatal and nonfatal injuries associated with ROVs

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[94] "Analysis of Reported Incidents Involving Deaths or Injuries Associated with Recreational Off-Highway Vehicles (ROVs)," U.S. Consumer Product Safety Commission, Bethesda, MD (May 2012).
[95] Robert Rutledge, Allen Lalor, Dale Oller, et al., The Cost of Not Wearing Seat Belts: A Comparison of Outcome in 3396 Patients," Annals of Surgery, Vol. 217, No. 2, 122−127 (1993).
[96] Note that the Rutledge study looked only at the difference in the severity of cases involving belted, as opposed to unbelted victims. It did not estimate the number of injuries that were actually prevented. It should also be noted that the Rutledge study focused only on patients that were hospitalized for at least one day. It might not be as applicable to patients who were treated and released without being admitted to a hospital.
[97] In these incidents, the researchers found the effectiveness of seat belts was 74 percent in passenger cars and 80 percent in light trucks. Incidents involving overturning of the vehicle or the ejection of the victim are associated with a larger proportion of the fatal injuries involving ROVs. At least 65 percent of the fatalities were in incidents where the vehicle rolled sideways and at least 70 percent of those injured or killed were either fully or partially ejected.

are associated with rollovers, which suggests that a higher effectiveness estimate could be warranted.

The work by Rutledge, et al, showed that mean hospital stays were about 20 percent less and hospital charges were 31 percent less for belted patients. This work provides some evidence that seat belts can reduce some components of the societal costs of nonfatal injuries by 20 to 31 percent. In this analysis we use the low end of this range, 20 percent, and assume that it applies to all components of the societal costs associated with nonfatal ROV injuries, including work losses and pain and suffering. The assumed 20 percent reduction in societal costs could come about because some injuries were prevented entirely or because the severity of some injuries was reduced.

These assumptions are justified because the seat belts used in ROVs are the same type of seat belts used in automobiles. Additionally, the requirement that ROVs have a passive means to restrict the egress or excursion of an occupant in the event of a rollover would ensure that there would be some passive features on ROVs that will help to retain occupants within the protective structure of the ROV just as there are in automobiles. We welcome comment on the accuracy of these estimates and underlying assumptions and will consider alternative estimates or assumptions that commenters wish to provide.

A separate estimate of the benefit of the requirement for a passive means to restrict occupant egress or excursion is not calculated. The primary benefit of this requirement is to ensure that ROVs have passive features that are more effective at retaining occupants within the protective zone of the vehicle in the event of a rollover. Therefore, the passive means to restrict occupant egress or excursion acts synergistically with the seat belt requirements to keep occupants within the protective zone of the vehicle or ROPS, and in addition, provides justification for applying to the proposed rule for ROVs estimates from studies on the effectiveness of seat belts in automobiles.

i. Benefit of Limiting Speed if Driver's Seat Belt Is not Fastened

As noted previously, the benefit of the occupant-retention requirements would be the reduction in the societal costs of fatal and nonfatal injuries that would be expected. The incremental benefit of applying the requirement to limit the speed of the vehicle if the driver's seat belt is not fastened is discussed below. The incremental benefit of applying the same requirement to the front passengers is discussed separately.

Potential Reduction in Fatal Injuries

Table 9 shows the 231 fatality cases that CPSC has reviewed according to the seating location of the victim and whether the victim was wearing a seat belt. Ignoring the cases in which the location of the victim or the seat belt use by the victim is unknown (and thereby, erring on the side of underestimating the benefits), the data show that about 40 percent (92 ÷ 231) of the deaths happened to drivers who were not wearing seat belts. If the pattern of deaths in 2010 is presumed to match the overall pattern of the deaths reviewed by CPSC, then about 20 of the reported 49 deaths associated with ROVs in 2010[98] would have been to drivers who did not have their seat belts fastened. (The actual pattern of deaths in any given year will likely be higher or lower than the overall or average pattern. In this analysis, we imposed the overall pattern to the reported fatalities in 2010, so that the results would be more representative of all reported ROV fatalities.)

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[98] The collection of fatalities associated with ROVs in 2010 was ongoing at the time this analysis was conducted. The actual number of deaths associated with ROVs in 2010 could be higher.

Table 9. ROV Fatalities by Victim Location and Seat Belt Use (2003 through 2011)

Location	Seat Belt Use			
	Yes	No	Unknown or N/A	Total
Driver	16	92	33	141
Right Front Passenger	10	33	6	49
Middle Front Passenger	0	6	0	6
Rear Passenger	0	3	1	4
Unknown Location	1	6	5	12
Cargo Area	1	8	1	10
Bystander or Other	0	3	6	9
Total	28	150	53	231

Source: CPSC Directorate for Epidemiology.

The requirement limiting the maximum speed would apply only to incidents involving unbelted drivers that occurred at speeds of greater than 15 mph. Of the ROV incidents that the Commission has reviewed, the speed of the vehicle was reported for only 89 of the 428 incidents. Therefore, estimates based on this data need to be used cautiously. Nevertheless, for victims who are known to have been injured and for which both their the seat belt use and the speed of the vehicle are known, about 73 percent of the unbelted victims were traveling at speeds greater than 15 mph. (Victims who were involved in an ROV incident but were not injured, or whose injury status is not known, were not included in this analysis.) Consequently, if we assume that 73 percent of the fatalities occurred to unbelted drivers who were traveling at speeds greater than

15 mph, then about 15 (20 x 0.73) of the fatalities in 2010 would have been addressed, although not necessarily prevented, by the proposed requirement.

As discussed previously, in passenger cars, NHTSA assumes that a belted driver has a 45 percent reduction in the risk of death. If seat belts have the same effectiveness in reducing the risk of death in ROVs, the seat belt/speed limitation requirement would have reduced the number of fatal injuries to drivers of ROVs by about 7 (15 x 0.45) in 2010, if all ROVs in use at the time had met this requirement.[99] This represents an annual risk reduction of 0.0000123 deaths per ROV in use (7 ÷ 570,000).

As discussed previously, in this analysis, we assume a value of $8.4 million for each fatality averted. However, in this analysis, we assume that each fatal injury prevented by the use of seat belts still resulted in a serious, but nonfatal, injury. The average societal cost of a hospitalized injury involving all ATVs and UTVs in 2010 was about $350,000 in 2012 dollars. (Based on the ICM estimates of the cost of a hospitalized injury using NEISS Product Codes 3285, 3286, 3287, and 5044.) Subtracting this from the assumed societal cost of $8.4 million per death results in a societal cost reduction of $8.05 million per death averted. Thus, a reduction in societal costs of fatal injuries of about $99 per ROV in use (0.0000123 x $8.05 million) per year could be attributable to the seat belt/speed limitation requirement.

Potential Reduction in Societal Cost of Nonfatal Injuries

As discussed previously, for this analysis, we assumed that the seat belt/speed limitation requirement will reduce the societal cost of nonfatal ROV injuries by 20 percent. The assumed

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[99] Alternatively, the drivers could opt to leave their seat belts unfastened and accept the lower speed. Because the risk of having an accident is probably directly related to the speed of the vehicle, this option would also be expected to reduce the number of fatal injuries.

20 percent reduction in societal costs could result because some injuries were prevented entirely, or because the severity of some injuries was reduced. The CPSC has investigated several hundred nonfatal injuries associated with ROVs. Table 10 summarizes the nonfatal injuries according to seating location and seat belt use. (Cases in which the occupant was not injured, or cases in which it is unknown whether the occupant was injured, were not included in this analysis.) Again, ignoring the cases in which the location of the victim or the seat belt use by the victim is unknown (and thereby, erring on the side of underestimating the benefits), the data indicate that about 12 percent (46 ÷ 388) of the nonfatal injuries happened to drivers who were not wearing seat belts. This suggests that 1,332 (11,100 x 0.12) of the approximately 11,100 medically attended injuries in 2010 would have involved unbelted drivers. Assuming, as with the fatal injuries, that 73 percent were traveling at a speed greater than 15 mph at the time of incident, 972 (1,332 x 0.73) of the injuries in 2010 could have been addressed by the proposed seat belt/speed limitation requirement. These 972 injuries in 2010 represent an injury rate of about 0.00170526 (972 ÷ 570,000) per ROV in use.

Table 10. Nonfatal ROV Injuries by Victim Location and Seat Belt Use (2003 to 2011)

	Seat Belt Use			
Location of Victim	Yes	No	Unknown or N/A	Total
Driver	23	46	51	120
Right Front Passenger	28	35	9	72
Middle Front Passenger	0	14	1	15
Rear Passenger	2	3	0	5
Unknown Location	8	21	128	157
Cargo Area	3	13	0	16
Bystander	0	0	3	3
Total	64	132	192	388

Source: CPSC Directorate for Epidemiology.

Based on estimates from the CPSC's ICM, the average societal cost of the injuries addressed is estimated to be $29,383. Applying this cost estimate to the estimated injuries per ROV that could be addressed by the standard results in an annual societal cost of about $50 per ROV in use (0.00170526 x $29,383). If wearing seat belts could have reduced this cost by 20 percent (by reducing either the number or severity of injuries), the societal benefit, in terms of the reduced costs associated with nonfatal injuries, would be about $10 per ROV in use.

Total Benefit Over the Useful Life of an ROV

The total benefit of the seat belt/speed limitation requirement per ROV would be the present value of the expected annual benefit per ROV in use, summed over the vehicle's expected useful life. Above, using 2010 as the base year, we estimated that the annual benefit per ROV was about $99 in terms of reduced deaths and $10 in terms of reduced nonfatal injuries, for a total of $109 per ROV. Assuming that ROVs have the same operability rates as ATVs, the present value of the estimated benefit over the useful life of an ROV would be approximately $1,498 per vehicle, at a 3 percent discount rate.

The cost of the requirement to limit the speed of the vehicle if the driver's seat belt is not fastened was estimated to be between $26 and $51 per vehicle. Additionally, the cost of the requirement for a means to restrict occupant egress and excursion via a passive method was estimated to be about $7 per vehicle. Therefore, the total cost would be between $33 and $58 per vehicle. The benefit of the requirement, estimated to be about $1,498 per vehicle, is substantially greater than the estimated cost of the requirement.

ii. Benefit of Limiting Speed if a Front Passenger's Seat Belt Is not Fastened

The potential incremental benefit of limiting the speed of an ROV if a front passenger's seat belt is not fastened can be calculated following the same procedure used to calculate the benefits of a requirement limiting the maximum speed when the driver's seat belt is not fastened. From the data presented in Table 9 (and ignoring the cases in which the seating location of the victim or the seat belt use is unknown), there were 33 victims seated in the right front passenger position, and six who were seated in the middle front passenger position were not using a seatbelt. However, some of the victims listed as a middle front seat passenger were not seated in places intended to be a seat. In some cases, the victim might have been seated on a console; in other cases, the victim might have been sharing the right front passenger seat and not a separate seat. Based on the information available about the incidents, we believe that only three of the six victims reported to be "middle front passengers," were actually in positions intended by the manufacturer to be middle seats. Therefore, about 16 percent (36 ÷ 231) of the fatal injuries involved front seat passengers who were not wearing seat belts.

Applying this estimate to the fatalities in 2010 suggests that about 8 of the 49 fatalities happened to front passengers who were not wearing seat belts. Assuming that about 73 percent of the incidents involved vehicles traveling faster than 15 mph, about 6 of the fatalities would have been addressed, but not necessarily prevented, by the requirement. Assuming that seat belts reduce the risk of fatal injuries by 45 percent, about 3 fatalities might have been averted. This represents a risk reduction of 0.00000526 deaths per ROV in use (3 ÷ 570,000). Assuming a societal benefit of $8.05 million for each death averted results in an estimated annual benefit of about $42 per ROV in use ($8.05 million x 0.00000526) in reduced fatal injuries.

Similarly, the data show that 35 of the victims who suffered nonfatal injuries were seated in the right front passenger location, and 14 were seated in the middle front position. However, we believe that only 8 of the 14 were actually seated in a position intended by the manufacturer to be a seat. Therefore, 43 of the 388 victims (or about 11 percent of the total) with nonfatal injuries were front passengers who were not wearing seat belts. This suggests that 1,221 of the estimated 11,100 medically attended injuries in 2010 involved unbelted front passengers. Using the assumption that 73 percent of these incidents occurred at speeds greater than 15 mph, then about 891 of the injuries might have been addressed by the requirement, or about 0.00156315 injuries per ROV in use (891 ÷ 570,000). Assuming that the average cost of a nonfatal injury involving ROVs is $29383, the estimated societal cost of these injuries is about $46 per ROV in use. If wearing seat belts could have reduced the societal cost of the nonfatal injuries by 20 percent, then the benefits of the requirement would have been about $9 per ROV in use, per year.

Combining the benefits of the reduction in the societal cost of deaths ($42 per ROV in use) and the societal cost of injuries ($9 per ROV in use) yields an estimated benefit of $51 per ROV in use. Assuming that ROVs have the same operability rates as ATVs over time, and assuming a discount rate of 3 percent, the estimated benefit would be $701 over the expected useful life of an ROV. This is greater than the expected cost of this potential requirement of $26 per vehicle.

iii. Impact of Any Correlation in Seat Belt Use Between Driver and Passengers

The analysis above used a simplifying assumption that the use of seat belts by the passenger is independent of the use of seat belts by the driver. Therefore, we assumed that limiting the maximum speed of the ROV if the driver's seat belt was not fastened would have no impact on the seat belt use by any passenger. However, there is some evidence that the use of seat belts by passengers is correlated with the seat belt use of the driver. In the incidents examined by the Commission, of the 121 right front passengers with known seat belt usage, the driver and right passenger had the same seat belt use status most of the time (about 82 percent). In other words, most of the time, the driver's and right passenger's seat belts were either both fastened or both unfastened. This suggests that if the drivers were required to fasten his or her seat belt, at least some of the passengers would also fasten their seat belts.

The implication that a correlation exists between seat belt use by drivers and by passengers indicates that the benefits of requiring the driver's seat belt to be fastened were underestimated and the benefits of extending the requirement to include the right front passenger are over estimated. For example, if 80 percent of the passengers who would not normally wear their seat belts were to wear their seat belts because the driver was required to wear his or her seat belt (for the ROV to exceed 15 mph), then 80 percent of the benefit, or $561 ($701 x 0.80) attributed above to extending the speed limitation requirement to the front passengers would be attributed rightfully to the requirement that the driver's seat belt be fastened; and only 20 percent, or $140 ($701 x 0.20) would be attributable to the requirement that the front passengers' seat belts be fastened. In this example, the $140 in benefits attributed to extending the speed limitation requirement to include the front passenger's seat belts would still exceed the quantifiable cost of doing so, which was estimated to be $26.

E. Summary of the Costs and Benefits of the Proposed Rule

As described previously, manufacturers would incur costs of $128,000 to $195,000 per model to test ROV models for compliance with the requirements of the proposed rule and to research, develop, and implement any needed changes to the models so that they would comply with the requirements. These costs would be incurred before the model is brought to market. To express these costs on a per-unit basis, we assumed that, on average, 1,800 units of a model were produced annually and that a typical model is produced for 5 years. These costs are summarized in Table 11.

Table 11. Summary of Certification Testing and Research and Development Costs

Description	Cost per Model	Cost per Unit*
Lateral Stability and Vehicle Handling Requirements		
Compliance Testing	$24,000	$3
Redesign of Noncomplying Models	$43,000	$5
Retesting of Redesigned Models	$24,000	$3
Total Costs for Lateral Stability and Vehicle Handling	*$24,000 to $91,000*	*$3 to $10*
Occupant Retention Requirements		
Research, Design, Implementation	$100,000	$11
Certification Testing	$4,000	<$1
Total R&D and Testing Costs for Seat Belt Requirement	*$104,000*	*$12*
Total Certification Testing and Research and Development Costs	***$128,000 to $195,000***	***$14 to $22***

* Per-unit costs are rounded to the nearest whole dollar. The sums might not equal the totals due to rounding.

In addition to the testing, research, and development costs described above, manufacturers will incur some additional manufacturing costs for extra parts or labor required to manufacture ROVs that meet the requirements for the proposed rule. These costs are summarized in Table 12. As for the vehicle handling requirements, some modifications to vehicles that do not comply might increase manufacturing costs; other modifications could decrease manufacturing costs. Therefore, we have assumed, on average, that there will not be any additional manufacturing costs required to meet the vehicle handling requirements. However, most manufacturers will incur additional manufacturing costs to meet the occupant-retention requirements. These costs are expected to average between $47 and $72 per vehicle. Adding the estimated upfront testing, research, development, and implementation costs per unit from Table 11 brings the total cost of the proposed rule to an estimated $61 to $94 per vehicle.

Table 12. Summary of Per-Unit Costs and Benefits

Description	Value Per Unit
Costs	
Manufacturing Costs	
Lateral Stability and Vehicle Handling Requirements	$0
Passive Occupant Retention Requirement	$7
Seat Belt/Speed Limitation Requirement – Driver Seats	$14 to $39
Seat Belt/Speed Limitation Requirement – Front Passenger Seats	$26
Total Manufacturing Costs	***$47 to $72***
Certification Testing and Research and Development Costs (from Table 4)	*$14 to $22*
Total Quantifiable Cost	**$61 to $94**
Benefits	
Lateral Stability and Vehicle Handling Requirements	(not quantifiable)
Occupant Retention Requirements	$2,199
Total Quantifiable Benefits	**$2,199**
Net Quantifiable Benefits	**$2,105 to $2,138**

We were able to estimate benefits for the occupant retention requirement. Applying this requirement to just the driver's seat belt would result in benefits of about $1,498 per unit. Applying the seat belt/speed limitation requirement to the front passenger seat belts could result in an additional benefit of $701 per unit. Therefore, the quantifiable benefits of the proposed rule would be $2,199 per unit. The benefit associated with the vehicle handling and lateral stability requirement could not be quantified. Therefore, the benefits of the proposed rule could exceed the $2,199 estimated above.

The fact that the potential benefits of the lateral stability and vehicle handling requirements could not be quantified should not be interpreted to mean that they are low or insignificant. This only means that we have not developed the data necessary to quantify these benefits. The purpose of the occupant retention requirements is to reduce the severity of injuries, but this requirement is not expected to reduce the risk of an incident occurring. The lateral stability and vehicle handling requirement, on the other hand, is intended to reduce the risk of an incident occurring that involves an ROV, and therefore, prevent injuries from happening in the first place. At this time, however, we do not have a basis for estimating what would be the effectiveness of the lateral stability and vehicle handling requirements.

Notably, to the extent that the lateral stability and vehicle handling requirements are effective in reducing the number of incidents, the incremental benefit of the occupant retention requirements also would be reduced. Additionally, if the lateral stability and vehicle handling requirements can reduce the number of accidents involving ROVs, there would be fewer resulting injuries whose severity would be reduced by the occupant retention requirements. However, the resulting decrease in the incremental benefit of the seat belt/speed limitation requirement would be less than the benefit attributable to the lateral stability and vehicle handling requirements. Again, this is largely because the benefit of preventing an injury from occurring in the first place is greater than the benefit of reducing the severity of harm of the injury.

Although some assumptions used in this analysis would serve to reduce the estimated benefit of the draft proposed rule (*e.g*., ignoring incidents in which the use of seat belts was unknown), the analysis also assumes that all drivers and front seat passengers would opt to fasten their seat belts if the speed of the vehicle was limited; and the analysis also would assume that no driver or passenger would attempt to defeat the system, which could be accomplished simply by passing the belt behind the rider, or passing the belt behind the seat before latching the belt. To the extent that consumers attempt to defeat the seat belt/speed limitation system, the benefits are overestimated.

The estimated costs and benefits of the rule on an annual basis can be calculated by multiplying the estimated benefits and costs per-unit by the number of ROVs sold in a given year. In 2013, 234,000 ROVs were sold. If the proposed rule had been in effect that year, the total quantifiable cost would have been between $14.3 million and $22.0 million ($61 and $94 multiplied by 234,000 units, respectively). The total quantifiable benefits would have been at least $515 million ($2,199 x 234,000). Of the benefits, about $453 million (or about 88 percent) would have resulted from the reduction in fatal injuries, and about $62 million (or about 12 percent) of the benefits would have resulted from a reduction in the societal cost of nonfatal injuries. About $47 million of the reduction in the societal cost of nonfatal injuries would have been due to a reduction in pain and suffering.

F. Alternatives

The Commission considered several alternatives to the requirements in the proposed rule. The alternatives considered included: (1) not issuing a mandatory rule, but instead, relying on voluntary standards; (2) including the dynamic lateral stability requirement or the understeer requirement, but not both; (3) requiring a more intrusive audible or visual seatbelt reminder, instead of limiting the speed of the vehicle if the seatbelt is not fastened; (4) extending the seatbelt/speed limitation requirement to include rear seats; (5) requiring an ignition interlock if the seatbelts are not fastened instead of limiting the maximum speed; and (6) limiting the maximum speed to 10 mph, instead of 15 mph, if the seatbelts are not fastened. Each of these alternatives is discussed below. The discussion includes the reasons that the Commission did not include the alternative in the proposed rule as well as qualitative discussion of costs and benefits where possible.

1. No Mandatory Standard/Rely on Voluntary Standard

If CPSC did not issue a mandatory standard, most manufacturers would comply with one of the two voluntary standards that apply to ROVs. However, neither voluntary standard requires that ROVs understeer, as required by the proposed rule. According to ES staff, drivers are more likely to lose control of vehicles that oversteer, which can lead to the vehicle rolling over or causing other types of accidents.

Both voluntary standards have requirements that are intended to set standards for dynamic lateral stability. ANSI/ROHVA 1-2011 uses a turn-circle test for dynamic lateral stability that is more similar to the test in the proposed rule (for whether the vehicle understeers) than it is to the test for dynamic lateral stability. The dynamic stability requirement in ANSI/OPEI B71.9-2012 uses a J-turn test, like the proposed rule, but measures different variables during the test and uses a different acceptance criterion. However, ES staff does not believe that the tests procedures in either standard have been validated properly to be deemed capable of providing useful information about the dynamic stability of the vehicle. Moreover, the voluntary standards would find some vehicles to be acceptable, even though their lateral acceleration at rollover is less than 0.70 g, which is the acceptance criterion in the proposed rule.

Both voluntary standards require manufacturers to include a lighted seat-belt reminder that is visible to the driver and remains on for at least 8 seconds after the vehicle is started, unless the driver's seatbelt is fastened. However, virtually all ROVs on the market already include this feature; and therefore, relying only on the voluntary standards would not be expected to raise seatbelt use over current levels of use.

The voluntary standards include requirements for retaining the occupant within the protective zone of the vehicle if a rollover occurs, including two options for restraining the occupants in the shoulder/hip area. However, testing performed by CPSC identified weaknesses in the performance-based tilt table test option that allows unacceptable occupant head ejection beyond the protective zone of the vehicle ROPs. CPSC testing indicated that a passive shoulder barrier could reduce the head excursion of a belted occupant during quarter-turn rollover events. The Commission believes that this can be accomplished by a requirement for a passive barrier, based on the dimensions of the upper arm of a 5th percentile adult female, at a defined area near the ROV occupants' shoulder, as contained in the proposed rule.

In summary, not mandating a standard would not impose any additional costs on manufacturers, but neither would it result in any additional benefits in terms of reduced deaths and injuries. Therefore, not issuing a mandatory standard was not proposed by the Commission.

2. Removing Either the Lateral Stability Requirement or the Handling Requirement

The CPSC considered including a requirement for either dynamic stability or vehicle handling, but not both. However, the Commission believes that both of these characteristics need to be addressed. According to ES staff, a vehicle that meets both the dynamic stability requirement and the understeer requirement should be safer than a vehicle that meets only one of the requirements. Moreover, the cost of meeting just one requirement is not substantially lower than the cost of meeting both requirements. The cost of testing a vehicle for compliance with both the dynamic lateral stability requirement and the vehicle handling/understeer requirement was estimated to be about $24,000. However, the cost of testing for compliance with just the dynamic stability requirement would be about $20,000, or only about 17 percent less than the cost of testing for compliance with both requirements. This is because the cost of renting and transporting the vehicle to the test site, instrumenting the vehicle for the tests, and making some initial static measurements are virtually the same for both requirements and would only have to be done once, if the tests for both requirements were conducted on the same day. Moreover, changes in the vehicle design that affect the lateral stability of the vehicle could also impact the handling of the vehicle. For these reasons, the proposed rule includes a dynamic stability requirement and a vehicle handling requirement.

3. Require Intrusive Seatbelt Reminder in Lieu of the Speed Limitation Requirements

Instead of seatbelt/speed limitation requirements in the proposed rule, the Commission considered a requirement for ROVs to have loud or intrusive seatbelt reminders. Currently, most ROVs meet the voluntary standards that require an 8-second visual seatbelt reminder. Some more intrusive systems have been used on passenger cars. For example, the Ford "BeltMinder" system resumes warning the driver after about 65 seconds if his or her seatbelt is not fastened and the car is traveling at more than 3 mph. The system flashes a warning light and sounds a chime for 6 seconds every 30 seconds for up to 5 minutes so long as the car is operating and the driver's seatbelt is not fastened. Honda developed a similar system in which the warning could last for longer than 9 minutes if the driver's seatbelt is not fastened. Studies of both systems found that a statistically significant increase in the use of seatbelts of 5 percent (from 71 to 76 percent) and 6 percent (from 84 to 90 percent), respectively.[100] However, these more intrusive seatbelt warning systems are unlikely to be as effective as the seatbelt speed limitation requirement in the proposed rule. The Commission believes that the requirement will cause most drivers and passengers who wish to exceed 15 mph to fasten their seatbelts. Research supports this position. One experiment used a haptic feedback system to increase the force the driver needed to exert to depress the gas pedal when the vehicle exceeded 25 mph if the seatbelt was not fastened. The system did not prevent the driver from exceeding 25 mph, but it increased the amount of force required to depress the gas pedal to maintain a speed greater than 25 mph. In this experiment all seven participants chose to fasten their seatbelts.[101]

The more intrusive seatbelt reminder systems used on some passenger cars have been more limited in their effectiveness. The Honda system, for example, reduced the number of unbelted drivers by about 38 percent; the Ford system reduced the number of unbelted drivers by only 17 percent.[102] Additionally, ROVs are open vehicles and the ambient noise is likely higher than in the enclosed passenger compartment of a car. It is likely that some ROV drivers would not hear the warning and be motivated to fasten their seatbelts unless the warning was substantially louder than the systems used in passenger cars.

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[100] Caroleene Paul, "Proposal for Seatbelt Speed Limiter On Recreational Off-Highway Vehicles (ROVs)," CPSC Memorandum (2013).

[101] Ron Van Houten, Bryan Hilton, Richard Schulman, and Ian Reagan, "Using Haptic Feedback to Increase Seatbelt Use of Service Vehicle Drivers," U.S. Department of Transportation, Report No. DOT HS 811 434 (January 2011).

[102] The Honda system increased seatbelt use from 84 percent to 90 percent. Therefore, the percentage of unbelted drivers was reduced by about 38 percent, or 6 percent divided by 16 percent. The Ford system increased seatbelt use from 71 percent to 76 percent. Therefore, the percentage of unbelted drivers was reduced by about 17 percent, or 5 percent divided by 29 percent.

The cost to manufacturers of some forms of more intrusive seat belt reminders could be less than the cost of the speed limitation requirement in the draft proposed rule. However, the cost of the seat belt/speed limitation requirement was estimated to be less than $72 per ROV.[103] If the experience with the Honda and Ford systems discussed above are relevant to ROVs, the benefits of a more intrusive seat belt reminder system could be less than 38 percent of the benefits estimated for the requirement in the draft proposed rule or less than $835 per ROV. Therefore, even if the cost of a more intrusive seat belt reminder system was close to $0, the net benefits would be less than the seat belt/speed limitation requirement in the draft proposed rule, which were estimated to be at least $2,105. Therefore, the alternative of a more intrusive seat belt reminder was not included in the proposed rule.

4. Extending the Seatbelt/Speed Limitation Requirement to Include Rear Seats

The Commission considered extending the seatbelt/speed limitation requirement to include the rear passenger seats, when present. According to one exposure survey, about 20 percent of the respondents reported that their ROVs had a seating capacity of at least four occupants, which indicates that the ROV had rear passenger seating locations.[104]

The cost of extending this requirement to include the rear passenger seats would be expected to be the same per seat as extending the requirement to include the right-front and

[103] This estimate is based on manufacturing cost estimates of $39 to apply the requirement to the driver's seat and $26 to apply the requirement to the front passenger's seat, plus $12 for research, development and certification testing.

[104] Heiden Associates, Results from the 2008 ROV Exposure Survey (APPENDIX 2 to Joint Comments of Arctic Cat Inc., Bombardier Recreational Products Inc., Polaris Industries Inc., and Yamaha Motor Corporation, U.S.A regarding CPSC Advance Notice of Proposed Rulemaking-Standard for Recreational Off-Highway Vehicles: Docket No. CPSC – 2009-0087), Alexandria Virginia (December 4, 2009).) This suggests that there were about 114,000 ROVs with rear passenger seats in 2010 (0.2 x 570,000).

middle-front passengers, or $24 per seat. Therefore, the cost of this requirement would be $48 to $72 per ROV, depending upon whether the ROV had two or three rear seating locations.

Three of the 231 fatalities (or 1.3 percent) involved a person in a rear seat who did not have their seatbelt fastened. Using the same assumptions used to calculate the benefits of the seatbelt/speed limitation for passengers in the front seats (*i.e.*, that 73 percent occurred at speeds of 15 mph or greater and seatbelts would reduce the risk of death by 45 percent), extending the requirement to include the rear seats could have potentially reduced the number of fatalities in 2010 by 0.2 or about one death every 5 years, all other things equal. Therefore, extending the seatbelt/speed limitation requirement to the rear passenger seats could reduce the annual risk of fatal injury by 0.00000175 (0.2 ÷ 114,000) per ROV in use. Assuming a societal benefit of $8.05 million per death averted results in an estimated annual benefit of about $14 per ROV in use ($8.05 million x 0.00000175) in terms of reduced fatal injuries.

Three of the 388 nonfatal injuries (or 0.8 percent) involved passengers in rear seats who did not have their seatbelts fastened. This suggests that about 89 of the estimated 11,100 medically attended injuries in 2010 may have happened to unbelted rear passengers. Again, assuming that 73 percent of these occurred at speeds of 15 mph or faster, about 65 medically attended injuries might have been addressed by the seatbelt/speed limitation requirement if applied to the rear seating locations. This represents a risk of a nonfatal, medically attended injury of 0.0005702 (65 ÷ 114,000) per ROV in use per year. The societal cost of this risk is $17, assuming an average nonfatal, medically attended injury cost of $29,383. If seatbelts could reduce the cost of these injuries by 20 percent, by reducing the number of injuries in their severity, the value of the reduction would be $3 per ROV in use per year.

Combining the benefit of $14 for the reduction in fatal injuries and $3 for the reduced cost of nonfatal, medically attended injuries yields a combined benefit of $17 per ROV in use per year. The present value of this estimated benefit over the expected useful life of a ROV is $234. This is greater than the quantifiable cost of $48 to $72. However, these estimates of the costs and benefits are probably oversimplified the costs may have been understated and the benefits overstated. The Commission is hesitant to recommend this alternative for the several reasons.

First, as discussed earlier, a system that includes all passenger seats would comprise more parts than a system that included only the front passenger seats. A failure in only one of the parts could result in significant cost to the users for repairs, lost time and utility of the vehicle while it is being repaired, or the inability of the vehicle to reach its potential speed. These failures could occur because a faulty seat belt latch sensor does not detect or signal that a seatbelt is latched or because a faulty seat switch incorrectly registers the presence of a passenger when a passenger is not present. This cost cannot be quantified. However, if such failures are possible, the costs of extending the seatbelt/speed limitation requirement to include the rear seats would be higher than the $48 to $72 estimated above.

Second, as discussed previously, there is some correlation between the seatbelt use of the driver and other passengers on the ROV. If the driver and front passengers fasten their seatbelts, there is reason to believe that some rear passengers will also fasten their seatbelts. If so, the benefits of including the rear seat passengers could be overestimated above. Moreover, even if there was no correlation, including only the driver and front seat passengers would still achieve about 98 percent of the total potential benefits from the seatbelt/speed limitation requirement.[105]

5. Requiring an Ignition Interlock Instead of Limiting the Maximum Speed

The Commission considered whether an ignition interlock requirement that did not allow the vehicle to be started unless the driver's seatbelt was buckled would be appropriate for ROVs. However, the history of ignition interlock systems to encourage seatbelt use on passenger cars suggests that consumer resistance to an ignition interlock system could be strong. In 1973, NHTSA proposed requiring an interlock system on passenger cars. However, public opposition to the proposed requirement led Congress to prohibit NHTSA from requiring an ignition interlock system.[106] For this reason, the Commission is not proposing this alternative. Instead, the proposed rule would allow people to use ROVs at low speeds without requiring seat belts to be fastened.

6. Limiting the Maximum Speed to 10 mph if the Driver's Seatbelt Is Not Fastened

The Commission considered limiting the maximum speed of the ROV to 10 mph if the driver's seatbelt was not fastened, instead of 15 mph, as in the proposed rule. In making this determination, we weigh some potentially quantifiable factors against some unquantifiable factors. The expected benefits of limiting the maximum speed to 10 mph are higher than the expected benefits of limiting the maximum speed to 15 mph. Based on the injuries reported to

[105] The potential net benefit of the seatbelt/speed limitation requirement resulting from its application to the driver and front passengers was estimated to be $2,199 per ROV. The potential net benefit resulting from its application to the rear seats was estimated to be $234 per ROV with rear seats. However, only about 20 percent of ROVs were assumed to have rear seats. Therefore, the weighted benefit over all ROVs of extending the seatbelt/speed limitation requirement to include the rear seats would be about $47 per ROV ($234 x 0.2). The potential weighted benefit would be $2,246, of which about 2 percent ($47 ÷ $2,246) would be attributable to extending the requirement to the rear seats.

[106] Caroleene Paul, "Proposal for Seatbelt Speed Limiter on Recreational Off-Highway Vehicles (ROVs)," CPSC Memorandum (2013). U.S. Consumer Product Safety Commission, Bethesda MD (2013).

CPSC for which the speed was reported and the seatbelt use was known, about 15 percent of the people injured in ROV accidents who were not wearing seatbelts were traveling between 10 and 15 mph. Therefore, decreasing the maximum allowed speed of an ROV to 10 mph if the driver's or right front passenger's seatbelt is not fastened could increase the expected benefits of the requirement by up to 21 percent ($0.15 \div 0.73$). There would be no difference between the two alternatives in terms of the quantified costs.

Although the quantified benefits would be increased and the quantified costs would not be affected by this alternative, the Commission believes that the unquantifiable costs would be higher if the maximum speed allowed was set at 10 mph instead of 15 mph. Commission staff believes this could have a negative impact on consumer acceptance of the requirement. The unquantifiable costs include: the time, inconvenience, and discomfort to some users who would prefer not to wear seatbelts. These users could include: people using the ROVs for work or utility purposes, who might have to get on and off the ROV frequently, and who are likely to be traveling at lower rates of speed, but who occasionally could exceed 10 mph. Some of these users could be motivated to defeat the requirement (and this could be done easily), which could reduce the benefits of the proposed rule. Allowing ROVs to reach speeds of up to 15 mph without requiring the seatbelt to be fastened would mitigate some of the inconvenience or discomfort of the requirement to these users, and correspondingly, consumers would have less motivation to attempt to defeat the requirement.

ROV manufacturers would have the option of setting the maximum speed that their models could reach without requiring the seatbelts to be fastened—so long as the maximum speed was no greater than 15 miles per hour. Therefore, manufacturers could set a maximum speed of less than 15 mph if they believed this was in their interest to do so. One ROV manufacturer has introduced ROV models that will not exceed 9.3 mph (15 km/hr.) unless the driver's seatbelt is fastened.

G. Conclusion

We estimate the quantifiable benefits of the proposed rule to be about $2,199 per ROV, and we estimate the quantifiable costs to be about $61 to $94 per ROV. Therefore, the benefits would exceed the costs by a substantial margin. However, the only benefits that could be quantified would be the benefits associated with the seat belt/speed limitation requirement. The lateral stability and vehicle handling requirements would also be expected to reduce deaths and injuries and so result in additional benefits, but these were not quantifiable.

There could be some unquantifiable costs associated with the rule. Some consumers might find the requirement to fasten their seat belts before the vehicle can exceed 15 mph to be inconvenient or uncomfortable. The 15 mph threshold as opposed to a 10 mph threshold was selected for the requirement to limit the number of consumers who would be inconvenienced by the requirement and might be motivated to defeat the system. Some consumers might prefer an ROV that oversteers under more conditions than the proposed rule would allow. However, the number of consumers who have a strong preference for oversteering vehicles is probably low.

Several alternatives to requirements in the proposed rule were considered, including relying on voluntary standards or requiring more intrusive seat belt reminders (as opposed to the speed limitation requirement). However, the Commission determined that the benefits of the requirements in the proposed rule would probably exceed their costs, considering both the quantifiable and unquantifiable costs and benefits.

XI. Paperwork Reduction Act

This proposed rule contains information collection requirements that are subject to public comment and review by OMB under the Paperwork Reduction Act of 1995 (44 U.S.C. 3501–3521). In this document, pursuant to 44 U.S.C. 3507(a)(1)(D), we set forth:

- a title for the collection of information;
- a summary of the collection of information;
- a brief description of the need for the information and the proposed use of the information;
- a description of the likely respondents and proposed frequency of response to the collection of information;
- an estimate of the burden that shall result from the collection of information; and
- notice that comments may be submitted to the OMB.

Title: Safety Standard for Recreational Off-Highway Vehicles (ROVs)

Number of Respondents**:** We have identified 20 manufacturers of ROVs.

Number of Models: We estimate that there are about 130 different models of ROVs, or an average of 6.5 models per manufacturer. This estimate counts as a single model, all models of a manufacturer that do not appear to differ from each other in terms of performance, such as engine size, width, number of seats, weight, horsepower, capacity, and wheel size. In other words, if the models differed only in terms of accessory packages, or in the case of foreign manufacturers, differed only in the names of the domestic distributors, then they were counted as the same model.

Number of Reports per Year: Manufacturers will have to place a hang tag on each ROV sold. In 2013, about 234,000 ROVs were sold, or about 1,800 units per model. This would be a reasonable estimate of the number of responses per year. On average, each manufacturer would have about 11,700 responses per year.

Burden Estimates per Model:

The reporting burden of this requirement can be divided into two parts. The first is designing the hang tag for each model. The second is printing and physically attaching the hang tag to the ROV. These are discussed in more detail below.

Designing the Hang tag: We estimate that it will take about 30 minutes to design the hang tag for each model. The first year the rule is in effect, manufacturers will have to design the hang tag for each of their models. However, the same model might be in production for more than one year. If ROV models have a production life of about 5 years before being redesigned, then the same hang tag might be useable for more than 1 year. Therefore, in year 1, on average, the burden on each manufacturer will be about 3.25 hours to design the hang tag (0.5 hours per model x 6.5 models). In subsequent years, the burden on each manufacturer will be about 0.65 hours assuming that manufacturers will have to redesign the hang tag only when they redesign the ROV and that ROVs are redesigned, on average, about every 5 years. Assuming this work will be performed by a professional employee, the cost per manufacturer will be $206 the first year and $41 in each subsequent year.[107]

*Printing and Placing the Hang tag on Each Vehicle***:** Based on estimates for printing obtained at: http://www.uprinting.com and estimates for the ties obtained from

[107] This estimate is based on the total compensation for management, professional, and related workers in private, goods producing industries, as reported by the Bureau of Labor Statistics (March 2014), available at http://www.bls.gov/ncs/. Please note, in the draft regulatory analysis, we are using 2010 as the base year with all values expressed in 2012 dollars. Therefore, these estimates might be slightly higher than estimated in the regulatory analysis.

http://blanksusa.com, we estimate that the cost of the printed hang tag and wire for attaching the hang tag to the ROV will be about $0.08. Therefore, the total cost of materials for the average manufacturer with 6.5 models, producing 1,800 units of each model, would be about $936 per year ($0.08 x 6.5 models x 1,800 units).

We estimate that it will take about 20 seconds to attach a hang tag to each vehicle. Assuming an annual production of 1,800 units of each model, on average, this comes to 10 hours per model or an average of 65 hours per manufacturer or respondent, assuming an average of 6.5 models per manufacturer. Assuming a total compensation of $26.12 per hour, the cost would be $261 per model or $1,698 per manufacturer, assuming an average of 6.5 models per manufacturer.[108]

Total Burden of the Hang tag Requirement:

The total burden of the hang tag requirement the first year will consist of the following components:

Designing the Hang tags: 65 hours (0.5 hours x 130 models). Assuming a total compensation rate of $63.36 per hour (professional and related workers), the cost would be $4,118.

Placing the Hang tags on the Vehicles: 1,300 hours (234,000 vehicles x 20 seconds). Assuming a total compensation rate of 26.12 per hour (production, transportation, and material moving workers), the total cost is $33,956.

[108] Estimate is based on the total compensation for production, transportation, and material-moving workers, private, goods-producing industries, as reported by the Bureau of Labor Statistics (March 2014), available at: http://www.bls.gov/ncs/.

Total Compensation Cost: The total compensation cost for this requirement would be $38,074 in the first year. In subsequent years, the burden of designing the hang tag is estimated to be about one-fifth the burden in the initial year, or 13 hours, assuming that each ROV model either undergoes a significant design change or is replaced by a different model every 5 years. Therefore, the compensation cost of designing the hang tag in subsequent years would be about $824 ($4,118/5). The total compensation cost in subsequent years would be $34,780.

Total Material Cost: The cost of the printed hang tags and ties for attaching the hang tag to the vehicles is estimated to be about 8 cents each. Therefore, the total material cost would be $18,720 ($0.08 x 234,000 units).

<u>Total Cost of Hang tag Requirement</u>: Based on the above estimates, the total cost of the hang tag requirement in the initial year is estimated to be about $56,794. In subsequent years, the total cost would be slightly less, about $53,500.

In compliance with the Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)), we have submitted the information collection requirements of this rule to the OMB for review. Interested persons are requested to submit comments regarding information collection by [INSERT DATE 30 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER], to the Office of Information and Regulatory Affairs, OMB (see the ADDRESSES section at the beginning of this notice).

Pursuant to 44 U.S.C. 3506(c)(2)(A), we invite comments on:

- whether the collection of information is necessary for the proper performance of the CPSC's functions, including whether the information will have practical utility;
- the accuracy of the CPSC's estimate of the burden of the proposed collection of information, including the validity of the methodology and assumptions used;

- ways to enhance the quality, utility, and clarity of the information to be collected;
- ways to reduce the burden of the collection of information on respondents, including the use of automated collection techniques, when appropriate, and other forms of information technology; and
- the estimated burden hours associated with label modification, including any alternative estimates.

XII. Initial Regulatory Flexibility Analysis

This section provides an analysis of the impact on small businesses of a proposed rule that would establish a mandatory safety standard for ROVs. Whenever an agency is required to publish a proposed rule, section 603 of the Regulatory Flexibility Act (5 USC 601–612) requires that the agency prepare an initial regulatory flexibility analysis (IRFA) that describes the impact that the rule would have on small businesses and other entities. An IRFA is not required if the head of an agency certifies that the proposed rule will not have a significant economic impact on a substantial number of small entities. 5 USC 605. The IRFA must contain:

(1) a description of why action by the agency is being considered;

(2) a succinct statement of the objectives of, and legal basis for, the proposed rule;

(3) a description of and, where feasible, an estimate of the number of small entities to which the proposed rule will apply;

(4) a description of the projected reporting, recordkeeping and other compliance requirements of the proposed rule, including an estimate of the classes of small entities which will be subject to the requirement and the type of professional skills necessary for preparation of the report or record; and

(5) an identification to the extent practicable, of all relevant Federal rules which may duplicate, overlap or conflict with the proposed rule.

An IRFA must also contain a description of any significant alternatives that would accomplish the stated objectives of the applicable statutes and that would minimize any significant economic impact of the proposed rule on small entities. Alternatives could include: (1) establishment of differing compliance or reporting requirements that take into account the resources available to small businesses; (2) clarification, consolidation, or simplification of compliance and reporting requirements for small entities; (3) use of performance rather than design standards; and (4) an exemption from coverage of the rule, or any part of the rule thereof, for small entities.

A. Reason for Agency Action

ROVs were first introduced in the late 1990s. Sales of ROVs increased substantially over the next 15 years. The number of deaths associated with ROVs has substantially increased over the same period, from no reported deaths in 2003, to at least 76 reported deaths in 2012. As explained in this preamble, some ROVs on the market have hazardous characteristics that could be addressed through a mandatory safety standard.

B. Objectives of and Legal Basis for the Rule

The Commission proposes this rule to reduce the risk of death and injury associated with the use of ROVs. The rule is promulgated under the authority of the Consumer Product Safety Act (CPSA).

C. Small Entities to Which the Rule Will Apply

The proposed rule would apply to all manufacturers and importers of ROVs. Under criteria set by the U.S. Small Business Administration (SBA), manufacturers of ROVs are considered small businesses if they have fewer than 500 employees. We have identified one ROV manufacturer with fewer than 500 employees.

Importers of ROVs could be wholesalers or retailers. Under the criteria set by the SBA, wholesalers of ROVs and other motor vehicles or powersport vehicles are considered small businesses if they have fewer than 100 employees; and retail dealers that import ROVs and other motor or powersport vehicle dealers are considered small if their annual sales volume is less than $30 million. We are aware of about 20 firms in 2013 that import ROVs from foreign suppliers that would be considered small businesses.[109] (There may be other small firms that manufacture or import ROVs of which we are not aware.)

D. Compliance, Reporting, and Record Keeping Requirements of Proposed Rule

The proposed rule would establish a mandatory safety standard consisting of several performance requirements for ROVs sold in the United States. The proposed rule would also establish test procedures through which compliance with the performance requirements would be determined. The proposed rule includes: (1) lateral stability and vehicle handling requirements that specify a minimum level of rollover resistance for ROVs and a requirement that ROVs exhibit sub-limit understeer characteristics; and (2) occupant retention requirements that would limit the maximum speed of an ROV to no more than 15 miles per hour (mph), unless the seat belts of the driver and front passengers are fastened, and would require ROVs to have a passive means, such as a barrier or structure, to limit the ejection of a belted occupant in the event of a rollover.

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[109] The Commission made these determinations using information from Dun & Bradstreet, Reference USAGov, company websites, and regional business publications.

Manufacturers would be required to test their ROV models to check that the models comply with the requirements of the proposed rule, and if necessary, modify their ROV models to comply. The costs of these requirements are discussed more fully in the preliminary regulatory analysis. Based on that analysis, we expect that the test for lateral stability and the test for vehicle handling will be conducted at the same time, and we estimate that the cost of this combined testing would be about $24,000 per model. In many cases, we expect that this testing will be performed by a third party engineering consulting or testing firm. If an ROV model must be modified to comply with the requirement and then retested, we estimate that the cost to manufacturers could reach $91,000 per model, including the cost of the initial testing, the cost of modifying design of the model, and the cost of retesting the model after the model has been modified. We estimate that the cost of implementing the occupant retention requirements will be about $104,000 per model. This includes the cost to research, develop, implement, and test a system that will limit the speed of the ROV when the seat belts are not fastened, as well as an occupant protection barrier or structure. Therefore, the total cost of certification testing and research and design could range from about $128,000 to $195,000. (Costs are expressed in 2012 dollars.)

In addition to the upfront testing and research and development costs, there will be some ongoing manufacturing costs associated with the proposed rule. These manufacturing costs include the cost of the parts required to meet any of the requirements of the proposed rule, such as seat belt use sensors and the necessary wiring and the cost of installing these parts on the vehicles during assembly. As estimated in the preliminary regulatory analysis, the ongoing manufacturing costs would be $47 to $72 per vehicle.

The proposed rule includes a requirement that manufacturers report the lateral acceleration at rollover value of an ROV model to potential consumers through the use of a hang tag attached to the ROV. Manufacturers would obtain the rollover resistance value when they conduct the lateral stability and vehicle handling tests to determine compliance with both requirements. The required format of the hangtag is described in the proposed rule. We estimate that it will cost manufacturers less than $0.25 per vehicle to print the hangtags with the rollover resistance values and to attach the hangtags to the vehicles.

E. Federal Rules that May Duplicate, Overlap, or Conflict with the Proposed Rule

In accordance with Section 14 of the Consumer Product Safety Act (CPSA), manufacturers would have to issue a general conformity certificate (GCC) for each ROV model, certifying that the model complies with the proposed rule. According to Section 14 of CPSA, GCCs must be based on a test of each product or a reasonable testing program; and GCCs must be provided to all distributors or retailers of the product. The manufacturer would have to comply with 16 CFR part 1110 concerning the content of the GCC, retention of the associated records, and any other applicable requirement.

F. Potential Impact on Small Entities

One purpose of the regulatory flexibility analysis is to evaluate the impact of a regulatory action and determine whether the impact is economically significant. Although the SBA allows considerable flexibility in determining "economically significant," CPSC staff typically uses one percent of gross revenue as the threshold for determining "economic significance." When we cannot demonstrate that the impact is lower than one percent of gross revenue, we prepare a regulatory flexibility analysis.[110]

1. Impact on Small Manufacturers

The sole, small ROV manufacturer may need to devote some resources to bringing its ROV models into compliance with the proposed rule. This is a relatively new manufacturer of ROVs and other utility vehicles. We do not have information on the extent to which the models offered by this manufacturer would meet the requirements of the proposed rule or the extent to which this particular manufacturer would be impacted by the proposed rule.

2. Impact on Small Importers

CPSC is aware of about 20 firms that import ROVs from foreign suppliers that would be considered small businesses. As explained more fully below, a small importer could be adversely impacted by the proposed rule if its foreign supplier does not provide testing reports or a GCC and the small importer must conduct the testing in support of a GCC. Additionally, a small importer could experience a significant impact if the foreign supplier withdraws from the U.S. market rather than conduct the necessary testing or modify the ROVs to comply with the proposed rule. If sales of ROVs are a substantial source of the importer's business, and the importer cannot find an alternative supplier of ROVs, the impact could be significant. However, we do not expect a widespread exodus of foreign manufacturers from the U.S. market. The U.S. market for ROVs has been growing rapidly in recent years, and at least some foreign

[110] The one percent of gross revenue threshold is cited as example criteria by the SBA and is commonly used by agencies in determining economic significance (see U.S. Small Business Administration, Office of Advocacy. *A Guide for Government Agencies: How to Comply with the Regulatory Flexibility Act and Implementing the President's Small Business Agenda and Executive Order 13272*. May 2012, pp 18-20. http://www.sba.gov/sites/default/files/rfaguide_0512_0.pdf)

manufacturers will likely want to continue taking advantage of these business opportunities by maintaining a U.S. presence. In addition, most of these importers also import products other than ROVs, such as scooters, motorcycles, and other powersport equipment. Therefore, ROVs are not their sole source of revenue. Importers may be able to reduce any impact on their revenue by increasing imports and sales of these other products.

Small importers will be responsible for issuing a GCC certifying that their ROVs comply with the proposed rule if the rule becomes final. However, importers may issue GCCs based upon certifications provided by or testing performed by their suppliers. The impact on small importers should not be significant if their suppliers provide the certificates of conformity or testing reports on which the importers may rely to issue their own GCCs.

If a small importer's supplier does not provide the GCC or testing reports, then the importer would have to test each model for conformity. Importers would likely contract with an engineering consulting or testing firm to conduct the certification tests. As discussed in the regulatory analysis, the certification testing could cost more than $28,000 per model ($24,000 for the lateral stability and vehicle handling requirements and $4,000 for the seat belt/speed limitation requirement). This would exceed 1 percent of the revenue for about one-half of the small importers, assuming that they continue to import the same mix of products as in the pre-regulatory environment.

G. Conclusion

We do not know how many, if any, foreign suppliers might exit the market rather than comply with the proposed rule. Nor do we know the number of foreign suppliers that may not be willing to provide small importers with testing reports or GCCs. A small importer could experience a significant impact if the importer has to conduct testing in support of a GCC. We expect that most importers, however, will rely upon certifications or testing performed by their suppliers. Thus, although uncertainty exists, the proposed rule will not likely have a significant direct impact on a substantial number of small firms.

H. Alternatives for Reducing the Adverse Impact on Small Businesses

The Commission welcomes comments on this IRFA. Small businesses that believe they will be affected by the proposed rule are especially encouraged to submit comments. The comments should be specific and describe the potential impact, magnitude, and alternatives that could reduce the impact of the proposed rule on small businesses.

Several alternatives to the proposed rule were considered, some of which could reduce the potential impact on some small firms. These include: (1) not issuing a mandatory standard; (2) dropping the lateral stability requirement or the vehicle handling requirement; (3) requiring a more intrusive seat belt reminder instead of the speed limitation requirement; and (4) requiring an ignition interlock if a seat belt is not fastened, instead of limiting the maximum speed. For the reasons discussed below, the CPSC did not include these alternatives in the proposed rule.

1. Not Issuing a Mandatory Standard

If CPSC did not issue a mandatory standard, most manufacturers would comply with one of the two voluntary standards that apply to ROVs and there would be no impact on the small manufacturer or small importers. However, neither voluntary standard requires that ROVs understeer, as required by the proposed rule. According to ES staff, drivers are more likely to lose control of vehicles that oversteer, which can lead to the vehicle rolling over or to other types of accidents. Additionally, although both voluntary standards have requirements for dynamic lateral stability or rollover resistance, ES staff does not believe that the test procedures in in these standards have been properly validated as being capable of providing useful information about the dynamic stability of the vehicle.

The voluntary standards require that manufacturers include a lighted seat-belt reminder that is visible to the driver and remains on for at least 8 seconds after the vehicle is started, unless the driver's seat belt is fastened. However, virtually all ROVs on the market already include this feature; and therefore, relying only on the voluntary standards would not be expected to raise seat belt use over its current level. Moreover, the preliminary regulatory analysis showed that the projected benefits of the seat belt/speed limitation requirement would be substantially greater than the costs.

Finally, the Commission believes that the occupant retention barrier in the current ROVs could be improved at a modest cost per ROV. For these reasons, the Commission believes that relying on compliance with voluntary standards is not satisfactory and is adopting the requirements in the proposed rule.

2. <u>Dropping the Lateral Stability Requirement or the Understeer Requirement</u>

The Commission considered including a performance requirement for either lateral stability or vehicle handling, but not both. As mentioned previously, the vehicle handling requirement is designed to allow ROVs to understeer. However, the Commission believes that both of these characteristics need to be addressed. According to ES staff, a vehicle that meets both the lateral stability requirement and the understeer requirement should be safer than a vehicle that meets only one of the requirements. Moreover, the cost of meeting just one requirement is not substantially lower than the cost of meeting both requirements. The cost of testing a vehicle for compliance with both the dynamic lateral stability and vehicle handling requirements was estimated to be about $24,000. The cost of testing for compliance with the lateral stability requirement would be about $20,000, and the cost of testing for compliance with just the vehicle handling requirement would be about $17,000. Moreover, changes in the vehicle design that affect the lateral stability of the vehicle could also impact the handling of the vehicle. For these reasons, the proposed rule includes both the lateral stability and understeer requirements in the proposed rule.

<u>3. Require ROVs to Have Loud or Intrusive Seat Belt Reminders in Lieu of the Speed Limitation Requirements</u>

Instead of seat belt/speed limitation requirements in the proposed rule, the Commission considered requiring ROVs to have loud or intrusive seat belt reminders. Most ROVs currently have a seat belt reminder in the form of a warning light that comes on for about 8 seconds. Most do not include any audible warning. As discussed in the preliminary regulatory analysis, staff considered requiring a more intrusive seat belt reminder, such as a loud audible warning that would sound for a minute or more. Manufacturers would incur some costs to comply with a requirement for a more intrusive seat belt reminder. For example, the seat belt use sensors (estimated to cost about $7 per seat) and sensor switches (estimated to cost about $13 per seat) would still be required. However, the research and development costs to design and implement a more intrusive seat belt reminder system would probably be less than the estimated cost to develop a system that limited the maximum speed of the vehicle.

Some intrusive systems have been used on passenger cars and have been found to be effective in increasing seat belt use. One system reduced the number of unbelted drivers by 17 percent and another by about 38 percent.[111] However, a more intrusive seat belt warning system is unlikely to be as effective as the seat belt/speed limitation requirement in the proposed rule. ROVs are open vehicles and the ambient noise is likely higher than in the enclosed passenger compartment of a car. It is likely that some ROV drivers would not hear the warning and be motivated to fasten their seat belts, unless the warning was substantially louder than the systems used in passenger cars. The Commission believes that the requirement will cause most drivers and passengers who want to exceed 15 mph to fasten their seat belts. Moreover, the analysis in the preliminary regulatory analysis showed that the societal benefits of the seat belt/speed limitation requirement in the proposed rule would exceed the costs by a substantial margin. Because CPSC does not believe that a more intrusive seat belt reminder would be effective in a ROV, and because Commission staff believes that the seat belt/speed limitation requirement would result in substantial net benefits, this alternative was not included in the proposed rule.

4. Requiring an Ignition Interlock Instead of Limiting the Maximum Speed

CPSC considered whether an ignition interlock requirement that did not allow the vehicle to be started unless the driver's seat belt was buckled would be appropriate for ROVs. However, the history of ignition interlock systems as a way to encourage seat belt use on passenger cars suggests that consumer resistance to an ignition interlock system that prevents starting the vehicle could be strong. For this reason, CPSC rejects this alternative, and instead, proposes a rule that allows people to use ROVs at low speeds without having to fasten their seat belts. However, manufacturers who believe that the cost of an ignition interlock system will be substantially lower than a system that limits the maximum speed of the vehicle, and who do not

[111] Memorandum from Caroleene Paul, "Proposal for Seat Belt Speed Limiter on Recreational Off-Highway Vehicles (ROVs)," U.S. Consumer Product Safety Commission, Bethesda, MD 8 December 2013).

believe that consumer rejection of an ignition interlock system will be a problem, can use an ignition interlock system to comply with the seat belt speed limitation requirement.

XIII. Environmental Considerations

The Commission's regulations address whether we are required to prepare an environmental assessment or an environmental impact statement. If our rule has "little or no potential for affecting the human environment," the rule will be categorically exempted from this requirement. 16 CFR 1021.5(c)(1). The proposed rule falls within the categorical exemption.

XIV. Executive Order 12988 (Preemption)

As required by Executive Order 12988 (February 5, 1996), the CPSC states the preemptive effect of the proposed rule, as follows:

The regulation for ROVs is proposed under authority of the CPSA. 15 U.S.C. 2051–2089). Section 26 of the CPSA provides that "whenever a consumer product safety standard under this Act is in effect and applies to a risk of injury associated with a consumer product, no State or political subdivision of a State shall have any authority either to establish or to continue in effect any provision of a safety standard or regulation which prescribes any requirements as the performance, composition, contents, design, finish, construction, packaging or labeling of such product which are designed to deal with the same risk of injury associated with such consumer product, unless such requirements are identical to the requirements of the Federal Standard". 15 U.S.C. 2075(a). Upon application to the Commission, a state or local standard may be excepted from this preemptive effect if the state or local standard: (1) provides a higher degree of protection from the risk of injury or illness than the CPSA standard, and (2) does not unduly burden interstate commerce. In addition, the federal government, or a state or local government, may establish and continue in effect a non-identical requirement that provides a higher degree of protection than the CPSA requirement for the hazardous substance for the federal, state or local government's use. 15 U.S.C. 2075(b).

Thus, with the exceptions noted above, the ROV requirements proposed in today's Federal Register would preempt non-identical state or local requirements for ROVs designed to protect against the same risk of injury if the rule is issued in final.

XV. Certification

Section 14(a) of the CPSA imposes the requirement that products subject to a consumer product safety rule under the CPSA, or to a similar rule, ban, standard or regulation under any other act enforced by the Commission, must be certified as complying with all applicable CPSC-enforced requirements. 15 U.S.C. 2063(a). A final rule on ROVs would subject ROVs to this certification requirement.

XVI. Effective Date

The CPSA requires that consumer product safety rules take effect not later than 180 days from their promulgation unless the Commission finds there is good cause for a later date. 15 U.S.C. 2058(g)(1). The Commission proposes that this rule would take effect 180 days after publication of the final rule in the Federal Register and would have two compliance dates. ROVs would be required to comply with the lateral stability and vehicle handling requirements (§§ 1411.3 and 1422.4) 180 days after publication of a final rule in the Federal Register. ROVs would be required to comply with the occupant protection requirements (§ 1422.5) 12 months after publication of a final rule in the Federal Register. The requirements would apply to all ROVs manufactured or imported on or after the applicable date.

CPSC believes ROV models that do not comply with the lateral stability and vehicle handling requirements can be modified, with changes to track width and suspension, in less than

4 person-months (a high estimate) and can be tested for compliance in one day. Therefore, CPSC believes 180 days is a reasonable time period for manufacturers to modify vehicles if necessary, conduct necessary tests, and analyze test results to ensure compliance with the lateral stability and vehicle handling requirements.

The Commission is proposing the longer compliance date for the occupant protection requirements because we understand that some manufacturers will need to redesign and test new prototype vehicles to meet these requirements. This design and test process is similar to the process that manufacturers use when introducing new model year vehicles. We also estimate that it will take approximately 9 person-months per ROV model to design, test, implement, and begin manufacturing vehicles to meet the occupant protection performance requirements. Therefore, staff believes that 12 months from publication of a final rule would be sufficient time for ROVs to comply with all of the proposed requirements.

XVII. Proposed Findings

The CPSA requires the Commission to make certain findings when issuing a consumer product safety standard. Specifically, the CPSA requires that the Commission consider and make findings about the degree and nature of the risk of injury; the number of consumer products subject to the rule; the need of the public for the rule and the probable effect on utility, cost, and availability of the product; and other means to achieve the objective of the rule, while minimizing the impact on competition, manufacturing, and commercial practices. The CPSA also requires that the rule must be reasonably necessary to eliminate or reduce an unreasonable risk of injury associated with the product and issuing the rule must be in the public interest. 15 U.S.C. 2058(f)(3).

In addition, the Commission must find that: (1) if an applicable voluntary standard has been adopted and implemented, that compliance with the voluntary standard is not likely to reduce adequately the risk of injury, or compliance with the voluntary standard is not likely to be substantial; (2) that benefits expected from the regulation bear a reasonable relationship to its costs; and (3) that the regulation imposes the least burdensome requirement that would prevent or adequately reduce the risk of injury. *Id*. These findings are discussed below.

Degree and nature of the risk of injury. CPSC received 428 reports of ROV-related incidents from the Injury and Potential Injury Incident (IPII) and In-Depth Investigation (INDP) databases that occurred between January 1, 2003 and December 31, 2011, and were received by December 31, 2011. There were a total of 826 victims involved in the 428 incidents. Among the 428 ROV-related incidents, there were a total of 231 reported fatalities and 388 reported injuries. Seventy-five of the 388 injuries (19 percent) could be classified as severe; that is, the victim has lasting repercussions from the injuries received in the incident, based on the information available. The remaining 207 victims were either not injured or their injury information was not known. Of the 428 ROV-related incidents, 76 involved drivers under 16 years of age (18 percent); 227 involved drivers 16 years of age or older (53 percent); and 125 involved drivers of unknown age (29 percent).

Using data reported through NEISS from January 1, 2010 to August 31, 2010, the Commission conducted a special study to identify cases that involved ROVs that were reported through NEISS. Based on information obtained through the special study, the estimated number of emergency department-treated ROV-related injuries occurring in the United States between January 1, 2010 and August 31, 2010, is 2,200 injuries. Extrapolating for the year 2010, the estimated number of emergency department-treated ROV-related injuries is 3,000, with a corresponding 95 percent confidence interval of 1,100 to 4,900.

Number of consumer products subject to the rule. Sales of ROVs have increased substantially since their introduction. In 1998, only one firm manufactured ROVs, and fewer than 2,000 units were sold. By 2003, when a second major manufacturer entered the market, almost 20,000 ROVs were sold. The only dip in sales occurred around 2008, which coincided with the worst of the credit crisis and a recession that also started about the same time. In 2013, an estimated 234,000 ROVs were sold by about 20 different manufacturers.

The number of ROVs available for use has also increased substantially. Because ROVs are a relatively new product, we do not have any specific information on the expected useful life of ROVs. However, using the same operability rates that CPSC uses for ATVs, we estimate that there were about 570,000 ROVs available for use in 2010. By the end of 2013, there were an estimated 1.2 million ROVs in use.

The need of the public for ROVs and the effects of the rule on their utility, cost, and availability.

Currently there are two varieties of ROVs: utility and recreational. Early ROV models emphasized the utility aspects of the vehicles, but the recreational aspects of the vehicles have become very popular.

Regarding the effects of the rule on ROVs utility, according to comments on the ANPR provided by several ROV manufacturers, some ROV users "might prefer limit oversteer in the off-highway environment." To the extent that the requirements in the proposed rule would reduce the ability of these users to reach limit oversteer intentionally, the proposed rule could have some adverse impact on the utility or enjoyment that these users receive from ROVs.

These impacts would probably be limited to a small number of recreational users who enjoy activities or stunts that involve power oversteering or limit oversteer.

Although the impact on consumers who prefer limit oversteer cannot be quantified, the Commission expects that the impact will be low. Any impact would be limited to consumers who wish to engage intentionally in activities involving the loss of traction or power oversteer. The practice of power oversteer, such as the speed at which a user takes a turn, is the result of driver choice. The proposed rule would not prevent ROVs from reaching limit oversteer under all conditions; nor would the proposed rule prevent consumers from engaging in these activities. At most, the proposed rule might make it somewhat more difficult for users to reach limit oversteer in an ROV.

The seat belt speed limiter requirement could have an effect on utility and impose some unquantifiable costs on some users who would prefer not to use seat belts. The cost to these users would be the time required to buckle and unbuckle their seat belts and any disutility cost, such as discomfort caused by wearing the seat belt. We cannot quantify these costs because we do not know how many ROV users choose not to wear their seat belts; nor do we have the ability to quantify any discomfort or disutility that they would experience from wearing seat belts. However, the proposed rule does not require that the seat belts be fastened unless the vehicle is traveling faster than 15 mph. This should serve to mitigate these costs because many people who would be inconvenienced or discomforted by the requirement, such as people using the vehicle for work or utility purposes, or who must frequently get on and off the vehicle, are likely to be traveling at lower speeds.

The effect of the rule on cost and availability of ROVs is expected to be minimal. The average manufacturer’s suggested retail prices (MSRP) of ROVs, weighted by units sold, was about $13,100 in 2013, with a range of about $3,600 to $20,100. The Commission estimates the per-unit cost to ROVs of the rule to be $61 to $94. Because this per-unit cost resulting from the rule is a very small percentage of the overall retail price of an ROV, it is unlikely that the rule would have much of an effect on the cost or availability of ROVs.

Other means to achieve the objective of the rule, while minimizing the impact on competition and manufacturing. The Commission does not believe the rule will have adverse impact on competition. The preliminary regulatory analysis estimates the per-unit cost to ROVs of the rule to be $61 to $94. The average manufacturer's suggested retail prices (MSRP) of ROVs, weighted by units sold, was about $13,100 in 2013, with a range of about $3,600 to $20,100. The per-unit cost resulting from the rule is a very small percentage of the overall retail price of an ROV. With such a relatively low impact, it is unlikely that ROV companies would withdraw from the market or that the number of ROV models will be affected. Therefore, the preliminary regulatory analysis supports a finding that the proposed rule is unlikely to have an impact on competition.

The Commission believes that some, but not all, ROV models already meet the rule's requirement that the speed of the vehicle be limited if the driver's seat belt is not fastened. Before implementing any changes to their vehicles to meet the requirement, manufacturers whose ROVs do not meet the seatbelt speed limiter requirement would have to analyze their options for meeting the requirement. This process would include developing prototypes of system designs, testing the prototypes, and refining the design of the systems based on this testing. Once the manufacturer has settled on a system for meeting the requirement, the system will have to be incorporated into the manufacturing process of the vehicle. This will involve producing the engineering specifications and drawings of the system, parts, assemblies, and subassemblies that are required. Manufacturers will need to obtain the needed parts from their suppliers and incorporate the steps needed to install the system on the vehicles in the assembly line. The Commission believes that manufacturers should be able to complete activities related to meeting the lateral stability and handling requirements within 180 days after publication of the final rule and activities related to meeting the occupant protection requirements within 12 months after publication of the final rule. The Commission's proposed effective date of 12 months for the occupant protection requirements may reduce the impact of the proposed requirements on manufacturing.

Unreasonable risk. CPSC received 428 reports of ROV-related incidents from the Injury and Potential Injury Incident (IPII) and In-Depth Investigation (INDP) databases that occurred between January 1, 2003 and December 31, 2011, and were received by December 31, 2011. There were a total of 826 victims involved in the 428 incidents. Among the 428 ROV-related incidents, there were a total of 231 reported fatalities and 388 reported injuries. Seventy-five of the 388 injuries (19 percent) could be classified as severe; that is, the victim has lasting repercussions from the injuries received in the incident based on the information available.

The estimated cost and benefits of the rule on an annual basis can be calculated by multiplying the estimated benefits and costs per unit by the number of ROVs sold in a given year. In 2013, 234,000 ROVs were sold. If the proposed rule had been in effect that year, the total quantifiable cost would have been between $14.3 million and $225.0 million ($61 and $94 multiplied by 234,000 units, respectively). The total quantifiable benefits would have been at least $515 million ($2,199 x 234,000). Of the benefits, about $453 million (or about 88 percent) would have resulted from the reduction in fatal injuries, and about $62 million (or about 12 percent) of the benefits would have resulted from a reduction in the societal cost of nonfatal injuries. The reduction in the societal cost of nonfatal injuries, which amounts to about $47 million, would represent a reduction in pain and suffering. The Commission concludes preliminarily that ROVs pose an unreasonable risk of injury and finds that the proposed rule is reasonably necessary to reduce that unreasonable risk of injury.

Public interest. This proposed rule is intended to address identified aspects of ROVs, ROV design, and ROV use, which are believed to contribute to ROV deaths and injuries, with a goal of reducing such incidents. The CPSC believes that adherence to the requirements of the proposed rule will reduce ROV deaths and injuries in the future; thus the rule is in the public interest. Specifically, the Commission believes that improving lateral stability (by increasing rollover resistance) and improving vehicle handling (by correcting oversteer to understeer) are the most effective approaches to reducing the occurrence of ROV rollover incidents. ROVs with higher lateral stability are less likely to roll over because more lateral force is necessary to cause rollover. ROVs exhibiting understeer during a turn are also less likely to roll over because lateral acceleration decreases as the path of the ROV makes a wider turn, and the vehicle is more stable if a sudden change in direction occurs.

Furthermore, the Commission believes that when rollovers do occur, improving occupant protection performance (by increasing seat belt use) will mitigate injury severity. CPSC analysis of ROV incidents indicates that 91 percent of fatally ejected victims were not wearing a seat belt at the time of the incident. Increasing seat belt use, in conjunction with better shoulder retention performance, will significantly reduce injuries and deaths associated with an ROV rollover event.

In summary, the Commission finds preliminarily that promulgating the proposed rule is in the public interest.

Voluntary standards. The Commission is aware of two voluntary standards that are applicable to ROVs, ANSI/ROHVA 1, *American National Standard for Recreational Off-Highway Vehicles,* and ANSI/B71.9, *American National Standard for Multipurpose Off-Highway Utility Vehicles.* As described previously in detail in the preamble, the Commission believes that the current voluntary standard requirements do not adequately reduce the risk of injury or death associated with ROVs. Neither voluntary standard requires that ROVs understeer, as required by the proposed rule. Based on testing and experience with the Yamaha Rhino repair program, the Commission believes that drivers are more likely to lose control of vehicles that oversteer, which can lead to the vehicle rolling over or to other types of accidents.

Both voluntary standards have requirements that are intended to set standards for dynamic lateral stability. ANSI/ROHVA 1-2011 uses a turn-circle test for dynamic lateral stability. That is more similar to the test in the proposed rule for determining whether the vehicle understeers, than it is to the test for dynamic lateral stability. The dynamic stability requirement in ANSI/OPEI B71.9-2012 uses a J-turn test, like the proposed rule, but measures different variables during the test and uses a different acceptance criterion. The Commission does not believe that the tests procedures in either standard have been validated properly as being capable of providing useful information about the dynamic stability of the vehicle. Moreover, the voluntary standards would find some vehicles acceptable, even though their lateral acceleration at rollover is less than 0.70 g, which is the acceptance criterion in the proposed rule.

Both voluntary standards require that manufacturers include a lighted seat-belt reminder that is visible to the driver and that remains on for at least 8 seconds after the vehicle is started, unless the driver's seatbelt is fastened. However, virtually all ROVs on the market already include this feature, and therefore, relying only on the voluntary standards would not be expected to raise seatbelt use over its current level.

The voluntary standards include requirements for retaining the occupant within the protective zone of the vehicle in the event of a rollover, including two options for restraining the occupants in the shoulder/hip area. However, testing performed by CPSC identified weaknesses in the performance-based tilt table test option that allows unacceptable occupant head ejection beyond the protective zone of the vehicle Rollover Protective Structure (ROPS). CPSC testing indicated that a passive shoulder barrier could reduce the head excursion of a belted occupant during quarter-turn rollover events. The Commission believes that this can be accomplished by a requirement for a passive barrier based on the dimensions of the upper arm of a 5th percentile adult female, at a defined area near the ROV occupants' shoulder, as contained in the proposed rule.

Relationship of benefits to costs. The estimated costs and benefits of the rule on an annual basis can be calculated by multiplying the estimated benefits and costs per unit, by the number of ROVs sold in a given year. In 2013, 234,000 ROVs were sold. If the proposed rule had been in effect that year, the total quantifiable cost would have been between $14.3 million and $22.0 million ($61 and $94 multiplied by 234,000 units, respectively). The total quantifiable benefits would have been at least $515 million ($2,199 x 234,000).

On a per-unit basis, we estimate the total cost of the proposed rule to be $61 to $94 per vehicle. We estimate the total quantifiable benefits of the proposed rule to be $2,199 per unit. This results in net quantifiable benefits of $2,105 to $2,138 per unit. Quantifiable benefits of the proposed rule could exceed the estimated $1,329 per unit because the benefit associated with the vehicle handling and lateral stability requirement could not be quantified.

Based on this analysis, the Commission finds preliminarily that the benefits expected from the rule bear a reasonable relationship to the anticipated costs of the rule.

Least burdensome requirement. The Commission considered less-burdensome alternatives to the proposed rule on ROVs, but we concluded that none of these alternatives would adequately reduce the risk of injury:

1) Not issuing a mandatory rule, but instead relying upon voluntary standards. If CPSC did not issue a mandatory standard, most manufacturers would comply with one of the two voluntary standards that apply to ROVs. As discussed previously, the Commission does not believe either voluntary standard adequately addresses the risk of injury and death associated with ROVs.

2) Including the dynamic lateral stability requirement or the understeer requirement, but not both. The Commission believes that both of these characteristics need to be addressed. A vehicle that meets both the dynamic stability requirement and the understeer requirement should be safer than a vehicle that meets only one of the requirements. Moreover, the cost of meeting just one requirement is not substantially lower than the cost of meeting both requirements. The cost of testing a vehicle for compliance with both the dynamic lateral stability and vehicle handling/understeer requirement was estimated to be about $24,000. However, the cost of testing for compliance with just the dynamic stability requirement would be about $20,000, or only about 17 percent less than the cost of testing for compliance with both requirements. This is because the cost of renting and transporting the vehicle to the test site, instrumenting the vehicle for the tests, and making some initial static measurements are virtually the same for both requirements and would only have to be done once if the tests for both requirements were conducted on the same day. Moreover, changes in the vehicle design that affect the lateral

stability of the vehicle could also impact the handling of the vehicle. For these reasons, the proposed rule includes both a dynamic stability and vehicle handling requirement.

3) Instead of seatbelt/speed limitation requirements in the proposed rule, the Commission considered a requirement for ROVs to have loud or intrusive seatbelt reminders. Currently, most ROVs meet the voluntary standards that require an 8-second visual seatbelt reminder. Some more intrusive systems have been used on passenger cars. For example, the Ford “BeltMinder” system resumes warning the driver after about 65 seconds if his or her seatbelt is not fastened and the car is traveling at more than 3 mph. The system flashes a warning light and sounds a chime for 6 seconds every 30 seconds for up to 5 minutes as long as the car is operating and the driver’s seatbelt is not fastened. Honda developed a similar system in which the warning could last for longer than 9 minutes if the driver’s seatbelt is not fastened. Studies of both systems found that a statistically significant increase in the use seatbelts of 5 percent (from 71 to 76 percent) and 6 percent (from 84 to 90 percent), respectively.

However, these more intrusive seatbelt warning systems are unlikely to be as effective as the seatbelt speed limitation requirement in the proposed rule. The Commission believes that the seatbelt speed limitation requirement will cause most drivers and passengers who desire to exceed 15 mph to fasten their seatbelts. Research supports this position. One experiment used a haptic feedback system to increase the force the driver needed to exert to depress the gas pedal when the vehicle exceeded 25 mph if the seatbelt was not fastened. The system did not prevent the driver from exceeding 25 mph, but the system increased the amount of force required to depress the gas pedal to maintain a speed greater than 25 mph. In this experiment, all seven participants chose to fasten their seatbelts. A follow-up study on the haptic feedback study focused on 20 young drivers ranging in age from 18 to 21, and a feedback force set at 20 mph instead of 25 mph. The study results showed that the mean seat belt use increased from 54.7 percent to 99.7 percent, and the few instances in which seat belts were not worn were on trips of 2 minutes long or less. Most significantly, participants rated the system as very acceptable and agreeable (9 out of a 10-point scale).

The more intrusive seatbelt reminder systems used on some passenger cars have been more limited in their effectiveness. The Honda system, for example, reduced the number of unbelted drivers by about 38 percent; the Ford system reduced the number of unbelted drivers by only 17 percent. (The Honda system increased seatbelt use from 84 percent to 90 percent. Therefore, the percentage of unbelted drivers was reduced by about 38 percent, or 6 percent divided by 16 percent. The Ford system increased seatbelt use from 71 percent to 76 percent. Therefore, the percentage of unbelted drivers was reduced by about 17 percent, or 5 percent divided by 29 percent.) Additionally, ROVs are open vehicles and the ambient noise is likely higher than in the enclosed passenger compartment of a car. It is likely that some ROV drivers would not hear the warning, and therefore, they would be motivated to fasten their seatbelts, unless the warning was substantially louder than the systems used in passenger cars. Therefore, the Commission believes that the loud or intrusive seat belt reminders would not be as effective as the seat belt speed limiter requirement.

For the reasons set forth above, the Commission finds preliminarily that the rule imposes the least burdensome requirement that prevents or adequately reduces the risk of injury for which promulgation of the rule is proposed.

XVIII. Request for Comments

We invite all interested persons to submit comments on any aspect of the proposed rule. In particular, the Commission invites comments regarding the estimates used in the preliminary regulatory analysis and the assumptions underlying these estimates. The Commission is especially interested in data that would help the Commission to refine its estimates to more accurately reflect the expected costs of the proposed rule as well as any alternate estimates that interested parties can provide. The Commission is also interested in comments addressing whether the proposed compliance dates of 180 days after the publication of the final rule to meet the lateral stability and vehicle handling requirements and 12 months after the publication of the final rule to meet the occupant protection requirements are appropriate.

Comments should be submitted in accordance with the instructions in the **ADDRESSES** section at the beginning of this notice.

XIV. Conclusion

For the reasons stated in this preamble, the Commission proposes requirements for lateral stability, vehicle handing, and occupant protection to address an unreasonable risk of injury associated with ROVs.

List of Subjects

16 CFR Part 1422

Consumer protection, Imports, Information, Labeling, Recreation and Recreation areas, Incorporation by reference, Safety.

For the reasons discussed in the preamble, the Commission proposes to amend Title 16 of the Code of Federal Regulations as follows:

1. Add part 1422 to read as follows:

PART 1422-SAFETY STANDARD FOR RECREATIONAL OFF HIGHWAY VEHICLES

Sec.

1422.1 Scope, Purpose and Compliance Dates.

Authority: 15 U.S.C. 2056, 2058 and 2076.

§ 1422.1 Scope, Purpose and Compliance Dates.

(a) This part 1422, a consumer product safety standard, establishes requirements for recreational off-highway vehicles (ROVs), as defined in § 1422.2(b). The standard includes requirements for dynamic lateral, vehicle handling, and occupant protection. These requirements are intended to reduce an unreasonable risk of injury and death associated with ROVs.

(b) This standard does not apply to the following vehicles, as defined by the relevant voluntary standards:

(1) Golf carts

(2) All-terrain vehicles

(3) Fun karts

(4) Go karts

(5) Light utility vehicles

(c) Any ROV manufactured or imported on or after [date that is 180 days after publication of a final rule] shall comply with the lateral stability requirements stated in § 1422.3 and the vehicle handling requirements stated in § 1422.4. Any ROV manufactured or imported on or after [date that is 12 months after publication of final rule] shall comply with the occupant protection requirements stated in § 1422.5.

§ 1422.2 Definitions.

In addition to the definitions in section 3 of the Consumer Product Safety Act (15 U.S.C. 2051), the following definitions apply for purposes of this part 1422.

(a) *Recreational off-highway vehicle (ROV)* means a motorized vehicle designed for off-highway use with the following features: four or more wheels with pneumatic tires; bench or bucket seating for two or more people; automotive-type controls for steering, throttle, and braking; rollover protective structure (ROPS); occupant restraint; and maximum speed capability greater than 30 mph.

(b) *Two-wheel lift* means the point at which the inside wheels of a turning vehicle lift off the ground, or when the uphill wheels of a vehicle on a tilt table lift off the table. Two-wheel lift is a precursor to a rollover event. We use this term interchangeably with the term "tip-up."

(c) *Threshold lateral acceleration* means the minimum lateral acceleration of the vehicle at two-wheel lift.

§ 1422.3 Requirements for dynamic lateral stability.

(a) *General.* The Recreational Off-Highway Vehicle (ROV) requirement for lateral stability is based on the average threshold lateral acceleration at rollover, as determined by a 30 mph dropped throttle J-turn test. This threshold lateral acceleration is measured parallel to the ground plane at the center of gravity (CG) of the loaded test vehicle and occurs at the minimum steering wheel angle required to cause the vehicle to roll over in a 30 mph dropped throttle J-turn test on a flat and level, high-friction surface. Rollover is achieved when all of the wheels of the ROV that are on the inside of the turn lift off the ground. For convenience, this condition is referred to as two-wheel lift, regardless of the number of wheels on the ROV. Testing shall be conducted on a randomly selected representative production vehicle.

(b) *Test surface.* Tests shall be conducted on a smooth, dry, uniform, paved surface constructed of asphalt or concrete. The surface area used for dynamic testing shall be kept free of debris and substances that may affect test results during vehicle testing.

(1) *Friction.* Surface used for dynamic testing shall have a peak braking coefficient greater than or equal to 0.90 and a sliding skid coefficient greater than or equal to 0.80 when measured in accordance with ASTM E 1337, Standard Test Method for Determining Longitudinal Peak Braking Coefficient of Paved Surfaces Using Standard Reference Tire, approved December 1, 2012, and ASTM E274, Standard Test Method for Skid Resistance of Paved Surfaces Using a Full-Scale Tire, approved January 2011, respectively. The Director of the Federal Register approves these incorporations by reference in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. You may obtain a copy from ASTM International, 100 Bar Harbor Drive, P.O. Box 0700, West Conshohocken, PA 19428; http://www.astm.org/cpsc.htm. You may inspect a copy at the Office of the Secretary, U.S. Consumer Product Safety Commission, Room 820, 4330 East West Highway, Bethesda, MD 20814, telephone 301-504-7923, or at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202-741-6030, or go to:

http://www.archives.gov/federal_register/code_of_federal regulations/ibr_locations.html.

(2) *Slope.* The test surface shall have a slope equal to or less than 1 degree (1.7% grade).

(3) *Ambient conditions.* The ambient temperature shall be between 0 degrees Celsius (32 º Fahrenheit) and 38 ºC (100 ºF). The maximum wind speed shall be no greater than 16 mph (7 m/s).

(c) *Test conditions.*

(1) *Vehicle condition.* An ROV used for dynamic testing shall be configured in the following manner:

(i) The test vehicle shall be a representative production vehicle. The ROV shall be in standard condition. Adjustable seats shall be located in the most rearward position.

(ii) The ROV shall be operated in two-wheel drive mode, with selectable differential in its most-open setting. The tires shall be the manufacturer's original-equipment tires intended for normal retail sale to consumers. The tires shall be new when starting the tests, then broken-in by conducting a minimum total of ten J-turns with five in the right-turning direction and five in the left-turning direction. The J-turns conducted for tire break-in shall be conducted at 30 mph and steering angles sufficient to cause two-wheel lift.

(iii) Springs or shocks that have adjustable spring or damping rates shall be set to the manufacturer's recommended settings for delivery.

(iv) Tires shall be inflated to the ROV manufacturer's recommended settings for normal operation for the load condition specified in 1422.3(c)(vi). If more than one pressure is specified, the lowest value shall be used.

(v) All vehicle operating fluids shall be at the manufacturer's recommended level, and the fuel tank shall be full to its rated capacity.

(vi) The ROV shall be loaded, such that the combined weight of the test operator, test equipment, and ballast, if any, shall equal 430 lbs. ± 11 lbs. (195 kg ± 5 kg).

(vii) The center of gravity (CG) of the equipped test vehicle shall be no more than 0.5 inch below (and within 1.0 inch in the x-axis and y-axis directions) the CG of the vehicle as it is sold at retail and loaded according to 1422.3(c)(vi).

(2) *Vehicle test equipment.*

(i) *Safety equipment*. Test vehicles shall be equipped with outriggers on both sides of the vehicle. The outriggers shall be designed to minimally affect the loaded vehicle's center of gravity location, shall permit the vehicle to experience two-wheel lift during dynamic testing, and shall be capable of preventing a full vehicle rollover.

(ii) *Steering controller*. The test vehicle shall be equipped with a programmable steering controller (PSC), capable of responding to vehicle speed, with a minimum steering angle input rate of 500 degrees per second, and accurate within $\pm$ 0.25 degree. The steering wheel setting for 0.0 degrees of steering angle is defined as the setting which controls the properly aligned vehicle to travel in a straight path on a level surface. The PSC shall be operated in absolute steering mode, where the amount of steering used for each test shall be measured relative to the PSC reading when the vehicle steering is at zero degrees.

(iii) *Vehicle instrumentation.* The vehicle shall be instrumented to record lateral acceleration, vertical acceleration, longitudinal acceleration, forward speed, steering wheel angle, steering wheel angle rate, vehicle roll angle, roll angle rate, pitch angle rate, and yaw angle rate. See Table 1 for instrumentation specifications. Ground plane lateral acceleration shall be calculated by correcting the body-fixed acceleration for roll angle. A roll motion inertia measurement sensor that provides direct output of ground plane lateral acceleration at the vehicle CG may also be used in lieu of manual correction to obtain ground plane lateral acceleration. Roll angle may be calculated from roll rate data.

Table 1. Instrumentation Specification
For J-Turn and Constant Radius Testing of ROVs

Parameter	Accuracy
Vehicle Speed	± 0.10 mph
Acceleration (x, y, and z directions)	± 0.003 g
Steering Wheel Angle	± 0.25 deg.
Steering Wheel Angle Rate	± 0.5 deg./sec.
Pitch, Roll, and Yaw Rates	± 0.10 deg./sec.
Roll Angle*	± 0.20 deg.

* For constant radius testing, roll angle must be measured directly or roll rate accuracy must be ± 0.01 deg./sec.

(d) *Test procedure*.

(1) Set the vehicle drive train in its most-open setting. For example, two-wheel drive shall be used instead of four-wheel drive, and a lockable differential, if so equipped, shall be in its unlocked, or "open," setting.

(2) Drive the vehicle in a straight path to define zero degree (0.0) steer angle.

(3) Program the PSC to input a 90-degree turn to the right at a minimum of 500 degrees per second as soon as the vehicle slows to 30 mph. Program the PSC to hold steering angles for a minimum of 4 seconds before returning to zero steer angle. The steering rate when returning to zero may be less than 500 degrees per second.

(4) Conduct a 30 mph dropped throttle J-turn.

(i) Accelerate the vehicle in a straight line to a speed greater than 30 mph.

(ii) As the vehicle approaches the desired test location, engage the PSC and fully release the throttle.

(iii) The PSC shall input the programmed steering angle when the vehicle decelerates to 30 mph. Verify that the instrumentation recorded all of the data during this J-turn event.

(5) Conduct additional J-turns, increasing the steer angle in 10-degree increments, as required, until a two-wheel lift event is visually observed.

(6) Conduct additional J-turns, decreasing the steering angle in 5-degree increments to find the lowest steering angle that will product two-wheel lift. Additional adjustments, up or down, in 1-degree increments may be used.

(7) Repeat the process of conducting J-turns to determine minimum steer angle to produce two-wheel lift in left turn direction.

(8) Start the data acquisition system.

(9) Conduct J-turn test trials in the left and right directions using the minimum steering angles determined in § 1422.3(d)(6) and § 1422.3(d)(7) to verify that the steering angle produces two-wheel lift in both directions.

(10) Conduct five J-turn test trials with two-wheel lift in the left and right turn directions in one direction heading on the test surface (10 total trials). On the same test track, but in the opposite heading on the test surface, conduct five more J-turn test trials with two-wheel lift in the left and right turn directions (10 total trials). A minimum data set will consist of 20 total J-turn test trials with half of the tests conducted in one direction on the test surface and half of the tests conducted in the opposite direction. Review all data parameters for each trial to verify that the tests were executed correctly. Any trials that do not produce two-wheel lift should be diagnosed for cause. If cause is identified, discard the data and repeat the trial to replace the data. If no cause can be identified, repeat 1422.3(d) (5) through1422.3 (d) (7) to ensure that the correct steering angle has been determined. Additional J-turn tests may be added to the minimum data set in groups of four, with one test for each left/right turn direction and one test for each direction heading on the test surface.

(11) Determine value of threshold lateral acceleration at rollover.

(i) Data recorded in 1422.3(d) (10) shall be digitally low-pass filtered to 2.0 hertz, using a phaseless, eighth-order, Butterworth filter to eliminate noise artifacts on the data.

(ii) Plot the data for ground plane lateral acceleration corrected to the test vehicle CG location, steering wheel angle, and roll angle recorded for each trial in the 1422.3(d)(10).

(iii) Find and record the peak ground plane lateral acceleration occurring between the time of the PSC input and the time of two-wheel lift.

(iv) If a body-fixed acceleration sensor is used, correct the lateral acceleration data for roll angle, using the equation:

$$A_y\ ground = A_y \cos \Phi - A_z \sin \Phi$$

(Φ = vehicle body roll angle)

(v) Calculate the threshold lateral acceleration at rollover value, which is the average of the peak values for ground plane lateral acceleration for all of the trials conducted in section 1422.3(d) (10) that produced two-wheel lift.

(e) *Performance requirements*. The minimum value for the threshold lateral acceleration at rollover shall be 0.70 g or greater.

(f) *Consumer information requirements*. The manufacturer shall provide a hang tag with every ROV that is visible to the driver and provides the value of the threshold lateral acceleration at rollover of that model vehicle. The label must conform in content, form, and sequence to the hang tag shown in Figure 1.

(1) *Size*. Every hang tag shall be at least 6 inches (152 mm) wide x 4 inches (102 mm) tall.

(2) *Content*. Every hang tag shall contain the following:

(i) Value of the threshold lateral acceleration at rollover of that model vehicle displayed on a progressive scale.

(ii) The statement – "**Compare** with other vehicles before you buy."

(iii) The statement – "The value above is a measure of this vehicle's resistance to rolling over on a flat surface. Vehicles with higher numbers are more stable."

(iv) The statement – "Other vehicles may have a higher rollover resistance; compare before you buy."

(v) The statement – "Rollover cannot be completely eliminated for any vehicle."

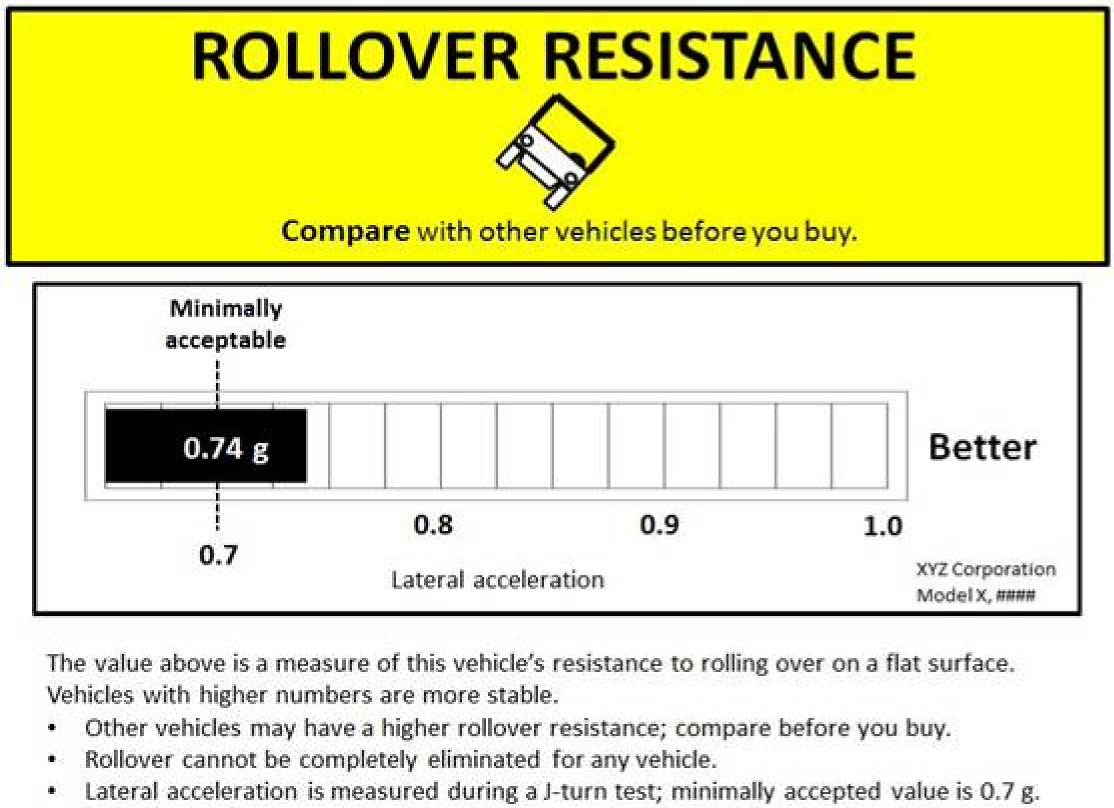
(vi) The statement – "Lateral acceleration is measured during a J-turn test; minimally accepted value is 0.7 g."

(vii) The manufacturer's name and vehicle model, *e.g.*, XYZ corporation, Model x, ####.

(3) *Format.* The hang tag shall be formatted as shown in Figure 1.

(4) *Attachment.* Every hang tag shall be attached to the ROV and conspicuous to the seated driver.

Figure 1. Hang tag



§ 1422.4 Requirements for vehicle handling.

(a) *General.* The ROV requirement for vehicle handling shall be based on the vehicle's steering gradient, as measured by the constant radius test method described in SAE Surface Vehicle Recommended Practice J266, published January 1996. The Director of the Federal Register approves this incorporation by reference in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. You may obtain a copy from ASTM International, 100 Bar Harbor Drive, P.O. Box 0700, West Conshohocken, PA 19428; http://www.astm.org/cpsc.htm. You may inspect a copy at the Office of the Secretary, U.S. Consumer Product Safety Commission, Room 820, 4330 East West Highway, Bethesda, MD 20814, telephone 301-504-7923, or at the National Archives and

Records Administration (NARA). For information on the availability of this material at NARA, call 202-741-6030, or go to:

http://www.archives.gov/federal_register/code_of_federal regulations/ibr_locations.html.

(b) *Test surface*. Tests shall be conducted on a smooth, dry, uniform, paved surface constructed of asphalt or concrete. The surface area used for dynamic testing shall be kept free of debris and substances that may affect test results during vehicle testing.

(1) *Friction*. Surface used for dynamic testing shall have a peak braking coefficient greater than or equal to 0.90 and a sliding skid coefficient greater than or equal to 0.80 when measured in accordance with ASTM E 1337 and ASTM E274, respectively.

(2) *Slope.* The test surface shall have a slope equal to or less than 1 degree (1.7% grade).

(3) *Ambient conditions*. The ambient temperature shall be between 0 degrees Celsius (32 º Fahrenheit) and 38 ºC (100 ºF). The maximum wind speed shall be no greater than 16 mph (7 m/s).

(c) *Test conditions*.

(1) *Vehicle condition*. A vehicle used for dynamic testing shall be configured in the following manner.

(i) The test vehicle shall be a representative production vehicle. The ROV shall be in standard condition. Adjustable seats shall be located in the most rearward position.

(ii) The ROV shall be operated in two-wheel drive mode with selectable differential in its most-open setting. The tires shall be the manufacturer's original-equipment tires intended for normal retail sale to consumers. The tires shall be new when starting the tests, then broken-in by conducting a minimum total of ten J-turns with five in the right-turning direction and five in the left-turning direction. The J-turns conducted for tire break-in shall be conducted at 30 mph and steering angles sufficient to cause two-wheel lift. Tires used for the full test protocol to establish the threshold lateral acceleration at rollover value for the test vehicle are acceptable for use in the handling performance test protocol.

(iii) Springs or shocks that have adjustable spring or damping rates shall be set to the manufacturer's recommended settings for delivery.

(iv) Tires shall be inflated to the ROV manufacturer's recommended settings for normal operation for the load condition specified in 1422.4(c)(vi). If more than one pressure is specified, the lowest value shall be used.

(v) All vehicle operational fluids shall be at the manufacturer's recommended level and the fuel tank shall be full to its rated capacity.

(vi) The ROV shall be loaded, such that the combined weight of the test operator, test equipment, and ballast, if any, shall equal 430 lbs. ± 11 lbs. (195 kg ± 5 kg).

(vii) The center of gravity (CG) of the equipped test vehicle shall be no more than 0.5 inch below (and within 1.0 inch in the x-axis and y-axis directions) the CG of the vehicle as it is sold at retail and loaded according to 1422.4(c)(vi).

(2) *Vehicle test equipment*.

(i) *Safety equipment*. Test vehicles shall be equipped with outriggers on both sides of the vehicle. The outriggers shall be designed to minimally affect the loaded vehicle's center of gravity location, shall permit the vehicle to experience two-wheel lift during dynamic testing, and shall be capable of preventing a full vehicle rollover.

(ii) *Vehicle instrumentation*. The vehicle shall be instrumented to record lateral acceleration, vertical acceleration, longitudinal acceleration, forward speed, steering wheel angle, steering wheel angle rate, vehicle roll angle, roll angle rate, pitch angle rate, and yaw angle rate.

See Table 1 in 1422.3(c) for instrumentation specifications. Ground plane lateral acceleration shall be calculated by correcting the body-fixed acceleration for roll angle. A roll motion inertia measurement sensor that provides direct output of ground plane lateral acceleration at the vehicle CG may also be used in lieu of manual correction to obtain ground plane lateral acceleration.

(d) *Test Procedure*. (1) Handling performance testing shall be conducted using the constant radius test method described in SAE Surface Vehicle Recommended Practice J266. The minimum radius for constant-radius testing shall be 100 feet. In this test method, the instrumented and loaded vehicle is driven while centered on a 100-ft. radius circle marked on the test surface, with the driver making every effort to maintain the vehicle path relative to the circle. The vehicle is operated at a variety of increasing speeds, and data are recorded for those various speed conditions to obtain data to describe the vehicle handling behavior across the prescribed range of ground plane lateral accelerations. Data shall be recorded for the lateral acceleration range from 0.0 g to 0.5 g.

(2) Start the data acquisition system.

(3) Drive the vehicle on the circular path at the lowest possible speed. Data shall be recorded with the steering wheel position and throttle position fixed to record the approximate Ackermann angle.

(4) Continue driving the vehicle to the next speed at which data will be taken. The vehicle speed shall be increased and data shall be taken until it is no longer possible for the driver to maintain directional control of the vehicle. Test shall be repeated at least three times so that results can be examined for repeatability and then averaged.

(5) *Data collection, method 1 - discrete data points***.** In this data acquisition method, the driver maintains a constant speed while maintaining compliance with the circular path, and data

points are recorded when a stable condition of speed and steering angle is achieved. After the desired data points are recorded for a given speed, the driver accelerates to the next desired speed setting, maintains constant speed and compliance with the path, and data points are recorded for the new speed setting. This process is repeated to cover the speed range from 0.0 mph to 28 mph, which will map the lateral acceleration range from near 0.0 g to 0.50 g. Increments of speed shall be 1 to 2 miles per hour, to allow for a complete definition of the understeer gradient. Data shall be taken at the lowest speed practicable to obtain an approximation of the vehicle's Ackermann steering angle.

(6) *Data collection, method 2 - continuous data points* In this data acquisition method, the driver maintains compliance with the circular path while slowly increasing vehicle speed; and data from the vehicle instrumentation is recorded continuously, so long as the vehicle remains centered on the intended radius. The rate of speed increase shall not exceed 0.93 mph per second. Initial speed shall be as low as is practicable, in order to obtain an approximation of the vehicle's Ackermann steering angle. The speed range shall be 0.0 mph to 28.0 mph, which will be sufficient to produce corrected lateral accelerations from near 0.0 g to 0.50 g.

(7) *Vehicle dimension coordinate system*. The coordinate system described in SAE Surface Vehicle Recommended Practice J670, published in January 2008, shall be used. The Director of the Federal Register approves this incorporation by reference in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. You may obtain a copy from ASTM International, 100 Bar Harbor Drive, P.O. Box 0700, West Conshohocken, PA 19428; http://www.astm.org/cpsc.htm. You may inspect a copy at the Office of the Secretary, U.S. Consumer Product Safety Commission, Room 820, 4330 East West Highway, Bethesda, MD 20814, telephone 301-504-

7923, or at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202-741-6030, or go to:

http://www.archives.gov/federal_register/code_of_federal regulations/ibr_locations.html.

(8) *Data analysis*. The lateral acceleration data shall be corrected for roll angle using the method described 1422.3(11)(iv). To provide uniform and comparable data, the ground plane lateral acceleration shall also be corrected to reflect the value at the test vehicle's center of gravity. The data shall be digitally low-pass filtered to 1.0 Hz, using a phase-less, eighth-order, Butterworth filter, and plotted with ground plane lateral acceleration on the abscissa versus hand-wheel steering angle on the ordinate. A second-order polynomial curve fit of the data shall be constructed in the range from 0.01 g to 0.5 g. The slope of the constructed plot determines the understeer gradient value in the units of degrees of hand-wheel steering angle per g of ground plane lateral acceleration (degrees/g). Using the coordinate system specified in 1422.4(d)(7), positive values for understeer gradient are required for values of ground plane lateral acceleration values from 0.10 g to 0.50 g.

(e) *Performance requirements*. Using the coordinate system specified in section 1422.4(d)(7), values for the understeer gradient shall be positive for values of ground plane lateral acceleration values from 0.10 g to 0.50 g. The ROV shall not exhibit negative understeer gradients (oversteer) in the lateral acceleration range specified.

§ 1422.5 Requirements for occupant protection performance.

(a) *General.* The ROV requirement for occupant protection shall be based on the maximum vehicle speed limitation when the seat belt of any occupied front seat is not buckled, and on passive coverage of the occupant shoulder area as measured by a probe test.

(b) *Vehicle speed limitation.*

(1) *Test surface.* Tests shall be conducted on a smooth, dry, uniform, paved surface constructed of asphalt or concrete. The surface area used for dynamic testing shall be kept free of debris and substances that may affect test results during vehicle testing.

(i) *Friction*. Surface shall have a peak braking coefficient greater than or equal to 0.90, and a sliding skid coefficient greater than or equal to 0.80, when measured in accordance with ASTM E 1337 and ASTM E274, respectively.

(ii) *Slope.* The test surface shall have a slope equal to or less than 1 degree (1.7% grade).

(2) *Test condition 1*. Test conditions shall be as follows:

(i) The test vehicle shall be a representative production vehicle. The ROV shall have a redundant restraint system in the driver's seat.

(ii) ROV test weight shall be the vehicle curb weight plus the test operator, only. If the test operator weighs less than 215 lbs. ± 11 lbs. (98 kg ± 5 kg), then the difference in weight shall be added to the vehicle to reflect an operator weight of 215 lbs. ± 11 lbs. (98 kg ± 5 kg).

(iii) Tires shall be inflated to the pressures recommended by the ROV manufacturer for the vehicle test weight.

(iv) The driver's seat belt shall not be buckled; however, the driver shall be restrained by the redundant restraint system for test safety purposes.

(3) *Test condition 2*. Test conditions shall be as follows:

(i) The test vehicle shall be a representative production vehicle. in standard condition.

(ii) ROV test weight shall be the vehicle curb weight, plus the test operator and a passenger surrogate that will activate the seat occupancy sensor. If the test operator weighs less than 215 lbs. ± 11 lbs. (98 kg ± 5 kg), then the difference in weight shall be added to the vehicle to reflect an operator weight of 215 lbs. ± 11 lbs. (98 kg ± 5 kg).

(iii) Tires shall be inflated to the pressures recommended by the ROV manufacturer for the vehicle test weight.

(iv) The driver's seat belt shall be buckled. The front passenger's seat belt(s) shall not be buckled.

(4) *Test procedure*. Measure the maximum speed capability of the ROV under Test Condition 1, specified in paragraph (b)(2) of this section, and Test Condition 2, specified in paragraph (b)(3) of this section using a radar gun or equivalent method. The test operator shall accelerate the ROV until maximum speed is reached, and shall maintain maximum speed for at least 15 m (50 ft.). Speed measurement shall be made when the ROV has reached a stabilized maximum speed. A maximum speed capability test shall consist of a minimum of two measurement test runs conducted over the same track, one each in opposite direction. If more than two measurement runs are made, there shall be an equal number of runs in each direction. The maximum speed capability of the ROV shall be the arithmetic average of the measurements made.

(5) *Performance requirement*. The maximum speed capability of a vehicle with an unbuckled seat belt of the driver or any occupied front passenger seat shall be 15 mph or less.

(c) *Passive coverage of shoulder area.*

(1) *General test conditions*.

(i) Probes shall be allowed to rotate through a universal joint.

(ii) Forces shall be quasi-statically applied and held for 10 seconds.

(2) *Shoulder/Hip Performance Requirement.* The vehicle structure or restraint system must absorb the force specified in §1422.5(c)(5) with less than 25 mm (1 inch) of permanent deflection along the horizontal lateral axis.

(3) *Location of Applied Force.* Locate point R on the vehicle, as shown in Figure X of ANSI/ROHVA 1-2011, American National Standard for Recreational Off-Highway Vehicles, approved July 11, 2011. The Director of the Federal Register approves this incorporation by reference in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. You may obtain a copy from ASTM International, 100 Bar Harbor Drive, P.O. Box 0700, West Conshohocken, PA 19428; http://www.astm.org/cpsc.htm. You may inspect a copy at the Office of the Secretary, U.S. Consumer Product Safety Commission, Room 820, 4330 East West Highway, Bethesda, MD 20814, telephone 301-504-7923, or at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202-741-6030, or go to:

http://www.archives.gov/federal_register/code_of_federal regulations/ibr_locations.html. All measurements for the point shall be taken with respect to the base of the seatback. The base of the seatback lies on the surface of the seat cushion along the centerline of the seating position and is measured without a simulated occupant weight on the seat. Point R is located 432 mm (17 inches) along the seat back above the base of the seatback. The point is 152 mm (6 inches) forward of and perpendicular to the seatback surface as shown in the figure. For an adjustable seat, Point R is determined with the seat adjusted to the rear-most position. Point R2 applies to an adjustable seat and is located in the same manner as Point R except that the seat is located in the forward-most position.

(4) *Barriers.* Remove all occupant protection barriers that require action on the part of the consumer to be effective (i.e. remove nets). Passive barriers that do not require any consumer action are allowed to remain.

(5) *Shoulder/Hip Test Method.* Apply a horizontal, outward force of 725 N (163 lbf.). Apply the force through the upper arm probe shown in Figure 2. The upper arm probe shall be oriented so that Point Q on the probe is coincident with Point R for a vehicle with a fixed seat, or Point Q shall be coincident with any point between R and R2 for a vehicle with an adjustable seat. The probe's major axis shall be parallel to the seatback angle at a point 17 inches along the seat back above the base of the seatback.

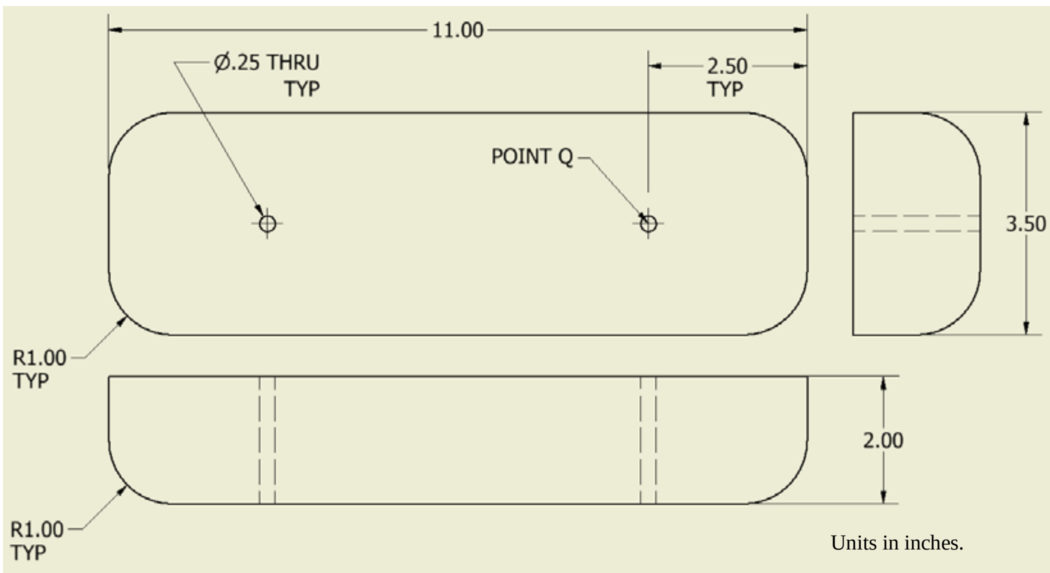


Figure 2. Shoulder/Hip Zone Probe

§ 1422.6 Findings.

(a) *General.* In order to issue a consumer product safety standard under the Consumer Product Safety Act, the Commission must make certain findings and include them in the rule. 15 U.S.C. 2058(f)(3). These findings are discussed in this section.

(b) *Degree and nature of the risk of injury.* CPSC received 428 reports of ROV-related incidents from the Injury and Potential Injury Incident (IPII) and In-Depth Investigation (INDP) databases that occurred between January 1, 2003 and December 31, 2011, and were received by December 31, 2011. There were a total of 826 victims involved in the 428 incidents. Within the

428 ROV-related incidents, there were a total of 231 reported fatalities and 388 reported injuries. Seventy-five of the 388 injuries (19 percent) could be classified as severe, that is, the victim has lasting repercussions from the injuries received in the incident, based on the information available. The remaining 207 victims were either not injured or their injury information was not known. Of the 428 ROV-related incidents, 76 involved drivers under 16 years of age (18 percent); 227 involved drivers 16 years of age or older (53 percent); and 125 involved drivers of unknown age (29 percent).

Using data reported through the National Electronic Injury Surveillance System (NEISS) from January 1, 2010 to August 31, 2010, the Commission conducted a special study to identify cases that involved ROVs that were reported through NEISS. (NEISS is a stratified national probability sample of hospital emergency departments that allows the Commission to make national estimates of product-related injuries.) Based on information obtained through the special study, the estimated number of emergency department-treated ROV-related injuries occurring in the United States between January 1, 2010 and August 31, 2010, is 2,200 injuries. Extrapolating for the year 2010, the estimated number of emergency department-treated ROV-related injuries is 3,000, with a corresponding 95 percent confidence interval of 1,100 to 4,900.

(c) *Number of consumer products subject to the rule.* Sales of ROVs have increased substantially since their introduction. In 1998, only one firm manufactured ROVs, and fewer than 2,000 units were sold. By 2003, when a second major manufacturer entered the market, almost 20,000 ROVs were sold. The only dip in sales occurred around 2008, which coincided with the worst of the credit crisis and recession that also started about the same time. In 2013, an estimated 234,000 ROVs were sold by about 20 different manufacturers. (This information is based upon a Commission analysis of sales data provided by Power Products Marketing, Eden Prairie, MN.)

The number of ROVs available for use has also increased substantially. Because ROVs are a relatively new product, we do not have any specific information on the expected useful life of ROVs. However, using the same operability rates that CPSC uses for ATVs, we estimate that there were about 570,000 ROVs available for use in 2010. By the end of 2013, there were an estimated 1.2 million ROVs in use.

d) *The need of the public for ROVs and the effects of the rule on their utility, cost, and availability.* Currently there are two varieties of ROVs: utility and recreational. Early ROV models emphasized the utility aspects of the vehicles, but the recreational aspects of the vehicles have become very popular.

In terms of the effects of the rule on ROVs utility, according to several ROV manufacturers, some ROV users “might prefer limit oversteer in the off-highway environment.” (This assertion was contained in a public comment on the ANPR for ROVs (Docket No. CPSC-2009-0087) submitted jointly on behalf of Arctic Cat, Inc., Bombardier Recreational Products, Inc., Polaris Industries, Inc., and Yamaha Motor Corporation, USA.) To the extent that the requirements in the proposed rule would reduce the ability of these users to intentionally reach limit oversteer, the proposed rule could have some adverse impact on the utility or enjoyment that these users receive from ROVs. These impacts would probably be limited to a small number of recreational users who enjoy activities or stunts that involve power oversteering or limit oversteer.

While the impact on consumers who prefer limit oversteer cannot be quantified, the Commission expects that it will be low. Any impact would be limited to those consumers who wish to intentionally engage in activities involving the loss of traction or power oversteer. The practice of power oversteer is the result of driver choices, such as the speed at which a user takes a turn. The proposed rule would not prevent ROVs from reaching limit oversteer under all conditions; nor would the rule prevent consumers from engaging in these activities. At most, the proposed rule might make it somewhat more difficult for users to reach limit oversteer in an ROV. Moreover, consumers who have a high preference for vehicles that oversteer would be able to make aftermarket modifications, such as adjustments to the suspension of the vehicle, or using different wheels or tires to increase the potential for oversteering.

The seat belt speed limiter requirement could have a negative effect on utility and impose some unquantifiable costs on some users who would prefer not to use seat belts. The cost to these users would be the time required to buckle and unbuckle their seat belts and any disutility cost, such as discomfort caused by wearing the seat belt. We cannot quantify these costs because we do not know how many ROV users choose not to wear their seat belts, nor do we have the ability to quantify any discomfort or disutility that they would experience from wearing seat belts. However, the proposed rule does not require that the seat belts be fastened unless the vehicle is traveling 15 mph or faster. This should serve to mitigate these costs because many people who would be inconvenienced or discomforted by the requirement, such as people using the vehicle for work or utility purposes or who must frequently get on and off the vehicle are likely to be traveling at lower speeds.

The effect of the rule on cost and availability of ROVs is expected to be minimal. The average manufacturer's suggested retail prices (MSRP) of ROVs, weighted by units sold, was about $13,100 in 2013, with a range of about $3,600 to $20,100. The preliminary regulatory analysis estimates the per-unit cost to ROVs of the rule to be $61 to $94. Because this per-unit cost resulting from the rule is a very small percentage of the overall retail price of a ROV, it is unlikely that the rule would have more than a minimal effect on the cost or availability of ROVs.

e) *Other means to achieve the objective of the rule, while minimizing the impact on competition and manufacturing.* The Commission does not believe the rule will have adverse impact on competition. The preliminary regulatory analysis estimates the per-unit cost to ROVs of the rule to be $61 to $94. The average manufacturer's suggested retail prices (MSRP) of ROVs, weighted by units sold, was about $13,100 in 2013, with a range of about $3,600 to $20,100. The per-unit cost resulting from the rule is a very small percentage of the overall retail price of a ROV and is unlikely to have any impact on competition.

The Commission believes that some but not all ROV models already meet the rule's requirement that the speed of the vehicle be limited if the driver's seat belt is not fastened. Before implementing any changes to their vehicles to meet the requirement, manufacturers whose ROVs do not meet the seatbelt speed limiter requirement would have to analyze their options for meeting the requirement. This process would include developing prototypes of system designs, testing the prototypes and refining the design of the systems based on this testing. Once the manufacturer has settled upon a system for meeting the requirement, the system will have to be incorporated into the manufacturing process of the vehicle. This will involve producing the engineering specifications and drawings of the system, parts, assemblies, and subassemblies that are required. Manufacturers will need to obtain the needed parts from their suppliers and incorporate the steps needed to install the system on the vehicles in the assembly line. The Commission believes that manufacturers should be able to complete all of these activities and be ready to produce vehicles that meet the requirement within 12 calendar months. The Commission is proposing a 12-month effective date for the occupant protection requirements to minimize the burden on manufacturing.

f) Unreasonable risk. CPSC received 428 reports of ROV-related incidents from the Injury and Potential Injury Incident (IPII) and In-Depth Investigation (INDP) databases that occurred between January 1, 2003 and December 31, 2011, and were received by December 31, 2011. There were a total of 826 victims involved in the 428 incidents. Within the 428 ROV-related incidents, there were a total of 231 reported fatalities and 388 reported injuries. Seventy-five of the 388 injuries (19 percent) could be classified as severe, that is, the victim has lasting repercussions from the injuries received in the incident, based on the information available.

The estimated cost and benefits of the rule on an annual basis can be calculated by multiplying the estimated benefits and costs per unit by the number of ROVs sold in a given year. In 2013, 234,000 ROVs were sold. If the proposed rule had been in effect that year, the total quantifiable cost would have been between $14.3 million and $22.0 million ($61 and $94 multiplied by 234,000 units, respectively). The total quantifiable benefits would have been at least $515 million ($2,199 x 234,000). Of the benefits, about $453 million (or about 88 percent) would have resulted from the reduction in fatal injuries, and about $62 million (or about 12 percent) of the benefits would have resulted from a reduction in the societal cost of nonfatal injuries. About $47 million of the reduction in the societal cost of nonfatal injuries would have been due to a reduction in pain and suffering. We conclude preliminarily that ROVs pose an unreasonable risk of injury and that the proposed rule is reasonably necessary to reduce that risk.

g) *Public interest.* This proposed rule is in the public interest because it may reduce ROV-related deaths and injuries in the future. The Commission believes that improving lateral stability (by increasing rollover resistance) and improving vehicle handling (by correcting oversteer to sub) are the most effective approaches to reduce the occurrence of ROV rollover incidents. ROVs with higher lateral stability are less likely to roll over because more lateral force is necessary to cause rollover. ROVs exhibiting understeer during a turn are also less likely to rollover because lateral acceleration decreases as the path of the ROV makes a wider turn, and the vehicle is more stable if a sudden change in direction occurs.

The Commission believes that, when rollovers do occur, improving occupant protection performance (by increasing seat belt use) will mitigate injury severity. CPSC analysis of ROV incidents indicates that 91 percent of fatally ejected victims were not wearing a seat belt at the time of the incident. Increasing seat belt use, in conjunction with better shoulder retention performance, will significantly reduce injuries and deaths associated with an ROV rollover event.

h) *Voluntary standards.* The Commission is aware of two voluntary standards that are applicable to ROVs, ANSI/ROHVA 1, *American National Standard for Recreational Off-Highway Vehicles* and ANSI/B71.9, *American National Standard for Multipurpose Off-Highway Utility Vehicles.* As described in detail previously in the preamble, the Commission believes that the current voluntary standard requirements not adequately reduce the risk of injury or death associated with ROVs. Neither voluntary standard requires that ROVs understeer, as required by the proposed rule. According to the ES staff, drivers are more likely to lose control of vehicles that oversteer, which can lead to the vehicle rolling over or to other types of accidents.

Both voluntary standards have requirements that are intended to set standards for dynamic lateral stability. ANSI/ROHVA 1-2011 uses a turn-circle test for dynamic lateral stability that is more similar to the test in the proposed rule for whether the vehicle understeers than it is to the test for dynamic lateral stability. The dynamic stability requirement in

ANSI/OPEI B71.9-2012 uses a J-turn test, like the proposed rule, but measures different variables during the test and uses a different acceptance criterion. However, ES staff does not believe that the tests procedures in either standard have been properly validated as being capable of providing useful information about the dynamic stability of the vehicle. Moreover, the voluntary standards would find some vehicles acceptable even though their lateral acceleration at rollover is less than 0.70 g, which is the acceptance criterion in the proposed rule.

Both voluntary standards require that manufacturers include a lighted seat-belt reminder that is visible to the driver and remains on for at least 8 seconds after the vehicle is started, unless the driver’s seatbelt is fastened. However, virtually all ROVs on the market already include this feature and, therefore, relying only on the voluntary standards would not be expected to raise seatbelt use over its current level.

The voluntary standards include requirements for retaining the occupant within the protective zone of the vehicle in the event of a rollover including two options for restraining the occupants in the shoulder/hip area. However, testing performed by CPSC identified weaknesses in the performance-based tilt table test option that allows unacceptable occupant head ejection beyond the protective zone of the vehicle Rollover Protective Structure (ROPS). CPSC testing indicated that a passive shoulder barrier could reduce the head excursion of a belted occupant during quarter-turn rollover events. The Commission believes that this can be accomplished by a requirement for a passive barrier based on the dimensions of the upper arm of a 5^{th} percentile adult female, at a defined area near the ROV occupants’ shoulder as contained in the proposed rule.

(i) *Relationship of benefits to costs.* The estimated cost and benefits of the rule on an annual basis can be calculated by multiplying the estimated benefits and costs per unit by the number of

ROVs sold in a given year. In 2013, 234,000 ROVs were sold. If the proposed rule had been in effect that year, the total quantifiable cost would have been between $14.3 million and $22.0 million ($61 and $94 multiplied by 234,000 units, respectively). The total quantifiable benefits would have been at least $515 million ($2,199 x 234,000).

On a per unit basis, we estimate the total cost of the proposed rule to be $61 to $94 per vehicle. We estimate the total quantifiable benefits of the proposed rule to be $2199 per unit. This results in net quantifiable benefits of $2105 to $2138 per unit. Quantifiable benefits of the proposed rule could exceed the estimated $2199 per unit because the benefit associated with the vehicle handling and lateral stability requirement could not be quantified.

j) *Least burdensome requirement.* The Commission considered less burdensome alternatives to the proposed rule regarding ROVs, but concluded that none of these alternatives would adequately reduce the risk of injury.

(i) Not issuing a mandatory rule, but instead relying upon voluntary standards. If CPSC did not issue a mandatory standard, most manufacturers would comply with one of the two voluntary standards that apply to ROVs. The Commission does not believe either voluntary standard adequately addresses the risk of injury and death associated with ROVs.

(ii) Including the dynamic lateral stability requirement or the understeer requirement, but not both. The Commission believes that both of these characteristics need to be addressed. According to CPSC's Directorate for Engineering Sciences, a vehicle that meets both the dynamic stability requirement and the understeer requirement should be safer than a vehicle that meets only one of the requirements. Moreover, the cost of meeting just one requirement is not substantially lower than the cost of meeting both requirements. The cost of testing a vehicle for compliance with both the dynamic lateral stability and vehicle handling/understeer requirement was estimated to be about $24,000. However, the cost of testing for compliance with just the dynamic stability requirement itself would be about $20,000, or only about 17 percent less than the cost of testing for compliance with both requirements together. This is because the cost of renting and transporting the vehicle to the test site, instrumenting the vehicle for the tests, and making some initial static measurements are virtually the same for both requirements and would only have to be done once if the tests for both requirements were conducted on the same day. Moreover, changes in the vehicle design that affect the lateral stability of the vehicle could also impact the handling of the vehicle. For these reasons, the proposed rule includes both a dynamic stability and vehicle handling requirement.

(iii) Instead of seatbelt/speed limitation requirements in the proposed rule, the Commission considered a requirement for ROVs to have loud or intrusive seatbelt reminders. Currently, most ROVs meet the voluntary standards that require an 8-second visual seatbelt reminder. Some more intrusive systems have been used on passenger cars. For example, one system resumes warning the driver after about 65 seconds if his or her seatbelt is not fastened and the car is traveling at more than 3 mph. The system flashes a warning light and sounds a chime for 6 seconds every 30 seconds for up to 5 minutes so long as the car is operating and the driver’s seatbelt is not fastened. A similar system is used in which the warning could last for longer than 9 minutes if the driver’s seatbelt is not fastened. Although studies of both systems found an increase in the use seatbelts, the systems’ effectiveness was limited. Moreover, audible warnings are not likely to be effective in ROVs. ROVs are open vehicles and the ambient noise is higher than in the enclosed passenger compartment of a car ROV drivers would not hear the warning and be motivated to fasten their seatbelts unless the warning was substantially louder than the systems used in passenger cars.

In contrast, these more intrusive seatbelt warning systems are unlikely to be as effective as the seatbelt speed limitation requirement in the proposed rule. The Commission believes that the requirement in the proposed rule will cause most drivers and passengers that desire to exceed 15 mph to fasten their seatbelts. Research supports this position. One experiment used a haptic feedback system to increase the force the driver needed to exert to depress the gas pedal when the vehicle exceeded 25 mph if the seatbelt was not fastened. The system did not prevent the driver from exceeding 25 mph, but it increased the amount of force required to depress the gas pedal to maintain a speed greater than 25 mph. In this experiment all 7 participants chose to fasten their seatbelts.

Dated: ________________

____

Todd A. Stevenson,
Secretary, Consumer Product Safety Commission

BRIEFING PACKAGE

NOTICE OF PROPOSED RULEMAKING (NPR) FOR
RECREATIONAL OFF-HIGHWAY VEHICLES (ROVs)

September 2014

For Further Information Contact:

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EXECUTIVE SUMMARY

Product: Recreational off-highway vehicles (ROVs) are motorized vehicles that have four or more pneumatic tires, non-straddle seating, automotive-type controls for steering, throttle, and braking, and a maximum vehicle speed greater than 30 miles per hour (mph).[1] ROVs were first introduced in the late 1990s but did not become popular until 2003. Sales of ROVs have increased from fewer than 20,000 units in 2003, to approximately 234,000 units in 2013. By the end of 2013, CPSC staff estimated there were more than 1.2 million ROVs in use. Polaris Industries Inc. (Polaris), Arctic Cat, Bombardier Recreational Products (BRP), American Honda Motor Company, Inc. (Honda), Deere & Company (John Deere), Kawasaki Motors Corporation, U.S.A. (Kawasaki), and Yamaha Motor Corporation, U.S.A. (Yamaha) account for more than 90 percent of the ROV market.

Incident Data: As of April 5, 2013, CPSC staff is aware of 550 reported ROV-related incidents that occurred between January 1, 2003 and April 5, 2013; there were 335 reported fatalities and 506 reported injuries related to these incidents. In 2012, CPSC staff conducted a multidisciplinary review of 428 ROV-related incidents that occurred between January 1, 2003 and December 31, 2011. [2] Of the 428 incidents, 291 (68 percent) involved lateral rollover of the vehicle. A total of 826 victims were involved in the 428 reported incidents, including 231 fatalities and 388 injuries. One hundred fifty of the 231 fatalities (65 percent) and 67 of the 75 severely injured victims (89 percent) involved a lateral rollover of the ROV. Of the 610 fatally and nonfatally injured victims who were on the ROV at the time of the incident, 433 (71 percent) were ejected from the ROV; and 269 (62 percent) of these victims were struck by a part of the vehicle. Seat belt use or non-use is known for 374 victims; of these, 282 (75 percent) victims were not wearing a seat belt at the time of the incident. Of the 225 fatal victims who were in or on the ROV at the time of the incident, 194 (86 percent) were ejected partially or fully from the vehicle. Seat belt use is known for 155 of the 194 ejected victims; of these, 141 (91 percent) were not wearing a seat belt.

Based on the incident data, CPSC staff believes that ROV rollover and occupant ejection is a dominant hazard pattern that has significant potential for improvement. Improving the lateral rollover resistance and vehicle steering characteristics of ROVs is a strategy for reducing the occurrence of ROV rollover events. Increasing occupant protection performance of ROVs is a strategy to protect ROV users when rollover events occur.

Recommendation for Proposed Rule: CPSC staff contracted SEA, Limited (SEA) to conduct static and dynamic tests of 10 sample ROVs available in the U.S. market. The dynamic tests include tests to measure the rollover resistance of the vehicles (J-turn test), the steering characteristics of the vehicle (constant radius test), and the occupant protection performance of the vehicles (roll simulation test). Based on the testing, data analysis, and technical feasibility, CPSC staff recommends the following lateral stability, vehicle handling, and occupant protection performance and information requirements:

[1] Definition from ANSI/ROHVA 1 *American National Standard for Recreational Off-Highway Vehicles.*
[2] Received as of December 31, 2011. All incident analysis is based on reported information.

1. ROVs shall demonstrate a minimum level of rollover resistance of 0.70 g threshold lateral acceleration at rollover when tested in a 30 mile per hour J-turn test procedure.[3]
2. ROVs shall have a hang tag at the point of sale that provides information about the vehicle's rollover resistance on a progressive scale.
3. ROVs shall exhibit understeer in the lateral acceleration range from 0.10 g to 0.50 g when tested in a 100 foot constant radius test.
4. ROVs shall not exceed a speed of 15 mph if the seat belt of any occupied front seat is not buckled.
5. ROVs shall pass a probe test applied in the shoulder zone area of the ROV.

CPSC staff believes that a minimum requirement for rollover resistance of 0.70g threshold lateral acceleration, coupled with a requirement that a vehicle model's rollover resistance is displayed on a hang tag at point of purchase, will increase the rollover resistance of the overall ROV market and will reduce the occurrence of ROV rollovers. CPSC staff also believes a vehicle handling requirement for understeer will reduce the occurrence of rollovers caused by sudden increases in lateral acceleration associated with ROVs that oversteer. Prevention of ROV rollovers will reduce deaths and injuries associated with ROV rollover events.

CPSC staff also believes that a requirement for limitation of the ROV's speed to 15 mph if occupied front seat belts are not buckled, coupled with robust occupant shoulder retention, will increase the occupant protection performance of ROVs during rollover events. Prevention of occupant ejection will reduce deaths and injuries associated with occupants who are ejected during ROV rollover events.

Economic Evaluation: The costs associated with the lateral stability and vehicle handling provisions of the draft proposed rule are expected to amount to $3 to $10 per vehicle. These requirements are intended to reduce the risk of an ROV rolling sideways when making a turn. CPSC staff estimates that the requirements would have to prevent less than 0.2 percent of the rollover incidents for the benefits of the requirements to exceed the costs.

The estimated costs associated with the occupant protection requirements of the draft proposed rule are expected to amount to $59 to $84 per vehicle. These requirements are intended to reduce deaths and injuries by increasing seat belt use and improving occupant protection. The estimated benefits of the proposed occupant protection requirements amount to about $2,199 per vehicle, substantially exceeding the $59 to $84 estimated costs.

On a per-unit basis, staff estimates the total costs of the proposed rule to be $61 to $94 per vehicle. Staff estimates the total quantifiable benefits of the proposed rule to be $2,199 per unit. This results in net quantifiable benefits of $2,105 to $2,138 per unit. Staff notes that quantifiable benefits of the proposed rule could exceed the estimated $2,199 per unit because the benefit associated with the vehicle handling and lateral stability requirement could not be quantified.

Voluntary Standards: CPSC staff is aware of two voluntary standards that are applicable to ROVs, ANSI/ROHVA 1, *American National Standard for Recreational Off-Highway Vehicles*

[3] Lateral acceleration is expressed as a multiple of free-fall acceleration (g).

(published July 2011) and ANSI/B71.9, *American National Standard for Multipurpose Off-Highway Utility Vehicles* (published March 2012). The Recreational Off-Highway Vehicle Association (ROHVA) developed ANSI/ROHVA 1 for recreation-oriented ROVs and the Outdoor Power Equipment Institute (OPSI) developed ANSI/OPEI B71.9 for utility-oriented ROVs. CPSC staff has participated in the development of these standards and has communicated concerns regarding vehicle rollover resistance, vehicle handling, and occupant protection throughout the development of both voluntary standards. CPSC staff reviewed both voluntary standards and determined that the requirements for rollover resistance, vehicle handling, and occupant protection were not adequate to address ROV deaths and injuries.

On August 29, 2013, CPSC staff sent a letter to the Recreational Off-Highway Vehicle Association (ROHVA) and the Outdoor Power Equipment Institute (OPEI) with suggested modifications of the voluntary standard requirements to address staff's concerns.[4] On November 27, 2013, ROHVA responded that it plans to adopt less stringent versions of CPSC staff's proposed requirements to improve the lateral stability and occupant protection performance of ROVs.[5] On March 13, 2014, ROHVA sent CPSC staff the Canvass Draft of proposed revisions to ANSI/ROHVA 1-2011. Staff responded to the Canvass Draft on May 23, 2014, and summarized why staff believes ROHVA's proposed requirements will not reduce the number of deaths and injuries from ROVs.[6] On July 31, 2014, ROHVA sent CPSC staff a response in which ROHVA disagreed with CPSC staff's analysis and recommendations regarding the Canvass Draft.

Conclusion/Recommendation: As of April 5, 2013, CPSC staff is aware of 550 reported ROV-related incidents that occurred between January 1, 2003 and April 5, 2013; there were 335 reported fatalities and 506 reported injuries related to these incidents. In 2012, CPSC staff conducted a multidisciplinary review ROV-related incidents that occurred and were reported between January 1, 2003 and December 31, 2011. From January 1, 2003 to December 31, 2011, CPSC staff is aware of 428 reported ROV-related incidents, including 231 fatalities and 388 injuries. CPSC staff's analysis of the 428 incidents identifies ROV rollover and occupant ejection as a dominant hazard pattern. Technical analysis shows that CPSC staff's recommended requirements will reduce ROV deaths and injuries by reducing the occurrence of ROV rollovers and reducing the severity of injuries when rollovers occur. Staff believes that the recommended requirements are technologically feasible and that the potential benefits of the draft proposed rule substantially exceed the rule's costs. Moreover, staff believes that the current voluntary standards for ROVs will not reduce deaths and injuries associated with ROV rollover and occupant ejection. For these reasons, CPSC staff recommends that the Commission publish the draft notice of proposed rulemaking (NPR) for ROVs submitted with this briefing package.

[4] Letter from Caroleene Paul (CPSC) to Paul Vitrano (ROHVA), dated August 29, 2013. Retrieved at: http://www.cpsc.gov/Global/Regulations-Laws-and-Standards/Voluntary-Standards/Draft-Voluntary-Standards-Proposals/CPSCstafflettertoROHVA.pdf.
[5] Letter from Paul Vitrano (ROHVA) to Caroleene Paul (CPSC), dated November 27, 2013. Retrieved at: http://www.cpsc.gov/Global/Regulations-Laws-and-Standards/Voluntary-Standards/Voluntary-Standards-Reports/LettertoCPaulApps112713.pdf.
[6] Letter from Caroleene Paul (CPSC) to Tom Yager (ROHVA), dated May 23, 2014. Retrieved at: http://www.cpsc.gov/Global/Regulations-Laws-and-Standards/Voluntary-Standards/ROHVA/052314signedCommentLettertoROHVACanvassDraft03032014.pdf.

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UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
4330 EAST WEST HIGHWAY
BETHESDA, MD 20814

This document has been electronically approved and signed.

Memorandum

September 23, 2014

TO:	The Commission Todd Stevenson, Secretary
THROUGH:	Stephanie Tsacoumis, General Counsel DeWane Ray, Deputy Executive Director
FROM:	George Borlase, Assistant Executive Director Office of Hazard Identification and Reduction Caroleene Paul, Project Manager Directorate for Engineering Sciences
SUBJECT:	Proposed Rule for Recreational Off-Highway Vehicles (ROVs)

I. INTRODUCTION

Recreational off-highway vehicles (ROVs) are motorized vehicles that combine off-road capability with utility and recreational use. Reports of ROV-related fatalities and injuries prompted the U.S. Consumer Product Safety Commission (CPSC, Commission) to publish an advance notice of proposed rulemaking (ANPR) in October 2009 to consider whether there may be unreasonable risks of injury and death associated with ROVs.[7] The ANPR began a rulemaking proceeding under the Consumer Product Safety Act (CPSA).

This briefing package summarizes the analyses performed by CPSC staff on the following:

- review of ROV-related incident data and hazard characteristics;
- review of static and dynamic tests performed by CPSC contractors in the areas of lateral stability, vehicle handling, and occupant protection;
- review of adequacy of current voluntary standards for ROVs; and
- summary of comments that were received in response to the 2009 ANPR and staff's responses to those comments.

In addition, the briefing package presents CPSC staff's recommendations for a proposed rule, followed by a preliminary regulatory analysis that discusses the potential benefits and costs of the draft proposed rule requirements, along with an initial regulatory flexibility analysis that discusses the potential impact of the draft proposed rule on small businesses.

Staff is recommending that the Commission publish a notice of proposed rulemaking (NPR) to address the lateral rollover hazards associated with the use of ROVs.

[7] 74 FR 55495 Standard for Recreational Off-Highway Vehicles.

II. DISCUSSION

A. Basic Terms and Concepts

This memorandum uses several terms that refer to aspects of ROV design and analysis that may not be familiar to the reader. This section provides explanations of some basic terms and concepts. Tab A provides additional explanations.

- **Rollover**: a movement in which the vehicle rotates 90 degrees or more about the long axis of the vehicle.
- **Lateral stability**: stability about the roll axis of a vehicle (see Figure 1).
- **Pitch stability**: stability about the short axis of a vehicle (see Figure 1).
- **Yaw stability**: stability about the vertical axis of a vehicle (see Figure 1).
- **Roll over protective structure (ROPS)**: a system of structural members designed to protect a seated and belted occupant from being crushed by the vehicle during a rollover event (see Figure 2). The ROPS is often called a roll cage.

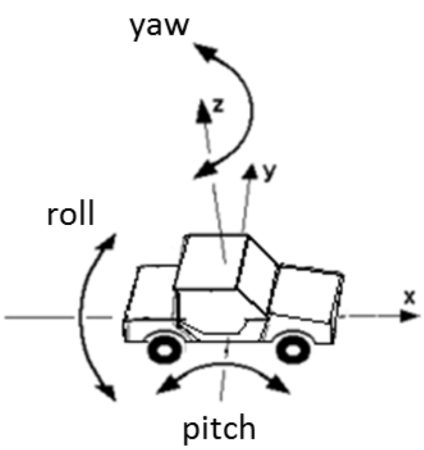


Figure 1. Vehicle Axes

Figure 2. Roll Over Protective Structure (ROPS)

B. Product Review

1. Description

ROVs are motorized vehicles designed for off-highway use and have the following features: four or more pneumatic tires designed for off-highway use; bench or bucket seats for two or more occupants; automotive-type controls for steering, throttle, and braking; and a maximum vehicle speed greater than 30 miles per hour (mph). ROVs are also equipped with rollover protective structures (ROPS), seat belts, and other restraints (such as doors, nets, and shoulder barriers) for the protection of occupants.

ROVs and All-Terrain Vehicles (ATVs) are similar in that both are motorized vehicles designed for off-highway use, and are used for utility and recreational purposes. However, ROVs differ significantly from ATVs in vehicle design. ROVs have a steering wheel instead of a handle bar for steering; foot pedals instead of hand levers for throttle and brake control; and bench or bucket seats rather than straddle seating for the occupant(s). Most importantly, ROVs only require steering wheel input from the driver to steer the vehicle, and the motion of the occupants has little or no effect on vehicle control or stability. ATVs require riders to steer with their hands and to maneuver their body front to back and side to side to augment the ATV's pitch and lateral stability.

Early ROV models emphasized the utility aspects of the vehicles, but the recreational aspects of the vehicles have become very popular. Currently, there are two distinct varieties of ROVs: utility and recreational (see Figure 3 and Figure 4). Models emphasizing utility have larger cargo beds, higher cargo capacities, and lower top speeds. Models emphasizing recreation have smaller cargo beds, lower cargo capacities, and higher top speeds. Utility and recreational ROVs have a maximum speed that exceed 30 mph; therefore, both types of ROVs are covered by the scope of this NPR.

Figure 3. Typical Utility ROV

Figure 4. Typical Recreational ROV

2. ROV Market (see Tab B)

<u>Manufacturers</u>

The number of manufacturers marketing ROVs in the United States has increased substantially in recent years. The first utility vehicle that exceeded 30 mph, thus putting it in the ROV category, was introduced in the late 1990s. No other manufacturer offered an ROV until 2003. In 2013, there were 20 manufacturers known to CPSC to be supplying ROVs to the U.S. market. One manufacturer accounted for about 60 percent of the ROVs sold in the United States in 2013. Another seven manufacturers, including one based in China, accounted for about 36 percent of the ROVs sold in the same year. None of these seven manufacturers accounted for more than 10 percent of the market. The rest of the market was divided among about 12 other manufacturers, most of which were based in China or Taiwan.[8]

About 92 percent of ROVs sold in in the United States are manufactured in North America. About 7 percent of the ROVs sold in the United States are manufactured in China (by nine

[8] Market share is based upon Commission analysis of sales data provided by Power Products Marketing, Eden Prairie, MN (2014).

different manufacturers). Less than 1 percent of ROVs are produced in other countries other than the United States or China.[9]

Retail Prices

The average manufacturer's suggested retail prices (MSRP) of ROVs in 2013 was approximately $13,100, with a range of about $3,600 to $20,100. The average MSRP for the eight largest manufacturers in terms of market share was about $13,300. The average MSRP of ROVs sold by the smaller, mostly Chinese, manufacturers was about $7,900.[10]

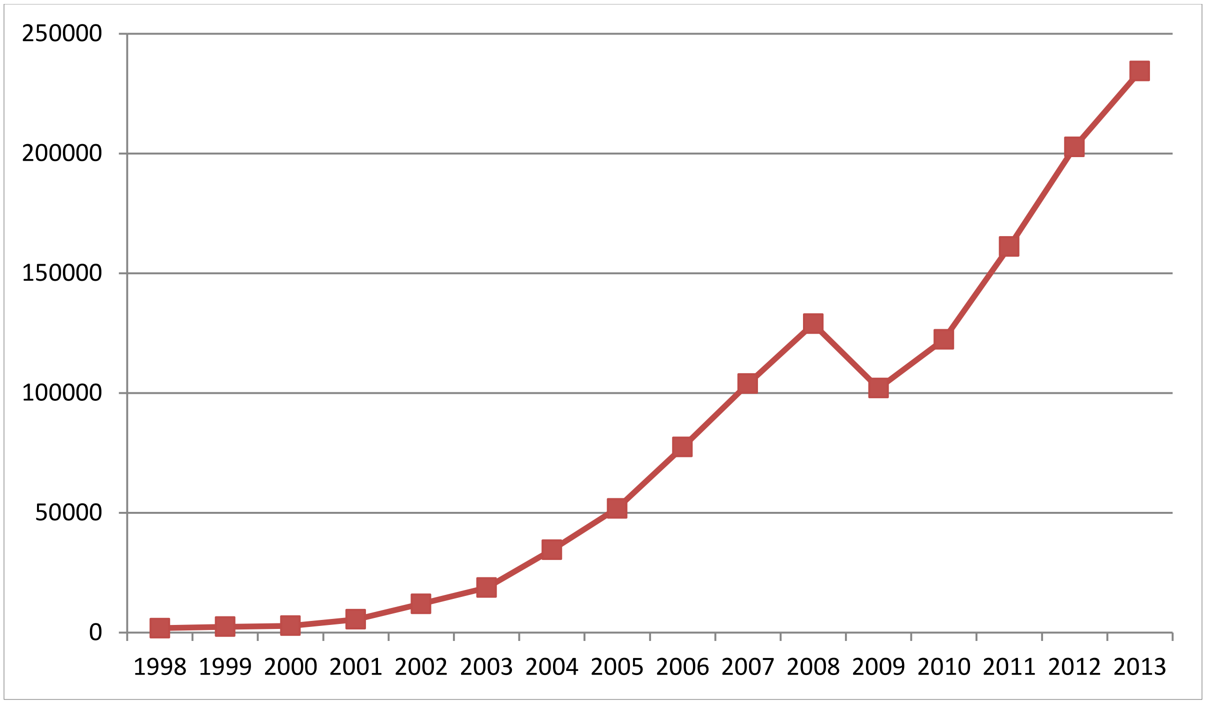
The retail prices of ROVs tend to be somewhat higher than the retail prices of other recreational and utility vehicles. The MSRPs of ROVs are about 10 percent higher, on average, than the MSRPs of low-speed utility vehicles. A comparison of MSRPs for the major manufacturers of ATVs and ROVs indicates that ROVs are priced about 10 to 35 percent higher than ATVs offered by the same manufacturer.[11]

Sales and Number in Use

Sales of ROVs have increased substantially since their introduction. In 1998, only one firm manufactured ROVs, and fewer than 2,000 units were sold. By 2003, when a second major manufacturer entered the market, almost 20,000 ROVs were sold. The only dip in sales occurred around 2008, which coincided with the worst of the credit crisis and recession that also started about the same time. In 2013, an estimated 234,000 ROVs were sold by 20 different manufacturers.[12] ROV sales have increased steadily from 1998 through 2013 (see Figure 5).

The number of ROVs available for use has also increased substantially. Because ROVs are a relatively new product, staff does not have specific information on the expected useful life of ROVs. However, using the same operability rates that CPSC uses for ATVs, staff estimates that there were about 570,000 ROVs available for use in 2010.[13] By the end of 2013, staff estimates there were 1.2 million ROVs in use.

[9] This information is based upon a Commission analysis of sales data provided by Power Products Marketing, Eden Prairie, MN (2012).
[10] MSRPs for ROVs were reported by Power Products Marketing, Eden Prairie, MN (2014).
[11] Based upon a CPSC staff analysis of data provided by Power Products Marketing, Eden Prairie, MN, and an examination of the suggested retail prices on several manufacturers' Internet sites. Another source indicates that the price of one ROV or other utility vehicle is about two-thirds the price of two ATVs ("2009 Utility Vehicle Review," Southern Sporting Journal, October 2008, Vol. 14, Issue 5, pp. 58-70, accessed through: http://web.ebscohost.com on March 17, 2011).
[12] Based upon a CPSC staff analysis of sales data provided by Power Products Marketing, Eden Prairie, MN.
[13] CPSC Memorandum from Mark S. Levenson, Division of Hazard Analysis, to Susan Ahmed, Associate Executive Director, Directorate for Epidemiology, "2001 ATV Operability Rate Analysis," U.S. Consumer Product Safety Commission, Bethesda, Maryland (19 August 2003).



Source: CPSC analysis of data compiled by Power Products Marketing.

Figure 5. ROV Sales (units), 1998-2013

C. Incident Data (see Tab D, Tab E, and Tab F)

1. Reported Incidents (see Tab D)

CPSC staff reviewed 428 reports of ROV-related incidents from the Injury and Potential Injury Incident (IPII) and In-Depth Investigation (INDP) databases that occurred between January 1, 2003 and December 31, 2011, and were received by December 31, 2011. ROV incidents can involve more than one injury or fatality because they often involve a driver and other passengers. From the 428 reported incidents, there were 826 victims involved. Of these victims, there were 388 injured victims and 231 fatalities; the remaining 207 victims were either not injured or their injury information was not known. Children younger than 16 years of age made up 23 percent of the injured victims and 33 percent of the fatalities.

Of the 428 ROV-related incidents, 76 involved drivers under 16 years of age (18 percent); 227 involved drivers 16 years of age or older (53 percent); and 125 involved drivers of unknown age (29 percent). Of the 227 incidents involving adult drivers, 86 (38 percent) are known to have involved the driver consuming at least one alcoholic beverage before the incident; 52 (23 percent) did not involve alcohol; and 89 (39 percent) have an unknown alcohol status of the driver.

Of the 619 victims who were injured or killed, most (66 percent) were in a front seat of the ROV, either as a driver or passenger, when the incidents occurred. The remaining victims were in the rear of the ROV or in an unspecified location of the ROV.

In many of the ROV-related incidents resulting in at least one death, CPSC staff was able to obtain more detailed information on the events surrounding the incident through an In-Depth Investigation (IDI). Of the 428 ROV-related incidents, 224 involved at least one death. This includes 218 incidents resulting in one fatality, five incidents resulting in two fatalities, and one incident resulting in three fatalities, for a total of 231 fatalities. Of the 224 fatal incidents, 145 (65 percent) occurred on an unpaved surface, 38 (17 percent) occurred on a paved surface, and 41 (18 percent) occurred on an unknown terrain surface.

As of April 5, 2013, CPSC staff is aware of 122 additional ROV-related incidents that were reported on or after January 1, 2012 (see Tab F). There have been 104 additional ROV-related fatalities reported to CPSC staff between January 1, 2012 and April 5, 2013, for a total of 335 reported ROV-related fatalities from January 1, 2003 through April 5, 2013. An additional 118 ROV-related injuries have also been reported from January 1, 2012 through April 5, 2013, making 506 the total number of reported ROV-related injuries from January 1, 2003 through April 5, 2013. Staff conducted a preliminary review of the additional reported incidents and did not detect a change in the hazard patterns identified.

2. National Electronic Injury Surveillance System (NEISS) (see Tab E)

CPSC staff conducted a special study of ROV-related injuries reported through the National Electronic Injury Surveillance System (NEISS). Staff used the results to estimate the number of nonfatal injuries associated with ROVs that were treated in hospital emergency departments nationwide. The NEISS special study included reported injuries occurring in the United States between January 1, 2010 and August 31, 2010. NEISS is a stratified national probability sample of hospital emergency departments that allows CPSC staff to make national estimates of product-related injuries. The sample consists of about 100 of the approximately 5,400 U.S. hospitals that have at least six beds and provide 24-hour emergency service. [14] Consumer product-related injuries treated in emergency departments of the NEISS member hospitals are coded from the medical record. As such, information about the injury is extracted, but specifics about the product and its use are often not available.

NEISS does not contain a separate category or product code for ROVs. Injuries associated with ROVs are usually assigned to either an ATV product category (product codes 3285-3287) or to the utility vehicle (UTV) category (product code 5044). A total of 2,018 injuries that were related to ATVs or UTVs were recorded in NEISS between January 1, 2010 and August 31, 2010. CPSC staff attempted follow-up interviews with each victim (or a relative of the victim) to gather more information about the incidents and the vehicles involved. CPSC staff determined whether the vehicle involved was an ROV based on the make and model of the vehicle reported in the interviews. If the make and model of the vehicle was not reported, the case was not counted as an ROV.

A total of 688 surveys were completed, resulting in a 33 percent response rate for this survey. Of the 688 completed surveys, 16 were identified as involving an ROV based on the make and

[14] Schroeder, T., Ault, K. The NEISS Sample (Design and Implementation): 1999 to Present. Bethesda, MD: U.S. Consumer Product Safety Commission; 2001. Retrieved from http://www.cpsc.gov/neiss/2001d011-6b6.pdf.

model of the vehicle involved. It is possible that more cases involved an ROV, but it was not possible to identify them due to lack of information on the vehicle make and model.

The estimated number of emergency department-treated ROV-related injuries occurring in the United States between January 1, 2010 and August 31, 2010, is 2,200 injuries. Extrapolating for the year 2010, the estimated number of emergency department-treated ROV-related injuries is 3,000, with a corresponding 95 percent confidence interval of 1,100 to 4,900.

D. Hazard Characteristics (see Tab D)

<u>Rollover</u>

As mentioned in section C.1 above, CPSC staff reviewed 428 reports of ROV-related incidents from the IPII and INDP databases that occurred between January 1, 2003 and December 31, 2011, and were received by December 31, 2011. Of the 428 reported ROV-related incidents, 291 (68 percent) involved rollover of the vehicle, more than half of which occurred while the vehicle was in a turn (52 percent). Of the 224 fatal incidents, 147 (66 percent) involved rollover of the vehicle, and 56 of those incidents (38 percent) occurred on flat terrain.

A total of 826 victims were involved in the 428 reported incidents, including 231 fatalities and 388 injuries. Of the 231 reported fatalities, 150 (65 percent) died in an incident involving lateral rollover of the ROV. Of the 388 injured victims, 75 (19 percent) were classified as severely injured; 67 (89 percent) of these victims were injured in incidents that involved lateral rollover of the ROV.

<u>Occupant Ejection and Seat Belt Use</u>

From the 428 ROV-related incidents reviewed by CPSC staff, 817 victims were reported to be in or on the ROV at the time of the incident, and 610 (75 percent) were known to have been injured or killed. Seatbelt use is known for 477 of the 817 victims; of these, 348 (73 percent) were not wearing a seatbelt at the time of the incident.

Of the 610 fatal and nonfatal victims who were in or on the ROV at the time of the incident, 433 (71 percent) were ejected partially or fully from the ROV, and 269 (62 percent) of these victims were struck by a part of the vehicle, such as the roll cage or side of the ROV, after ejection. Seat belt use is also known for 374 of the 610 victims; of these, 282 (75 percent) were not wearing a seat belt.

Of the 225 fatal victims who were in or on the ROV at the time of the incident, 194 (86 percent) were ejected partially or fully from the vehicle, and 146 (75 percent) were struck by a part of the vehicle after ejection. Seat belt use is known for 155 of the 194 ejected victims; of these, 141 (91 percent) were not wearing a seat belt.

E. Yamaha Rhino (see Tab J)

In 2008, CPSC staff began investigating ROVs following reports of serious injuries and fatalities associated with the Yamaha Rhino vehicle, manufactured by Yamaha Motor Corporation, USA (Yamaha). Staff investigated more than 50 incidents, including 46 driver and passenger deaths associated with the Yamaha Rhino model vehicle. More than two-thirds of the incidents involved rollovers, and many involved unbelted occupants. Of the rollover-related deaths and hundreds of reported injuries, many appeared to have involved turns at relatively low speeds on level terrain.

CPSC staff contracted the U.S. Army's Aberdeen Test Center (ATC) to conduct static and dynamic tests to characterize the Yamaha Rhino vehicle and to identify factors that contribute to rollover. Results of the static and dynamic tests showed that the Yamaha Rhino vehicle exhibited low lateral stability, transitioned from understeer to severe oversteer, and exhibited poor occupant protection during simulation of a rollover event.

In March 2009, CPSC staff negotiated a repair program on the Yamaha Rhino 450, 660, and 700 model ROVs to address stability and handling issues with the vehicles.[15] Yamaha voluntarily agreed to design changes through a repair program that would increase the vehicle's lateral stability and change the vehicle's handling characteristic from oversteer to understeer. The repair consisted of the following: (1) addition of 50-mm spacers on the vehicle's rear wheels to increase the track width, (2) the removal of the rear stabilizer bar to effect understeer characteristics, and (3) continued installation of half doors and hand holds to protect occupants.

CPSC staff reviewed reports of ROV-related incidents from the IPII and INDP databases that occurred between January 1, 2003 and May 31, 2012, and identified 242 Yamaha Rhino-related incidents.[16] Of the 242 total incidents involving a Yamaha Rhino vehicle reported to CPSC during this time period, 187 incidents occurred before the Yamaha Rhino repair program was announced on March 31, 2009. After the repair notice, 55 incidents occurred. The number of incidents that occurred by quarters of a year are shown below in Figure 6.

[15]CPSC Release #09-172, March 31, 2009, Yamaha Motor Corp. Offers Free Repair for 450, 660, and 700 Model Rhino Vehicles.
[16] The data are only those reported to CPSC staff and are not representative of all incidents.

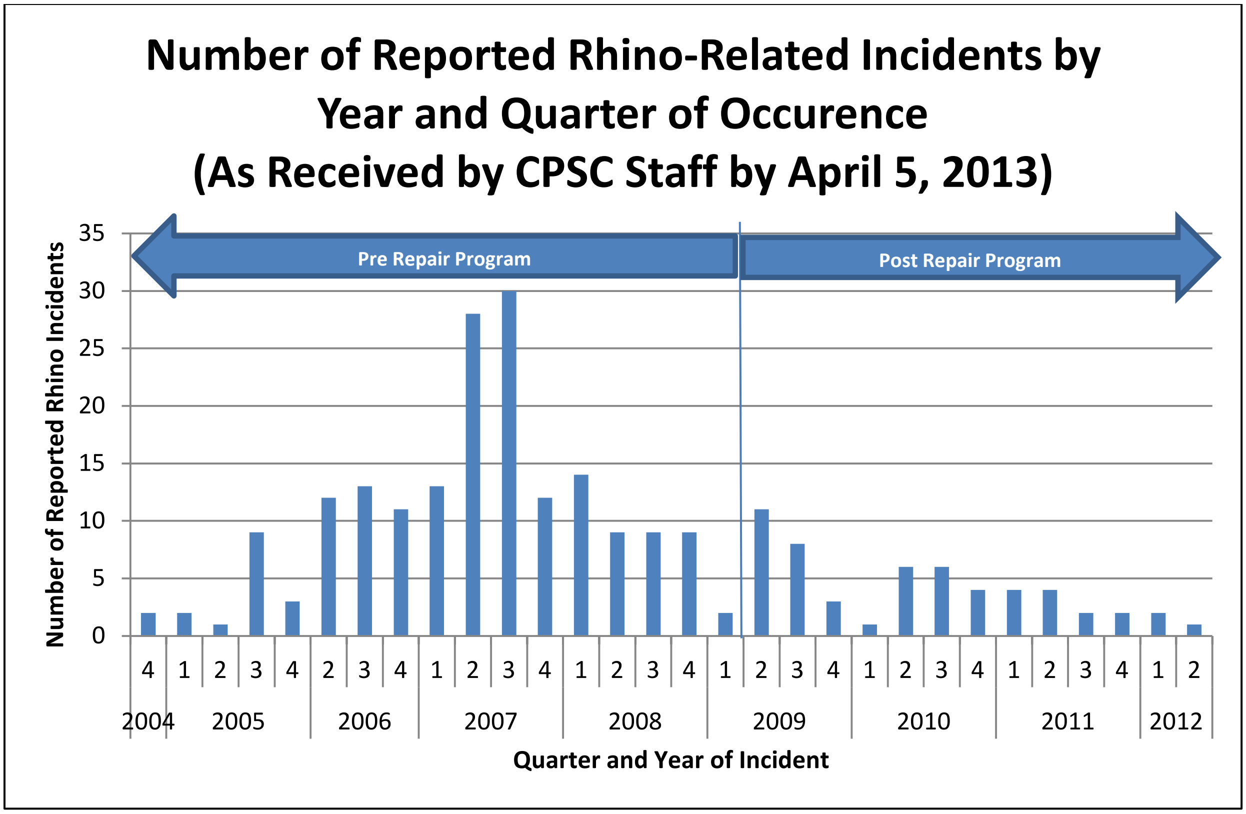


Figure 6. Number of Reported Yamaha Rhino Incidents from January 2003 to May 2012.

As shown in Figure 6, the number of Rhino-related incidents consumers and others reported to CPSC decreased noticeably after the repair program was started.

CPSC staff also analyzed the 242 Yamaha Rhino-related incidents reported to CPSC and identified 46 incidents in which a Yamaha Rhino vehicle rolled over during a turn on flat or gentle terrain. Forty-one of the 46 incidents involved an unrepaired Rhino vehicle and two incidents involved a repaired Rhino vehicle (both incidents occurred on terrain with a 5 to 10 degree slope). Staff did not find incidents involving repaired Rhino vehicles rolling over on flat terrain during a turn.

CPSC staff believes the decrease in Rhino-related incidents after the repair program was initiated can be attributed to the vehicle modifications made by the repair program. Specifically, correction of oversteer and improved lateral stability can reduce rollover incidents by reducing the risk of sudden and unexpected increases in lateral acceleration during a turn, and increasing the amount of force required to roll the vehicle over. Staff believes that lateral stability and vehicle handling have the most effect on rollovers during a turn on level terrain because the rollover is caused primarily by lateral acceleration generated by friction during the turn. Staff's review of rollover incidents during a turn on level ground indicates that repaired Rhino vehicles are less likely than unrepaired vehicles to roll over. Staff believes this is further evidence that increasing lateral stability and correcting oversteer to understeer contributed to the decrease in Yamaha Rhino incidents. The experience gained from the Yamaha Rhino investigation became the basis for staff's approach in developing technical requirements for a proposed rule.

III. STAFF RECOMMENDATIONS FOR PROPOSED RULE

A. Overview of Technical Work (see Tab A and Tab H)

In February 2010, CPSC staff contracted SEA, Limited (SEA), to conduct an in-depth study of vehicle dynamic performance and static rollover measures for ROVs. SEA evaluated a sample of 10 ROVs that represented the recreational and utility oriented ROVs available that year in the U.S. market. SEA tested and measured several characteristics and features that relate to the rollover performance of the vehicles and to the vehicle's handling characteristics.

In 2011, SEA designed and built a roll simulator to measure and analyze occupant response during quarter-turn roll events of a wide range of machines, including ROVs. CPSC staff contracted SEA to conduct occupant protection performance evaluations of seven ROVs with differing occupant protection designs.

The following SEA reports have been published on the CPSC website:

Report Title	Author	Date Posted
Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles	Gary J. Heydinger, Ph.D., P.E.	April 1, 2011
Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles – Additional Results for Vehicle J	Gary J. Heydinger, Ph.D., P.E.	August 1, 2011
Test and Evaluation of Recreational Off-Highway Vehicles (ROVs) Dynamic Occupant Protection Performance Tests	Douglas R. Morr, P.E.	July 24, 2013
Circle Testing of Two Recreational Off-Highway Vehicles on a Dirt Surface	Gary J. Heydinger, Ph.D., P.E.	August 7, 2013
Results from Proposed ROHVA and OPEI Dynamic Maneuvers – Vehicles A, F, and J	Gary J. Heydinger, Ph.D., P.E.	August 7, 2013
Repeatability of J-Turn Testing of Four Recreational Off-Highway Vehicles	Gary J. Heydinger, Ph.D., P.E.	November 6, 2013

B. Recommended Requirements for Proposed Rule

1. Overview

CPSC staff believes that improving lateral stability (by increasing rollover resistance) and improving vehicle handling (by correcting oversteer to understeer) are the most effective approaches to reduce the occurrence of ROV rollover incidents. ROVs with higher lateral stability are less likely to roll over because more lateral force is necessary to cause rollover. ROVs exhibiting understeer during a turn are also less likely to roll over because steering control is stable and the potential for the driver to lose control is low.

CPSC staff believes that when rollovers do occur, improving occupant protection performance is the most effective approach to mitigate injury severity. CPSC staff's analysis of ROV incidents indicates that 91 percent of fatally ejected victims were not wearing a seat belt at the time of the incident. Increasing seat belt use, in conjunction with better shoulder retention performance, will significantly reduce injuries and deaths associated with an ROV rollover event.

To address these hazards, staff recommends mandatory performance requirements for:

- A minimum level of rollover resistance of the ROV when tested using the J-turn test procedure;
- A hang tag providing information about the vehicle's rollover resistance on a progressive scale;
- Understeer performance of the ROV when tested using the constant radius test procedure;
- Limited maximum speed of the ROV when tested with occupied front seat belts unbuckled; and
- A minimum level of passive shoulder protection when tested using a probe test.

2. Lateral Stability

a. Basic Terms

- **Lateral acceleration**: acceleration that generates the force that pushes the vehicle sideways. During a turn, lateral acceleration is generated by friction between the tires and surface. Lateral acceleration is expressed as a multiple of free- fall gravity (g).
- **Two-wheel lift:** point at which the inside wheels of a turning vehicle lift off the ground, or when the uphill wheels of a vehicle on a tilt table lift off the table. This is a precursor to a rollover event.
- **Threshold lateral acceleration**: minimum lateral acceleration of the vehicle at two-wheel lift.
- **Untripped rollover**: rollover that occurs during a turn due solely to the lateral acceleration generated by friction between the tires and the road surface.
- **Tripped rollover**: rollover that occurs when the vehicle slides and strikes an object that provides a pivot point for the vehicle to roll over.

b. Staff's Technical Work

<u>Static Measures to Evaluate ROV Lateral Stability</u>

CPSC and SEA staff conducted the following static measurements to compare lateral stability of a group of 10 ROVS.

- **Static stability factor (SSF)** is a static measure of a vehicle's rollover resistance, defined mathematically as the track width (T) divided by twice the center of gravity height (H), or $SSF = \frac{T}{2H}$ (see Figure 7).

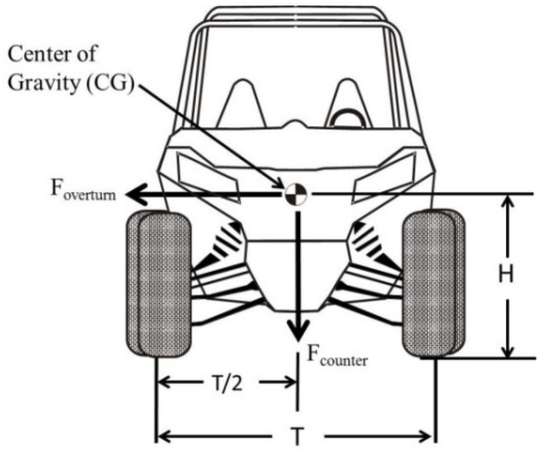


Figure 7. Components of SSF

- **Tilt Table Ratio (TTR)** is a static measure of a vehicle's rollover resistance, defined mathematically as the tangent of the Tilt Table Angle (TTA). The TTA is measured by placing the ROV on a rigid platform and tilting the platform until both up-hill wheels of the vehicle lift off the platform (see Figure 8). The angle of the platform relative to the horizontal is the TTA.

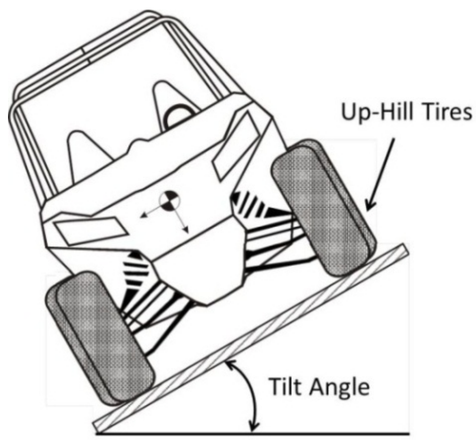


Figure 8. Tilt Table Ratio (TTR) = Tan (Tilt Angle)

Table 1 shows the measured values for SSF and TTR per vehicle. Larger SSF and TTR values generally correspond to better lateral stability, but these measures do not account for dynamic tire deflections or suspension compliance. Because ROVs are designed with long suspension travel and soft tires for off-road performance, CPSC staff was concerned that SSF and TTR would not accurately characterize the dynamic lateral stability of the vehicle. Therefore, SEA conducted dynamic J-turn tests to determine whether SSF or TTR measurement corresponded with actual dynamic measures for lateral stability, which is the threshold lateral acceleration at rollover (A_y).

Table 1. Vehicle Ascending Rank Order for A_y, SSF, TTR (Operator Plus Passenger Load)

Vehicle Rank (A_y)	A_y (g)	SSF	TTR
D	0.625	0.942	0.667
B	0.655	0.932	0.664
A	0.670	0.887	0.650
J	0.670	0.962	0.730
I	0.675	1.045	0.712
F	0.690	0.881	0.739
E	0.700	0.965	0.784
H	0.705	0.918	0.724
C	0.740	0.991	0.803
G	0.785	1.031	0.810

Adapted from: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles – Additional Results for Vehicle J. Retrieved from http://www.cpsc.gov/PageFiles/93928/rovj.pdf.

J- Turn Test

The J-turn test consists of driving the vehicle at a set speed and turning the steering wheel to an angle that results in two-wheel lift (a precursor to rollover). The threshold lateral acceleration is measured during this maneuver. In 2001, NHTSA evaluated the J-turn test as a method to measure the rollover resistance of automobiles, and determined that the J-turn test is the most objective and repeatable method for vehicles with low rollover resistance.[17] Specifically, the J-turn test is objective because a programmable steering machine turns the steering wheel during the test, and the test results show that the vehicle speed, lateral acceleration, and roll angle data observed during J-turn tests were highly repeatable.[17] Vehicles with high rollover resistance (such as passenger automobiles) do not exhibit untripped rollover on pavement during a J-turn test because the vehicle's tires lose traction and slide in a severe turn rather than roll over. NHTSA determined that the J-turn test was not severe enough to roll over the automobiles used in the test program.[17] The threshold lateral acceleration of a vehicle cannot be measured if rollover does not occur. In contrast, vehicles with low rollover resistance exhibit untripped rollover on pavement during a J-turn test, and the lateral acceleration at rollover threshold can be measured. Because ROVs have low rollover resistance and exhibit untripped rollover on pavement, the J-turn test is the most appropriate method to measure the rollover resistance of ROVs.

SEA conducted J-turn tests on the sample group of 10 ROVs. These tests are conducted by driving the test vehicle in a straight path, releasing the throttle, and rapidly turning the steering wheel to a specified angle once the vehicle slows to a specified speed. The steering wheel angle

[17] Forkenbrock, G. and Garrott, W. (2002). A Comprehensive Experimental Evaluation of Test Maneuvers That May Induce On-Road, Untripped, Light Vehicle Rollover Phase IV of NHTSA's Light Vehicle Rollover Research Program. DOT HS 809 513.

and vehicle speed are selected that produce two-wheel lift of the vehicle.[18] Outriggers, which are beams that extend to either side of a vehicle, on the ROV, allow the vehicle to roll but prevent full rollover. The sequence of events in the test procedure is shown in Figure 9.

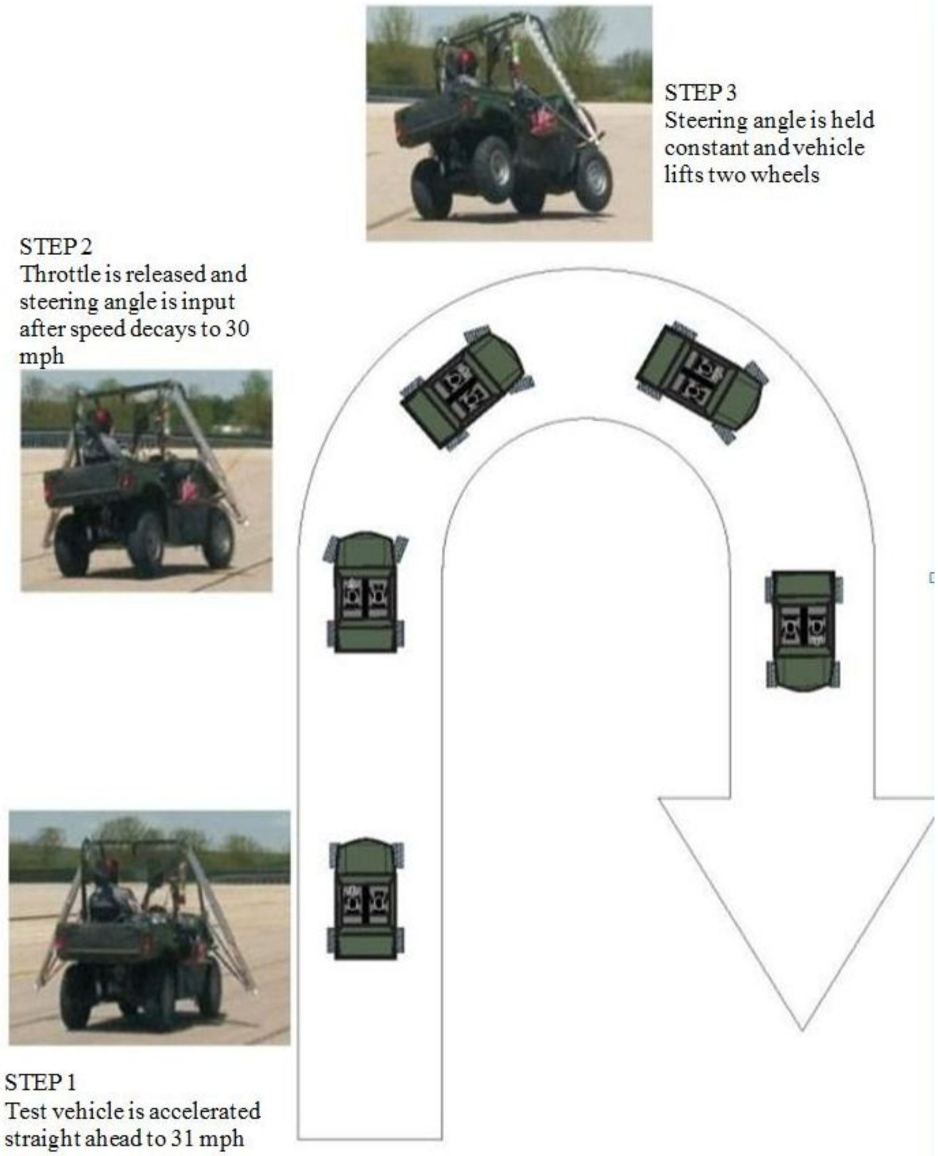


Figure 9. J-Turn Test Sequence of Events

An example of two-wheel lift is shown in Step 3 of Figure 9. During the J-turn test, friction between the ROV tires and the pavement creates a side force that acts to overturn the vehicle. The lateral acceleration associated with this force can be measured. Rollover in an ROV begins when the lateral acceleration builds to the point that the vehicle can no longer counterbalance the roll generated by the lateral acceleration.[19] Therefore, staff believes that the lateral acceleration

[18] Two-wheel lift refers to a condition where all of the wheels of the vehicle that are located on the inside of the turn lift off the ground. Most ROVs have four wheels, but some models have six or more wheels.
[19] Gillespie, T. (1992). Fundamentals of Vehicle Dynamics. Society of Automotive Engineers, Inc. p.309-311.

at two-wheel lift, or threshold lateral acceleration, is a direct measure of the ROV's rollover resistance.

SEA also conducted J-turn tests on four ROVs to measure the repeatability of the lateral acceleration measurements and found the tests to be very repeatable. [20] The results of the repeatability tests indicate the standard deviation for sets of 10 test runs (conducted in opposite directions and left/right turn directions) ranged from 0.002 g to 0.013 g.

ROVs that exhibit higher threshold lateral acceleration have a higher rollover resistance because more force is required to roll the ROV over. Thus, ROVs that exhibit higher threshold lateral acceleration are more stable than ROVs with lower threshold lateral accelerations. All of the 10 ROVs tested by SEA exhibited untripped rollover in the J-turn tests at lateral accelerations ranging from 0.625 g to 0.785 g.

Conclusion

CPSC staff believes that the threshold lateral acceleration at rollover (A_y) is the most appropriate metric to use when measuring rollover resistance for ROVs because A_y is the measured limit over which the ROV will rollover, as opposed to static metrics that predict the rollover propensity of an ROV. Comparison of the SSF, TTR, and A_y values for each ROV indicate that there is a lack of correspondence between the static metrics (SSF and TTR) and the direct measurement of threshold lateral acceleration at rollover (A_y) (see Table 1). Static metrics cannot be used to evaluate ROV rollover resistance because static tests are unable to account fully for the dynamic tire deflections and suspension compliance exhibited by the ROVs during a J-turn maneuver.

c. Recommended Requirements for Minimum Lateral Acceleration

Requirement

CPSC staff recommends a performance requirement that ROVs demonstrate a minimum threshold lateral acceleration at rollover of 0.70 g or greater in a J-turn test as described in the draft NPR (see Tab A). CPSC staff believes the J-turn test is the most appropriate method to measure the rollover resistance of ROVs because the J-turn test has been evaluated by NHTSA as the most objective and repeatable method for vehicles with low rollover resistance.[17] ROVs have low rollover resistance and exhibit untripped rollover on pavement during J-turn tests; therefore, the lateral acceleration at rollover threshold can be measured. Staff also verified that the J-turn test is objective and repeatable for ROVs by conducting numerous J-turn tests on several ROVs.[20]

[20] Heydinger, G. (2013). Repeatability of J-Turn Testing of Four Recreational Off-Highway Vehicles. Retrieved from http://www.cpsc.gov//Global/Research-and-Statistics/Injury-Statistics/Sports-and-Recreation/ATVs/SEAReporttoCPSCRepeatabilityTestingSeptember%202013.pdf.

Rationale

The Yamaha Rhino repair program improved the Yamaha Rhino vehicle's rollover resistance and handling by adding spacers on the vehicle's rear wheels and removing the rear stabilizer bar. The rollover resistance of an unrepaired Yamaha Rhino is 0.670 g compared to 0.705 g for a repaired vehicle (see Vehicle A and Vehicle H, respectively, in Table 1), which indicates that similar repair changes in other ROVs could also increase their rollover resistance to 0.70 g and above.

Results of J-turn tests performed on a sample of 10 ROVs available in the U.S. market indicate that six of the 10 ROVs tested measured threshold lateral accelerations below 0.70 g (values ranged from 0.625 g to 0.690 g, see Table 1). CPSC staff believes that minor changes to vehicle suspension and/or track width spacing, similar to the changes in the Yamaha Rhino repair program (see Tab J), can increase the threshold lateral acceleration of these vehicles to 0.70 g or greater.

The number of Rhino-related incidents decreased noticeably after the Yamaha Rhino repair program was started in March 2009 (see Tab J). CPSC staff also analyzed incidents in which a Yamaha Rhino vehicle rolled over during a turn on flat or gentle terrain and identified at least 41 incidents involving an unrepaired Rhino vehicle, compared to two incidents involving a repaired Rhino vehicle on gentle terrain with a slope of 10 degrees. Staff did not find any incidents involving a repaired Rhino vehicle that rolled over during a turn on flat terrain.

CPSC staff believes the decrease in Rhino-related incidents after the repair program was initiated and the low number of vehicle rollover incidents associated with repaired Rhino vehicles are evidence that increasing the lateral stability of an ROV and correcting oversteer characteristics to understeer reduces the occurrence of ROV rollover on level terrain.

Relevant Voluntary Standards

As discussed further in section IV of this memorandum, CPSC staff does not believe the current voluntary standards for ROVs, ANSI/ROHVA 1-2011 *American National Standard for Recreational Off-Highway Vehicles* and ANSI/OPEI B71.9-2012 *American National Standard for Multipurpose Off-Highway Utility Vehicles*, will promote improvement in the rollover resistance of ROVs. The static stability requirements in the voluntary standards are requirements that all ROVs can pass and the tests do not provide an incentive for manufacturers to improve the rollover resistance of ROVs. Similarly, the dynamic stability requirements are basically requirements almost all ROVs can pass and the tests do not measure the threshold lateral acceleration at rollover for ROVs.

Conclusion

Because staff believes that the current voluntary standard requirements do not adequately address improved rollover resistance of ROVs and thus do not adequately reduce the risk of injury, and based on the demonstrated safety benefits of improved rollover resistance of the Yamaha Rhino vehicle after implementation of the March 2009 repair program, CPSC staff recommends that the

Commission propose a performance requirement that ROVs demonstrate a minimum threshold lateral acceleration at rollover of 0.70 g or greater in a J-turn test, as described in the draft NPR.

d. Recommended Requirements for Hang Tag

Requirement

CPSC staff also recommends a requirement that manufacturers provide information on the value of each model vehicle's threshold lateral acceleration at rollover, in the form of a hang tag, as described in the draft NPR (see Tab M). The Consumer Product Safety Act (CPSA) authorizes the CPSC to "require by rule that any manufacturer of a consumer product give notification of performance and technical data to prospective purchasers and the first purchaser of such product to assist consumers in evaluating the comparative safety of consumer products.[21] CPSC staff believes the hang tag will allow consumers to make informed decisions on the comparative lateral stability of ROVs when making a purchase, and likewise, will provide a competitive incentive for manufacturers to improve the rollover resistance of ROVs.

Rationale

The recommended hang tag is based on information labels developed by NHTSA and the Federal Trade Commission (FTC). NHTSA developed the New Car Assessment Program (NCAP) star-rating system in 1978 to provide consumers with information on the crashworthiness of passenger vehicles.[22] The FTC developed the EnergyGuide label in 1979 to provide consumers with information on the energy efficiency of appliances.[23]

NHTSA believed that consumer information on the rollover risk of passenger cars would influence consumers to purchase vehicles with a lower rollover risk and inspire manufacturers to produce vehicles with a lower rollover risk.[24] In 2001, NHTSA began including rollover resistance information in its NCAP.[25] A subsequent study of SSF trends in automobiles found that SSF values increased for all vehicles after 2001, particularly SUVs, which tended to have the worst SSF values in the earlier years.[24] CPSC staff believes a similar increase in rollover resistance can be achieved in ROVs by making the value of each model vehicle's threshold lateral acceleration available to consumers. ROVs that exhibit higher threshold lateral acceleration have a higher rollover resistance, and thus, are more stable than ROVs with lower threshold lateral accelerations.

The size and components of the recommended hang tag are based on hang tag requirements for ATVs, studies on label effectiveness, and the current EnergyGuide label for appliances.

[21] Section 27(e) of the Consumer Product Safety Act, 15 U.S.C. 2076(e).
[22] Hershman, L. (2001). The U.S. New Car Assessment Program (NCAP): Past, Present and Future. Paper Number 390. Retrieved from http://www-nrd.nhtsa.dot.gov/pdf/nrd-01/esv/esv17/proceed/00245.pdf.
[23] 16 CFR part 305.
[24] Walz, M. C. (2005). Trends in the Static Stability Factor of Passenger Cars, Light Trucks, and Vans. DOT HS 809 868. Retrieved from http://www.nhtsa.gov/cars/rules/regrev/evaluate/809868/pages/index.html.
[25] 65 FR 34988 (June 1, 2000).

The voluntary standard for ATVs, ANSI/SVIA 1-2011, *American National Standard for Four Wheel All-Terrain Vehicles*, requires that every ATV offered for sale come with a hang tag that provides the appropriate age recommendation and information on the intended usage.[26] CPSC staff believes requirements for the size of the hang tag (6 inches x 4 inches) and delivery of the hang tag (every hang tag shall be attached to the ATV) are applicable to ROVs because the ROV hang tag also provides point-of-purchase information to the consumer on a product that is similar to ATVs and often sold in the same dealership.

The sample hang tag and features are shown below in Figure 10.

1) **ROV Icon.** CPSC staff recommends an ROV icon in a rollover condition to identify the product and hazard. Research studies have found that warning labels with pictorial symbols are more noticeable to consumers.[27] Although the hang tag is not a warning label, staff believes the ROV icon will help consumers notice and understand the intent of the hang tag.
2) **Graph label (Better).** Graphical information should be clear and informative with the axes labeled fully complete with the units of measurement.[28] CPSC staff recommends the label “Better” at the right end of the scale to indicate that the higher values (as shading increases to the right) correspond to a greater rollover resistance during a turn on a flat surface.
3) **Manufacturer, Model, Model number, Model year.** The EnergyGuide label provides information on the manufacturer, model, and size of the product so consumers can identify exactly what product the label describes.[29] CPSC staff recommends a similar identification of the ROV model on the hang tag for consumers to compare values among different model ROVs.
4) **Textual information.** Text should paraphrase the importance of the graphic and how to interpret the information presented.[28] The EnergyGuide label provides textual information in the form of bullets below the graphic of the scale to inform the consumer further about the meaning of the value displayed. CPSC staff recommends similar textual information on the hang tag to provide consumers with more definition of the lateral acceleration value given in the graph.
5) **Graph identifier and label (Minimally acceptable).** CPSC staff recommends a vertical dotted line to show the minimum acceptable lateral acceleration for ROVs, 0.7g. This ”minimally acceptable” label allows consumers to judge visually the ROV lateral acceleration value, as compared to the minimum value of 0.7 g.
6) **Graph scale beginning lower than the minimally acceptable value (0.65 g).** CPSC staff recommends the scale begin at 0.65 g. The 0.05 g range below 0.7 g provides a visual shaded range for vehicles that only meet, but do not exceed, the minimum 0.7 g lateral acceleration requirement.

[26] As directed by the Consumer Product Safety Improvement Act, the Commission mandated the ATV voluntary standard as a CPSC standard, 16 C.F.R. part 1420. 15 U.S.C. § 2089(a)(1) and (b)(1).
[27] Wogalter, M., Dejoy, D., and Laughery, K. (1999). *Warnings and Risk Communication*. Philadelphia, PA: Taylor & Francis, Inc.
[28] Markel, M. (2001). *Technical Communication.* Boston, MA: Bedford/St. Martin’s.
[29] Guide to EnergyGuide label retrieved at http://www.consumer.ftc.gov/articles/0072-shopping-home-appliances-use-energyguide-label.

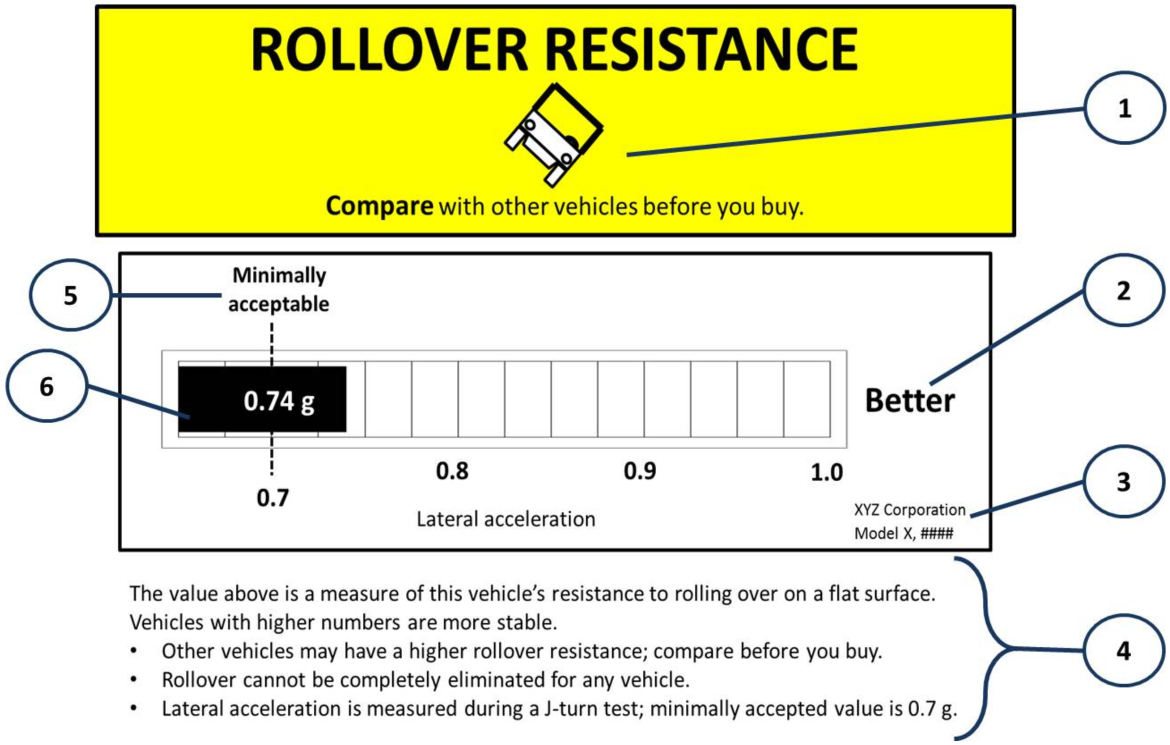


Figure 10. Sample recommended ROV hang tag

<u>Voluntary Standards</u>

The current voluntary standards for ROVs, ANSI/ROHVA 1-2011, *American National Standard for Recreational Off-Highway Vehicles,* and ANSI/OPEI B71.9-2012, *American National Standard for Multipurpose Off-Highway Utility Vehicles,* do not include a requirement for conveying the rollover resistance of each model ROV to consumers.

<u>Conclusion</u>

Because staff believes that the current voluntary standard requirements do not adequately address improved rollover resistance of ROVs and thus do not adequately reduce the risk of injury, and based on the demonstrated safety benefits of improvements in the rollover resistance of the Yamaha Rhino vehicle through the March 2009 repair program, CPSC staff recommends that the Commission propose a requirement that manufacturers provide information on the value of each model ROV's threshold lateral acceleration at rollover on a hang tag, as described in the draft NPR.

3. Vehicle Handling

a. Basic Terms

- **Understeer**: path of vehicle during a turn where the vehicle steers less into a turn than the steering wheel angle input by the driver. If the driver does not correct for the understeer path of the vehicle, the vehicle continues on a straighter path than intended (see Figure 11).

- **Oversteer**: path of vehicle during a turn where the vehicle steers more into a turn than the steering wheel angle input by the driver. If the driver does not correct for the oversteer path of the vehicle, the vehicle spirals into the turn more than intended (see Figure 11).
- **Sub-limit** understeer or oversteer: steering condition that occurs while the tires have traction on the driving surface.
- **Limit** understeer or oversteer: steering condition that occurs when the traction limits of the tires have been reached and the vehicle begins to slide.

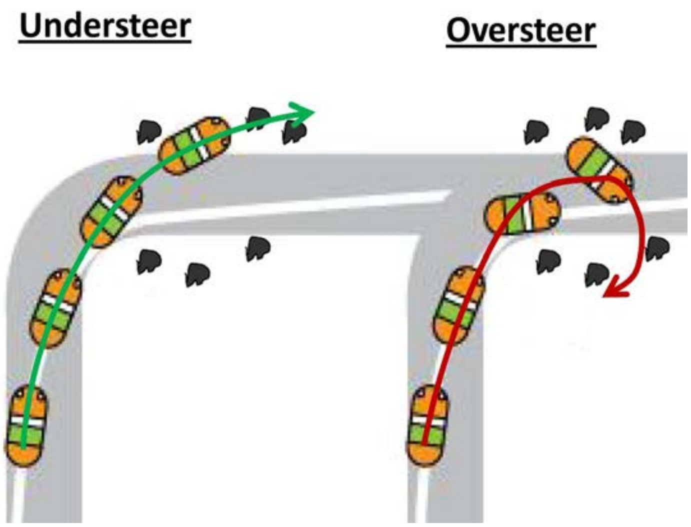


Figure 11. Understeer and Oversteer Path

b. Staff's Technical Work

<u>Constant Radius Test</u>

SAE International (formerly Society of Automotive Engineers) standard, SAE J266, Surface Vehicle Recommended Practice, *Steady-State Directional Control Test Procedures for Passenger Cars and Light Trucks*, establishes test procedures to measure the vehicle handling properties of passenger cars and light trucks. These test procedures are also applicable to ROVs because ROVs are similar to cars, have four steerable wheels and a suspension system, and thus, ROVs obey the same principles of motion as automobiles (see Tab A).

SEA used the constant radius test method, described in SAE J266, to evaluate the sample ROVs' handling characteristics. The test consists of driving each vehicle on a 100 ft. radius circular path from very low speeds up to the speed where the vehicle experiences two-wheel lift or cannot be maintained on the path of the circle. For a constant radius test, "understeer" is defined as the condition when the steering wheel angle required to maintain the circular path increases as the vehicle speed increases because the vehicle is turning less than intended. "Neutral steer" is defined as the condition when the steering wheel angle required to maintain the circular path is unchanged as the vehicle speed increases. "Oversteer" is defined as the condition when the average steering wheel input required to maintain the circular path decreases as the vehicle speed increases because the vehicle is turning more than intended.

SEA tested 10 ROVs; five of those vehicles (A, D, F, I, and J) exhibited sub-limit transitions to oversteer when tested on asphalt (see Figure 12).[30] The five remaining vehicles (B, C, E, G, and H) exhibited a sub-limit understeer condition for the full range of the test.

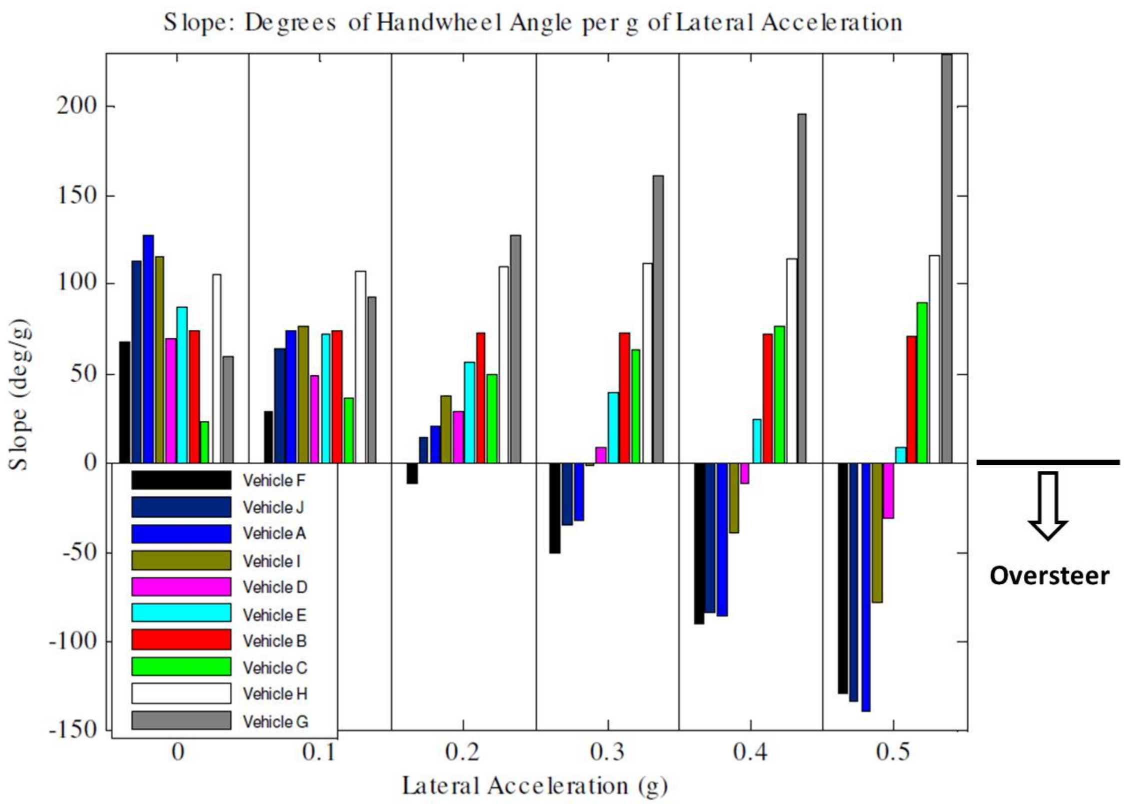


Figure 12. Steering Gradient Slopes at Selected Values of Lateral Acceleration for Tested ROVs
Source: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles – Additional Results for Vehicle J. Retrieved from http://www.cpsc.gov/PageFiles/93928/rovj.pdf. Appendix B, page 24.

Slowly Increasing Steer (SIS) Test

SAE J266, Surface Vehicle Recommended Practice, *Steady-State Directional Control Test Procedures for Passenger Cars and Light Trucks*, also establishes test procedures for the Constant Speed Variable Steer Angle Test. SEA calls this test the constant speed slowly increasing steer (SIS) test. During the SIS test, the ROV driver maintains a constant speed of 30 mph, and the vehicle's steering wheel angle is slowly increased at a rate of 5 degrees per second until the ROV rolls over. SEA conducted SIS tests on the sample of 10 ROVs.

Plots from the ROV SIS tests show a sudden increase in lateral acceleration that is found only in vehicles that exhibit sub-limit oversteer (see Figure 13). The sudden increase in lateral

[30] Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles – Additional Results for Vehicle J. Retrieved from http://www.cpsc.gov/PageFiles/93928/rovj.pdf. Appendix B, page 24.

acceleration is exponential and represents a dynamically unstable condition.[31] This runaway lateral acceleration is undesirable because it can cause a vehicle with high lateral stability (such as a passenger car) to spin out of control, or it can cause a vehicle with low lateral stability (such as an ROV) to roll over suddenly.

In Figure 13, Vehicle A is an ROV that transitions to oversteer; Vehicle H is the same model ROV, but a later model year in which the oversteer has been corrected to understeer.[32]

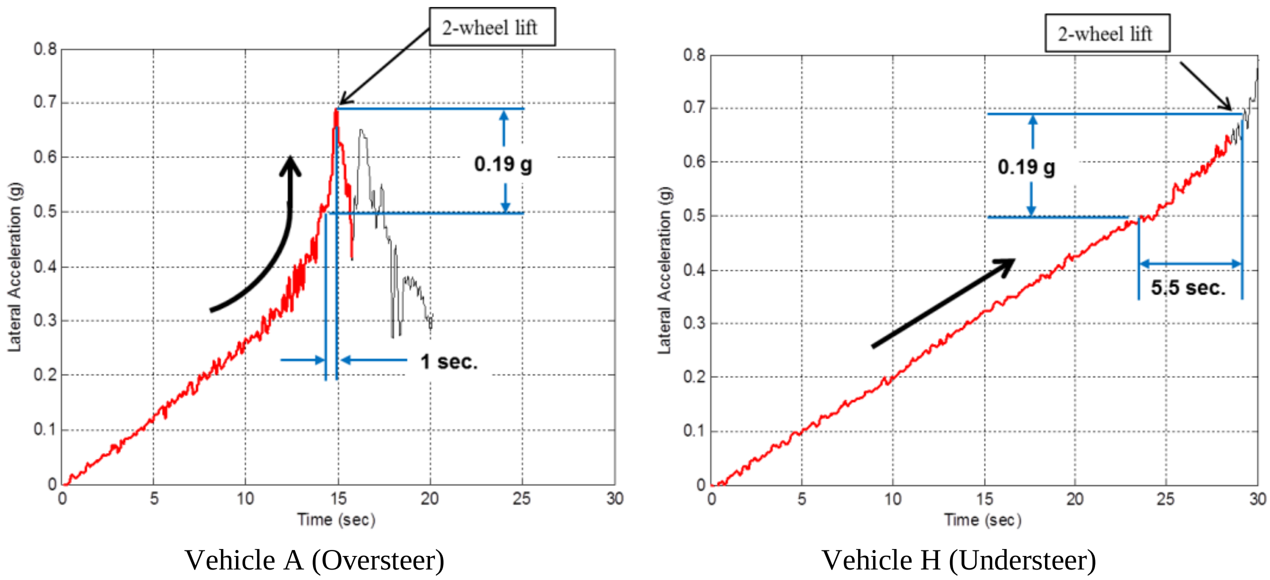


Figure 13. SIS Plots of Lateral Acceleration Gain Over Time

Source: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles . Retrieved from http://www.cpsc.gov/PageFiles/96037/rov.pdf. Appendix D.

When Vehicle A reached its dynamically unstable condition, the lateral acceleration suddenly increased from 0.50 g to 0.69 g (difference of 0.19 g) in less than 1 second, and the vehicle rolled over.[33] In contrast, Vehicle H never reached a point of runaway lateral acceleration increase because the condition does not develop in understeering vehicles.[31] The increase in Vehicle H's lateral acceleration remains linear, and the lateral acceleration increase from 0.50 g to 0.69 g (same difference of 0.19 g) occurs in 5.5 seconds.

SEA test results indicate that ROVs that exhibited sub-limit oversteer also exhibited a sudden increase in lateral acceleration that caused the vehicle to roll over. An ROV that exhibits this sudden increase in lateral acceleration is directionally unstable and uncontrollable.[31,34,35]

[31] Gillespie, T. (1992). Fundamentals of Vehicle Dynamics. Society of Automotive Engineers, Inc. p.204-205.
[32] Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles . Retrieved from http://www.cpsc.gov/PageFiles/96037/rov.pdf. Appendix D.
[33] Outriggers on the vehicle prevented full rollover of the vehicle.
[34] Bundorf, R. T. (1967). The Influence of Vehicle Design Parameters on Characteristic Speed and Understeer. SAE 670078.
[35] Segel, L. (1957). Research in the Fundamentals of Automobile Control and Stability. SAE 570044.

Plots of the vehicle path during SIS tests further illustrate how an oversteering ROV (Vehicle A) will roll over earlier in a turn than an understeering ROV (Vehicle H), when the vehicles are operated at the same speed and steering rate (see Figure 14). Vehicle A and Vehicle H follow the same path until Vehicle A begins to oversteer and its turn radius becomes smaller. Vehicle A becomes dynamically unstable, its lateral acceleration increases exponentially, and the vehicle rolls over suddenly. In contrast, Vehicle H continues to travel 300 more feet in the turn before the vehicle reaches its threshold lateral acceleration and rolls over. A driver in Vehicle H has more margin (in time and distance) to correct the steering to prevent rollover than a driver in Vehicle A because Vehicle H remains in understeer during the turn, while Vehicle A transitions to oversteer and becomes dynamically unstable.

Slowly Increasing Steer (SIS) Test for
Vehicle A (----oversteer) and Vehicle H (— understeer)

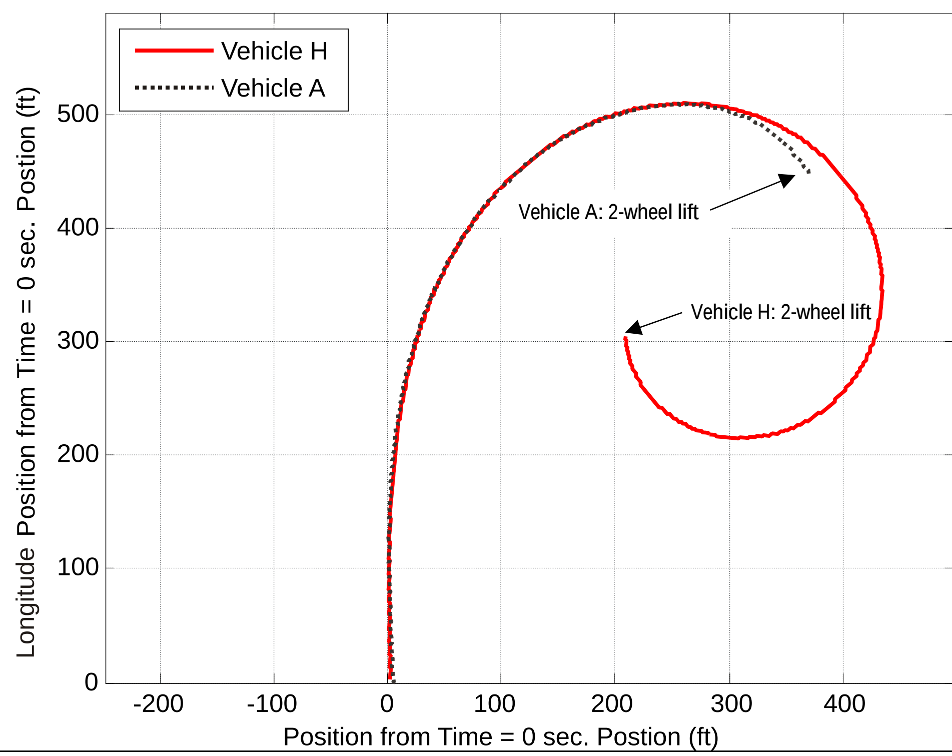


Figure 14. Path of Vehicle A and H During SIS Test (Superimposed In The Right Turn Direction)

<u>Conclusion</u>

CPSC staff believes that tests conducted by SEA provide strong evidence that sub-limit oversteer in ROVs is an unstable condition that can lead to a rollover incident, especially given the low rollover resistance of ROVs. All ROVs that exhibited sub-limit oversteer reached a dynamically unstable condition during a turn where the increase in lateral acceleration suddenly became exponential. CPSC staff believes this runaway lateral acceleration can contribute to ROV rollover on level ground, and especially on pavement.

c. Recommended Requirement for Vehicle Handling

Requirement

CPSC staff recommends a performance requirement that ROVs exhibit sub-limit understeer in the range of lateral acceleration from 0.10 g to 0.50 g when tested on a 100 ft. radius circle in a constant radius test, as described in the draft NPR (see Tab A). CPSC staff believes the constant radius test is the most appropriate method to measure an ROV's steering gradient because SAE J266, Surface Vehicle Recommended Practice, *Steady-State Directional Control Test Procedures for Passenger Cars and Light Trucks*, establishes the constant radius test as a method to measure understeer/oversteer in passenger cars. These test procedures are also applicable to ROVs because ROVs are similar to cars, have four steerable wheels and a suspension system, and thus, ROVs obey the same principles of motion as automobiles (see Tab A).

CPSC staff believes the appropriate lateral acceleration range to measure steering gradient is from 0.10 g to 0.50 g because SEA test results indicate that spurious data occur at the beginning and end of a constant radius test conducted up to vehicle rollover.[36] Data collected in the range of 0.10 g to 0.50 g of lateral acceleration provide the most accurate plots of the vehicle's steering characteristic (see Tab A).

Rationale

CPSC staff believes ensuring sub-limit understeer will reduce rollover events because sub-limit understeer eliminates the potential for sudden and exponential increase in lateral acceleration that can cause ROV rollovers. Tests conducted by SEA show that ROVs in sub-limit oversteer transition to a condition in which the lateral acceleration increases suddenly and exponentially.[37] CPSC staff believes this condition can lead to untripped ROV rollovers or may cause ROVs to slide and experience tripped rollover.

The Yamaha Rhino repair program improved the Yamaha Rhino vehicle's handling by adding spacers on the vehicle's rear wheels and removing the rear stabilizer bar (see Tab J). The sub-limit oversteer, exhibited by an unrepaired vehicle, changed to sub-limit understeer after the repair (see Vehicle A and Vehicle H, respectively, in Figure 12).[38] Additionally, SEA test results show that an unrepaired, oversteering Rhino vehicle reached a dynamically unstable condition during a turn in which the lateral acceleration increased suddenly and caused the vehicle to roll over.[39] In contrast, a repaired, understeering Rhino vehicle did not exhibit this sudden increase in

[36] Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles . Retrieved from http://www.cpsc.gov/PageFiles/96037/rov.pdf. Page 20.
[37] Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles . Retrieved from http://www.cpsc.gov/PageFiles/96037/rov.pdf. Appendix D.
[38] Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles – Additional Results for Vehicle J. Retrieved from http://www.cpsc.gov/PageFiles/93928/rovj.pdf. Appendix B, page 24.
[39] Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles . Retrieved from http://www.cpsc.gov/PageFiles/96037/rov.pdf. Appendix D. Page 1-2. Vehicle A.

lateral acceleration[40] because the dynamic instability does not exist in vehicles operating in sub-limit understeer.

CPSC staff believes the constant radius test results shown in Figure 12 demonstrate that ROVs can be designed to understeer in sub-limit operation with minimum cost and without diminishing the utility or recreational value of this class of vehicle. Half of the vehicles tested already exhibit sub-limit understeer condition for the full range of the test, and this includes both utility and recreational model ROVs.

The number of Rhino-related incidents decreased noticeably after the Yamaha Rhino repair program, which included understeer corrections, was started in March 2009 (see Tab J). CPSC staff also analyzed incidents in which a Yamaha Rhino vehicle rolled over during a turn on flat or gentle terrain and identified at least 41 incidents involving an unrepaired Rhino vehicle, compared to two incidents involving a repaired Rhino vehicle on gentle terrain with a slope of 10 degrees. Staff did not find any incidents involving a repaired Rhino vehicle that rolled over during a turn on flat terrain.

CPSC staff believes the decrease in Rhino-related incidents after the repair program was initiated and the low number of vehicle rollover incidents associated with repaired Rhino vehicles are evidence that increasing the lateral stability of an ROV and correcting oversteer characteristics to understeer reduces the occurrence of ROV rollover on level terrain. In particular, staff believes the elimination of runaway lateral acceleration associated with oversteer contributed to a decrease in Rhino-related rollover incidents.

Voluntary Standards

As discussed further in section IV. of this memorandum, CPSC staff does not believe the current voluntary standards for ROVs will correct sub-limit oversteer in ROVs because the standards do not have vehicle handling requirements.

Conclusion

Because staff believes the current voluntary standard requirements do not adequately address improved rollover resistance of ROVs (through elimination of sub-limit oversteer handling characteristics) and thus do not adequately reduce the risk of injury, and based on the demonstrated safety benefits of improved rollover resistance of the Yamaha Rhino vehicle after implementation of the March 2009 repair program, CPSC staff recommends that the Commission propose a performance requirement that ROVs exhibit sub-limit understeer in the range of lateral acceleration from 0.10 g to 0.50 g when tested on a 100 ft. radius circle, as described in the draft NPR.

[40] Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles . Retrieved from http://www.cpsc.gov/PageFiles/96037/rov.pdf. Appendix D. Page 22-23. Vehicle H.

4. Occupant Protection

a. Overview and Basic Terms

The open compartment configuration of ROVs is intentional and allows for easy ingress and egress, but the configuration also increases the likelihood of complete or partial ejection of the occupants in a rollover event. ROVs are equipped with a ROPS, seat belts, and other restraints for the protection of occupants (see Figure 15). Occupants who remain in the ROV and surrounded by the ROPS, an area known as the protective zone, are generally protected from being crushed by the vehicle during a quarter-turn rollover. Seat belts are the primary restraint for keeping occupants within the protective zone of the ROPS (see Tab I).

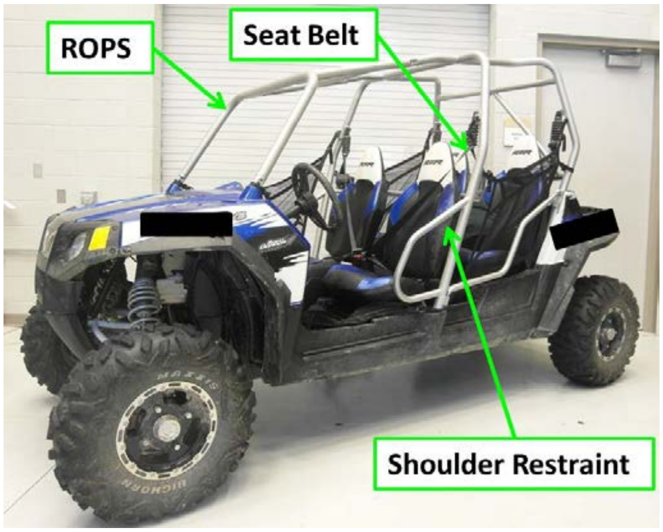


Figure 15. Occupant Protection Components on ROVs

NHTSA evaluates the occupant protection performance of passenger vehicles with tests that simulate vehicle collisions and tests that simulate vehicle rollover.[41] The NHTSA tests use anthropometric test devices (ATDs), or crash test dummies, to evaluate occupant excursion and injury severity during the simulation tests. The occupant movement during these tests is called occupant kinematics. Occupant kinematics is an important element of dynamic tests because forces act on an occupant from many different directions during a collision or rollover.

There are no standardized tests to evaluate the occupant protection performance of ROVs. However, a test to evaluate occupant protection performance in ROVs should be based on simulations of real vehicle rollover. In a rollover event, the vehicle experiences lateral acceleration and lateral roll. A valid simulation of an ROV rollover will reproduce the lateral acceleration and the roll rate experienced by an ROV during a real rollover event.

[41] Federal Motor Vehicle Safety Standard. (1971) 49 CFR 571.208.

b. Seat belts

Seat Belt Use in Incidents

CPSC staff's analysis of 428 ROV-related incidents indicates that where seat belt use is known, 75 percent of all victims were not wearing seat belts, and 91 percent of fatally ejected victims were not wearing seat belts (see Tab I). In addition, 24 percent of all victims were front passengers on the ROV; 64 percent of nonfatal front passenger victims were not wearing seat belts, and 80 percent of the fatal front passenger victims were not wearing seat belts

ROHVA also performed an analysis of hazard and risk issues associated with ROV-related incidents and determined that lack of seat belt use is the top incident factor.[42] ROHVA stated additionally: "Based on the engineering judgment of its members and its review of ROV incident data provided by the CPSC, ROHVA concludes that the vast majority of hazard patterns associated with ROV rollover would be eliminated through proper seat belt use alone."[43]

The issue of low seat belt use in ROV-related incidents mirrors a similar phenomenon in seat belt use rates in fatal passenger vehicle accidents. In 2005, 55 percent of passenger vehicle fatalities were unbelted, 68 percent of pickup truck driver fatalities were unbelted, and 71 percent of pickup truck passenger fatalities were unbelted.[44]

Literature Review

Vehicle manufacturers use seat belt reminders as the primary method to encourage occupants to buckle their seat belts. However, numerous studies have concluded that seat belt reminders vary in effectiveness, based on the aggressiveness of the reminder (see Tab I). Seat belt reminders are more effective when the reminders are aggressive or annoying but not so much so that users will reject or bypass the system. An effective system also motivates users, rather than simply reminding them, to buckle up seat belts by tying seat belt use to eliminating an annoyance. The benefits of aggressive seat belt reminders are more pronounced among people who do not regularly wear seat belts.

A NHTSA study of seat belt reminder effectiveness concluded that: (1) systems with only visual reminders are not effective; (2) more annoying systems are more effective, but that creates the challenge of designing an effective system that is acceptable; (3) potential gains in seat belt use do not come simply from reminding users, but also from motivating users, such as tying seat belt use to eliminating an annoyance; and (4) the positive effects of enhanced seat belt reminders on

[42] Heiden, E. (2009). Summary of Recreational Off-Highway Vehicle (ROV) Hazard Analysis. Memorandum from E. Heiden to P. Vitrano. Docket No. CPSC-2009-0087. Regulations.gov.
[43] Yager, T. (2011) Letter to Caroleene Paul. dated April 18, 2011. Recreational Off-Highway Vehicle Association (ROHVA) written response to CPSC staff's ballot on proposed American National Standard ANSI/ROHVA 1-201X. p. 8. Retrieved from http://www.cpsc.gov/Global/Regulations-Laws-and-Standards/Voluntary-Standards/ROHVA/041811ROHVA1stBallotResponseLtrtoCPSConrevisiontovolstd.pdf.
[44] National Highway Traffic Safety Administration. (2005). *Occupant Protection Traffic Safety Facts – 2005*. (DOT HS-810-621). Washington, D.C.: National Highway Traffic Safety Administration, U.S. Department of Transportation.

belt use were more pronounced for the low belt use propensity groups (people who regularly do not wear seat belts).[45,46]

Innovative Technologies

Researchers developed more innovative in-vehicle technology, beyond visual and audible warnings, to study the effectiveness of systems that hindered a vehicle function if the driver's seat belt was not buckled. One system allowed drivers to start the vehicle but delayed the driver's ability to place the vehicle in gear if the seat belt was not buckled.[47] A follow-up system made it more difficult for the driver to depress the gas pedal when the vehicle exceeded 25 mph if the driver's seat belt was not buckled.[48] Study participants were more receptive to the latter system, which was a consistent and forceful motivator to buckle the seat belt without affecting the general operation of the vehicle. Another study focused on a system that made it more difficult for the driver to depress the gas pedal when the vehicle exceeded 20 mph.[49] The study results showed that seat belt use increased to 100 percent, and most significantly, participants rated the system as very acceptable and agreeable (9 out of a 10 point scale).

In 2010, Bombardier Recreation Products (BRP) introduced the Can-Am Commander 1000 ROV with a seat belt speed limiter system that restricts the vehicle speed to 9 mph if the driver's seat belt is not buckled. CPSC staff performed dynamic tests to verify that the vehicle's speed was limited when the driver's seat belt was not buckled. On level ground, the vehicle's speed was limited to 6 to 9 mph when the driver was unbelted, depending on the ignition key and transmission mode selected (see Tab K).

In 2013, BRP introduced the Can-Am Maverick vehicle as a sport-oriented ROV that also includes a seat belt speed limiter system. CPSC staff did not test the Maverick vehicle because a sample vehicle was not available for testing.

In 2014, Polaris Industries (Polaris) announced that model year 2015 Ranger and RZR ROVs will include an interlocking seatbelt system that limits the speed of the vehicle to 15 mph if the

[45] Freedman, M., Lerner, N., Zador, P., Singer, J., and Levi, S. (2009). Effectiveness and Acceptance of Enhanced Seat Belt Reminder Systems: Characteristics of Optimal Reminder Systems. (DOT HS 811 097). Washington, D.C.: National Highway Traffic Safety Administration, U.S. Department of Transportation.
[46] Lerner, N., Singer, J., Huey, R., Jenness, J. (2007). Acceptability and Potential Effectiveness of Enhanced Seat Belt Reminder System Features. (DOT HS 810 848). Washington, D.C.: National Highway Traffic Safety Administration, U.S. Department of Transportation.
[47] Van Houten, R., Malenfant, J.E.L., Austin, J., & Lebbon, A. (2005). The Effects of a Seatbelt-gearshift Delay Prompt on the Seat Belt Use of Motorists Who Do Not Regularly Wear Seatbelts. *Journal of Applied Behavior Analysis, 38*, 195-203.
[48] Van Houten, R., Hilton, B., Schulman, R., and Reagan, I. (2011). Using Haptic Feedback to Increase Seat Belt Use of Service Vehicle Drivers. (DOT HS 811 434). Washington, D.C.: National Highway Traffic Safety Administration, U.S. Department of Transportation.
[49] Hilton, Bryan W. (2012). The Effect of Innovative Technology on Seatbelt Use. *Masters Theses*. Paper 103. Retrieved from http://scholarworks.wmich.edu/cgi/viewcontent.cgi?article=1110&context=masters_theses.

seatbelt is not engaged.[50] CPSC staff has not tested these vehicles because they are not yet available on the market.

User Acceptance of Innovative Technologies in ROVs (see Tab N)

CPSC staff believes studies of seat belt reminder systems on automobiles are an appropriate foundation for ROV analysis because ROVs are typically driven by licensed drivers and the seating environment is similar to an automobile. However, staff believes data on ROV users' experience and acceptance of seat belt reminders are necessary to validate the analysis.

CPSC staff was not aware of any studies that provide data on the effectiveness of seat belt reminder systems on ROVs or user acceptance of such technologies. Therefore, staff contracted Westat, Inc. (Westat), to conduct focus groups with ROV users to explore their opinions of seat belt speed limitation systems on ROVs. Phase 1 of the effort involved conducting focus groups of ROV users and asking questions about ROV use and user opinions of the Can-Am speed limitation system that were shown in a video to the participants. Results of Phase 1 were used to develop the protocol for Phase 2, in which participants drove an ROV equipped with a seat belt speed limitation system. Phase 2 of the effort conducts focus groups of ROV users who provide feedback after driving and interacting with an ROV, in which the maximum speed has been limited to 10 mph, 15 mph, and 20 mph.

Results of Phase 1 of the Westat study indicate that participants:

- admit to being part-time seat belt users;
- cite familiarity and low-risk perception as reasons for not wearing seat belts;
- value easy ROV ingress and egress over seat belt use;
- generally travel around 5 mph when driving on their own property, and overall, drive 15 to 30 mph for typical use;
- had negative personal but positive parental reactions to the speed limitation technology at 10 mph;
- were more accepting of the speed limitation technology if the speed was raised to 15 mph or if the system was tied to a key control.

Phase 2 of the Westat study is ongoing, and a report of the results is expected by December 2015. The results will provide data on ROV users' acceptance of a seat belt speed limitation technology with a threshold speed of 10 mph, 15 mph, and 20 mph. Staff believes the results will provide additional rationale for determining a threshold speed for a seat belt speed limitation technology that balances users acceptance (as high a speed as possible) with safe operation of the ROV without seat belt use (as low a speed as possible).

c. Staff's Technical Work

[50] Retrieved at: http://www.weeklytimesnow.com.au/machine/sidebyside-vehicles-soon-to-get-safety-improvements/story-fnkerd6b-1227023275396.

To explore occupant protection performance testing for a product for which no standard test protocol exists, CPSC staff contracted Active Safety Engineering (ASE) to conduct two exploratory pilot studies to evaluate potential test methods. After completion of the pilot studies, CPSC staff contracted SEA, Limited (SEA) to conduct occupant protection performance evaluation tests based on a more advance test device designed by SEA.

Pilot Study 1

ASE used a HYGE™ accelerator sled to conduct dynamic rollover simulations on sample ROVs, occupied by a Hybrid III 50th percentile male anthropomorphic test device (ATD).[51] The HYGE™ system causes a stationary vehicle, resting on the test sled, to roll over by imparting a short-duration lateral acceleration to the test sled. As shown in Figure 16, the torso of an unbelted ATD ejected partially from the ROV during a simulated rollover. In comparison, the torso of a belted ATD remained in the ROV during a simulated rollover (see Figure 17). The tests demonstrated that use of a seat belt prevented full ejection of the ATD's torso.

Figure 16. Unbelted occupant test using HYGE™ sled test device.

Figure 17. Belted occupant test using HYGE™ sled test device.

Pilot Study 2

In a follow-up pilot study, ASE used a deceleration platform sled rather than a HYGE™ accelerator sled to impart the lateral acceleration to the test vehicle (Monk, 2010). The deceleration sled is more accurate than the HYGE™ sled in re-creating the lower energy rollovers associated with ROVs.

As shown in Figure 18, an unbelted ATD ejected fully from the vehicle during tests conducted at the rollover threshold of the ROV. In comparison, a belted ATD partially ejected from the vehicle during tests conducted at the same lateral acceleration (see Figure 19). These exploratory

[51] HYGE Inc. manufactures crash simulation systems that simulate the effects of a collision in an acceleration rather than a deceleration mode. HYGE™ systems are used by automobile manufacturers to test passenger safety devices such as seats, seat belts, child restraints, and air bags.

tests with belted and unbelted occupants indicate the importance of using seat belts to prevent full ejection of the occupant during a rollover event.

Figure 18. Unbelted occupant test using deceleration sled test device.

Figure 19. Belted occupant test using deceleration sled test device.

<u>SEA Roll Simulator</u>

SEA designed and built a roll simulator to measure and analyze occupant response during quarter-turn roll events of a wide range of machines, including ROVs.[52] The SEA roll simulator produces lateral accelerations using a deceleration sled and produces roll rates using a motor to rotate the test sled (see Figure 20).

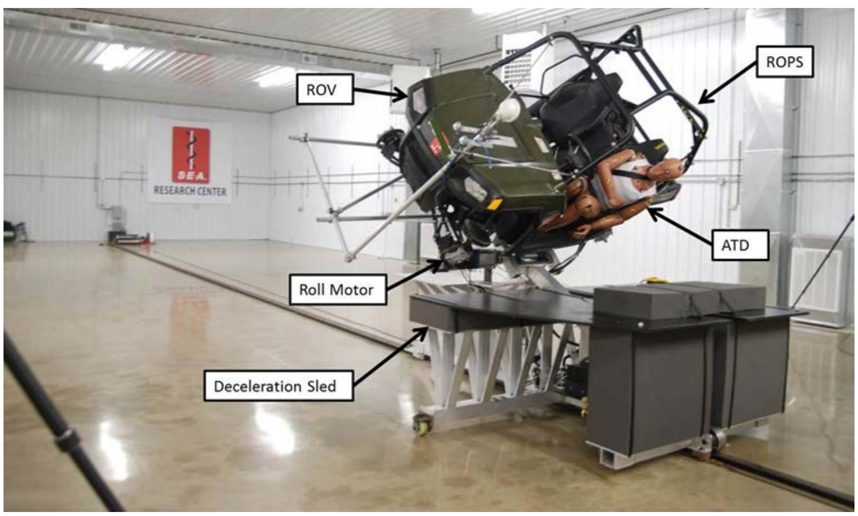


Figure 20. SEA Roll Simulator

Source: Zagorski, S. B., Heydinger, G. J., Sidhu, A., Guenther, D.A., and Andreatta, D. A. (2011). Modeling and Validation of a Roll Simulator for Recreational Off-Highway Vehicles. IMECE 2011-6203.

SEA validated the roll simulator as an accurate simulation of ROV rollover and occupant kinematics by comparing roll rates, lateral accelerations, and ATD ejections that were created by

[52] Zagorski, S. B., Heydinger, G. J., Sidhu, A., Guenther, D.A., and Andreatta, D. A. (2011). Modeling and Validation of a Roll Simulator for Recreational Off-Highway Vehicles. IMECE 2011-6203.

the simulator with actual values measured during autonomous rollover. Results show that the roll simulator accurately re-creates the conditions of an ROV rollover. Staff believes that the vehicle kinematics on the SEA rollover simulator more accurately represent real-world events because SEA validated the sled kinematics against full-vehicle real-world rollover events.

SEA simulated tripped and untripped rollovers of seven sample ROVs using belted and unbelted ATD occupants.[53] Plots of the head excursion data (shown as red, blue, and green plots) indicate how well the vehicle's occupant protection features retain the occupant inside the protective zone of the ROPS during a roll simulation (see Figure 21). Head displacement plots above the ROPS Plane indicate the occupant's head stayed inside the ROPS zone, and plots below the ROPS Plane indicate that the occupant's head moved outside the ROPS zone.

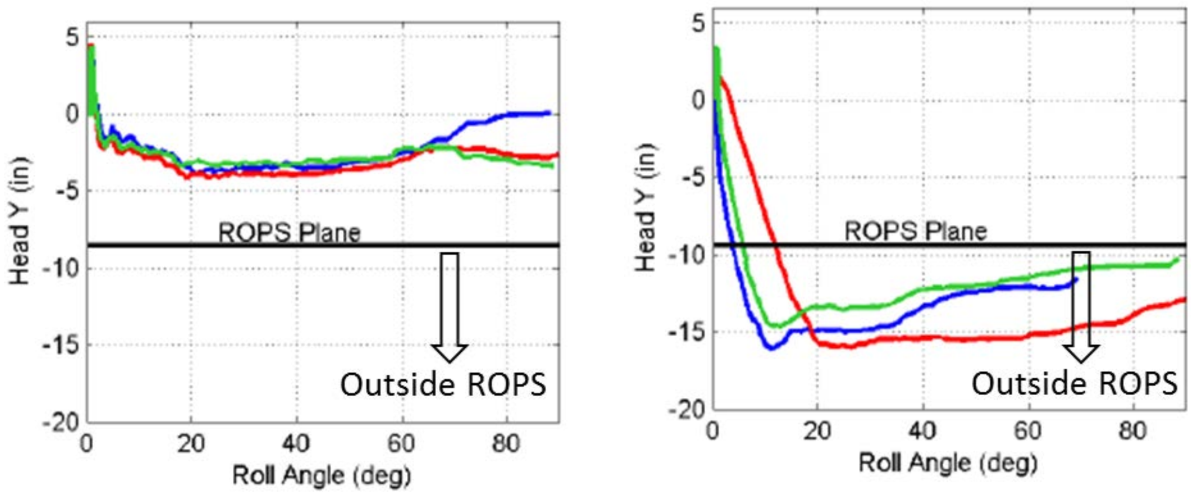


Figure 21. Exemplar Plots of Head Excursion During ROV Roll Simulation

Source: Morr, D. (2012) Test and Evaluation of Recreational Off-Highway Vehicles (ROVs) Dynamic Occupant Protection Performance Tests. Retrieved from http://www.cpsc.gov/Global/Research-and-Statistics/Technical-Reports/Sports-and-Recreation/ATV-ROV/ROVOccupantProtectionPerformanceTests.pdf.

The SEA roll simulator test results indicate that five of the seven ROVs tested allowed a belted occupant's head to eject outside the ROPS of the vehicle during a quarter-turn rollover simulation. The occupant protection performance of belted occupants varied from vehicle to vehicle, depending on seat belt design, passive hip and shoulder coverage, whether the rollover was tripped or untripped, and ROPS dimensions and geometry (see Tab H).

CPSC staff analysis of the SEA roll simulator test results indicate that vehicles with the best occupant protection performance restricted movement of the occupant with combinations of quick-locking seat belts, passive coverage in the hip and shoulder areas of the occupant, and large ROPS zones around the occupant's head (see Tab H). Rollover tests indicate that a seat belt is effective at preventing full occupant ejection, but in some cases where the seat belt does not lock quickly, partial occupant ejection still occurs. However, when a seat belt is used in conjunction with a passive shoulder barrier restraint, testing indicates that the occupant remains within the protective zone of the vehicle's ROPS during quarter-turn rollover events.

[53] Morr, D. R. (2012). Test and Evaluation of Recreational Off-Highway Vehicles (ROVs) Dynamic Occupant Protection Performance Tests. Retrieved from http://www.cpsc.gov/Global/Research-and-Statistics/Technical-Reports/Sports-and-Recreation/ATV-ROV/ROVOccupantProtectionPerformanceTests.pdf.

The SEA roll simulator test results also indicate that unbelted occupants are partially or fully ejected from all vehicles, regardless of the presence of other passive restraints such as hip restraints or shoulder restraints. While passive shoulder barriers may not provide substantial benefit for occupant protection in unbelted rollovers, the roll simulator test results indicate shoulder restraints significantly improved occupant containment when used in conjunction with a seat belt.

Although the SEA roll simulator is the most advanced test equipment viewed by CPSC staff to date, and the test results provide clear evidence of occupant head excursion, not enough test data has been generated to base dynamic occupant protection performance test requirements on a device like the roll simulator. Therefore, staff is using the roll simulator test results to focus on occupant protection requirements that maximize occupant retention through seat belt use with passive shoulder restraint.

ANSI/ROHVA 1-2011 Occupant Protection Tests

CPSC staff tested 10 sample ROVs to the occupant retention system (ORS) zone requirements specified in ANSI/ROHVA 1-2011. Requirements are specified for Zone 1 – Leg/Foot, Zone 2 – Shoulder/Hip, Zone 3 – Arm/Hand, and Zone 4 – Head/Neck. CPSC staff focused on the requirements for Zone 2 because occupant ejection occurs in this zone (see Tab H).

ANSI/ROHVA Zone 2 – Shoulder/Hip requirements allow the vehicle to pass one of two different test methods to meet that zone's requirement. Under the first option, a construction-based method defines an area near the occupant's side that must be covered by a passive barrier. The test involves applying a 163-lbf. load at a point in the defined test area without failure or deformation of the barrier. Under the second options, a performance-based method specifies a tilt table test with a vehicle occupied by a belted test dummy. When the vehicle is tilted to 45 degrees on the tilt table, the ejection of the dummy must not exceed 5 inches beyond the vehicle width.

Results of CPSC staff tests indicate that only four of 10 vehicles passed the construction-based test requirements; and eight of 10 vehicles passed the performance-based test requirements (see Tab H). CPSC staff analysis identified a primary weakness with the performance-based tilt table tests. The performance-based test criteria measure the torso excursion outside the vehicle width, not the excursion outside the protective zone of the ROPS. An occupant must remain inside the envelope of the ROPS to be protected; therefore, the requirement allows an inherently unsafe condition where the occupant moves outside the protective zone of the vehicle's ROPS.

CPSC staff measured the difference between the outermost point of the ROV and the outermost point on the ROPS near the occupant's head (see Figure 22). On one vehicle, the vehicle's maximum width was 6.75 inches outside the maximum ROPS width near the occupant's head. Because the requirement is based on a 5-inch limitation beyond the vehicle width, the occupant's torso could be 11.75 inches (6.75 inches plus 5 inches) outside of the vehicle ROPS and still meet the performance-based requirement.

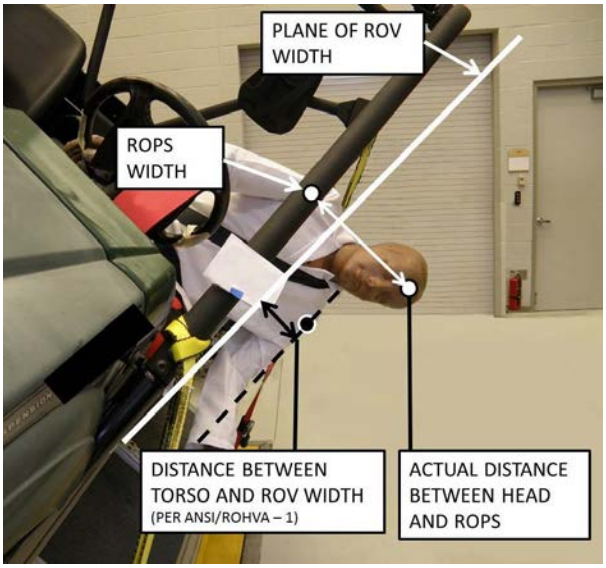


Figure 22. Difference Between Torso and Head Excursion During Tilt Table Test

CPSC staff also compared the occupant head excursion relative to the torso excursion during the tilt table tests. Due to occupant rotation during the tests, the maximum head displacement exceeded the torso displacement by up to 3 inches. The discrepancy between head and torso displacement and between the vehicle width and ROPS width can result in occupant head ejection that is 14.75 inches (11.75 inches plus 3 inches) outside the protective zone of the ROPS and still meet the performance-based requirement.

d. Recommended Requirements for Occupant Protection – Speed Limitation

Requirement

CPSC staff recommends a performance requirement that limits the maximum speed that an ROV can attain to 15 mph or less when tested with unbelted front seat belts in the maximum speed test described in the draft NPR. The voluntary standard for ATVs and ROVs establish test protocols to measure maximum speed on level ground, and staff believes the same maximum speed test is the most appropriate method to measure the limited speed of an ROV.

Rationale

Results of CPSC staff's exploratory testing of belted and unbelted occupants in simulated ROV rollover events showed that forces during a rollover event eject unbelted occupants from the vehicle, while belted occupants remain within the vehicle (see Tab H and Tab I). This observation corresponds with the incident data for ROV rollovers, where 91 percent of the fatal victims who were partially or fully ejected from the vehicle were not wearing seat belts.[54] Of those incidents that involved occupant ejection, many occupants were killed when struck by the

[54] Although a small number of incidents involved belted victims who were still partially or full ejected from the vehicle, the majority of incidents involved unbelted victims who were ejected from the vehicle.

vehicle after they were ejected. CPSC staff believes that many of the ROV occupant-ejection deaths and injuries can be eliminated if occupants wear seat belts.

Studies have shown that automobile seat belt reminders do not increase seat belt use, unless the reminders are aggressive enough to motivate users to buckle seat belts without alienating the user into bypassing or rejecting the system (see Tab I). Based on CPSC staff's testing and literature review, and the low seat belt use rates in ROV-related incidents, staff believes a seat belt speed limiting system that restricts the maximum speed of the vehicle to 15 mph if any occupied front seats are not buckled is the most effective method to increase seat belt use rates in ROVs.

CPSC staff believes that in-vehicle technology that limits the speed of the ROV if the front occupied seats are not buckled will be accepted by ROV users because the technology does not interfere with the operation of the ROV below the threshold speed, and users will be motivated to wear seat belts to exceed the threshold speed. This belief is based on automotive studies that showed drivers accepted a system that reduced vehicle function (more effort to depress the accelerator pedal) after a threshold speed if the driver's seat belt was not buckled. The system did not interfere with the operation of the vehicle below the threshold speed, and drivers were willing to buckle their seat belts to access unhindered speed capability of the vehicle.

CPSC staff also believes speed-limitation technology will be accepted by ROV users because the technology is already included on the BRP Can-Am Commander and Can-Am Maverick model ROVs, and the manufacturer with the largest ROV market share, Polaris, announced that it will introduce the technology on model year 2015 Ranger and RZR ROVs.

CPSC staff's literature review concludes that intrusive reminders are effective at changing user behavior, as long as the reminder is not so intrusive that users bypass the system (see Tab I). Limitation of vehicle speed is the intrusive reminder for ROV users to buckle their seat belt; therefore, staff believes that the threshold speed for a seat belt speed limitation system should be as high as possible to gain user acceptance (and reduce bypass of the system), but low enough to allow relatively safe operation of the vehicle.

CPSC staff believes 15 mph is the appropriate speed threshold for a seat belt speed limitation system for the following reasons:

Relatively Safe Operation of the ROV at 15 mph

- ANSI/NGCMA Z130.1 – 2004, *American National Standard for Golf Carts – Safety and Performance Specifications,* specifies the maximum speed for golf carts at 15 mph. This standard establishes 15 mph as the maximum acceptable speed for unbelted drivers and passengers (golf carts do not have seat belts or ROPS) in vehicles that are often driven in off-road conditions.
- SAE J2258, *Surface Vehicle Standard for Light Utility Vehicles,* specifies a speed of 15 mph as acceptable for a vehicle, with a lateral stability of at least 25 degrees on a tilt table test, without seat belts or ROPS. This standard also establishes 15 mph as the maximum acceptable speed for unbelted drivers and passengers in vehicles that are driven in off-road conditions.

- Polaris Ranger and RZR model year 2015 ROVs will be equipped with a seat belt speed limiter that limits the vehicle speed to 15 mph if the driver's seat belt is not buckled. The decision by the largest manufacturer of ROVs establishes 15 mph as the maximum acceptable speed for unbelted ROV drivers.
- The fundamental relationship between speed and lateral acceleration is[55]:

$$A = V^2/R$$

where A = lateral acceleration
V = velocity
R = radius of turn

The minimum proposed lateral acceleration threshold at rollover for ROVs is 0.70 g, and the typical turn radius of an ROV is 16 feet.[56] Therefore, without any additional effects of tire friction, the speed at which rollover would occur during a turn on level ground is 13 mph.[57] In reality, friction at the tires would increase the speed at which rollover occurs above 13 mph.

User Acceptance of 15 mph

- Results of Westat's focus group study of ROV users indicate that ROV users value easy ingress and egress from an ROV and generally drive around 15 mph to 30 mph during typical use of the ROV. Users had negative personal but positive parental reactions to a speed threshold of 10 mph, and were more accepting of a speed limitation technology if the threshold speed was 15 mph.
- There are many situations in which an ROV is used at slow speeds, such as mowing or plowing, carrying tools to jobsites, and checking property. CPSC staff believes a speed limitation threshold of 15 mph allows the most latitude for ROV users to perform utility tasks where seat belt use is often undesired.
- CPSC staff believes ROV user acceptance of a seat belt speed limitation system will be higher at 15 mph than the speed threshold of 9 mph on the Commander ROV. Although BRP continues to sell the Can-Am Commander and Can-Am Maverick ROVs with speed limitations set around 10 mph, focus group responses indicated that many ROV users believe 10 mph is too low a speed limit to be acceptable and will bypass the system. The 15 mph threshold is 50 percent higher than a 10 mph threshold, and staff believes the difference will increase user acceptance of the system. Staff believes Polaris's decision to include seat belt speed limiters with a 15 mph threshold speed in model year 2015 Ranger and RZR ROVs supports staff's belief that user acceptance of a speed limitation system will be higher at 15 mph than 10 mph.

[55] Halliday, D. and Resnick, R. (1974). Fundamentals of Physics Volume 1. New York, NY: John Wiley & Sons. p 111.
[56] Turn radius values retrieved at: http://www.atv.com/features/choosing-a-work-vehicle-atv-vs-utv-2120.html and http://www.utvunderground.com/2014-kawasaki-teryx-4-le-6346.html.
[57] Staff recognizes that on a slope, the lateral acceleration due to gravity can cause ROV rollover at speeds below 15 mph. However, staff believes it is appropriate to use level ground as a baseline.

Voluntary Standards

ANSI/ROHVA 1-2011, *American National Standard for Recreational Off-Highway Vehicles* and ANSI/OPEI B71.9-2012, *American National Standard for Multipurpose Off-Highway Utility Vehicles,* require only an 8-second reminder light to motivate users to buckle seat belts. This requirement is similar to the Federal Motor Vehicle Safety Standard (FMVSS) seat belt reminder requirements for automobiles. Manufacturers in the automotive industry have long since exceeded such minimal seat belt reminder requirements because studies have proven that the FMVSS requirements, and indeed visual only reminders, are not effective.[58]

CPSC staff believes that the ANSI/ROHVA 1-2011 and ANSI/OPEI B71.9 - 2012 requirements for an 8-second seat belt reminder light are not adequate to increase meaningfully seat belt use rates in ROVs because the seat belt reminder system is not intrusive enough to motivate drivers and passengers to wear their seat belts.

Conclusion

Because staff believes that current voluntary standard requirements do not adequately address increased seat belt use and thus do not adequately reduce the risk of injury, as supported by the high percentage of driver and front passenger victims who were ejected from ROVs during rollover events, CPSC staff recommends that the Commission propose a performance requirement that limits the maximum speed that an ROV can attain to 15 mph or less when performing maximum speed tests on level ground with front seat belts unbuckled, as described in the draft NPR.

e. Recommended Requirements for Occupant Protection – Shoulder Probe Test

Requirement

CPSC staff recommends a performance requirement that ROVs pass a probe test, in which a probe representing the upper arm of a 5th percentile female is applied at a defined area near the ROV occupants' shoulder, as described in the draft NPR (see Tab H). CPSC staff believes that the probe test is the most appropriate method to measure the occupant protection performance in the shoulder area of the ROV because various forms of the probe test are already used in the voluntary standard for ROVs and ATVs to determine occupant protection performance.

The test applies a probe with a force of 163 lbs. to a defined area of the vehicle's ROPS near the ROV occupants' shoulder. The vertical and forward locations for the point of application of the probe are based upon anthropometric data. The probe dimensions are based on the upper arm of a 5th percentile adult female, and represent the smallest size occupant that may be driving or riding an ROV. The 163 lb. force application represents a 50th percentile adult male occupant pushing against the barrier during a rollover event. The probe is applied for 10 seconds and the vehicle structure must absorb the force without bending more than 1 inch.

[58] Westefeld, A. and Phillips, B.M. (1976). Effectiveness of Various Safety Belt Warning Systems. (DOT HS 801 953). Washington, D.C.: National Highway Traffic Safety Administration, U.S. Department of Transportation.

Rationale

After exploring several methods to test occupant protection performance of ROVs during a rollover event, CPSC staff believes the SEA roll simulator is the most accurate simulation of a rollover because the roll simulator is able to reproduce the lateral acceleration and roll rate experienced by ROVs in rollover events. SEA conducted simulations of tripped and untripped rollovers on ROVs with belted and unbelted ATD occupants. CPSC staff's analysis of SEA's test results indicate that the best occupant retention performance results, in which occupants remain within the protective zone of the vehicle's ROPS, occurred when a seat belt is used in conjunction with a passive shoulder barrier restraint.

Voluntary Standards

CPSC staff does not believe the current voluntary standards for ROVs will ensure that the shoulder and head of belted occupants remain within the protective zone of the vehicle's ROPS during quarter-turn rollover events. ANSI/ROHVA 1-2011 allows ROVs to meet occupant protection performance requirements by passing a tilt table test that measures the movement of the torso of a belted test dummy outside the ROV. CPSC staff's test results indicate the tilt table test allows unacceptable occupant head excursion beyond the protective zone of the vehicle ROPS. ANSI/OPEI B71.9-2012 requires that ROVs be equipped with occupant side retention devices, but no performance tests are specified to determine compliance with the requirement. CPSC staff believes the ANSI/OPEI standard's lack of specific compliance tests and performance requirements fail to ensure that an occupant is adequately protected within the ROPS of an ROV during rollover events.

Conclusion

Because staff believes that current voluntary standard requirements do not adequately ensure that the shoulder and head of belted occupants remain within the protective zone of the ROPS during quarter-turn rollover events and thus do not adequately reduce the risk of injury, and based on number of injuries and deaths that can be reduced through seat belt use in conjunction with effective passive shoulder restraint, CPSC staff recommends that the Commission propose a performance requirement that ROVs pass a probe test in the shoulder area of an ROV, as described in the draft NPR.

C. Preliminary Regulatory Analysis

The Directorate for Economic Analysis (EC) conducted a preliminary regulatory analysis of the draft proposed rule that is included at Tab B. The main findings are summarized here.

1. Societal Cost of Fatal and Nonfatal Injuries

The intent of the proposed rule is to reduce the risk of injury and death associated with incidents involving ROVs. Therefore, any benefits of the proposed rule could be measured as a reduction in the societal costs of injuries and deaths associated with ROVs. Staff used 2010 as the baseline for staff's analysis because that is the year for which staff has the most comprehensive estimates of both fatal and nonfatal injuries associated with ROVs. Costs are reported in 2012 dollars.

Societal Costs of Fatal Injuries

As of April 5, 2013, CPSC staff identified 49 fatalities involving ROVs that occurred in 2010. Based on a cost of $8.4 million for each death, the societal costs associated with ROV-related fatalities in 2010 is approximately $411.6 million.

Societal Cost of Nonfatal Injuries

As described in Section II.C.2, CPSC staff conducted a special study of ROV-related injuries that were reported as ATV or UTV incidents through NEISS between January 1, 2010 and August 31, 2010. Based on the special study analysis, staff estimated that there were 3,000 ROV-related emergency department-treated injuries in 2010, with a corresponding 95 percent confidence interval of 1,100 to 4, 900.

The Injury Cost Model (ICM), developed by CPSC for estimating the societal cost of injuries, uses empirical relationships between cases initially treated in hospital emergency departments and cases initially treated in other medical settings to estimate the number of medically attended injuries that were treated outside of a hospital emergency department.[59] Using the ROV cases identified in the special study, the ICM estimates that 27 percent of the injuries were initially treated in hospital emergency departments. Applying this estimate to the estimate of 3,000 emergency department-treated injuries results in an estimate of 11,100 medically treated injuries involving ROVs in 2010.[60]

Based on the ICM estimated average societal cost of $29,383 for a medically attended injury associated with ROVs, the total societal costs of the medically attended injuries involving ROVs in 2010 was approximately $326.2 million.

Societal Costs of Fatal and Nonfatal Injuries per ROV in Use

The total estimated societal cost of fatal and nonfatal injuries associated with ROVs in 2010 was $737.8 million ($411.6 million + $326.2 million). Based on staff's estimate of 570,000 ROVs in use in 2010 (see Section II.B.2), and assuming that ROVs have the same operability rates as ATVs, staff estimates the present value of the societal cost of injuries over the expected 15 to 20 years of useful life of an ROV (at a 3 percent discount rate) is $17,784.[61,62]

[59] For a more complete discussion of the Injury Cost Model see Ted R. Miller, et al., The Consumer Product Safety Commission's Revised Injury Cost Model, (December 2000). Available at:
http://www.cpsc.gov/PageFiles/100269/costmodept1.PDF.
http://www.cpsc.gov/PageFiles/100304/costmodept2.PDF.

[60] The ICM estimate of 11,100 medically treated injuries includes the 3,000 emergency department-treated injuries in 2010.

[61] Staff's choice of discount rate is consistent with research suggesting that a real rate of 3 percent is an appropriate discount rate for interventions involving public health (see Gold, Marthe R, Joanna E. Siegel, Louise B. Russell and Milton C. Weinstein, 1996, *Cost-Effectiveness in Health and Medicine*, New York: Oxford University Press).

2. Lateral Stability and Vehicle Handling Requirements

The lateral stability and vehicle handling requirements of the draft proposed rule are intended to reduce incidents of ROV rollover during a turn.

Costs to Manufacturers

CPSC staff believes manufacturers will conduct tests to measure characteristics of their model ROVs to determine if the ROVs meet the recommended lateral stability and vehicle handling requirements. Staff believes these tests will include measurement of an ROV's center of gravity, rollover resistance, and vehicle handling characteristic. Staff estimates that manufacturers will incur costs of $24,000 to test an ROV model for compliance with the recommended lateral stability and vehicle handling requirements.[63]

If an ROV model does not meet the recommended lateral stability or vehicle handling requirements, CPSC staff believes the manufacturer will incur costs to adjust the vehicle's design. The Yamaha Rhino repair program demonstrated that an ROV that did not meet the lateral stability and vehicle handling requirements was successfully modified to meet the requirements by increasing the track width and reducing the rear suspension stiffness (by removing the sway bar) of the ROV. Based on experience with automotive manufacturing, the Directorate for Engineering Sciences believes that less than 1 or 2 person-months would be required to modify an ROV model that did not comply with the requirements. A high estimate would be that a manufacturer might require as many as 4 person-months (or about 700 hours) to modify. Assuming an hourly rate of $61.75, which is the estimated total hourly compensation for management, professional, and related workers, the cost to modify the design of an ROV model to meet the stability and handling requirements, using the high estimate, would be about $43,000.

Therefore, if test results show that an ROV model does not meet the recommended lateral stability and vehicle handling requirements, staff estimates that manufacturers will incur costs of $91,000 ($24,000 + $43,000 + $24,000) to test their ROV models for compliance with the lateral stability and vehicle handling requirements, modify the design of the models, and retest the vehicle to ensure compliance. Any added manufacturing costs, such as additional labor or components, are expected to be minimal because the assembly of an ROV already includes installation of a wheel axle and installation of a longer wheel axle or wheel spacer would not change the current assembly procedure. Likewise, the assembly of an ROV already includes

[62] The present value of the societal cost was calculated as follows:
$(\$1,294/1.03) \bullet X_1 + (\$1,294/1.03^2) \bullet X_{2} + \ldots + (\$1,294/1.03^i) \bullet X_i = \$17,784$, where X_i represents the likelihood that an ROV remains in use after *i* years.

[63] This estimate is based on the rates that CPSC has most recently paid a contractor for conducting these tests. For example, see contract CPSC-D-11-0003, which provides the following cost estimates: $3,000 for static measurement to determine center of gravity location, $19,000 to perform dynamic tests, and $2,000 to ship vehicles. This amounts to approximately $24,000.

installation of sway bars and shock absorbers; therefore, installation of different variations of these suspension components would not affect the current assembly procedure.

If these estimated costs of $24,000 to $91,000 were amortized over the full production of a model, which is estimated to average approximately 1,800 vehicles per model over a 5-year production, these costs may average about $3 to $10 per vehicle.[64]

Benefits

As mentioned above, the lateral stability and vehicle handling requirements of the draft proposed rule are intended to reduce incidents of ROV rollover during a turn. Therefore, the benefits of the recommended lateral stability and vehicle handling requirements may be measured as a reduction in the societal costs of injuries and deaths associated with ROV rollover during a turn.

As described in Section 1 above, staff estimates that the societal cost of deaths and injuries associated with ROVs is $17,784 over the useful life of an ROV. According to staff's review of ROV-related incident data, at least 35 percent of the injuries occurred when an ROV rolled sideways when making a turn. Therefore, staff estimates that the lateral stability and vehicle requirements of the draft proposed rule would address approximately $6,224 in societal costs per ROV ($17,784 x 0.35). Consequently, given that the estimated cost of the lateral stability and handling requirements is, at most, about $10 per ROV, the requirements would have to prevent less than 0.2 percent of the rollover incidents ($10 ÷ $6,224) for the benefits of the requirement to exceed the costs.

3. Occupant Protection Requirements

The occupant protection requirements (consisting of passive shoulder barrier requirement and vehicle speed limitation requirement) of the draft proposed rule are intended to keep occupants within the protective zone of the vehicle's ROPS in case of an accident, especially a lateral rollover.

Costs to Manufacturers

<u>Passive Shoulder Barrier Requirement</u>

CPSC staff believes manufacturers will meet the proposed passive shoulder coverage requirement with a fixed barrier or structure on the ROV. Most ROVs already have some occupant protection barriers or structures, and in some cases, these structures might already meet the requirements of the draft proposed rule. In other cases, they could be modified or repositioned to meet the requirements of the draft proposed rule. A simple barrier that would meet the requirement could be fabricated out of a length of metal tubing that is bent and bolted or welded to the ROPS or other suitable structure of the vehicle in the shoulder/hip zone of the vehicle, as defined in the draft proposed rule.

[64] Average number of ROV units sold is based on CPSC staff analysis of sales data from Power Products Marketing of Eden Prairie, MN.

Based on estimated costs for materials, labor, and front and rear seating capacity of ROVs, staff estimates that the weighted average cost per ROV to meet the passive barrier requirement would be approximately $7.

Speed Limitation Requirement

Based on CPSC staff's examination of and experience with speed-limiting technology, staff believes most systems that would meet the vehicle speed limitation requirement of the draft proposed rule will include the following:

- Sensor switch to indicate a seat is occupied
- A control system to limit vehicle speed based on sensor switches
- A means to limit the vehicle speed
- Wiring and feedback indicators.

Based on experience with automotive manufacturing, the Directorate for Engineering Sciences believes that manufacturers will incur approximately 9 person-months of effort to design a speed limitation system, produce and test prototypes, and modify the vehicle production process to incorporate the new technology. Based on compensation rates for professional occupations and staff's estimate of 9 person-months of effort (or 1,560 hours), staff estimates manufacturers will incur costs of $100,000 to research, design, and implement modifications to meet the seat belt speed limitation requirement.

Based on staff experience with testing the maximum speed of ATVs, the Directorate for Engineering Sciences estimates that manufacturers will incur costs of $4,000 to test an ROV model for compliance with the recommended seat belt speed limitation requirement.[65]

Therefore, staff estimates manufacturers will incur costs of about $104,000 per model for the research and development and testing that would be required to modify ROVs to meet the occupant retention requirements of the draft proposed rule. If these costs were spread over the full production of a model, these costs may average about $12 per vehicle.

In addition to the cost of developing and implementing the speed limitation system, manufacturers will incur costs to acquire any parts required for the system and install the parts on the vehicles. Based on research of part costs and engineering staff experience with automotive engineering practices, Table 2 summarizes staff's estimates of costs that manufacturers will incur to acquire and install parts for a system that limits vehicle speed if the driver's seat belt is not fastened:

[65] The estimate assumes that the testing will require three professional employees 4 hours to conduct the testing at $61.75 per hour per person. Additionally, the rental of the test facility will cost $1,000, rental of the radar gun will cost $400, and transportation to the test facility will cost $1,400. Installing the redundant seat belts into the test vehicle is estimated to cost $300. Staff assumes that the test vehicle can be sold after the testing is complete. If it cannot be sold, the cost of the testing would have to be increased to include the cost of the vehicle used in the testing.

Table 2. Estimated Manufacturing Costs of Speed Limitation Components for Driver Seat Belt Status (costs spread over the full production of a model ROV).

Component	Cost
Seat Belt Use Sensor	$7
Throttle or Engine Control	$0 to $25
Visual Signal to Driver	$1
Labor	$2
Quality Control Testing	$4
Total	***$14 to $39***

Incorporating the front passenger seats into the requirement would require additional seat belt latch switches and occupant sensor switches to determine if the seat belt of an occupied passenger seat is buckled. Staff estimates that manufacturers will incur parts and labor costs of $24 per passenger seat.[66] Therefore, the quantifiable cost of extending the seat belt/speed limitation requirement to include the front passenger seat belts would be $24 for ROVs with only two seating positions in the front (*i.e.*, the driver and right front passenger) and $48 for ROVs that have three seating positions in the front. According to a survey by Heiden Associates, about 9 percent of ROVs were reported to have a seating capacity of three.[67] Therefore, the average cost of extending the seat belt/speed limitation requirement per ROV would be $26 ($24 + .09 x $24).

In summary, staff estimates manufacturers will incur costs of $59 to $84 to design, manufacture, and test ROVs to meet the occupant protection requirements.[68]

Benefits

As mentioned above, the occupant protection requirements of the draft proposed rule are intended to keep occupants within the protective zone of the vehicle's ROPS in case of an accident, especially a lateral rollover. Therefore, the benefits of the recommended occupant protection requirements may be measured in terms of a reduction in the societal costs of injuries and deaths associated with occupants ejected from an ROV. Research conducted by NHTSA and others leads CPSC staff to project that the use of seat belts in ROVs, along with a passive

[66] Estimates are based on $7 for seat belt latch switch, $13 for seat sensor switch, and $4 for labor. NHTSA estimated the cost of a seat belt sensor switch to be $2 to $5 in 1997 dollars; CPSC staff adjusted the cost to 2012 dollars. Staff estimated the cost of a seat sensor switch based on the cost of a replacement occupant sensor switch in a riding lawn mower. Staff estimated labor costs assuming 5 minutes to install the components on an assembly line and labor compensation rate of $26.11, in accordance with the U.S. Department of Labor, Bureau of Labor Statistics, Employer Costs for Employee Compensation – Table 9, June 2012 (Retrieved from: http://www.bls.gov/news.release/archives/ecec_09112012.pdf.)

[67] Heiden Associates, Results from the 2009 ROV Exposure Survey (APPENDIX 2 to Joint Comments of Arctic Cat Inc., Bombardier Recreational Products Inc., Polaris Industries Inc., and Yamaha Motor Corporation, U.S.A regarding CPSC Advance Notice of Proposed Rulemaking-Standard for Recreational Off-Highway Vehicles: Docket No. CPSC – 2009-0087), Alexandria Virginia (December 4, 2009).

[68] Estimate is based on $12 in design and test costs, $7 to meet passive shoulder coverage requirement, $14 to $39 in parts and labor for driver seat component of speed limitation system, and $26 in parts and labor for passenger seat component of speed limitation system.

shoulder restraint, may reduce the risk of a fatality by 45 percent and may reduce the societal costs associated with nonfatal injuries by 20 percent. Using these estimates and information collected by CPSC on the characteristics of ROV incidents (*e.g.*, the location of the victims and seat belt use status), CPSC staff estimates that the occupant retention requirements could result in an annual reduction in the societal cost of injuries of $160 per ROV in use. Over the useful life of an ROV, the present value of this benefit is estimated to be $2,199. Consequently, the expected quantifiable benefits of the occupant protection requirements are significantly greater than the estimated costs of $59 to $84 per ROV.

4. Summary of the Costs and Benefits of Draft Proposed Rule

CPSC staff estimates that manufacturers will incur costs of:

- $3 to $10 per ROV unit to meet the recommended lateral stability and vehicle handling requirements; and
- $59 to $84 to meet the recommended occupant protection requirements.

CPSC staff estimates the benefits in potential reduction in fatal and nonfatal injuries to be:

- Unknown positive benefit per ROV if less than 0.2 percent of the rollover incidents are prevented by the recommended lateral stability and vehicle handling requirements; and
- $2,199 per ROV if recommended occupant protection requirements reduce ROV-related fatalities by 45 percent and reduce ROV-related nonfatalities by 20 percent.

On a per-unit basis, staff estimates the total costs of the proposed rule to be $61 to $94 per vehicle. Staff estimates the total quantifiable benefits of the proposed rule to be $2,199 per unit. This results in net quantifiable benefits of $2,105 to $2,138 per unit. Staff notes that quantifiable benefits of the proposed rule could exceed the estimated $2,199 per unit because the benefit associated with the vehicle handling and lateral stability requirement could not be quantified.

D. Initial Regulatory Flexibility Analysis

The Directorate for Economic Analysis (EC) conducted an initial flexibility analysis of the draft proposed rule that is included at Tab C. The main findings are summarized here.

The draft proposed rule will not likely have a significant direct impact on a substantial number of small firms. Currently, only one manufacturer meets SBA criteria to be considered small. Small importers may need to find alternate sources, if their existing supplier does not come into compliance with the draft proposed rule. However, some foreign suppliers will likely produce to U.S. standards due to the popularity and rising sales of ROVs. The only scenario in which small firms would likely experience a significant impact is if the importer has to conduct testing in support of a General Certificate of Conformity (GCC). We expect that most importers, however, will rely upon certifications or testing performed by their suppliers.

IV. VOLUNTARY STANDARDS

A. Background

Two different organizations developed separate voluntary standards for ROVs. The Recreational Off-Highway Vehicle Association (ROHVA) developed ANSI/ROHVA 1 *American National Standard for Recreational Off-Highway Vehicles* that sets mechanical and performance requirements for ROVs. Some ROV manufacturers that emphasize the utility applications of their vehicles worked with the Outdoor Power Equipment Institute (OPEI) to develop ANSI/OPEI B71.9 *American National Standard for Multipurpose Off-Highway Utility Vehicles*.

ROHVA member companies include: Artic Cat, BRP, Honda, John Deere, Kawasaki, Polaris, and Yamaha.[69] Work on ANSI/ROHVA 1 started in 2008, and completed with the publication of ANSI/ROHVA 1-2010. The standard was immediately opened for revision, and a revised standard, ANSI/ROHVA 1-2011, was published in July 2011.

OPEI member companies include: Honda, John Deere, Kawasaki, and Yamaha.[70] Work on ANSI/OPEI B71.9 was started in 2008, and completed with the publication of ANSI/OPEI B71.9-2012 in March 2012.

Both voluntary standards address design, configuration, and performance aspects of ROVs, including requirements for accelerator and brake controls; service and parking brake/parking mechanism performance; lateral and pitch stability; lighting; tires; handholds; occupant protection; labels; and owner's manuals.

CPSC staff participated in the canvass process used to develop consensus for ANSI/ROHVA 1 and ANSI/OPEI B71.9. From June 2009 to the present, CPSC staff has engaged actively with ROHVA and OPEI through actions that include the following:

- Sending correspondence to ROHVA and OPEI with comments on voluntary standard ballots that outlined CPSC staff's concerns that the voluntary standard requirements for lateral stability are too low, that requirements for vehicle handling are lacking, and requirements for occupant protection are not robust;
- Participating in public meetings with ROHVA and OPEI to discuss development of the voluntary standard and to discuss static and dynamic tests performed by contractors on behalf of CPSC staff;
- Sharing all CPSC contractor reports with test results of static and dynamic tests performed on ROVs by making all reports available on the CPSC website;
- Requesting copies of test reports on dynamic tests performed on ROVs by ROHVA for CPSC staff to review;
- Demonstrating dynamic test procedures and data collection to ROHVA and OPEI at a public meeting at an outdoor test facility in East Liberty, OH; and
- Submitting suggested changes and additions to the ANSI/ROHVA 1-2011 voluntary standard to improve lateral stability, vehicle handling, and occupant protection (OPEI was copied).

[69] ROHVA website retrieved from http://www.rohva.org/.
[70] OPEI presentation to CPSC staff at November 2, 2010 public meeting. Retrieved from http://www.cpsc.gov/PageFiles/80774/rohv11022010.pdf.

ANSI/ROHVA 1-2011 was published in July 2011, without addressing CPSC staff's concerns. CPSC staff requested, but has not received reports or test results of static or dynamic tests conducted by contractors on behalf of ROHVA.

ANSI/OPEI B71.9 - 2012 was published in March 2012, without addressing CPSC staff's concerns.

On August 29, 2013, CPSC staff sent a letter to ROHVA with suggested modifications to the voluntary standard requirements to address staff's concerns.[71] On November 27, 2013, ROHVA responded that it plans to adopt less stringent versions of CPSC staff's proposed requirements to improve the lateral stability and occupant protection performance of ROVs. On March 13, 2014, ROHVA sent CPSC staff the Canvass Draft of proposed revisions to ANSI/ROHVA 1-2011. Staff responded to the Canvass Draft on May 23, 2014, and summarized why staff believes ROHVA's proposed requirements will not reduce the number of deaths and injuries from ROVs. On July 31, 2014, ROHVA sent CPSC staff a response in which ROHVA disagreed with CPSC staff's analysis and recommendations to the Canvass Draft.

On February 21, 2014, OPEI sent a letter to CPSC staff requesting that the CPSC exclude multipurpose off-highway utility vehicles (MOHUVs) that meet the ANSI/OPEI B71.9-12 standard requirements from CPSC's rulemaking efforts.

1. Lateral Stability

ANSI/ROHVA 1-2011and ANSI/OPEI B71.9 include similar provisions to address static lateral stability and different provisions to address dynamic lateral stability:

Voluntary Standard Requirement: **ANSI/ROHVA 1-2011 Section 8.2 Stability Coefficient (K_{st}) and ANSI/OPEI B71.9-2012 Section 8.6 Stability Coefficient (K_{st})** specify a stability coefficient, K_{st}, which is calculated from the vehicle's center of gravity location and track width dimensions. The value of K_{st} for a vehicle at curb weight (without occupants) is required to be no less than 1.0.

Adequacy: CPSC staff believes the stability coefficient requirement does not adequately address lateral stability in ROVs because static tests are unable to account fully for the dynamic tire deflections and suspension compliance exhibited by ROVs in a dynamic maneuver. For practical purposes, K_{st} and SSF values provide the same information for ROVs because the difference in front and rear track widths are averaged in the SSF calculation. Table 3 shows the results of SSF measurements made by SEA for driver-plus-passenger load conditions. A comparison of how the vehicles would rank if the SSF (or K_{st}) were used instead of the threshold lateral acceleration at rollover (A_y) illustrates how poorly a stability coefficient correlates to the actual rollover resistance of the vehicle. The stability coefficient does not account for dynamic effects of tire compliance, suspension compliance, or vehicle handling, which are important factors in the vehicle's lateral stability.

[71] CPSC staff sent a courtesy copy of the August 29, 2013 recommendation letter to OPEI.

Table 3. Vehicle Ascending Rank Order A_y vs. SSF (Operator Plus Passenger Load)				
Vehicle Rank (A_y)	A_y (g)		Vehicle Rank (SSF)	SSF
D	0.625		F	0.881
B	0.655		A	0.887
A	0.670		H	0.918
J	0.670		B	0.932
I	0.675		D	0.942
F	0.690		J	0.962
E	0.700		E	0.965
H	0.705		C	0.991
C	0.740		G	1.031
G	0.785		I	1.045

Adapted from: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles – Additional Results for Vehicle J. Retrieved from http://www.cpsc.gov/PageFiles/93928/rovj.pdf.

Furthermore, all of the ROVs tested pass the K_{st} minimum of 1.0 for an unoccupied vehicle, as specified by ANSI/ROHVA 1-2011 and ANSI/OPEI B71.9-12. The K_{st} value of an ROV with no occupants is of limited value because an ROV in use has at least one occupant. CPSC staff believes the ANSI/ROHVA and ANSI/OPEI stability coefficient requirement is a requirement that all ROVs can pass, does not reflect the actual use of ROVs, does not promote improvement in lateral stability, and does not correspond to the actual rollover resistance of ROVs. CPSC staff believes the threshold lateral acceleration at rollover is a direct measure for rollover resistance, and its use would eliminate the need for a stability coefficient requirement.

Voluntary Standard Requirement: **ANSI/ROHVA 1-2011 Section 8.1 Tilt Table Test and ANSI/OPEI Section 8.7 Tilt Table Stability** specify tilt table tests in the driver-plus-passenger load condition and the gross vehicle weight rating (GVWR) load condition. The minimum tilt table angle (TTA) requirement for an ROV with a driver-plus-passenger load condition is 30 degrees, and the minimum TTA for GVWR load condition is 24 degrees.

Adequacy: CPSC staff believes the tilt table requirement does not adequately address lateral stability in ROVs because static tests are unable to account fully for the dynamic tire deflections and suspension compliance exhibited by ROVs in a dynamic maneuver. Table 4 shows the results of tilt table measurements made by SEA for driver-plus-passenger load condition. A comparison of how the vehicles would rank if the TTA were used instead of the direct measurement of threshold lateral acceleration at rollover (A_y) illustrates how poorly the TTA corresponds to the actual rollover resistance of the vehicle. The tilt table test does not account for dynamic effects of tire compliance, suspension compliance, or vehicle handling, which are important factors in the vehicle's lateral stability.

Furthermore, all of the ROVs tested passed the minimum 30 degree TTA requirement specified by ANSI/ROHVA 1-2011. The ROV with the lowest rollover resistance, as directly measured by threshold lateral acceleration at rollover (Vehicle D, A_y = 0.625 g, TTA = 33.7 degrees), exceeds the voluntary standard TTA requirement by 3.7 degrees, or 12 percent above the 30 degree minimum. The ROV that was part of a repair program to increase its roll resistance, Vehicle A, exceeds the TTA requirement by 3.0 degrees, or 10 percent above the 30 degree minimum.

Table 4. Vehicle Ascending Rank Order
Ay vs. TTA
(Operator Plus Passenger Load)

Vehicle Rank (A_y)	A_y (g)		Vehicle Rank (TTA)	TTA (deg.)
D	0.625		A	33.0
B	0.655		B	33.6
A	0.670		D	33.7
J	0.670		I	35.4
I	0.675		H	35.9
F	0.690		J	36.1
E	0.700		F	36.4
H	0.705		E	38.1
C	0.740		C	38.8
G	0.785		G	39.0

Source: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles – Additional Results for Vehicle J. Retrieved from http://www.cpsc.gov/PageFiles/93928/rovj.pdf.

CPSC staff believes the ANSI/ROHVA and ANSI/OPEI tilt table requirement is a requirement that all ROVs can pass and will not promote improvement among vehicles that have lower rollover resistance. The TTA requirement in the voluntary standard does not correlate to the actual rollover resistance of ROVs, allows a vehicle that was part of repair program to pass the test without having undergone the repair, and provides no incentive for manufacturers to improve the lateral stability of ROVs. CPSC staff believes the threshold lateral acceleration at rollover is a direct measure of rollover resistance, and its use would eliminate the need for a tilt table test requirement.

<u>Voluntary Standard Requirement:</u> **ANSI/ROHVA 1-2011 Section 8.3 Dynamic Stability** specifies a dynamic stability test based on a constant steer angle test performed on pavement. The standard describes the method for driving the vehicle around a 25-foot radius circle and slowly increasing the speed until 0.6 g of lateral acceleration is achieved; or 0.6 g lateral acceleration cannot be achieved because the vehicle experiences two-wheel lift of the inside wheels, or the vehicle speed is limited and will not increase with additional throttle input. The vehicle passes the dynamic test if at least 8 out of 10 test runs do not result in two-wheel lift.

Adequacy: CPSC staff does not believe the ANSI/ROHVA requirement accurately characterizes the lateral stability of an ROV because the ANSI/ROHVA requirement does not measure the threshold lateral acceleration at rollover. Staff is not aware of any standards, recognized test protocols, or real-world significance that supports using a constant steer angle test to assess dynamic lateral stability.

CPSC staff contracted SEA to conduct constant steer angle testing, as specified by the ROHVA standard, on vehicles A, F, and J of the ROV study.[72] Table 5 shows the results of the tests.

Table 5. Summary of Constant Steer Angle Test for 25 ft. Radius Path

Vehicle	Turn Direction (CW = clockwise CCW = counter-clockwise)	Test End Condition/Limit Response	ROHVA Test Pass/Fail Outcome
Vehicle A	Right (CW)	Two-wheel lift	Fail
	Left (CCW)	Two-wheel lift	Fail
Vehicle F	Right (CW)	Maximum Speed*	Pass**
	Left (CCW)	Maximum Speed*	Pass**
Vehicle J	Right (CW)	Two-wheel lift	Fail
	Left (CCW)	Maximum Speed/Spinout	Pass

* Maximum speed occurred very near 0.6 g of corrected lateral acceleration for Vehicle F.
** Two-wheel lift occurred for Vehicle F after the driver slowed from maximum speed at the end of the test.

Source: Heydinger, G. (2011) Results from Proposed ROHVA and OPEI Dynamic Maneuvers - Vehicles A, F, and J. Retrieved from http://www.cpsc.gov/Global/Research-and-Statistics/Technical-Reports/Sports-and-Recreation/ATV-ROV/ProposedROHVAandOPEIDynamicManeuvers.pdf.

Staff is concerned that ROVs with low lateral stability can pass ROHVA's dynamic stability requirement because the small turn radius limits the ROV's speed and prevents generation of the lateral accelerations necessary to assess rollover resistance (as shown by the results for Vehicle F). Staff is also concerned that the effects of oversteer can allow an ROV to pass the test because maximum speed is reached by vehicle spinout (as shown by the results for Vehicle J).

In 2001, NHTSA evaluated the J-turn test as a method to measure the rollover resistance of automobiles, and determined that the J-turn test is the most objective and repeatable method for vehicles with low rollover resistance.[73] Specifically, the J-turn test is objective because a programmable steering machine turns the steering wheel during the test, and the test results show that the vehicle speed, lateral acceleration, and roll angle data observed during J-turn tests were highly repeatable.[17] Lateral acceleration is the accepted measure by vehicle engineers for assessing lateral stability or rollover resistance.[74] This value is commonly used by engineers to compare rollover resistance from one vehicle to another. The ANSI/ROHVA test protocol does not measure the lateral acceleration at two-wheel lift, and the parameters of the test allow most

[72] Heydinger, G. J. (2011). Results from Proposed ROHVA and OPEI Dynamic Maneuvers - Vehicles A, F, and J. Retrieved from: http://www.cpsc.gov/Global/Research-and-Statistics/Technical-Reports/Sports-and-Recreation/ATV-ROV/ProposedROHVAandOPEIDynamicManeuvers.pdf.
[73] Forkenbrock, G. and Garrott, W. (2002). A Comprehensive Experimental Evaluation of Test Maneuvers That May Induce On-Road, Untripped, Light Vehicle Rollover Phase IV of NHTSA's Light Vehicle Rollover Research Program. DOT HS 809 513.
[74] Gillespie, T. (1992). Fundamentals of Vehicle Dynamics. Society of Automotive Engineers, Inc. p.309-319.

vehicles to pass. CPSC staff does not believe the ANSI/ROHVA dynamic stability requirement is a true measure of rollover resistance, and staff does not believe the requirement will improve the lateral stability of ROVs.

Voluntary Standard Requirement: **ANSI/OPEI B71.9-2012 Section 8.8 Dynamic Stability** specifies a dynamic stability test based on a 20 mph J-turn maneuver performed on pavement. At a steering input of 180 degrees in the right and left directions, the vehicle shall not exhibit two-wheel lift.

Adequacy: CPSC staff does not believe the ANSI/OPEI requirement accurately characterizes the lateral stability of an ROV because the specified test does not measure the threshold lateral acceleration at rollover. Staff is not aware of any standards or recognized test protocols that support using a J-turn maneuver with 180 degrees of steering wheel input to assess dynamic lateral stability of an ROV.

OPEI's use of the J-turn does not measure the lateral acceleration at two-wheel lift that produces ROV rollover. There is no correspondence between the ANSI/OPEI dynamic stability requirement and ROV lateral stability because the 180-degree steering wheel input does not correspond to a turning radius. For example, an ROV with a low steering ratio will make a sharper turn at 180 degrees of steering wheel input than an ROV with a high steering ratio.[75] In the ANSI/OPEI specified J-turn test, a vehicle with a larger steering ratio will make a wider turn, and generate less lateral acceleration, than a vehicle with a smaller steering ratio.

The steering ratio is set by the ROV manufacturer and varies depending on make and model. SEA measured the steering ratios of the 10 sample ROVs that were tested (see Figure 23). If the dynamic lateral stability requirement is defined by a steering wheel angle input, a manufacturer could increase the steering ratio of a vehicle to meet the requirement, rather than improve the vehicle's stability.

[75] The steering ratio relates the amount that the steering wheel is turned to the amount that the wheels of the vehicle turn. A higher steering ratio means the driver turns the steering wheel more to get the vehicle wheels to turn, and a lower steering ratio means the driver turns the steering wheel less to get the vehicle wheels to turn.

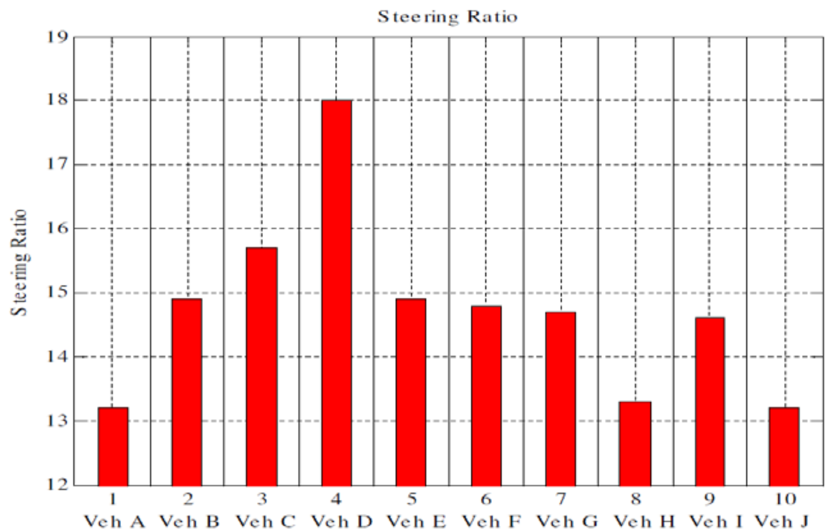


Figure 23. Steering Ratio = steering wheel input (degrees)/change in front wheel angle (degrees)
Source: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles – Additional Results for Vehicle J. Retrieved from http://www.cpsc.gov/PageFiles/93928/rovj.pdf.

CPSC staff contracted SEA to conduct J-turn testing, as specified by the ANSI/OPEI standard, on vehicles A, F, and J (see Table 6).

Table 6. Summary of J-Turn Test Results (20 mph with 180 degrees steering wheel angle input)

Vehicle	Turn Direction	Speed Required for 2-wheel	OPEI 20 mph test Pass/Fail Outcome
Vehicle A	Right	22 mph	Pass
	Left	21 mph	Pass
Vehicle F	Right	21 mph	Pass
	Left	22 mph	Pass
Vehicle J	Right	21 mph	Pass
	Left	23 mph	Pass

Source: Heydinger, G. (2011) Results from Proposed ROHVA and OPEI Dynamic Maneuvers - Vehicles A, F, and J. Retrieved from http://www.cpsc.gov/Global/Research-and-Statistics/Technical-Reports/Sports-and-Recreation/ATV-ROV/ProposedROHVAandOPEIDynamicManeuvers.pdf.

Staff is concerned that ROVs with low lateral stability can pass OPEI's dynamic stability requirement because an ROV that was part of a repair program (Vehicle A) to increase its roll resistance passed the ANSI/OPEI stability test. When the ANSI/OPEI J-turn maneuver was conducted just one mile above the requirement of 21 mph, Vehicle A failed. Similarly, when the maneuver was conducted at 22 mph, Vehicle F and Vehicle J failed. These results indicate that the parameters of the test protocol allow most ROVs to pass.

In 2001, NHTSA evaluated the J-turn test as a method to measure the rollover resistance of automobiles, and determined that the J-turn test is the most objective and repeatable method for vehicles with low rollover resistance.[76] Specifically, the J-turn test is objective because a programmable steering machine turns the steering wheel during the test, and the test results show that the vehicle speed, lateral acceleration, and roll angle data observed during J-turn tests were highly repeatable.[17] Lateral acceleration is the accepted measure by vehicle engineers for assessing lateral stability or rollover resistance. This value is commonly used by engineers to compare rollover resistance from one vehicle to another. The ANSI/OPEI test protocol does not measure the lateral acceleration at two-wheel lift, and the parameters of the test allow most vehicles to pass. CPSC staff does not believe the ANSI/OPEI dynamic stability requirement is a true measure of rollover resistance, and staff does not believe the requirement will improve the lateral stability of ROVs.

2. Vehicle Handling

ANSI/ROHVA 1-2011and ANSI/OPEI B71.9 both lack provisions to address vehicle handling:

Voluntary Standard Requirement: ANSI/ROHVA 1-2011 ANSI/OPEI B71.9-2012 do not specify a vehicle handling requirement.

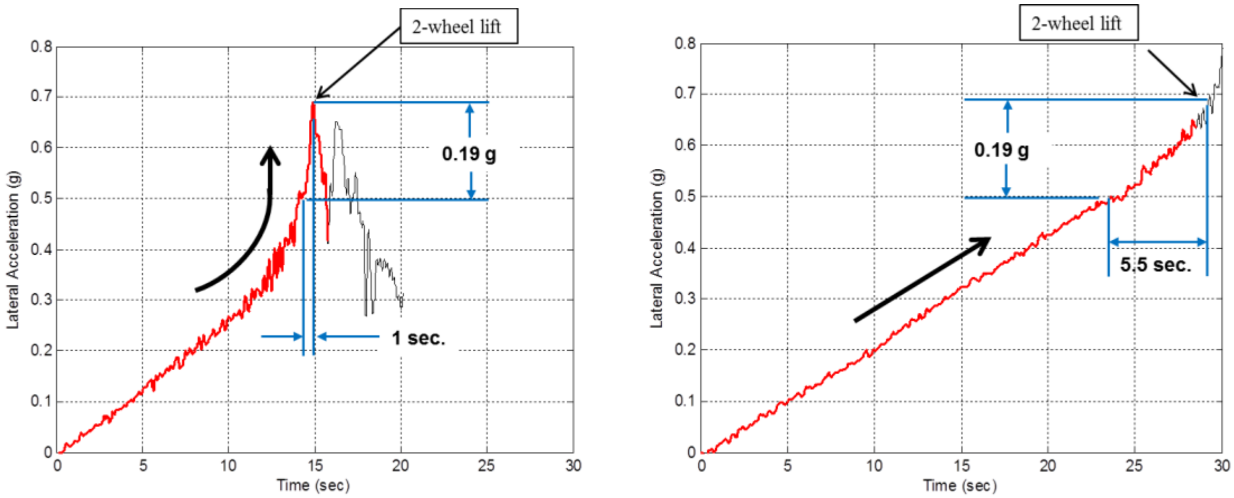
Adequacy: CPSC staff believes a requirement for sub-limit understeer is necessary to reduce ROV rollovers that may be produced by sub-limit oversteer in ROVs. Tests conducted by SEA show that ROVs in sub-limit oversteer transition to a condition where the lateral acceleration increases suddenly and exponentially. CPSC staff believes this condition can lead to untripped ROV rollovers or cause ROVs to slide into limit oversteer and experience tripped rollover.

ROVs that understeer in sub-limit conditions do not exhibit a sudden increase in lateral acceleration. Therefore, CPSC staff believes that ROVs should be required to operate in understeer at sub-limit conditions, based on the associated inherent dynamic stability of understeering ROVs and the smaller burden of steering correction that it places on the average driver who is familiar with driving a passenger vehicle that operates in sub-limit understeer.

Figure 24 shows plots of SIS tests conducted by SEA that illustrate the sudden increase in lateral acceleration that is found only in vehicles that exhibit sub-limit oversteer. The sudden increase in lateral acceleration is exponential and represents a dynamically unstable condition. This condition is undesirable because it can cause a vehicle with low lateral stability (such as an ROV) to roll over suddenly.

Figure 24, Vehicle A is an ROV that transitions to oversteer; Vehicle H is the same model ROV, but a later model year in which the oversteer has been corrected to understeer.

[76] Forkenbrock, G. and Garrott, W. (2002). A Comprehensive Experimental Evaluation of Test Maneuvers That May Induce On-Road, Untripped, Light Vehicle Rollover Phase IV of NHTSA's Light Vehicle Rollover Research Program. DOT HS 809 513.



Vehicle A (Oversteer) Vehicle H (Understeer)

Figure 24. SIS Plots of Lateral Acceleration Gain Over Time

Source: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles. Retrieved from http://www.cpsc.gov/PageFiles/96037/rov.pdf.

When Vehicle A reached its dynamically unstable condition, the lateral acceleration suddenly increased in less than 1 second, and the vehicle rolled over. In contrast, Vehicle H never reaches a dynamically unstable condition because the condition does not develop in understeering vehicles. The increase in Vehicle H's lateral acceleration remains linear, and vehicle rolls over almost 5 seconds later than Vehicle A.

Based on the decrease in injuries and deaths associated with Yamaha Rhino vehicles after the repair program was implemented, and on dynamic instability exhibited by sub-limit oversteering ROVs, CPSC staff believes requiring sub-limit understeer in all ROVs will reduce injuries and deaths associated with ROV rollover events.

3. Occupant Protection

ANSI/ROHVA 1-2011and ANSI/OPEI B71.9 include similar provisions to address occupant retention during a rollover event.

Voluntary Standard Requirement: **ANSI/ROHVA 1-2011 Section 11.2 Seat Belt Reminder** and **ANSI/OPEI B71.9-2012 Section 5.1.3.2 Seat Belt Reminder System** specify that ROVs shall be equipped with a seat belt reminder system that activates a continuous or flashing warning light visible to the operator for at least 8 seconds after the vehicle is started.

Adequacy: CPSC staff believes the requirement for an 8-second reminder light is not adequate to increase meaningfully seat belt use rates in ROVs because the system is not intrusive enough to motivate drivers and passengers to wear their seat belts. Results from past studies on automotive seat belt reminders conclude that visual reminders are ineffective (see Tab I). Numerous studies also conclude that reminder systems must be intrusive enough to motivate users to buckle their seat belts (see Tab I). The more intrusive reminders are more effective at changing user behavior, as long as the reminder is not so intrusive that users bypass the system.

Staff analysis of ROV-related incidents indicates that 91 percent of fatal victims, and 73 percent of all victims (fatal and nonfatal), were not wearing a seat belt at the time of the incident. Without seat belt use, occupants experience partial to full ejection from the ROV, and many are struck by the ROV after ejection. Staff believes many ROV deaths and injuries can be eliminated if occupants are wearing seat belts.

Automotive researchers have developed technology that motivates drivers to buckle seat belts by making it more difficult to drive faster than 20 to 25 mph if the driver's seat belt is not buckled (see Tab I). This concept shows promise in increasing seat belt use because the technology was acceptable to users and was 100 percent effective in motivating drivers to buckle their seat belts. One ROV manufacturer has also introduced a similar technology that limits the vehicle speed if the driver's seat belt is not buckled. ROVs with the speed limitation technology have been in the market since 2011.

Given the low seat belt use rate in ROV-related incidents, as well as the substantial potential reduction in injuries and deaths if seat belt use were higher, CPSC staff believes the requirement for seat belt reminders should be more stringent and should incorporate the most recent advances in technology developed in the automotive and ROV market.

<u>Voluntary Standard Requirement:</u> **ANSI/ROHVA 1-2011 Section 11.3 ORS Zones** specifies construction and performance requirements for four zones that cover the leg/foot, shoulder/hip, arm/hand, and head/neck areas of an occupant.[77] The construction requirements specify a force application test to set minimum guidelines for the design of doors, nets, and other barriers that are intended to keep occupants within the protection zone of the ROPS. The performance requirements use a tilt table and a Hybrid III 50th percentile male anthropomorphic test device (ATD) to determine occupant excursion when the vehicle is tilted 45 degrees laterally.

<u>Adequacy:</u> CPSC staff believes the tilt table performance requirements for Zone 2 – Shoulder/Hip are not adequate to ensure that occupants remain within the protective zone of the vehicle's ROPS during a rollover event. The tilt table test method measures the torso ejection outside the vehicle width, not the ejection outside the protective zone of the ROPS. CPSC staff's test results indicate the tilt table test allows unacceptable occupant head excursion beyond the protective zone of the vehicle ROPS. CPSC staff also believes the tilt table test method is not an accurate simulation of an ROV rollover event because the test method does not reproduce the lateral acceleration and roll experienced by the vehicle, and by extension, the occupants, during a rollover.

CPSC staff also believes the construction-based test method for Zone 2 is inadequate because the specified point of application (a single point) and 3 inch diameter test probe do not accurately represent contact between an occupant and the vehicle during a rollover event. Specifying a single point does not ensure adequate coverage because a vehicle with a passive barrier at only that point would pass the test. Similarly, a 3 inch diameter probe does not represent the upper arm of an occupant and therefore does not ensure adequate coverage.

[77] "Occupant retention system" (ORS) is defined in ANSI/ROHVA 1-2011 as a system, including three-point seat belts, for retaining the occupant(s) of a vehicle to reduce the probability of injury in the event of an accident.

Voluntary Standard Requirement: **ANSI/OPEI B71.9-2012 Section 5.1.4 Occupant Side Retention Devices** specifies ROVs shall be equipped with occupant side retention devices that reduce the probability of entrapment of a properly belted occupant's head, upper torso, and limbs between the vehicle and the terrain, in the event of a lateral rollover. Physical barriers or design features of the vehicle may be used to comply with the requirement, but no performance tests are specified to determine compliance with the requirement.

Adequacy: CPSC staff believes the occupant side retention requirements are not adequate because they lack performance requirements to gauge occupant protection performance. Performance requirements, based on occupant protection performance tests of ROV rollovers, are needed to ensure that occupants remain within the protective zone of the vehicle's ROPS during a rollover event.

V. COMMENTS TO ANPR

In this section, staff describes and responds to comments to the ANPR for ROVs. A summary of each of the commenter's topics is presented, and each topic is followed by CPSC staff's response. One hundred and sixteen comments were received, and all of the comments can be viewed on: *www.regulations.gov*, by searching under the docket number of the ANPR, CPSC-2009-0087.

Letters with multiple and detailed comments were submitted by the following:

- Joint comments submitted on behalf of Arctic Cat Inc., Bombardier Recreational Products Inc., Polaris Industries Inc., and Yamaha Motor Corporation, U.S.A. (Companies);
- Carr Engineering, Inc. (CEI);
- The OPEI/ANSI B 71.9 Committee (Committee); and
- ROHVA.

The respondents were ROV manufacturers and their associations, consultants to ROV manufacturers, and more than 110 consumers. Eighteen commenters supported developing regulatory standards for ROVs. The other commenters opposed rulemaking action. The commenters raised issues in five areas:

- Voluntary standard activities,
- Static stability metrics,
- Vehicle handling,
- Occupant protection, and
- Consumer behavior.

The comment topics are separated by category.

Voluntary Standard Activities

1. **Comment:** Comments from the Companies, ROHVA, and several individuals state that the CPSC should work with ROHVA to develop a consensus voluntary standard for ROVs, or that the CPSC should defer to ROHVA to develop the standard.

   Response: CPSC staff participated in the canvass process that was used to develop consensus for this standard. From June 2009 to the present, CPSC staff engaged actively with ROHVA through actions that include the following:

   - Sending correspondence to ROHVA with comments on voluntary standard ballots that outlined CPSC staff's concerns that the voluntary standard requirements for lateral stability are too low, that requirements for vehicle handling are lacking, and that requirements for occupant protection are not robust.
   - Participating in public meetings with ROHVA to discuss development of the voluntary standard and to discuss static and dynamic tests performed by contractors on behalf of CPSC staff.
   - Sharing all CPSC contractor reports with test results of static and dynamic tests performed on ROVs, by making all reports available on the CPSC website.
   - Requesting copies of test reports on dynamic tests performed on ROVs by ROHVA for CPSC staff review.
   - Demonstrating dynamic test procedures and data collection to ROHVA at a public meeting at an outdoor test facility in East Liberty, OH.
   - Submitting suggested changes and additions to the current voluntary standard to improve lateral stability, vehicle handling, and occupant protection.

   ANSI/ROHVA 1-2011, published in July 2011, did not address CPSC staff's concerns. CPSC staff requested but has not received reports or test results of static or dynamic tests conducted by contractors on behalf of ROHVA.

   On August 29, 2013, CPSC staff sent a letter to ROHVA with suggested modifications to the voluntary standard requirements to address staff's concerns. On November 27, 2013, ROHVA responded that it plans to adopt less stringent versions of CPSC staff's proposed requirements to improve the lateral stability and occupant protection performance of ROVs. On March 13, 2014, ROHVA sent CPSC staff the Canvass Draft of proposed revisions to ANSI/ROHVA 1-2011. Staff responded to the Canvass Draft on May 23, 2014, and summarized why staff believes ROHVA's proposed requirements will not reduce the number of deaths and injuries from ROVs. On July 31, 2014, ROHVA sent CPSC staff a response in which ROHVA disagreed with CPSC staff's analysis and recommendations to the Canvass Draft.

   CPSC staff believes the history of engagement with ROHVA, as detailed above, shows that staff has tried to work with ROHVA to improve the voluntary standard requirements to address low lateral stability, lack of vehicle handling requirements, and inadequate occupant protection requirements. Staff does not believe deferring to ROHVA will address those areas of concerns because, although ROHVA has made changes to the voluntary standard, the requirements still do not improve the lateral stability of ROVs, do not eliminate sub-limit oversteer handling, and do not improve occupant protection in a rollover event.

2. **Comment**: Comments from the Committee and ROHVA state that CPSC staff should defer to the current voluntary standards for ROVs. Several comments state that the current voluntary standards are adequate.

Response: ANSI/ROHVA 1-2011, *American National Standard for Recreational Off-Highway Vehicles,* is the voluntary standard that was developed for ROVs by members of ROHVA. The latest revision of the standard was published in July 2011.

ANSI/OPEI B71.9-2012, *American National Standard for Multipurpose Off-Highway Utility Vehicles,* is the voluntary standard that was developed for ROVs by members of the Outdoor Power Equipment Institute (OPEI). The latest revision of the standard was published in March 2012.

CPSC staff does not believe the ANSI/ROHVA voluntary standard or ANSI/OPEI voluntary standard adequately address the risk of injury and death associated with lateral rollovers of ROVs because the standards do not have robust lateral stability requirements, do not have vehicle handling requirement to ensure sub-limit understeer, and do not have robust occupant restraint requirements to protect occupants in the event of vehicle rollover.

Lateral Stability

CPSC staff believes the static stability requirements and the dynamic lateral stability requirements specified in both voluntary standards do not measure the vehicle's resistance to rollover. Static and dynamic tests conducted by SEA on a sample of ROVs available in the U.S. market indicate that the tests specified in ANSI/ROHVA 1-2011 and the ANSI/OPEI B71.9 are tests that all ROVs can pass and will not promote improvement in the rollover resistance of ROVs.

Vehicle Handling

In addition, ANSI/ROHVA 1-2011 and ANSI/OPEI B71.9 - 2012 do not have requirements for vehicle handling. CPSC staff believes a requirement for sub-limit understeer is necessary to reduce ROV rollovers that may be produced by sub-limit oversteer in ROVs. Tests conducted by SEA show that ROVs in sub-limit oversteer transition to a condition where the lateral acceleration increases suddenly and exponentially. CPSC staff believes this runaway increase in lateral acceleration can lead to untripped ROV rollovers or cause ROVs to slide into limit oversteer and experience tripped rollover.

Occupant Protection

ANSI/ROHVA 1-2011 and ANSI/OPEI B71.9 - 2012 require only an 8-second reminder light to motivate users to buckle seat belts. This requirement is similar to the Federal Motor Vehicle Safety Standard (FMVSS) seat belt reminder requirements for automobiles.

Manufacturers in the automotive industry have long since exceeded such minimal seat belt reminder requirements because studies have proven that the FMVSS requirements, and indeed visual-only reminders, are not effective.[78]

CPSC staff believes the ANSI/ROHVA 1-2011 and ANSI/OPEI B71.9 - 2012 requirements for an 8-second seat belt reminder light are not adequate to meaningfully increase seat belt use rates in ROVs because the seat belt reminder system is not intrusive enough to motivate drivers and passengers to wear their seat belts.

Lastly, the occupant protection requirements in ANSI/ROHVA 1-2011 and ANSI/OPEI B71.9 - 2012 are not based on valid occupant protection performance tests that simulate conditions of vehicle rollover. ANSI/OPEI B71.9 -2012 does not include any performance requirements for occupant protection. ANSI/ROHVA 1-2011 includes performance requirements based on static tilt tests that allow unacceptable occupant head ejection beyond the protective zone of the vehicle ROPS.

3. **Comment:** On August 29, 2013, CPSC staff sent a letter to ROHVA and OPEI with suggested modifications to the voluntary standard requirements to address staff's concerns. On November 27, 2013, ROHVA responded that it plans to adopt less stringent versions of CPSC staff's proposed requirements to improve the lateral stability and occupant protection performance of ROVs. On March 13, 2014, staff received the Canvass Draft of the proposed changes to ANSI/ROHVA 1. Staff responded to the Canvass Draft on May 23, 2014, and summarized why staff believes ROHVA's proposed requirements will not reduce the number of deaths and injuries from ROVs. On July 31, 2014, ROHVA sent CPSC staff a response in which ROHVA disagreed with CPSC staff's analysis and recommendations to the Canvass Draft.

The following is a summary of CPSC staff's comments (in letter dated May 23, 3014) to ROHVA's proposed changes to the voluntary standard.

Dynamic Stability: ROHVA proposed to change the dynamic stability test to a 30 mph J-turn test with steering wheel input of 110 degrees (at 500 degrees/sec) with pass/fail of whether two-wheel lift occurs.

Staff response: CPSC staff does not believe that the ANSI/ROHVA requirement accurately characterizes the lateral stability of the ROV. Nor can the requirement be used to compare stability performance between two vehicles. Moreover, it is unclear how ROHVA arrived at a proposed 110 degrees of steering wheel input. CPSC staff is not aware of any standards, recognized test protocols, or real-world significance that supports using a J-turn maneuver with 110 degrees of steering input to assess the lateral stability of an ROV.

ROHVA's use of the J-turn does not measure the lateral acceleration at two-wheel lift that produces ROV rollover. Rollover in an ROV begins when the lateral acceleration builds to

[78] Westefeld, A. and Phillips, B.M. (1976). Effectiveness of Various Safety Belt Warning Systems. (DOT HS 801 953). Washington, D.C.: National Highway Traffic Safety Administration, U.S. Department of Transportation.

the point that the vehicle can no longer counterbalance the roll moment generated by the lateral acceleration.[79] Therefore, staff believes the lateral acceleration at two-wheel lift is the best indicator of the ROV's lateral stability. There is no correspondence between the proposed ANSI/ROHVA dynamic stability requirement and ROV lateral stability because the 110-degree steering wheel input does not correspond to a turning radius and an associated lateral acceleration. For example, an ROV with a low steering ratio will make a sharper turn at 110 degrees of steering wheel input than an ROV with a high steering ratio.[80] In the proposed ANSI/ROHVA J-turn test, a vehicle with a larger steering ratio will make a wider turn and generate less lateral acceleration than a vehicle with a smaller steering ratio.

The results of J-turn tests conducted by SEA on 10 sample ROVs indicate that there is no correspondence between steering wheel input and lateral acceleration at two-wheel lift, as shown in Figure 25. For example, the lateral accelerations at two-wheel lift for Vehicles A, J, and I are 0.670 g, 0.670 g, and 0.675 g, respectively, with a standard deviation of .003 g, which is within 0.45 percent of the average value. If the steering wheel angle input corresponds to lateral acceleration, the steering wheel angles measured at two-wheel lift for Vehicles A, J, and I should be similarly within 1 percent of each other. However, the steering wheel angles measured for Vehicles A, J, and I are 95 degrees, 110 degrees, and 170 degrees, respectively, with a standard deviation of 40 degrees, which is a 32 percent variance from the average value. It is clear that the measured steering wheel angle does not correspond to the lateral acceleration value, and therefore, the steering wheel angle input cannot be used to compare or evaluate the rollover resistance of an ROV.

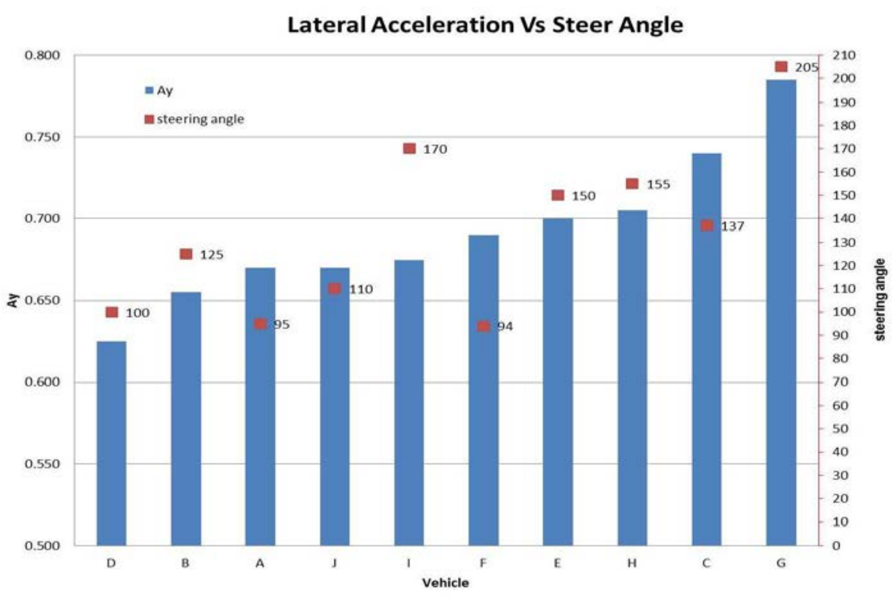


Figure 25. Lateral Acceleration and Steering Wheel Angle at Two-Wheel Lift for 30 mph J-Turn

Adapted from: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles – Additional Results for Vehicle J. Retrieved from http://www.cpsc.gov/PageFiles/93928/rovj.pdf.

[79] Gillespie, T. (1992). Fundamentals of Vehicle Dynamics. Society of Automotive Engineers, Inc. p.309-311.

[80] The steering ratio relates the amount that the steering wheel is turned to the amount that the wheels of the vehicle turns. A higher steering ratio means the driver turns the steering wheel more to get the vehicle wheels to turn, and a lower steering ratio means the driver turns the steering wheel less to get the vehicle wheels to turn.

CPSC staff is also concerned that ROHVA's proposed test introduces the effects of steering ratio into the outcome of the test.[81] The steering ratio is set by the ROV manufacturer and varies depending on make and model. Figure 26 shows the steering ratios of the 10 sample ROVs that were measured by SEA. If the dynamic lateral stability requirement is defined by a steering wheel angle input, a manufacturer could increase the steering ratio of a vehicle to meet the requirement rather than improve the vehicle's stability.

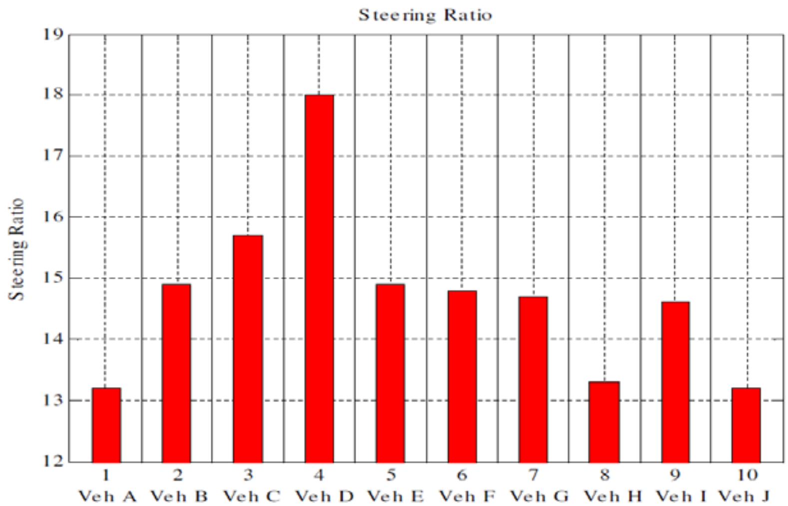


Figure 26. Steering Ratio of ROVs Tested by SEA

Source: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles – Additional Results for Vehicle J. Retrieved from http://www.cpsc.gov/PageFiles/93928/rovj.pdf.

For example, Vehicle A, with 0.670 g of lateral acceleration and 95 degrees of steering wheel angle at two-wheel lift, would fail the proposed ROHVA stability requirement because the steering wheel input at two-wheel lift is less than 110 degrees (see Figure 25). However, if the manufacturer changes the steering ratio of Vehicle A from 13.25 to 15.50, the steering wheel angle at two-wheel lift would increase to 111.6 degrees, and Vehicle A would pass the stability test without an increase in the 0.670 g lateral acceleration at two-wheel lift. Instead of increasing the roll resistance of the ROV, increasing the steer ratio would simply make the driver turn the steering wheel more to make a turn.

In conclusion, CPSC staff does not believe that ROHVA's proposed requirements for dynamic stability are a true measure of rollover resistance because measurement of steering wheel angle input appears to have no unique correspondence to lateral acceleration and introduces the effects of steer ratio into the measurement. Therefore, staff recommends a dynamic stability performance requirement that ROVs demonstrate a minimum lateral acceleration at two-wheel lift of 0.70 g or greater in a J-turn test conducted at 30 mph.

Hang tag: ROHVA proposed to add a hang tag with general warning information and other select messages.

[81] Staff expressed concern with the effects of steering ratio on the outcome of a J-turn test in a comment letter to OPEI dated April 14, 2011. Retrieved from http://www.cpsc.gov/PageFiles/117680/opei04142011.pdf.

Staff response**:** CPSC staff does not believe that the ANSI/ROHVA hang tag requirement provides information to aid the consumer in the buying decision process for ROVs. The ANSI/ROHVA hang tag requirement duplicates warning and instruction information that is already affixed to the ROV and repeated in the owner's manual. CPSC staff is concerned that a hang tag with redundant warning information may dilute the important safety messages currently displayed on the ROV and in the owner's manual.

CPSC staff believes a hang tag that is displayed at point of sale should provide the consumer with information that helps with the purchase decision. Information on a hang tag should be relevant to the purchase decision because hang tags are typically discarded after a product is purchased. For example, hang tag requirements in the voluntary standard for all-terrain vehicles (ATVs) provide information on the appropriate age recommendation for different sizes of ATVs, as well as information on the category of intended use.

CPSC staff believes the ANSI/ROHVA hang tag requirement should display each vehicle model's lateral acceleration at two-wheel lift, as measured by the J-turn test. The value should be displayed on a progressive scale to allow consumers to compare rollover resistance of each ROV before purchase. This information will allow a useful comparison of ROVs, whereas, the draft ANSI/ROHVA provision only duplicates current information. Staff believes the additional statements proposed by ROHVA regarding training, local laws, and hang tag removal do not help consumers with the purchase decision and should be conveyed by some other method than a hang tag.

Vehicle Handling: ROHVA proposed no action on vehicle handling because there is no sound data/rationale for CPSC proposal. ROHVA believes the new dynamic lateral stability test is sufficient and also accounts for handling characteristics (*i.e.*, J-turn maneuver is more demanding for oversteer vehicles).

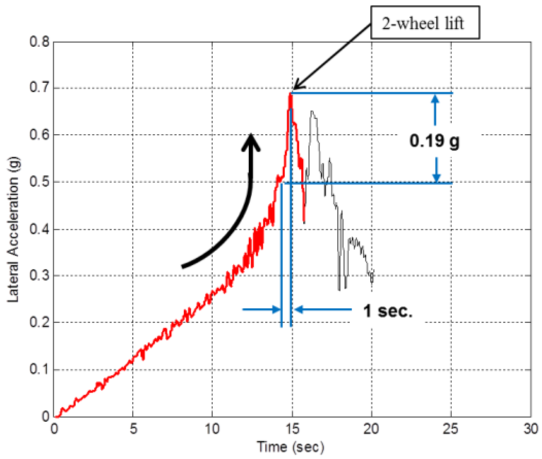
Staff response: CPSC staff believes a requirement for sub-limit understeer is necessary to reduce ROV rollovers that may be produced by sub-limit oversteer. As related in SEA's report, tests conducted by SEA show that ROVs in sub-limit oversteer transition to a condition where the lateral acceleration increases suddenly and exponentially.[82] CPSC staff believes that this condition can lead to untripped ROV rollovers or can cause ROVs to slide into limit oversteer and experience tripped rollover.

Figure 27 shows plots of slowly increasing steer (SIS) tests conducted by SEA that illustrate the sudden increase in lateral acceleration.[83] The sudden increase in lateral acceleration is exponential and represents a dynamically unstable condition.[84] This condition is undesirable

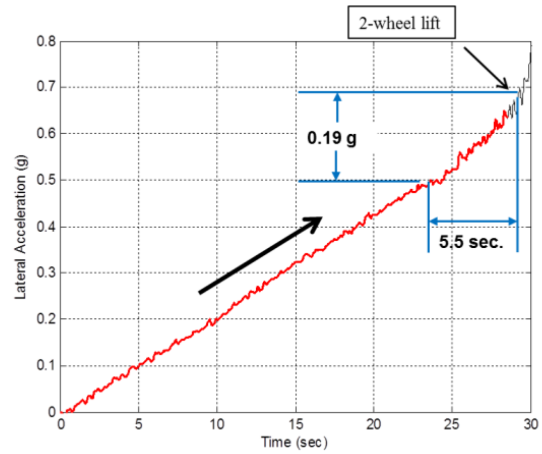
[82] Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles . Retrieved from http://www.cpsc.gov/PageFiles/96037/rov.pdf. Appendix D.
[83] The SIS test is also known as Constant Speed Variable Steer Angle Test and is described by SAE J266. During the test, the ROV driver maintains a constant speed of 30 mph and the vehicle's steering wheel angle is slowly increased at a rate of 5 degrees per second until the ROV rolls over. SEA conducted SIS tests on the sample of 10 ROVs.
[84] Gillespie, T. (1992). Fundamentals of Vehicle Dynamics. Society of Automotive Engineers, Inc. p.204-205.

because it can cause a vehicle with low lateral stability (such as an ROV) to roll over suddenly.

Figure 27, Vehicle A is an ROV that transitions to oversteer; Vehicle H is the same model ROV but a later model year in which the oversteer has been corrected to understeer.



Vehicle A (Oversteer)



Vehicle H (Understeer)

Figure 27. SIS Plots of Lateral Acceleration Gain Over Time

Source: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles. Retrieved from http://www.cpsc.gov/PageFiles/96037/rov.pdf.

When Vehicle A reached its dynamically unstable condition, the lateral acceleration suddenly increased from 0.50 g to 0.69 g (a difference of 0.19 g) in less than 1 second and the vehicle rolled over. In contrast, Vehicle H never reached a point where the lateral acceleration increases exponentially because the condition does not develop in understeering vehicles. The increase in Vehicle H's lateral acceleration remains linear, and the lateral acceleration increase from 0.50 g to 0.69 g (same difference of 0.19 g) occurs in 5.5 seconds.

CPSC staff believes that requiring sub-limit understeer will reduce rollover events because it eliminates the potential for sudden and exponential increase in lateral acceleration, a phenomenon associated with sub-limit oversteer that can cause ROV rollovers. SEA test results indicate that half of the 10 sample ROVs tested exhibited sub-limit transitions to oversteer, and the other half exhibited a sub-limit understeer condition for the full range of the test.[85] CPSC staff believes this demonstrates that ROVs can be designed to understeer in sub-limit operation with minimum cost and without diminishing the utility or recreational value of this class of vehicle.

<u>Seat Belt Reminder:</u> ROHVA proposed to change the "Seat Belt Reminder" provision to provide manufacturers the option to include either: (1) driver's seat belt interlock to limit the maximum speed capability of the vehicle and provide visible feedback to the driver that

[85] Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles – Additional Results for Vehicle J. Retrieved from http://www.cpsc.gov/PageFiles/93928/rovj.pdf. Appendix B, page 24.

vehicle speed is limited until the driver's seat belt is buckled; or (2) FMVSS 208-type audible alert─emit a continuous or repeating audible signal and illuminate a continuous or flashing warning light visible to the driver.

<u>Staff response:</u> CPSC staff is encouraged that ROHVA introduced specific performance requirements for in-vehicle technology that limit the maximum speed capability of the ROV until the driver's seat belt is buckled. However, staff believes that the vehicle speed limitation requirement for seat belt reminders should be mandatory, without the option of only an audio and visual warning. Based on staff's analysis of ROV-related incidents where victims were not wearing seat belts, staff also believes the requirement should include the seat belt status of front passengers, as well as the driver.

In Annex A of the Canvass Draft, ROHVA states that a key consideration in evaluating a seat belt reminder system is its effectiveness in leading vehicle occupants to use their seat belts. ROHVA also states that studies and data indicate that continuous/repeating audible and visual reminders are effective in increasing seat belt use in automobiles. CPSC staff believes the automobile studies prove a more general point that seat belt reminders must be aggressive and acceptable to be effective. In the open environment of ROVs, staff believes engine noise and helmet use would reduce or negate the effectiveness of an audio warning. In addition, staff believes the visual reminder is ineffective because it is the least aggressive method of reminding a person to use their seat belt.

In conclusion, CPSC staff believes ROHVA's introduction of a reminder system that limits the maximum speed of the ROV until the driver's seat belt is buckled is a positive step toward increasing seat belt use in ROVs. However, staff also believes that ROHVA's optional requirement for only an audio and visual warning will be ineffective in the open environment of ROVs. Therefore, staff believes a reminder system that limits the vehicle speed should be required.

4. **Comment:** On February 21, 2014, OPEI sent a letter to CPSC staff, requesting that the CPSC exclude multipurpose off-highway utility vehicles (MOHUVs) from CPSC's rulemaking efforts. OPEI states that there are key differences between work-utility vehicles and recreational vehicles. The differences include: maximum vehicle speed, engine and powertrain design, cargo box configuration and capacity, towing provisions, and vehicle usage.

   Response: CPSC staff's recommended requirements for lateral stability, vehicle handling, and occupant protection are intended to reduce deaths and injuries caused by ROV rollover and occupant ejection. ROVs are motorized vehicles that are designed for off-highway use and have four or more tires, steering wheel, non-straddle seating, accelerator and brake pedals, ROPS, restraint system, and maximum vehicle speed greater than 30 mph.

   "MOHUVs," as defined by ANSI/OPEI B71.9-2012, are vehicles with four or more wheels, a steering wheel, non-straddle seating, a ROPS, restraint system, and maximum speed between 25 and 50 mph. Therefore, CPSC staff believes that an MOHUV that exceeds 30 mph is an ROV that is subject to the scope of the proposed rulemaking. The differences (between work-utility vehicles and recreational vehicles) cited by OPEI do not exclude these ROVs from the hazard of rollover and occupant ejection.

Static Stability Metrics

1. **Comment:** Comments from CEI state that the Static Stability Factor (SSF), defined as T/2H, is not an appropriate metric for stability because there is no correlation between SSF values and ROV rollovers.

   Response: CPSC staff agrees that the SSF is not an appropriate metric for ROV lateral stability because staff compared the actual lateral acceleration at rollover threshold of several ROVs, as measured by the J-turn test, and found that static measures (K_{st}, SSF, and TTA) are not accurate predictors of the vehicle's rollover resistance. The static tests are unable to account fully for the dynamic tire deflections and suspension compliance exhibited by ROVs. Staff believes that the threshold lateral acceleration at rollover (Ay) is the most appropriate metric to use because it is a direct measure of the vehicle's resistance to rollover.

2. **Comment:** Comments from the Companies and the Committee state that NHTSA decided not to implement a minimum SSF standard for on-road vehicles because it would have forced the radical redesign of the characteristics of many, and in some cases all, vehicles of certain classes, which would have raised issues of public acceptance, and possibly even the elimination of certain classes of vehicles.

   Response: Contrary to the comment's implication that setting a minimum lateral stability (in this case SSF) is detrimental to vehicle design and that NHTSA abandoned the use of SSF, NHTSA concluded there is a causal relationship between SSF and rollover, and has incorporated the SSF in its New Car Assessment Program (NCAP) rating of vehicles.[86] In June 1994, NHTSA terminated rulemaking to establish a minimum standard for rollover resistance, and instead, focused on developing consumer safety information about vehicle stability.[87] In January 2001, NHTSA concluded that consumer information on the rollover risk of passenger cars would influence consumers to purchase vehicles with a lower rollover risk, and inspire manufacturers to produce vehicles with a lower rollover risk.[88] NHTSA consistently found that given a single-vehicle crash, the SSF is a good statistical predictor of the likelihood that it will roll over.[89] The number of single-vehicle crashes was used as an index of exposure to rollover because it eliminates the additional complexity of multi-vehicle impacts and because about 82 percent of light vehicle rollovers occur in single-

[86] Boyd, P. L. (2005). NHTSA'S NCAP Rollover Resistance Rating System. 19th International Technical Conference on the Enhanced Safety of Vehicles. Paper Number 05-0450. Retrieved from http://www-nrd.nhtsa.dot.gov/Pdf/ESV/esv19/05-0450-O.pdf.
[87] National Academies National Research Council Transportation Research Board *Motor Vehicle Rollover Rating System Study*. Retrieved from http://www.nhtsa.gov/cars/problems/studies/NASRoll/NASRolloverStudy.html.
[88] Walz, M. C. (2005). Trends in the Static Stability Factor of Passenger Cars, Light Trucks, and Vans. DOT HS 809 868. Retrieved from http://www.nhtsa.gov/cars/rules/regrev/evaluate/809868/pages/index.html.
[89] Rollover Prevention Docket No. NHTSA-2000-6859 RIN 2127-AC64. Retrieved from http://www.nhtsa.gov/cars/rules/rulings/rollover/Chapt05.html.

vehicle crashes.[89] NHTSA decided to use the SSF to indicate the risk of rollover in single-vehicle crashes and to incorporate the new rating into NHTSA's New Car Assessment Program (NCAP). Based on NHTSA's statistical analysis of single-vehicle crash data and vehicle SSF value, the NCAP provides a 5-star rating system: One star is for a 40 percent or higher risk of rollover in a single vehicle crash; two stars represents a risk of rollover between 30 percent and 40 percent; three stars demonstrates a risk of rollover between 20 percent and 29 percent; four stars is for a risk of rollover between 10 percent and 19 percent; and five stars is for a risk of rollover of less than 10 percent.

A subsequent study of SSF trends in automobiles found that SSF values increased for all vehicles after 2001, particularly SUVs, which tended to have the worst SSF values in the earlier years.[88] NHTSA's intention for manufacturers to improve the lateral stability of passenger vehicles was achieved through the NCAP rating, which was based predominantly on the SSF value of the vehicle.

Based on dynamic stability tests conducted by SEA and improvements in the Yamaha Rhino after the repair program, CPSC staff believes setting a minimum rollover resistance value for ROVs can improve the lateral stability of the current market of ROVs, without forcing radical designs or elimination of any models. However, CPSC staff believes continued increase in ROV lateral stability can be achieved by making the value of each model vehicle's threshold lateral acceleration at rollover available to consumers. Publication of an ROV model's rollover resistance value will allow consumers to make informed purchasing decisions regarding the comparative lateral stability of ROVs, and will provide a competitive incentive for manufacturers to improve the rollover resistance of ROVs.

3. **Comment:** Comments from the Companies and the Committee state that K_{st} is the more appropriate stability factor than SSF because it accounts for differences in the rear and track width, as well as differences in the fore and aft location of the vehicle's center of gravity.

   Response: K_{st} is a three-dimensional calculation of the two-dimensional SSF, and when the front and rear track widths are equal, K_{st} equals SSF. For practical purposes, K_{st} and SSF provide the same information on ROVs. Occupant-loaded values of K_{st} and SSF are informative to the design process of ROVs; however, K_{st} and SSF values do not account for all the dynamic factors that affect actual rollover resistance. Therefore, they do not represent the best stability metric for ROVs.

   CPSC staff compared the actual lateral acceleration at rollover threshold of several ROVs, as measured by the J-turn test, and found that the static measures (whether K_{st}, SSF, or TTA) are not accurate predictors of the vehicle's actual lateral stability. Direct dynamic measurement of the vehicle's resistance to rollover is possible with ROVs. Therefore, CPSC staff believes that J-turn testing to determine the threshold lateral acceleration at rollover should be used as the standard requirement to determine lateral stability.

4. **Comment:** Comments from CEI and the Companies state that tilt table angle or tilt table ratio should be used as a measure of lateral stability.

Response: CPSC staff compared the actual lateral acceleration at rollover threshold of several ROVs, as measured by the J-turn test, and found that the static measures ($K_{st,}$ or SSF, and TTA) are not accurate predictors of the vehicle's actual lateral stability.

CPSC staff believes the tilt table requirement in ANSI/ROHVA 1-2011 does not adequately address lateral stability in ROVs. A comparison of how the vehicles would rank if the TTA were used instead of the direct measurement of lateral acceleration at rollover (A_y) illustrates how poorly the TTA correlates to the actual rollover resistance of the vehicle. The tilt table test does not account for dynamic effects of tire compliance, suspension compliance, and vehicle handling, which are important factors in the vehicle's lateral stability.

Direct dynamic measurement of the vehicle's resistance to rollover is possible with ROVs. Therefore, CPSC staff believes that J-turn testing to determine the threshold lateral acceleration at rollover should be used as the standard requirement to determine lateral stability.

5. **Comment:** Comments from the Companies state that the ANSI/ROHVA 1, *American National Standard for Recreational Off-Highway Vehicles,* lateral stability requirement of K_{st}=1 and TTA=30 degrees is adequate and should be adopted by CPSC.

   Response: SEA tested 10 representative ROV samples to the tilt table requirements in ANSI/ROHVA 1-2011. All of the ROVs tested pass the minimum 30-degree TTA. Vehicle D, the vehicle with the lowest rollover resistance (A_y = 0.625 g, TTA = 33.7 degrees), exceeds the TTA requirement by 3.7 degrees, or 12 percent above the 30-degree minimum requirement. Vehicle A, the ROV that was part of a repair program to increase its roll resistance, exceeds the TTA requirement by 3.0 degrees, or 10 percent above the 30-degree minimum.

   The TTA requirement in the voluntary standard does not correlate to the actual rollover resistance of ROVs, allows a vehicle that was part of repair program to pass the test without having undergone the repair, and provides no incentive for manufacturers to improve the lateral stability of ROVs. CPSC staff believes that the threshold lateral acceleration at rollover value is a direct measure for rollover resistance, and its use would eliminate the need for tilt table testing as a requirement.

6. **Comment:** Comments from the Companies, the Committee, and several individuals state that the SSF values recommended by CPSC staff for ROVs would make the vehicles unusable for off-road use and would eliminate this class of vehicle.

   Response: CPSC staff no longer recommends using the SSF value as a measure of an ROV's rollover resistance. The SSF value of a vehicle represents the best theoretical lateral stability that the vehicle can achieve. CPSC staff compared the actual lateral acceleration at rollover threshold of several ROVs, as measured by the J-turn test, and found that the static measures (whether it is $K_{st,}$ or SSF, or TTA) are not accurate predictors of the vehicle's actual lateral stability due to the extreme compliance in the vehicle's suspension and tires. Therefore, staff believes that neither the $K_{st,}$ nor the SSF is an accurate measure of an ROV's lateral stability. CPSC staff believes that the vehicle's actual lateral acceleration at rollover threshold is the appropriate measure of the vehicle's lateral stability.

Vehicle Handling

1. **Comment:** Comments from CEI and the Companies state that measurements of understeer/oversteer made on pavement are not applicable to non-pavement surfaces. ROVs are intended for off-highway use and any pavement use is product misuse.

   Response: Both the ANSI/ROHVA and ANSI/OPEI standards specify dynamic testing on a paved surface. This indicates that ROHVA and OPEI agree that testing of ROVs on pavement is appropriate because pavement has a uniform high-friction surface. Tests conducted on pavement show how the vehicle responds at lateral accelerations that range from low lateral accelerations (associated with low friction surfaces like sand) up to the highest lateral acceleration that can be generated by friction at the vehicle's tires. This provides a complete picture of how the vehicle handles on all level surfaces. The amount of friction at the tires, and thus, the lateral accelerations generated, varies on non-paved surfaces, but the vehicle's handling at each lateral acceleration does not change when the driving surface changes.

2. **Comment:** Comments from CEI state that CEI has performed various tests and analyses on ROVs. In particular, CEI states that their tests demonstrate that ROVs that exhibit oversteer are not unstable. CEI states:

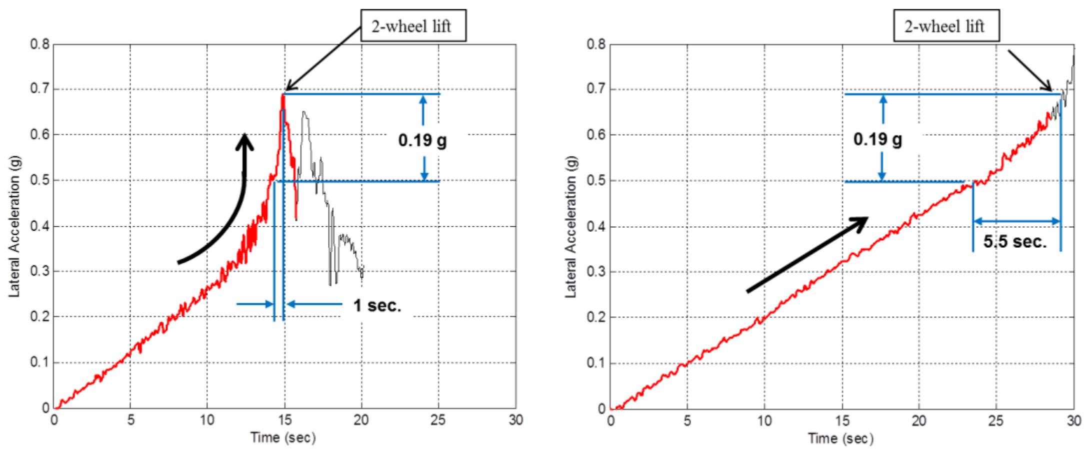
   " For a vehicle with an oversteer gradient, the static directional stability moment acts to reduce the radius of whatever turn the vehicle is negotiating. This moment becomes larger as oversteer gradient is made larger. At a 'critical speed' defined as the point where yaw damping moment and the static directional stability moment are of equal magnitude, only driver control input acts to maintain path. In other words, a vehicle with oversteer gradient travelling at 'critical speed' cannot maintain steady state response with a non-zero steady steering input. If this vehicle is traveling in a curved path above the "critical speed," the steering must be turned opposite the direction of the vehicle turn to maintain a steady state response."

   CEI also states, "[e]ven though different test conditions produce data that differ in detail, all tested machines were easily controllable to their limits and each had appropriate limits to allow safe operation." [Carr, L. (2010) Comment Lettter from Lee Carr. pp 22 and 30. Retrieved from http://www.regulations.gov/#!documentDetail;D=CPSC-2009-0087-0115]

   CEI concludes that these results confirm that the samples of machines tested are not directionally unstable, do not spin at the limit on any surfaces consistent with steering gradient measurement, and do not possess "undesirable steering characteristics." These, and tests done on straight line paths to the machines' top speeds, confirmed that they cannot reach a "critical speed."

Response: CPSC staff disagrees with the statement that ROVs that exhibit oversteer are stable. Vehicles that exhibit sub-limit oversteer have a unique and undesirable characteristic, marked by a sudden increase in lateral acceleration during a turn. This dynamic instability is called critical speed and is described by Thomas D. Gillespie in the *Fundamentals of Vehicle Dynamics* as the speed “above which the vehicle will be unstable.”[90] Gillespie further explains that an oversteer vehicle “becomes directionally unstable at and above the critical speed” because the lateral acceleration gain approaches infinity.

CEI states that their tests demonstrate that ROVs that exhibit oversteer are not unstable. However, testing performed by SEA shows that oversteering ROVs can exhibit a sudden increase in lateral acceleration, resulting in a roll over (see Tab A). Plots from SIS tests illustrate this sudden increase in lateral acceleration that is found only in vehicles that exhibit sub-limit oversteer (see Figure 28). Vehicle A is an ROV that transitions to oversteer; Vehicle H is the same model ROV, but a later model year in which the oversteer has been corrected to understeer.



Vehicle A (Oversteer) Vehicle H (Understeer)

Figure 28. SIS Plot of Lateral Acceleration Gain Over Time

Source: Heydinger, G. (2011) Vehicle Characteristics Measurements of Recreational Off-Highway Vehicles. Retrieved from http://www.cpsc.gov/PageFiles/96037/rov.pdf.

When Vehicle A reached its dynamically unstable condition, the lateral acceleration suddenly increased from 0.50 g to 0.69 g (difference of 0.19 g) in less than 1 second, and the vehicle rolled over.[91] In contrast, Vehicle H never reached a dynamically unstable condition because the condition does not develop in understeering vehicles. The increase in Vehicle H’s lateral acceleration remains linear, and the lateral acceleration increase from 0.50 g to 0.69 g (same difference of 0.19 g) occurs in 5.5 seconds. A driver in Vehicle H has more margin to correct the steering to prevent rollover than a driver in Vehicle A because Vehicle H remains in understeer during the turn, while Vehicle A transitions to oversteer and becomes dynamically unstable.

[90] Gillespie, T. (1992). Fundamentals of Vehicle Dynamics. Society of Automotive Engineers, Inc. p.204-205.
[91] Outriggers on the vehicle prevented full rollover of the vehicle.

SEA test results indicate that ROVs that exhibited sub-limit oversteer also exhibited a sudden increase in lateral acceleration that caused the vehicle to roll over. An ROV that exhibits this sudden increase in lateral acceleration is directionally unstable and uncontrollable.[92,93] CPSC staff believes that tests conducted by SEA provide strong evidence that sub-limit oversteer in ROVs is an unstable condition that can lead to a rollover incident, especially given the low rollover resistance of ROVs.

3. **Comment:** Comments from CEI and the Companies state that all vehicles, whether they understeer or oversteer, can be driven to limit conditions and can spin or plough. Any vehicle can exhibit "limit oversteer" through manipulation by the driver.

   Response: CPSC staff does not dispute that operator input and road conditions can affect limit oversteer or understeer in a vehicle. The vehicle handling requirements proposed by staff specify that vehicles exhibit sub-limit understeer. CPSC staff believes that sub-limit oversteer is an unstable condition that can lead to a rollover incident. Ten sample ROVs were tested by SEA; five of the 10 vehicles exhibited a desirable sub-limit understeer condition, and five exhibited a transition to undesirable sub-limit oversteer condition. CPSC staff believes that ROVs can be designed to understeer with minimal cost and without diminishing the utility or recreational value of this class of vehicle.

4. **Comment:** Comments from the Companies state that oversteer is desirable for path-following capability. Specifically, vehicles in oversteer will generally follow the path and allow directional control of the vehicle. High rear tire slip angles and tire longitudinal slip are needed for traction on off-highway surfaces, such as loose soil.

   Response: CPSC staff is not aware of any studies that define "path-following capability" and its relation to the sub-limit understeer or oversteer design of the vehicle. Of the 10 sample ROVs tested by SEA, five vehicles exhibited a desirable sub-limit understeer condition. CPSC staff is not aware of any reports of the steering of sub-limit understeering vehicles causing loss of control or preventing the driver from navigating off-road terrain.

   A significant body of research has been conducted over many years regarding the science of vehicle dynamic handling and control. CPSC staff has reviewed technical papers regarding vehicle handling research (see Tab A) and finds no agreement with the statement that "a vehicle in an oversteer condition will generally follow the path and allow directional control of the vehicle to be maintained longer." In fact, staff's research finds universal characterization of sub-limit oversteer as directionally unstable, highly undesirable, and dynamically unstable at or above the critical speed.[94] CPSC staff's review of 80 years of

[92] Bundorf, R. T. (1967). The Influence of Vehicle Design Parameters on Characteristic Speed and Understeer. SAE 670078.
[93] Segel, L. (1957). Research in the Fundamentals of Automobile Control and Stability. SAE 570044.
[94] Olley, M. (1934). Independent Wheel Suspension - Its Whys and Wherefores. SAE 340080.; Stonex, K. A. (1941). Car Control Factors and Their Measurement. SAE 410092.; Segel, L. (1957). Research in the Fundamentals of Automobile Control and Stability. SAE 570044.; Bergman, W. (1965). The Basic Nature of Vehicle Understeer – Oversteer. SAE 650085.; Bundorf, R. T. and Leffert, R. L. (1976). The Cornering Compliance Concept for

automotive research did not find support for the suggestion that sub-limit oversteer provides superior precision in handling and control.

Likewise, limit oversteer is described by the Companies as the result of the driver "operating the vehicle in a turn at a speed beyond what is safe and reasonable for that turn or applying excessive power in a turn." A vehicle in limit oversteer is essentially sliding with the rear of the vehicle rotating about the yaw axis. A vehicle in a slide is susceptible to a tripped rollover. ROVs have low rollover resistance and are at a high risk of a violent tripped rollover. Autonomous vehicle testing by SEA has duplicated these limit oversteer conditions and found that tripped rollovers can create in excess of 2 g to 3 g of instantaneous lateral acceleration, which produces a violent rollover event. Staff believes that eliminating sub-limit oversteer will reduce unintentional transitions to limit oversteer.

Staff does not agree that producing power oversteer by spinning the rear wheels is a necessity for negotiating low-friction, off-highway surfaces. Drifting or power oversteering is a risky practice that presents tripped rollover hazards and does not improve the vehicle's controllability. However, the practice of power oversteering is the result of driver choices that are not under the control of the manufacturer or the CPSC and will not be significantly affected by the elimination of sub-limit oversteer.

5. **Comment:** Comments from the Companies state that requiring ROVs to exhibit understeer characteristics could create unintended and adverse risk, such as gross loss of mobility. These commenters assert that CPSC would be trading one set of purported safety issues for another, equally challenging set of safety issues, and running against 100 years of experience in off-highway vehicle design and driving practice, which suggests that for off-highway conditions, limit oversteer is at least sometimes, if not most often, preferable to limit understeer.

   Response: ROVs that exhibit sub-limit understeering are currently in the U.S. market in substantial numbers. CPSC staff is not aware of any reports of the steering of sub-limit understeering vehicles causing loss of control or preventing the driver from navigating off-road terrain. CPSC is not aware of any reports of sub-limit understeering vehicles that exhibit the unintended consequences described by the Companies.

   For the reasons set forth in detail at Tab A, CPSC staff believes that sub-limit oversteer is an unstable condition that can lead to a rollover incident. Based on the Yamaha Rhino repair program and the SEA test results indicating that half of the sample ROVs tested already exhibit sub-limit understeer, CPSC staff believes that ROVs can be designed to understeer with minimum cost and without diminishing the utility or recreational value of this class of vehicle.

6. **Comment:** Comments from CEI, the Companies, and the Committee state that no correlation can be shown between understeer/oversteer and ROV crashes or rollovers.

Description of Vehicle Directional Control Properties. SAE 760713.; and Milliken, William F., Jr., et al. (1976). The Static Directional Stability and Control of the Automobile. SAE 760712.

Response: CPSC staff believes that from a design and engineering perspective, the physics of vehicle rollover inherently support the fact that increasing a vehicle's resistance to rollover will make the vehicle more stable. In addition, eliminating a vehicle characteristic that exhibits a sudden increase in lateral acceleration during a turn will reduce the risk of rollover. As reflected in staff's analysis at Tab A, CPSC staff believes that the constant radius tests and SIS tests conducted by SEA provide strong evidence that sub-limit oversteer is an unstable condition that can lead to a rollover incident.

Of the 428 ROV-related incidents reviewed by CPSC staff, 291 (68 percent) involved lateral rollover of the vehicle and more than half of these (52 percent) occurred while the vehicle was turning. Of the 147 fatal incidents that involved rollover, 26 (18 percent) occurred on a paved surface. A vehicle exhibiting oversteer is most susceptible to rollover in a turn where the undesirable sudden increase in lateral acceleration can cause rollover to occur quickly, especially on paved surfaces where an ROV can exhibit an untripped rollover.

CPSC staff believes that improving the rollover resistance and vehicle steering characteristics of ROVs is a practical strategy for reducing the occurrence of ROV rollover events.

Occupant Protection

1. **Comment:** Comments from CEI, the Companies, and the Committee state that seat belt use is critically important. Increasing seat belt use is the most productive and effective way to reduce ROV-related injuries and deaths because seat belt use is so low among those injured in ROV incidents. A major challenge clearly is how to get occupants to use the seat belt properly.

   Response: CPSC staff agrees that the use of seat belts is important in restraining occupants in the event of a rollover or other accident. Results of CPSC staff's testing of belted and unbelted occupants in simulated ROV rollover events indicate that seat belt use is required to retain occupants within the vehicle. Without seat belt use, occupants experience partial to full ejection from the vehicle. This scenario has been identified as an injury hazard in CPSC staff's review of ROV-related incidents. Of those incidents that involved occupant ejection, many occupants suffered crushing injuries caused by the vehicle.

   As reflected in Tab I, CPSC staff believes an 8-second reminder light, as required in ANSI/ROHVA 1-2011 and ANSI/OPEI B71.9-2012, is not adequate to increase meaningfully seat belt use rates in ROVs because the system is not intrusive enough to motivate drivers and passengers to wear their seat belts. Results from past studies on automotive seat belt reminders conclude that visual reminders are ineffective. Numerous studies also conclude that effective reminder systems have to be intrusive enough to motivate users to buckle their seat belts. The more intrusive reminders are more effective at changing user behavior, as long as the reminder is not so intrusive that users bypass the system.

CPSC staff believes that a seat belt speed limiting system that restricts the maximum speed of the vehicle to 15 mph, if the driver seat and any occupied front seats are not buckled, is the most effective method to increase meaningfully seat belt use rates in ROVs (see Tab I). The system is transparent to users at speeds of 15 mph and below, and consistently motivates occupants to buckle their seat belts to achieve speeds above 15 mph.

2. **Comment:** Comments from CEI state that four-point and five-point seat belts are not appropriate for ROVs. In contrast, several individual comments state that five-point seat belts should be required on ROVs.

   Response: CPSC staff identified lack of seat belt use as an injury hazard in CPSC staff's review of ROV-related incidents. The majority of safety restraints in the ROV incidents were three-point, and to some extent two-point, seat belts. Although four-point seat belts might be superior to three-point belts in retaining occupants in a vehicle, three-point seat belts have been shown to be effective in reducing the risk of death and serious injury in automotive applications.[95] CPSC staff believes it is unlikely that users who already do not use three-point seat belts will use the more cumbersome four-point and five-point seat belts.

   CSPC staff believes a more robust seat belt reminder system than the current voluntary standard requirement for a visual reminder light is required to motivate users to wear their seat belts because automotive studies of seat belt reminders indicate that visual reminders do not increase seat belt use.[96] Dynamic rollover tests of ROVs indicate that a three-point seat belt, in conjunction with a passive shoulder restraint, is effective in restraining an occupant inside the protective zone of the vehicle's ROPS during a quarter turn rollover.

3. **Comment:** Comments from CEI state that occupant protection requirements should be based on meaningful tests.

   Response: CPSC staff concurs that ROV occupant protection performance evaluation should be based on actual ROV rollovers or simulations of real-world rollovers. Occupant protection performance requirements for ROVs in the voluntary standard developed by ROHVA (ANSI/ROHVA 1-2011) and the voluntary standard developed by OPEI (ANSI/OPEI B71.9 -2012) are not supported by data from rollover tests (see Tab H).

   The SEA roll simulator is the most accurate simulation of an ROV rollover event because it has been validated by measurements taken during actual ROV rollovers. Preliminary rollover tests indicate that a seat belt, used in conjunction with a passive shoulder barrier, is effective at restraining occupants within the protective zone of the vehicle's ROPS during quarter-turn rollover events.

[95] Dinh-Zarr, T.B. et al. (2001). Reviews of Evidence Regarding Interventions to Increase the Use of Safety Belts. *American Journal of Preventative Medicine*, Vol. 21, Nos. 4S., pp. 48-65.
[96] Freedman, M. et al. (2009). Effectiveness and Acceptance of Enhanced Seat Belt Reminder Systems: Characteristics of Optimal Reminder Systems. (DOT HS 811 097). Washington, D.C.: National Highway Traffic Safety Administration, U.S. Department of Transportation.

ROV Incident Analysis

1. **Comment:** Comments from CEI state that ROV rollover incidents are caused by a small minority of drivers who intentionally drive at the limits of the vehicle and the driver's abilities, and intentionally drive in extreme environments.

   Response: As reflected in more detail in Tab D, of the 224 reported ROV incidents that involved at least one fatality, 147 incidents involved lateral rollover of the vehicle. Of the 147 lateral rollover fatalities, it is reported that the ROV was on flat terrain in 56 incidents (38 percent) and on a gentle incline in 18 incidents (12 percent). Of the 224 fatal ROV incidents, the vehicle speed is unknown in 164 incidents (73 percent), 32 incidents (14 percent) occurred at speeds of 20 miles per hour (mph) or less, and 28 incidents (13 percent) occurred at speeds more than 20 mph.[97] Of the 224 fatal ROV incidents, the age of the driver was younger than 16 years old in 61 incidents (27 percent). Of the 231 fatalities, 77 victims (33 percent) were children younger than 16 years of age.

   A review of the incident data shows that there is no indication that the majority of rollover incidents are caused by drivers who "purposely push the vehicle to and beyond its limits by engaging in stunts, racing, and intentional use of extreme environments." An analysis of the reported ROV incidents indicates that many of the details of the circumstances of the event, such as vehicle speed or terrain slope, are not known. Where details of the event are known, roughly 50 percent of the fatal lateral rollover incidents occurred on flat or gentle slope terrain, and 14 percent occurred at speeds below 20 miles per hour. Twenty-seven percent of the drivers in fatal rollover incidents are children under 16 years of age, and 33 percent of all ROV-related fatalities are children under 16 years of age.

2. **Comment:** Comments from the Companies state that CPSC staff failed to use data from the National Electronic Injury Surveillance System (NEISS) in its analysis of ROV hazards. The comments also suggest that analysis of the NEISS data on utility-terrain vehicles (UTVs) indicates that UTVs, and therefore, ROVs, have a low hospitalization rate.

   Response: The joint comment's conclusions based on the commenters' analyses of the NEISS UTV data are not technically sound because the NEISS results do not specifically identify ROVs. NEISS has a product code for UTVs and several product codes for ATVs, but there is no separate product code for ROVs. ATVs have a straddle seat for the operator and handlebars for steering. UTVs have bucket or bench seats for the operator/passengers, a steering wheel for steering, and may or may not have a ROPS. ROVs are a subset of UTVs and are distinguished by having a ROPS, seat belts, and a maximum speed above 30 mph. However, many official entities, news media, and consumers refer to ROVs as ATVs. Injuries associated with ROVs are usually assigned to either an ATV product category or to the UTV product category in NEISS. At a minimum, ROVs can be thought of as a subset of UTVs and/or ATVs, and ROVs cannot be identified through the NEISS case records on a consistent basis because identification requires the knowledge of the make/model of the

[97] Vehicle speeds were reported (*i.e.*, not measured by instrumentation) so can only be used qualitatively and not as accurate values of speed at which incidents occurred.

vehicle (which is not coded in the NEISS for any product). Occasionally, the NEISS narrative contains make/model identification, but this cannot be used to accurately and consistently identify ROVs.

CPSC staff conducted a special study in 2010, in which all cases coded as ATVs or UTVs were selected for telephone interviews to gather information about the product involved. Sixteen of the 668 completed surveys had responses that identified the vehicle as an ROV. CPSC analysis shows that many ROVs are coded as ATVs; many UTVs are also coded as ATVs; and identification of ROVs and UTVs is difficult because the NEISS narratives often do not include enough information to identify the product. The miscoding rate for UTVs and ROVs is high, and most likely the miscoding is due to consumer-reported information in the emergency department.

CPSC added the UTV product code 5044 to the NEISS in 2005. In the years 2005 to 2008 (the years cited in the joint comment document), the UTV product code had mostly out-of-scope records, with a large number of utility trailers and similar records. After these are removed, the only viable estimate is obtained by aggregating the cases across 2005 to 2008 to get an estimated 1,300 emergency department-treated injuries related to UTVs from 2005 to 2008 (see Tab K, Table 1). This estimate is considerably less than the estimate reported by Heiden in the joint comment. This estimate also does not include the UTV-related injuries that were miscoded as ATVs in the ATV product codes. ROV-related injuries are a subcategory of all these UTV-related injuries.

As the years have passed and the UTV product code is being used more as intended, a completely different picture is seen for UTVs. From 2009 to 2012, there are an estimated 6,200 emergency department-treated, UTV-related injuries (which can be attributed to an increase in the number of UTV-related injuries, a larger portion of injuries being identified in NEISS as UTVs, or combination of all of these and other factors not identified). Of these estimated 6,200 injuries, only 80.2 percent are treated and released. The proportion of treated and released for UTVs is significantly below the proportion of treated and released for all consumer products (92.0% of estimated consumer product-related, emergency department-treated injuries were treated and released from 2009 to 2012). This illustrates a hazard of more severe injuries associated with UTVs.

In conclusion, data are insufficient to support the arguments that UTV injuries are not as severe as those associated with other products. As more data have become available in recent years, it appears that about 80 percent of the injuries have been treated and released compared to about 92 percent of the injuries associated with all consumer products.

3. **Comment:** The Companies provided their own analysis of ROV-related reports that were used in CPSC staff's ANPR analysis. In particular, the Companies criticized CPSC staff's analysis because, the Companies assert, staff's analysis did not include factors related to incident conditions and user behavior.

Specifically, the Companies state that "CPSC has not sorted the IDIs and correlated them against vehicle performance indices according to the key factors that would be expected to influence rollover rate, including: specific types of accident, surface types (*e.g.*, gravel mud, hard dirt, two-layer soil), surface conditions (dry moist, wet, frozen), terrain (grade, cross-slope, obstacle-size), loading conditions (occupants, cargo), accident mechanism and causations (*e.g.*, control inputs and sequence, attempted task), misuse factors (*e.g.*, non-use of helmets, belts, improper maintenance, tire pressures), operator age and gender, or make-model-year of ROV."

The Companies provide their own analysis of ROV-related incidents and state that they "analyzed these completed IDIs for the presence of eight behavior patterns that are specifically enumerated and warned against by ROHVA and its members. These warned-against behavior patterns include: (1) doing stunts; (2) riding at excessive speeds; (3) riding on public or paved roads; (4) operation by a driver under the age of 16; (5) the use of alcohol or drugs while driving; (6) passengers riding in improper seating configurations; (7) riders failing to wear a helmet; (8) riders failing to wear a seatbelt. Heiden found that at least one warned-against behavior was present in 98 percent of the IDI-reported accidents, and that multiple warned-against behaviors were present in 88 percent of these accidents."

From the Companies' analysis, the Companies state that" among the 86 IDI-reported accidents that involved a rollover or overturn, 22 occurred when the driver was making a sharp turn or turning at an excessive rate of speed, 20 occurred when the driver was operating the vehicle on a steep grade, and 11 occurred when the driver was attempting a dangerous maneuver." [Daley, et al. (2010) Comment Letter from the Companies. pp 13, 39, and 40.]

Response: CPSC staff's analysis of incidents for the ANPR was a preliminary review of reported incidents to understand the overall hazard patterns. For the NPR, staff conducted an extensive multidisciplinary review of 428 reported ROV-related incidents with at least one death or injury. The results of this study are summarized in a report in the NPR briefing package with analyses of victim characteristics, hazard patterns, environmental characteristics, and make and model characteristics (see Tab D). The approach taken in the comments from the Companies, to remove reports from the analysis because there is unknown information, is not CPSC staff's approach in analyzing incident data. Unknowns from all reports are reported along with the knowns to ensure the full picture is seen, as every report will have at least one piece of unknown information, and every report will have at least one piece of known information. The unknowns are reported in all tables, if unknowns were recorded for the variables used.

The analysis of IDIs summarized in the comments from the Companies does not define what was meant by "excessive speed" or by "dangerous maneuver" or "sharp turn." In fact, in other places in the comments, the Companies state: "There is also no evidence suggesting that speed is an important factor in preventing accidents" (page 27). The Companies also state: "Tight steering turn capability is an important feature in certain ROVs, particularly those for trail use, because of the need to respond quickly to avoid obstacles and trail-edge drop-offs, and otherwise navigate in these off-highway terrains" (page 29). Thus, there is ambiguity in what the definitions could mean in the analysis of the IDIs (When is the vehicle at an excessive speed? When is a turn too sharp? When is a maneuver dangerous?).

CPSC staff's approach to analyzing the 428 incidents summarized in the reports available in the NPR briefing package is to consider the sequence of events, the vehicle, the driver, any passenger, and environment characteristics across all incidents. All definitions are set and used consistently by the multidisciplinary review team to understand the hazard patterns across all incidents, not to set blame in one place or another.

4. **Comment:** Comments from CEI state that the CPSC should start an effort to address human factors that pertain to risk taking behavior of the small minority of ROV users who operate the vehicles at their limits without crash worthiness concerns. In particular, CEI proposes that CPSC staff focus primarily on changing consumer behavior to wear seat belts, wear helmets, and refrain from driving ROVs irresponsibly.

   Response: CPSC staff agrees that human factors and behavior affect the risk of death and injury for ROV users. However, CPSC staff believes that establishing minimum requirements for ROVs can also reduce the hazards associated with ROVs. For the reasons reflected in this memorandum and accompanying materials, CPSC staff does not believe that the ANSI/ROHVA voluntary standard adequately addresses the risk of injury and death associated with lateral rollovers of ROVs because the standards do not have robust lateral stability requirements, do not have vehicle handling requirement to ensure understeer, and do not have robust occupant restraint requirements to protect occupants from vehicle rollover.

   An analysis of the reported ROV incidents indicates that many of the details of an event, such as vehicle speed or terrain slope, are not known. Where details of the event are known, roughly 50 percent of the fatal lateral rollover incidents occurred on flat or gentle slope terrain, and 14 percent occurred at speeds below 20 miles per hour. Twenty-seven percent of the drivers in fatal rollover incidents are children under 16 years of age, and 33 percent of all ROV-related fatalities are children under 16 years of age. There is no indication that the majority of rollover incidents are caused by drivers who intentionally drive under extreme conditions.

   Regarding seat belt use, results from past studies on automotive seat belt reminders conclude that visual seat belt reminders are ineffective. Numerous studies further conclude that effective reminder systems have to be intrusive enough to motivate users to buckle their seat belts. The more intrusive reminders are more effective at changing user behavior, as long as the reminder is not so intrusive that users bypass the system.

   CPSC staff believes a seat belt speed limiting system that restricts the maximum speed of the vehicle to 15 mph, if the driver seat and any occupied front seats are not buckled, is the most effective method to meaningfully increase seat belt use rates in ROVs. The system is transparent to users at speeds of 15 mph and below and consistently motivates occupants to buckle their seat belts to achieve speeds above 15 mph.

VI. STAFF RECOMMENDATION

As of April 5, 2013, CPSC staff is aware of 550 reported ROV-related incidents that occurred between January 1, 2003 and April 5, 2013; there were 335 reported fatalities and 506 reported injuries related to these incidents. In 2012, CPSC staff conducted a multidisciplinary review ROV-related incidents that occurred and were reported between January 1, 2003 and December 31, 2011. From January 1, 2003 to December 31, 2011, CPSC staff is aware of 428 reported ROV-related incidents, including 231 fatalities and 388 injuries. CPSC staff analysis of the 428 incidents identifies ROV rollover and occupant ejection as a dominant hazard pattern.

CPSC staff believes improving rollover resistance, vehicle handling, and occupant protection performance is an effective strategy for reducing deaths and injuries associated with ROV rollover. Technical analysis shows that CPSC staff's recommended requirements will reduce ROV deaths and injuries by reducing the occurrence of ROV rollovers and reducing the severity of injuries when rollovers occur. Staff believes that the recommended requirements are technologically feasible and that the potential benefits of the draft proposed rule substantially exceed the rule's costs. Moreover, staff believes that the current voluntary standards for ROVs will not reduce deaths and injuries associated with ROV rollover and occupant ejection.

CPSC staff recommends that the Commission publish an NPR for ROV safety that includes specific requirements on vehicle lateral stability, vehicle handling, and occupant protection performance. These requirements are stated in the draft NPR.

Additionally, CPSC staff recommends that the Commission propose an effective date of 180 days after publication of the final rule for manufacturers to comply with the lateral stability and vehicle handling requirements. For the occupant protection performance requirements, staff recommends a 12-month effective date following publication of the final rule. Staff believes ROV models that do not comply with the lateral stability and vehicle handling requirements can be modified, with changes to track width and suspension, in less than 4 person-months (a high estimate) and believes that these ROV models can be tested for compliance in 1 day. Therefore, staff believes that 180 days is a reasonable period of time for manufacturers to modify vehicles, if necessary; conduct required tests; and analyze test results to ensure compliance with the recommended lateral stability and vehicle handling requirements.

CPSC staff recognizes that vehicles that do not meet the occupant protection requirements may require modifications involving the addition of sensors and a means to limit vehicle speed. Staff recommends proposing the longer compliance date for the occupant protection requirements because staff believes that some manufacturers will need to redesign and test new prototype vehicles to meet these requirements. This design and test process is similar to the process that manufacturers use when introducing new model year vehicles. Staff also estimates that it will take approximately 9 person-months per ROV model to design, test, implement, and begin manufacturing the vehicle to meet the recommended occupant protection performance requirements. Therefore, staff believes that 12 months from publication of a final rule would be sufficient time for ROVs to comply with all of the proposed requirements.

TAB A

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
4330 EAST WEST HIGHWAY
BETHESDA, MD 20814

Memorandum

Date: September 19, 2014

TO: Caroleene Paul, Project Manager
Directorate for Engineering Sciences

THROUGH: George Borlase, Assistant Executive Director
Office of Hazard Identification and Reduction

Mark Kumagai, Division Director
Division of Mechanical Engineering

FROM: Anthony Teems, ESME
Directorate for Engineering Sciences

SUBJECT: Proposed lateral stability and vehicle handling requirements for Recreational Off-Highway Vehicles (ROVs)

I. EXECUTIVE SUMMARY

Recreational Off-Highway Vehicles (ROVs) have developed in recent years as a popular mode of off-highway transportation with utility and entertainment value. CPSC staff reviewed 428 ROV-related incidents with 388 injuries and 231 fatalities occurring in the period from January 2003 to December 2011 [10].[1] Of those 428 incidents, 68 percent (291) were lateral rollover events, resulting in 258 injuries and 150 fatalities. CPSC staff believes that ROV rollover is a dominant hazard pattern that has significant potential for improvement.

Improving lateral rollover resistance and vehicle handling is a strategy for reducing ROV rollover events. The National Highway Traffic Safety Administration (NHTSA) uses the Static Stability Factor (SSF), combined with dynamic test results, as a rollover resistance metric [17]. CPSC staff considered tilt table testing and various forms of dynamic testing to characterize rollover resistance. CPSC staff found that dynamic J-turn testing produces a more complete depiction of actual rollover resistance than tilt table testing, which is one measure of lateral stability employed in the standard *ANSI/ROHVA 1 – 2011 American National Standard for Recreational Off-Highway Vehicles*.

ROVs obey the same principles of motion as automobiles because both types of vehicles share key characteristics, such as pneumatic tires, steering wheel, and spring-damper suspension that contribute to the dynamic response of the vehicle. The automobile industry identifies oversteer as an undesirable trait because it is a directionally unstable steering response that leads to

[1] Bracketed numbers refer to references listed in Appendix C.

dynamic instability and loss of control [25]. Therefore, automobiles are designed to exhibit understeer characteristics for operating conditions that are within the traction limits of the tires [27]. Such a condition is called “sub-limit understeer” because the tires are operating below their traction limit. Five of the 10 vehicles in the CPSC test project exhibited a transition from understeer to oversteer below the traction limit of the tires during testing (“sub-limit oversteer”). Analysis by NHTSA and independent researchers has shown that sub-limit oversteer can adversely affect rollover resistance [1, 19]. Therefore, CPSC staff believes that sub-limit oversteer is an undesirable characteristic that contributes to ROV rollover events.

To improve rollover resistance in ROVs, and to mitigate rollover risks to users, CPSC staff recommends that the Commission establish the following performance requirements for ROVs:

1. ROVs shall exhibit understeer in the lateral acceleration range from 0.10 g[2] to 0.50 g when tested in a 100-foot radius turn circle test.
2. ROVs, when tested in a 30 mile per hour drop-throttle J-turn test procedure, shall demonstrate a minimum level for lateral acceleration threshold at rollover of 0.70 g or greater.
3. ROVs shall have a hangtag at the point of sale that provides information about the vehicle’s rollover resistance.

II. INTRODUCTION

A. Product

CPSC staff describes “ROVs” as self-propelled vehicles designed for off-highway use, with the following features: four or more wheels with pneumatic tires, side-by-side seating for one or more occupants, automotive-type controls, and top speeds greater than 30 miles per hour (mph). ROVs are equipped with Rollover Protective Structures (ROPS), seat belts, and other restraints, such as doors, nets, and shoulder bolsters for the protection of occupants. ROVs typically have four-wheel drive capabilities and four-wheel brakes. The vehicles are available with various seating arrangements for one, two, three, four, or six occupants. Two-seat versions have driver and passenger seated side-by-side in individual seats. Three-seat versions place driver and two passengers seated side-by-side on a bench seat. Four-seat versions place the driver and passenger seats in front and two additional passenger seats behind the front seats. Six-seat versions place occupants in front and rear bench seats, each accommodating three occupants. Top speeds for ROVs tested by CPSC staff vary from approximately 39 mph to 68 mph [12].

Early ROV models were equipped to retain the utility aspects of the vehicles. However, today there are two distinct varieties: utility and recreational ROVs. See Figures 1 and 2, respectively. Models emphasizing utility have larger cargo beds, greater cargo capacities, and lower top speeds. Models emphasizing recreation have smaller cargo beds, lower cargo capacities, and higher top speeds. Both varieties of ROVs will be included in the scope of the rule recommended by staff.

[2] “g” is a unit of acceleration, used in the study of vehicle dynamics, which is equal to the acceleration due to earth’s gravity. For reference, 1 g equals approximately 32.2 ft. /sec^2 (9.8 m/sec^2).

Figure 1 – Typical Utility ROV

Figure 2 – Typical Recreational ROV

B. Background

Off-road utility vehicles, or side-by-sides, were first introduced to the market in the late 1980s and early 1990s in response to demand for small vehicles that could be used off-highway and on rough terrain primarily for utility purposes. These vehicles were intended for work, including construction, farming, and use on large estates. The category was not specifically covered by any safety standards that existed at the time. One standard, American National Standards Institute/Industrial Truck Standards Development Foundation (ANSI/ITSDF) B56.8, *Safety Standard for Personnel and Burden Carriers*, was a potential guide; however, this standard was intended for transportation vehicles and industrial trucks used on non-road improved surfaces. Later in 1996, Society of Automotive Engineers (SAE) J2258, *Surface Vehicle Standard, Light Utility Vehicles*, was published, which applied to off-highway vehicles with gross vehicle weights of 5,500 lbs. or less, and with maximum design speed less than 25 mph.

As the off-highway category evolved, new models were developed to cater to the recreational market. Top speeds continued to increase, and the first versions of ROVs appeared on the market in the late 1990s. CPSC staff began investigating ROVs in October 2008, in response to reports of serious injuries and fatalities associated with one manufacturer's vehicles. As the investigation progressed, staff became aware of 181 incidents involving serious injuries or deaths involving ROVs that occurred from January 2003 to August 2009 [22]. The Commission published an advance notice of proposed rulemaking (ANPR) regarding ROVs in October 2009.

Working with vehicle dynamics engineers at the U.S. Army Aberdeen Test Center (ATC), staff evaluated four ROV models for rollover resistance and handling characteristics. Dynamic vehicle tests were used to quantify the rollover resistance and steering characteristics of the vehicles. This testing found rollover resistance for the ROV models to be extremely low compared to passenger automobiles. In the tests, certain ROV models transitioned from a desirable understeer condition to an undesirable sub-limit[3] oversteer condition when turning. Passenger car manufacturers avoid this oversteer condition because this condition is a directionally unstable steering response that leads to dynamic instability and loss of control [25, 27].

[3] Sub-limit oversteer occurs when a vehicle that is turning has traction on all four tires and does not skid. Limit oversteer occurs when a vehicle is turning and the lateral loads due to turning cause the rear tires to reach the limit of traction and begin skidding.

For the period from January 2003 to December 2011, CPSC staff reviewed 428 ROV-related incidents involving 388 injuries and 231 deaths. Of the 428 ROV incidents, 68 percent (291) are known to be lateral rollover events [10]. Therefore, CPSC staff believes that vehicle lateral rollover is the dominant ROV hazard pattern.

In February 2010, CPSC staff contracted SEA, Limited (SEA), to conduct an in-depth study of vehicle dynamic performance and static rollover measures for ROVs. SEA evaluated a representative sample of 10 ROVs from the top seven manufacturers available in the U.S. market. SEA tested and measured several characteristics and features that relate to rollover performance, using various approaches, including J-turn tests, constant-radius turn tests, constant-speed slowly increasing-steer tests, center-of-gravity-location measurement; SEA also conducted various tilt table static measurements. This in-depth study has established a performance baseline for the existing ROV market and has been used by staff to develop minimum performance requirements and test methods to address the rollover hazard in ROVs.

Staff conducted an extensive review of the technical literature regarding vehicle dynamics, rollover propensity, and vehicle handling. The technical literature reviewed included extensive research on automobiles dating back to the 1930s. Staff believes that this very large body of research is complete, consistent, and fully applicable to ROVs. The literature reviewed is universal in finding that oversteer is a highly undesirable handling characteristic that can lead to loss of vehicle control and rollover. Additionally, in recent years, NHTSA has been involved in research concerning vehicle rollover, as required by the Transportation Recall, Enhancement, Accountability, and Documentation (TREAD) Act of November 2000, and research concerning vehicle handling in the implementation of Electronic Stability Control (ESC) regulations for passenger vehicles and light trucks. Although NHTSA's work is specific to on-road vehicles, the research provides direction and insights that are useful in the investigation of rollover and handling tendencies for ROVs. The technical literature research and the work by NHTSA are discussed in Appendix B.

III. DISCUSSION

This discussion will focus on topics relating to vehicle rollover and dynamic handling performance.

A. Vehicle Steering and Handling

Typical drivers of automobiles do not notice much about the steering and handling of their vehicle, other than the automobile is comfortable to drive. Most drivers are unaware that small deviations in steering occur during a turn in everyday driving. Studies show that only a fraction of a percent of the highway driving population reaches lateral accelerations as high as 0.35 g [5]. Everyday highway driving for most people does not create much more than 0.25 g of lateral acceleration when turning. At this level of lateral acceleration in dry conditions, passenger cars are well within the traction limits of the tires, operating in understeer, and well behaved. Therefore, the directional control of the vehicle is stable, *i.e.*, it reaches equilibrium in the turn and requires only corrections in the direction of constant-radius turning. If passenger vehicles were to exhibit sub-limit oversteer in these conditions, drivers would experience unfamiliar corrections, higher sensitivity, the need to counter-steer during turning, and sudden vehicle spins due to loss of traction at the rear wheels.

When a vehicle turns, each tire deflects and creates what is known as a slip angle θ for each tire. The difference between the magnitude of the front tires' slip angle and the rear tires' slip angle determines whether the resultant effect on steering deviates to understeer or to oversteer (see Figure 4). When the front slip angles are greater than the rear slip angles, the vehicle condition is understeer. When the rear slip angles are greater than the front slip angles, the vehicle condition is oversteer. The vehicle condition can change as the lateral acceleration increases, as shown in Figure 9, where that particular vehicle starts in an understeering condition and then transitions to an oversteering condition.

Automobiles are designed to operate in understeer in sub-limit driving situations, which are situations that are within the traction limits of the tires. Limit oversteer occurs in automobiles when maneuvers cause the rear tires to lose traction and skid. However, sub-limit oversteer during a turn occurs, not because the rear tires lose traction, but rather, because the side forces and tire flex cause the rear slip angle to be greater than the front slip angle. This, in turn, causes the vehicle to increase steering to a higher angle than the steering angle input by the driver. If there is sufficient forward speed, and the driver does not correct for the oversteer path of the vehicle, the vehicle will continue to spiral inward, with a commensurate increase in lateral acceleration until the vehicle rolls over or the rear slides out into limit oversteer (see Figures 3 and 4).

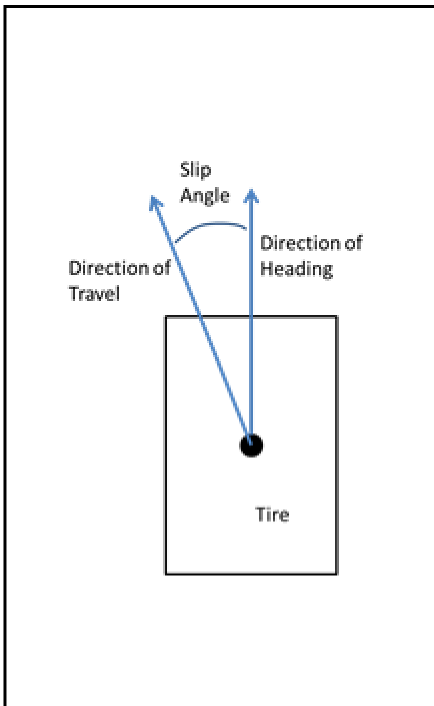


Figure 3- Slip Angle, θ

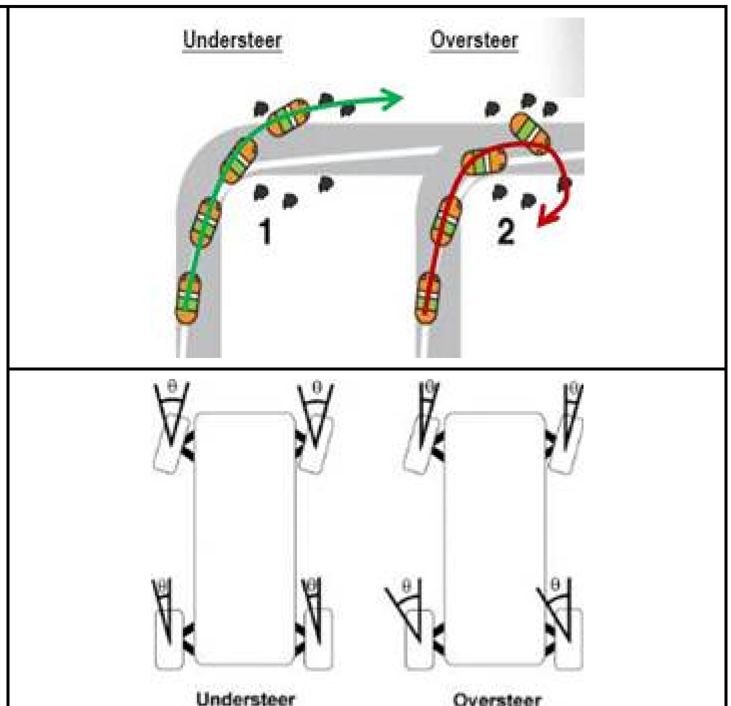


Figure 4- Understeer and Oversteer Angles and Paths

Sub-limit and limit oversteer are undesirable in both off-highway environments and on-highway environments due to the numerous trip hazards that can cause the vehicle to roll over. Vehicles that operate in sub-limit oversteer are prone to sudden transitions to limit oversteer when tire traction is lost, which results in vehicle spin. According to NHTSA's work regarding rollover resistance and electronic stability control spins create a sideways sliding motion of the vehicle, making the vehicle vulnerable to a tripped rollover [17, 19]. Ditches, rocks, ruts, and roots are examples of off-road objects on which a sliding vehicle can trip. In addition, ROVs are exposed to soft soil in most of the intended-use environments; a sliding tire in soft soil can push the soil into a small mound, which at some point may become sufficient to trip the vehicle.

For controllability, sub-limit understeer is a preferable and safer condition. When a vehicle is operating in understeer, the understeer decreases the lateral acceleration, and the driver increases the steering angle to compensate, until steer angle equilibrium is reached in the turn [25]. A vehicle operating in sub-limit oversteer does not reach steering angle equilibrium because oversteer increases the lateral acceleration, which increases the steering angle. This increasing deviation in steering requires the driver to turn the steering wheel in the opposite direction, or counter-steer, away from the direction of the turn, to maintain the desired path. Several cycles of steering and counter-steering may be required to negotiate a turn in an oversteering vehicle. If speed in a turn is sufficiently high to reach full dynamic instability, control of the vehicle will be lost in the process [3].

B. SEA Study of Existing ROVs

Staff contracted in February 2010 with SEA, an independent firm with experts in vehicle dynamic testing and static measurement. Under the contract, SEA collected test and measurement data on a sampling of 10 existing ROVs. In formulating the test objectives, staff focused on vehicle characteristics related to the rollover hazard and possible static measurement methods for determining the rollover resistance for any vehicle model.

Static Stability Factor (SSF)

Static Stability Factor (SSF) is a basic and relatively simple geometric relationship for evaluating vehicle rollover resistance. SSF approximates the lateral acceleration in units of gravitational acceleration (g) at which rollover begins in a simplified vehicle that is assumed to be a rigid body without suspension movement or tire deflections. NHTSA uses rollover risk, as determined from dynamic test results, in conjunction with SSF values to evaluate passenger vehicle rollover resistance for the New Car Assessment Program (NCAP) [17]. SSF relates the track width of the vehicle to the height of the vehicle center of gravity (CG), as shown in Figure 5. Loading condition is important because CG height and track width vary, depending on the vehicle load condition. Mathematically, the relationship is track width (T) divided by two times the CG height (H), or SSF=T/2H (see Figure 5). Higher values for SSF indicate lower risk for rollover, and lower SSF values indicate higher risk for rollover. The SSF equation is found in many texts and is given in reference [1], as Track Width Ratio.

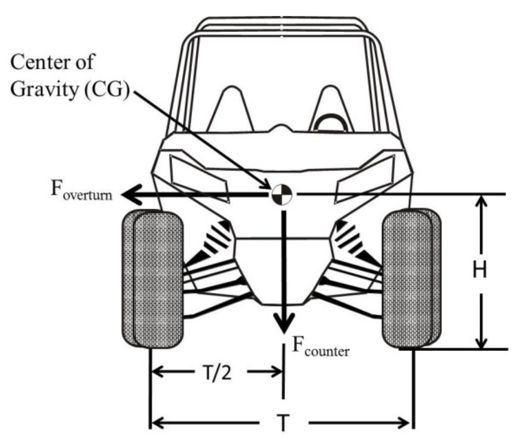


Figure 5 – SSF Dimensions, Vehicle Viewed from Front

SEA measured track width and CG height values for the sample group of 10 ROVs. SEA used their Vehicle Inertia Measurement Facility (VIMF) that incorporates the results of five different tests to determine the CG height. SEA has demonstrated that VIMF CG height measurements are repeatable within ±0.5 percent of the measured values [14]. Using the CG height and track width measurement, SEA calculated SSF values for several different load conditions.

Table 1 compares the SSF values of ROVs to on-road automobiles and trucks. The SSF values for ROVs used in this comparison were measured by SEA in the driver-only load condition. ROV SSF values range from 0.90 to 1.06, and averaged 0.98 [12]. SEA reported the SSF values for the on-road passenger cars, SUVs, trucks, and vans in the driver-only loading condition based on data collected on behalf of NHTSA [6]. The average passenger car SSF is 1.40 or 42 percent higher than the average SSF for ROVs. The average SUV SSF is 1.17 or 19 percent higher than the average SSF for ROVs.

The SSF values from the SEA report are averaged for each vehicle type and based on measurements of 528 models selected by NHTSA. The ROV SSF values were based on the average for the 10 vehicles measured by SEA.

Table 1 – Average SSF of ROVs Compared to On-Road Vehicles Driver-Only Load Condition [12, 6]

	ROVs 10 Models	2001-2008 Passenger Cars	2001-2008 SUVs	2001-2008 Pickup Trucks	2001-2008 Vans/Minivans
Average SSF	0.98	1.40	1.17	1.18	1.22
% Difference From ROV Avg.	0%	42%	19%	20%	24%
% Difference From ROV Low (0.90)	9%	56%	30%	31%	36%
% Difference From ROV High (1.06)	-8%	32%	10%	11%	15%
Range	0.90-1.06	1.19-1.65	1.04-1.29	1.00-1.39	1.07-1.36

Source: Bixel, et al., 2010 and Heydinger, et al., 2011

As seen in Table 1, the representative sample of ROVs has a lower average SSF value than the passenger cars, SUVs, pickup trucks, and minivans reported by SEA. There is a very small overlap with SUVs and pickup trucks in range values at approximately SSF=1.00 for the group of ROVs sampled.

These ROV SSF values are important in a discussion of rollover resistance because SSF is an important factor in a vehicle’s ability to resist an untripped rollover. An untripped rollover occurs when a vehicle executes a turn and the friction of the tires alone produces sufficient opposing side force to cause the vehicle to overturn. On pavement, vehicles with sufficiently high SSF values, such as SUVs and passenger cars, will lose tire traction and slide during a severe turn, rather than roll over. Vehicles with sufficiently low SSF values, such as the ROVs, will experience an untripped rollover on pavement, instead of losing traction and sliding.

Tilt Table Measurements

SEA conducted tilt table tests on the ROV sample group. In this test, the vehicles in various loaded conditions were placed on a rigid platform, and the angle of platform tilt was increased (see Figure 6) until both upper wheels of the vehicle lifted off the platform. The platform angle at two-wheel lift[4] is the Tilt Table Angle (TTA). The trigonometric tangent of the TTA is the Tilt Table Ratio (TTR). TTA and TTR are used to evaluate the stability of the vehicle. Larger TTA and TTR generally correspond to better lateral stability, except these measures do not account for dynamic tire deflections or dynamic suspension compliances. Tilt testing is a quick and simple static test that does not require sophisticated instrumentation. Tilt testing is used as a rollover metric in the voluntary standards created by the Recreational Off-Highway Vehicle Association (ROHVA) and the Outdoor Power Equipment Institute (OPEI). TTA and TTR values measured by SEA are shown in Table 2.

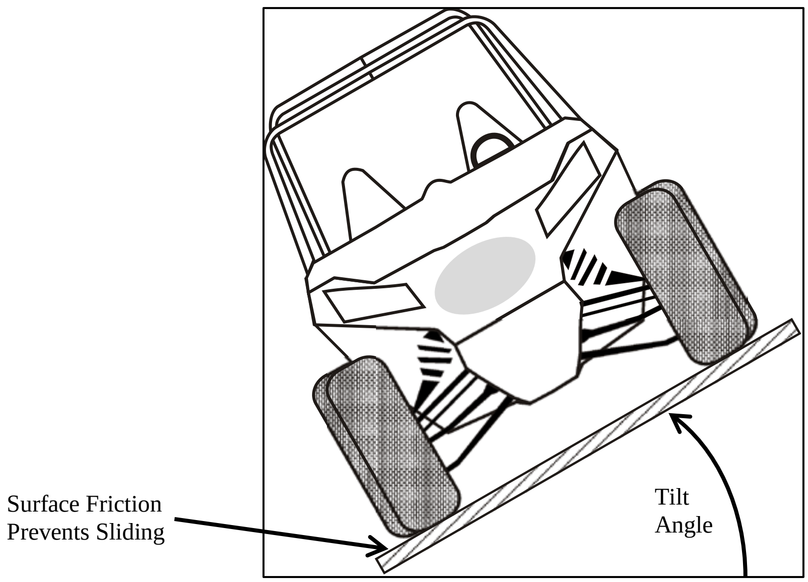


Figure 6 – Tilt Table Angle Measurement

Table 2
Tilt Table Angle (TTA) and Tilt Table Ratio (TTR)
(Operator Plus Passenger Load) [12]

Vehicle	A	B	C	D	E	F	G	H	I	J
TTA (deg.)	33.0	33.6	38.8	33.7	38.1	36.4	39.0	35.9	35.4	36.1
TTR Tan (TTA)	0.650	0.664	0.803	0.667	0.784	0.739	0.810	0.724	0.712	0.730

J-Turn Testing

Drop-throttle J-turn testing, also called step-steer testing, has been used by NHTSA to evaluate the untripped rollover resistance for automobiles [9]. J-turn tests are conducted by driving the test vehicle in a straight path, quickly releasing (dropping) the throttle and rapidly applying a

[4] Two-wheel lift is a term of convenience used to describe the condition where all of the wheels on one side of the vehicle lose contact with the supporting surface, regardless of the number of wheels actually present. A small number of ROV models have six wheels. The terms “two-wheel lift” and “tip-up” are used here interchangeably.

specified steering angle input once the vehicle slows to a specified speed. During the test, vehicles are fitted with outriggers to protect the driver by preventing full vehicle rollover. The sequence of events in the test procedure is shown in Figure 7. SEA conducted drop-throttle J-turn tests to measure the minimum lateral accelerations necessary to cause two-wheel lift (shown in Step 3) for each vehicle. Side loading of the vehicle occurs naturally as a result of the lateral acceleration that is created in the J-turn and this lateral acceleration can be measured and recorded. The lateral acceleration produced in the turn is directly proportional to the side loading force acting to overturn the vehicle according to the equation F= (m) (A_y), where F is force, m is the mass of the vehicle, and A_y is lateral acceleration.

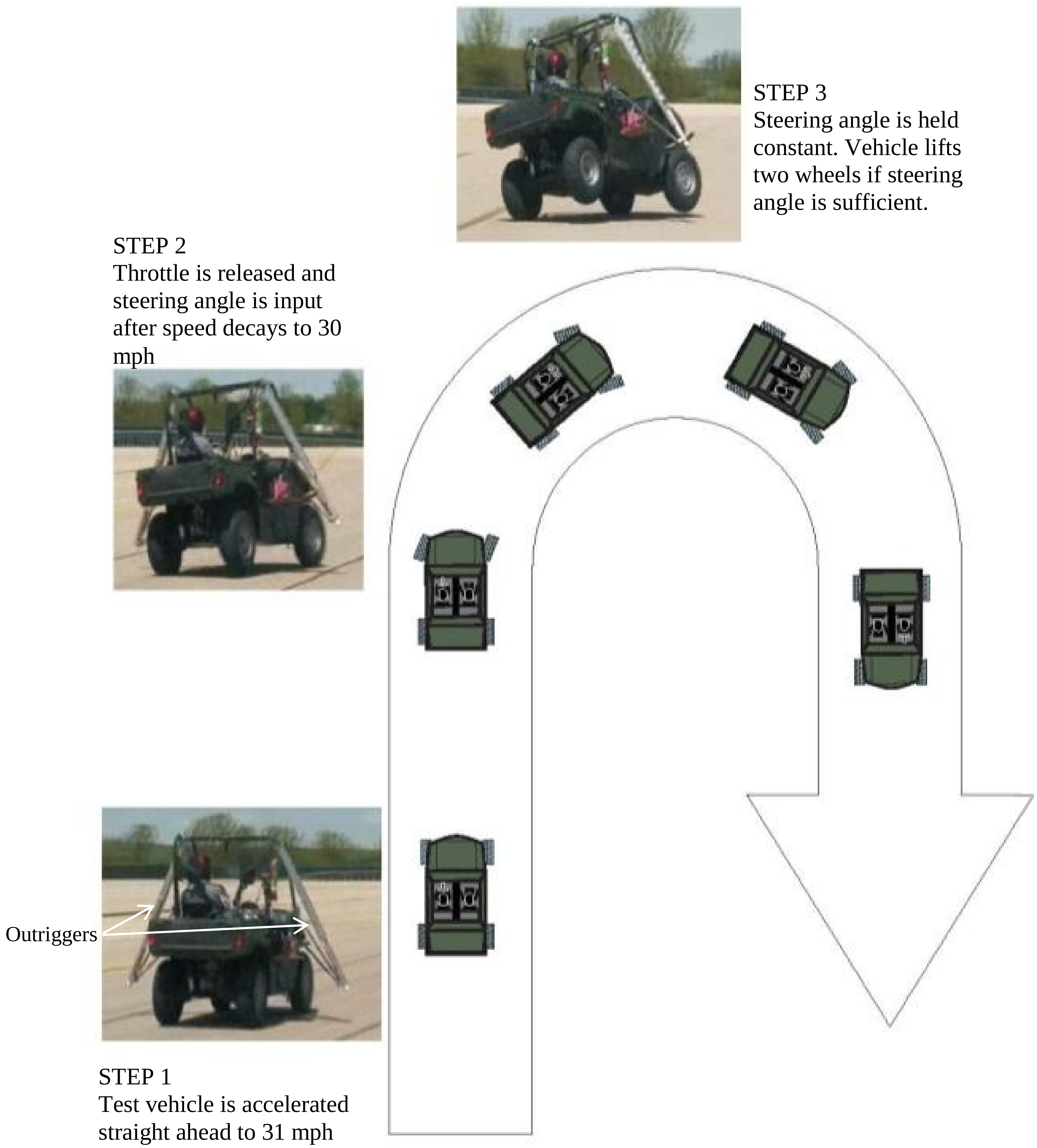


Figure 7 – J-Turn Sequence of Events

The J-turn testing was conducted at 30 mph. A programmable steering controller input the desired steering angles at a steering rate of 500 degrees per second for all vehicles. The chosen steering rate of 500 degrees per second is high enough to approximate a step input[5], but still within the capabilities of a driver. Preliminary tests were conducted by starting with a relatively low steering angle of 80 to 90 degrees and incrementally increasing the steering angle until two-wheel lift was achieved. When the steering angle that produced a gradual controlled two-wheel lift was determined, the test run for that vehicle load condition was conducted. Data recorded for each test run included speed, steering angle, roll rate and acceleration in three directions, longitudinal, lateral, and vertical. SEA processed and plotted the data to determine the minimum peak lateral acceleration required for two-wheel lift of the vehicle.

The J-turn test is a direct measure of the minimum or threshold lateral acceleration required to initiate a rollover event, or tip-up, of the test vehicle when turning. The terms “tip-up” and “two-wheel lift” are used in the discussion here to mean the initiation of a rollover event. Based on SEA’s testing, staff believes that this threshold lateral acceleration is the most accurate and representative measure of the ROV’s rollover resistance. ROV’s that exhibit higher threshold lateral acceleration have a higher rollover resistance, or are more stable than, ROVs with lower threshold lateral accelerations. All of the 10 ROVs tested in the study by SEA exhibited untripped rollover in the J-turn tests at steering wheel angles ranging from 93.8 to 205 degrees, and lateral accelerations ranging from 0.625 to 0.785 g. Table 3 shows the vehicles arranged in ascending order for threshold lateral acceleration (A_y) at tip up, SSF, TTA, and TTR. Table 3 illustrates the lack of correlation of the static metrics (SSF, TTA or TTR) with the direct dynamic measure of threshold lateral acceleration (A_y) at tip up. None of the static metrics provide a true and correct basis for comparison of ROV’s relative rollover resistance. Therefore, staff believes that the lateral acceleration threshold at rollover is the most appropriate metric to use when measuring and comparing rollover resistance for ROVs.

Table 3 - Vehicle Ascending Rank Order for
A_y, SSF, TTA,TTR (Operator Plus Passenger Load) [12]

Vehicle	A_y at Tip Up (g)		**Vehicle**	SSF		**Vehicle**	TTA (deg.)		**Vehicle**	TTR
D	0.625		F	0.881		A	33.0		A	0.650
B	0.655		A	0.887		B	33.6		B	0.664
A	0.670		H	0.918		D	33.7		D	0.667
J	0.670		B	0.932		I	35.4		I	0.712
I	0.675		D	0.942		H	35.9		H	0.724
F	0.690		J	0.962		J	36.1		J	0.730
E	0.700		E	0.965		F	36.4		F	0.739
H	0.705		C	0.991		E	38.1		E	0.784
C	0.740		G	1.031		C	38.8		C	0.803
G	0.785		I	1.045		G	39.0		G	0.810

Constant-Radius Turn Testing

[5] A step input is one that happens instantly and requires no time to complete. For steering input, time is required to complete the desired steering angle, so a steering step input is approximated by a high angular rate of steering input.

SAE J266, Surface Vehicle Recommended Practice, *Steady-State Directional Control Test Procedures for Passenger Cars and Light Trucks*, [24] establishes consistent test procedures to determine steady-state directional control properties for passenger cars and light trucks. ROVs have pneumatic tires, suspension systems, and steering controls that operate in the same manner as passenger cars and, therefore, these test methods are also applicable to ROVs.

SEA used the constant-radius turn test method described in SAE J266 to evaluate the sample ROV's handling characteristics. The test consists of driving each vehicle on a 100 ft. radius circular path, from very low speeds up to the speed where the vehicle tipped-up or could not be maintained on the path of the circle. The test vehicles were driven in the clockwise and counterclockwise directions. For a circle test: understeer can be defined as the condition when the steering wheel angle, required to maintain the circular path, increases as the vehicle speed increases; neutral-steer can be defined as the condition when the steering wheel angle, required to maintain the circular path, is unchanged as the vehicle speed increases; and oversteer can be defined as the condition when the average steering wheel input, required to maintain the circular path, decreases as the vehicle speed increases.

Data from the measurements made during SEA's tests were plotted as steering wheel angle versus lateral acceleration. Curve fits for the data, bold red and blue lines, were superimposed on the data plots (see Figures 8 and 9). The slope of the data curve at any point along the curve is the steering gradient, and indicates an understeer, neutral steer, or oversteer condition. A positive steering gradient indicates an understeer condition as shown in Figure 8. A negative steering gradient indicates an oversteer condition, as shown in Figure 9 for lateral acceleration (A_y) greater than 0.25 g. A zero steering gradient indicates a neutral steer condition, shown in Figure 9 as a bold black dot at the apex of each curve, where momentarily during the test, the steering angle is neither increasing or decreasing.

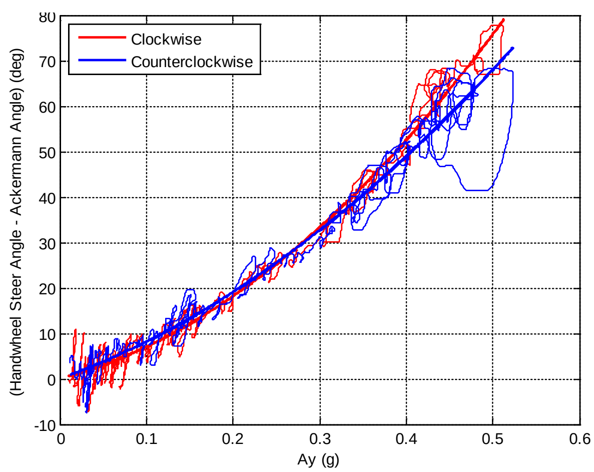


Figure 8 – Data Plot Showing Understeering Vehicle G [12]

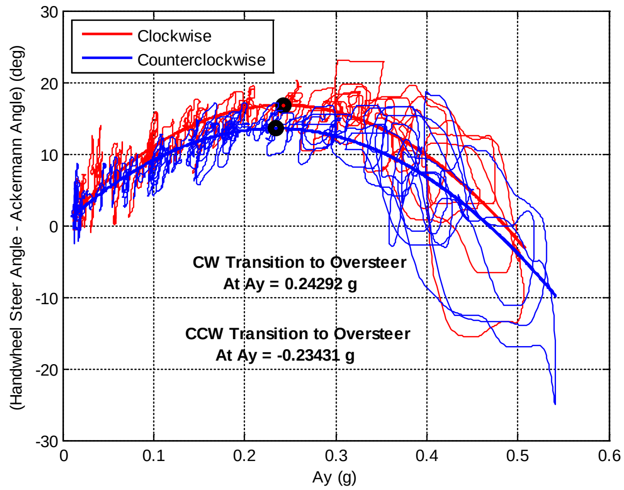


Figure 9 – Data Plot Showing Transition to Oversteer, Vehicle A [12]

Of the 10 vehicles tested by SEA, half of the vehicles (A, D, F, I, and J) exhibited sub-limit transitions to oversteer when tested on asphalt. The five remaining vehicles (B, C, E, G, and H) exhibited a desirable understeer condition up to 0.5 g. (see Figure 10).

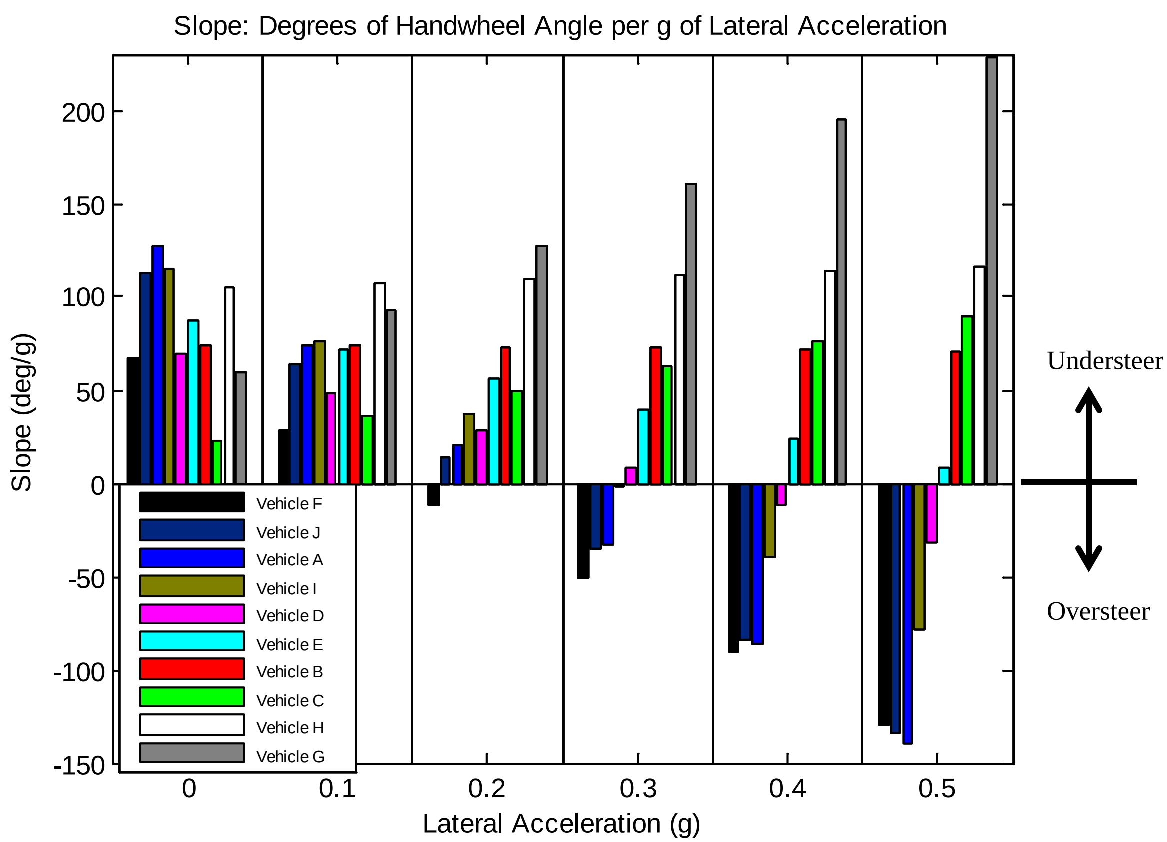


Figure 10 – Steering Gradients at Selected Values of Lateral Acceleration for Tested ROVs [12]

SEA engineers chose to use the constant radius turn test data in the range of lateral acceleration from 0.01 g to 0.50 g for curve fitting and characterization of each vehicle's handling properties. CPSC staff is recommending a lateral acceleration range of 0.10 g to 0.50 g as a requirement for characterizing the handling properties for ROVs. SEA states in their report, reference [12] page

20, “This range of data, from 0.01 g to 0.50 g, was selected because it provided a consistent range of lateral accelerations over which meaningful curve fits of the data could be made without weighting the spurious data that can occur at the beginning and end of a circle test taken to the limits of a vehicle’s response.” Indications of oversteer at lateral accelerations below 0.10 g are not significant for overall vehicle behavior. Therefore, staff’s recommendation includes increasing the lower limit from 0.01 g to 0.10g.

Oversteer Dynamic Instability

Vehicles that exhibit sub-limit oversteer have a unique operating characteristic, dynamic instability, which does not exist in vehicles that operate in understeer [25]. When a vehicle achieves the dynamically unstable condition, the lateral acceleration will increase at an exponential rate and will approach an infinite value if operation continues [7]. If this condition were experienced by an oversteering automobile with high SSF, the vehicle’s general reaction would cause the rear of the vehicle to “fishtail” from one side to the other, and end in a high rate vehicle spin or, possibly, a rollover. When this condition is experienced by a low SSF vehicle, such as an ROV, the general reaction is a sudden rollover with no spin or prior warning to the driver.

SEA conducted Constant Speed Slowly Increasing Steer (SIS) tests on 10 representative ROV models as part of the vehicle characteristics study. A similar test method is also found in SAE J266 [24], where it is termed the Constant Speed/Variable Steer Test. The SIS tests were conducted by driving each vehicle straight ahead at a constant speed of 30 mph and slowly increasing the steering angle until the vehicle reached a speed limiting condition or tip-up. A programmable steering controller (PSC) was used to increase the steering angle at a constant rate of 5 degrees per second. During the test, instrumentation for speed, steering angle, lateral acceleration, roll angle, and yaw rate were recorded.

Figures 11 and 12 show SIS test data plotted of lateral acceleration versus time for Vehicle A and Vehicle H. Vehicle H is the same model vehicle as Vehicle A, but Vehicle H is a later model year, where the sub-limit oversteer has been corrected to understeer.

Figure 11 shows that the lateral acceleration for the oversteering Vehicle A increases by 0.19 g in a period of 1 second. Vehicle A tipped-up immediately when the lateral acceleration peak occurred. In comparison, Figure 12 plot shows a linear increase in lateral acceleration of the understeering Vehicle H for the full range of the test. The increase in lateral acceleration of 0.19 g occurs over 5.5 seconds in Vehicle H compared to 1 second in Vehicle A.

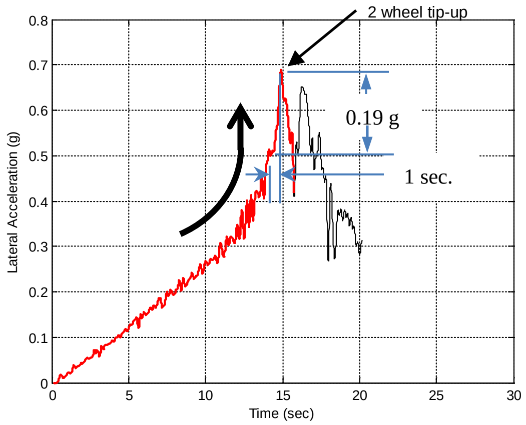


Figure 11 - Lateral Acceleration for Oversteering Vehicle A in the Dynamically Unstable Operating Condition [12]

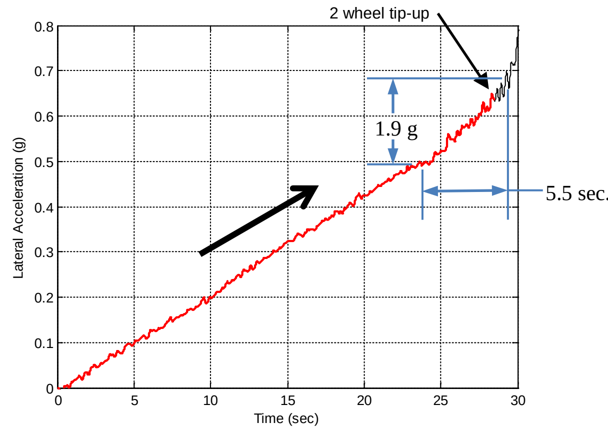


Figure 12 – Lateral Acceleration for Understeering Vehicle H [12]

To illustrate further the hazard resulting from sub-limit oversteer, Figure 13 shows the paths followed by Vehicles A and H during the SIS test. While each vehicle experienced two-wheel tip-up in the test, Vehicle A tipped approximately 15 seconds sooner than Vehicle H, according to the data shown in Figures 11 and 12. The delay in tip-up for Vehicle H allowed the vehicle to travel more than 300 feet further than Vehicle A before tip-up. Because the steering controller continues to increase the steering wheel angle at 5 five degrees per second for the duration of the test, the additional time and distance traveled resulted in additional steering wheel input for Vehicle H. Vehicle H allowed approximately 75 degrees more steering angle before tip up. The time delay and the increase in steering angle provides a much larger margin of error for the driver of the understeering Vehicle H, as compared to the sudden rollover that would be experienced by the driver of the oversteering Vehicle A.

Slowly Increasing Steer (SIS) Test for
Vehicle A (---- oversteer) and Vehicle H (— understeer)

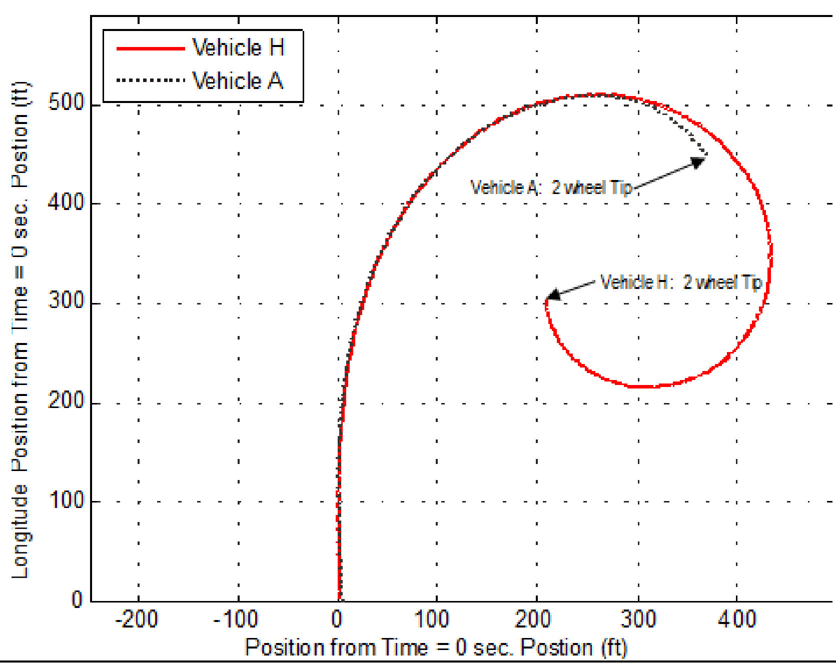


Figure 13- Path of Vehicle A and H in the SIS test (superimposed)

Source [12]

A vehicle that experiences oversteer in sub-limit conditions is directionally unstable when oversteer occurs, and as speed or steering angle increase during a turn, will reach an operating condition where the vehicle is dynamically unstable. Therefore, the vehicle is vulnerable to loss of control and rollover [7, 25]. In this operating condition, a vehicle with low rollover resistance, such as an ROV, will suddenly increase lateral acceleration, which will cause the vehicle to roll over suddenly and without warning. Because oversteering vehicles present the hazard associated with a dynamically unstable operating condition, staff believes that ROVs should have a mandatory requirement to operate in understeer at sub-limit conditions, as described in Appendix A.

IV. VOLUNTARY STANDARDS

A. ANSI/ROHVA 1 [23]

In 2011, ROHVA published the latest version of the standard -- ANSI/ROHVA 1 – 2011, *Recreational Off-Highway Vehicles*. The previous (and first) version of the standard was published in 2010.

The ANSI/ROHVA standard defines an ROV as an off-highway vehicle with a **minimum** top speed of 30 mph, no limit on maximum speed, a maximum engine displacement of 1000 cc, and a maximum Gross Vehicle Weight Rating (GVWR) of 3,750 lbs. The standard specifies requirements for service brakes, parking brakes, and controls specifications for engine, drive train, and steering. Lighting equipment, spark arresters, and warning labels are also covered by the standard.

The ANSI/ROHVA standard has requirements for rollover protective structures (ROPS) and for an occupant retention system that includes seat belts and passive restraints. CPSC staff has disagreed with ROHVA on certain aspects of the occupant retention system provisions of the standard, and staff's positions are detailed in a separate report (see Tab D).

Staff is primarily concerned with the dominant hazard patterns associated with ROV rollovers and is thus focusing here on those parts of the voluntary standard dealing with vehicle handling and roll over resistance. Staff disagrees with ROHVA regarding the lateral stability provisions in the ANSI/ROHVA standard and the lack of vehicle handling requirements in the standard, both of which affect ROV rollover resistance. The vehicles defined by the ANSI/ROHVA 1-2011 standard are included in staff's definition of ROVs and are intended to be subject to the requirements that CPSC staff recommends.

Lateral Stability

The ROHVA standard includes three provisions intended to address lateral stability or rollover resistance.

First, tilt table tests are required to be conducted at two load conditions. The driver-plus-passenger load condition requires the vehicle to pass a tilt table angle (TTA) test of 30 degrees. A vehicle loaded at its gross vehicle weight rating (GVWR – maximum weight as specified by the manufacturer including fluids, passenger and cargo) load condition is required to pass a TTA test of 24 degrees.

Second, the value of K_{st} for the vehicle is required to be no less than 1.0 at curb weight, which is the weight of the vehicle with all fluids filled to capacity. K_{st} is a static stability measure defined by the equation:

$$K_{st} = L\, t_2 + L_{cg}\,(t_1 - t_2) / 2LH_{cg.}$$

Where:
L = Wheel base of the vehicle
L_{cg}= Distance from rear axle to vehicle center of gravity (cg)
t_1 = Front track width
t_2 =Rear track width
H_{cg} = Height of the cg from the ground plane.

Third, a constant steering-angle dynamic test is required to demonstrate that the vehicle achieves, 8 out of 10 times, a corrected[6] lateral acceleration of 0.6 g without the occurrence of two-wheel lift of at least 2 inches; or the vehicle becomes speed limited 8 out of 10 times, prior to achieving a corrected lateral acceleration of 0.6 g or two-wheel lift of at least 2 inches.

Tilt Table Test Requirements

[6] To determine the relevant value of acceleration, measured values must be corrected to reflect the equivalent value of acceleration when located at the center of gravity of the test vehicle and parallel to the ground plane.

Section 8.1 Tilt Table Test of the ROHVA standard contains requirements and test procedures for tilt table testing. The ROV is placed on a platform and tilted to the required angle, as shown in Figure 6. One of the ROV's uphill wheels must remain in contact with the platform at the following specified tilt angles and loading conditions:

a. One of the ROV's uphill tires must remain in contact with the platform when it is tilted 30 degrees when loaded with simulated 215-lb. driver (95th percentile male) and 215-lb. passenger(s).
b. One of the ROV's uphill tires must remain in contact with the platform when it is tilted 24 degrees at gross vehicle weight rating (GVWR) load condition.

Tilt table tests, as included in the ROHVA standard, are commonly used to measure the static lateral stability of small off-road vehicles. The tilt table test is a static measure and does not account for dynamic effects of tire compliance, suspension compliance, or vehicle handling, which are important factors in determining the vehicle's lateral stability. Also, as the vehicle is tilted in the tilt table test, the effect of gravity shifts the weight of the vehicle and reduces the weight supported by part of the suspension, which does not simulate the load shift that occurs in dynamic conditions. The ROHVA test uses a TTA equal to 30 degrees as the pass/fail criteria. Table 4 shows the results of tilt table measurements made in the study of ROVs by SEA for the load condition of driver plus passenger. All of the ROVs tested would pass the 30 degree TTA requirement. Table 4 shows the rank order of the vehicles by the lateral acceleration threshold at tip-up and the rank order of the vehicles by TTA. Comparing the two rank order columns shows that the tilt table test results and direct measurement of lateral acceleration threshold at tip-up do not always correlate.

Table 4 – Vehicle Ascending Rank Order Comparison
J-Turn A_y at Tip-Up vs. TTA
(Operator Plus Passenger Load) [12]

Vehicle	A_y at Tip-Up (g)		Vehicle	TTA (deg.)
D	0.625		A	33.0
B	0.655		B	33.6
A	0.670		D	33.7
J	0.670		I	35.4
I	0.675		H	35.9
F	0.690		J	36.1
E	0.700		F	36.4
H	0.705		E	38.1
C	0.740		C	38.8
G	0.785		G	39.0

It is staff's view that the ROHVA tilt table test does not detect inadequate rollover resistance. CPSC staff believes that the lateral acceleration threshold at rollover value is a direct measure for rollover resistance and its use would eliminate the need for tilt table testing as a requirement of the standard.

Stability Coefficient K_{st} = 1

Section 8.2 Stability Coefficient (K_{st}) of the ROHVA standard specifies that ROVs have a K_{st} value not less than 1.0 in the curb weight condition. Curb weight is the weight of the vehicle when it is full of fuel and other fluids that are required for operation. Curb weight does not include passengers or cargo. As a representation of lateral stability, K_{st} is of little value when it is calculated for the curb weight condition. The load of a driver and passenger added to the vehicle has a large effect on the height of the center of gravity for an ROV. A more meaningful value would be K_{st} with the load of a driver, or with the load of a driver and passenger, as either would represent an actual condition of use for the vehicle.

For practical purposes, values K_{st} and SSF provide the same information. As has been discussed regarding SSF, occupant-loaded values of SSF and K_{st} are valid representations for the rollover resistance potential of a vehicle and are informative to the design process. However, K_{st} and SSF values do not account for all of the dynamic factors that affect actual rollover resistance, and therefore, do not represent the best form for a lateral stability metric in the case of ROVs. As is the situation with TTA, the effects of tire compliance, suspension compliance, and handling characteristics are not reflected in the values for K_{st} or SSF. Direct dynamic measurement of the physical principles that cause vehicles to roll over is possible with ROVs through J-turn testing; and therefore, staff believes that J-turn testing to determine the lateral acceleration threshold at rollover should be used as the standard requirement for the determination of lateral stability or rollover resistance.

Dynamic Stability Test

Section 8.3 Dynamic Stability of the ANSI/ROHVA standard is measured by a constant-steer-angle test, where the ROV is driven on a concrete or asphalt surface with the steering set at the Ackermann[7] angle for a steer radius of 25 feet. The standard describes the method for determining the Ackermann steer angle setting. The vehicle is loaded with test driver, instrumentation, outriggers, and ballast (if required) to a load condition representing a driver plus passenger. To conduct the test, the prepared vehicle with the steering angle set to the left or to the right is slowly accelerated while instrumentation is recording. The standard specifies in section **8.3.4.2 Dynamic Test** the following:

> ***6.*** *Continue accelerating until:*
> > *a. a corrected lateral acceleration of at least 0.6g is reached; or*
> > *b. a corrected lateral acceleration of at least 0.6g cannot be reached and:*
> > > *i. a two-wheel lift of two inches or more occurs; or*
> > > *ii. further increases in vehicle throttle input do not result in increases in vehicle speed.*

The test is repeated five times in the right-turning direction and five times in the left-turning direction for a total of 10 runs. The standard specifies in section **8.3.6 Performance Requirements**:

[7] Ackermann angle is the angle of the road-wheels required to turn the vehicle at any given turn radius when there are no steering deviations due to understeer or oversteer. To calculate the angle, use the equation: Ackermann Angle = arctangent (wheelbase/turn radius).

The vehicle shall pass the dynamic test if at least eight (8) of the ten (10) test runs result in no two-wheel lift on all tires on the inside of the turn above the test surface by at least 50 mm (2 in).

CPSC staff contracted SEA to conduct constant-steer testing as specified by the ROHVA standard, on vehicles A, F, and J of the ROV study [13]. Table 5 shows the results of the testing. For the three vehicles used in these tests, steering wheel angles were required to be set at 180 degrees to 200 degrees from straight ahead to achieve the 25-feet radius. At these severe steering angles, the highest speeds that could be achieved were about 15 mph. At this speed, one of the following occurred: (1) two-wheel lift occurred; (2) the vehicle speed was limited by the severe turn, and no two-wheel lift occurred; or (3) vehicle speed was limited due to spin out of the vehicle.

Table 5: Summary of Constant Steer Test Using Ackermann Geometric Steering Magnitude For 25 ft. Radius Path [13]

Vehicle	Turn Direction	Test End Condition/Limit Response	ROHVA Test Pass/Fail Outcome
Vehicle A	Right (CW)	Two-wheel lift	Fail
	Left (CCW)	Two-wheel lift	Fail
Vehicle F	Right (CW)	Maximum Speed*	Pass**
	Left (CCW)	Maximum Speed*	Pass**
Vehicle J	Right (CW)	Two-wheel lift	Fail
	Left (CCW)	Maximum Speed/Spinout	Pass

* Maximum speed occurred very near 0.6 g of corrected lateral acceleration for Vehicle F.
** Two-wheel lift occurred for Vehicle F after the driver slowed from maximum speed at the end of the test.

Vehicle A failed the ROHVA dynamic test, based on the data plots indicating that two-wheel lift occurred almost concurrently with achievement of 0.6 g. Vehicle F passed by achieving a maximum speed limit condition before achieving 0.6 g. Vehicle J failed all clockwise runs by lifting two-wheels prior to reaching 0.6 g and passed all counterclockwise runs by spinning out prior to reaching 0.6 g. Staff believes the differing results relative to turn direction for Vehicle J are due to a slightly earlier transition to oversteer in the clockwise direction. In constant-radius turn testing, Vehicle J transitioned to oversteer at 0.22 g in the clockwise direction and at 0.24 g in the counterclockwise direction.

SEA provided speed data plots for test vehicles A, F, and J, showing that maximum speeds reached were 17 mph, 16 mph, and 14 mph, respectively. Staff believes that due to the tight turn circle, the front tires created high friction with the test surface in the forward direction, limiting the vehicle maximum speed during the test. For this test procedure, if the ROV's speed cannot increase and the wheels do not lift off of the ground, the test is stopped and the ROV passes the dynamic stability requirements. This provision is not an indicator of the rollover resistance due to lateral acceleration because the test may be terminated before the vehicle can achieve its threshold lateral acceleration at rollover. This test subjects ROVs to lower lateral accelerations compared to lateral accelerations induced in a J-turn test.

Testing of Vehicle J showed that ROVs that spin-out can pass the ANSI/ROHVA dynamic stability requirements. Vehicle J transitioned from understeer to sub-limit oversteer during constant-radius turn testing and spun-out during constant steering-angle testing, which ended the test. Staff believes that this provision in the ANSI/ ROHVA dynamic stability requirement may encourage the intentional inclusion of sub-limit oversteering characteristics in vehicle designs because oversteering vehicles will spin-out at lower lateral accelerations and thereby pass the test.

Staff believes that the ANSI/ROHVA standard's constant steer test is a very poor indicator of rollover resistance because the test is ended if further increases in vehicle throttle input do not result in increases in vehicle speed. This speed-limited condition can be due to the front tires resisting increases in speed as a result of the tight turning radius or the ROV spinning-out because of the oversteering characteristics in vehicle designs. These conditions do not subject the vehicle to lateral accelerations that are adequate to assess rollover resistance.

Handling

The ANSI/ROHVA standard does not have a vehicle handling requirement.

B. ANSI/OPEI B71.9 [21]

In March 2012, the American National Standards Institute, Inc. (ANSI), worked with the Outdoor Power Equipment Institute (OPEI) to develop and publish ANSI/OPEI B71.9-2012, *American National Standard for Multipurpose Off-Highway Utility Vehicles*, which is a voluntary standard applicable to ROVs.

The ANSI/OPEI standard provides a definition of "multipurpose off-highway utility vehicles," which is very similar to the ANSI/ROHVA definition of "ROVs." The ANSI/OPEI's definition requires a minimum top speed of 25 mph and limits maximum speed to 50 mph. The ANSI/OPEI definition requires a minimum cargo load of 350 lbs. and limits GVWR to 4,000 lbs. The standard specifies requirements for service brakes, parking brakes or mechanism, and vehicle controls. Lighting equipment, spark arresters, and warning labels are also covered by the standard.

The ANSI/OPEI standard provides for occupant protection systems consisting of an Occupant Protective Structure (OPS), occupant restraints, occupant side-retention devices, seat belts, and handholds. CPSC staff disagrees with certain aspects of the occupant retention system provisions of the ANSI/OPEI standard, and those staff positions will be detailed in a separate report (see Tab D).

Staff is primarily concerned with the dominant hazard patterns associated with ROV rollovers. Staff disagrees with OPEI regarding the lateral stability provisions and the lack of vehicle handling requirements in the standard, both of which affect ROV rollover resistance. The vehicles defined by the ANSI/OPEI B71.9-2012 standard are included in staff's definition of ROVs and are intended to be subject to the requirements CPSC staff recommends.

Lateral Stability

The ANSI/OPEI standard includes three provisions relevant to lateral rollover of ROVs. First, tilt table tests are required to be conducted at two load conditions. The driver-plus-passenger load condition requires passing a tilt table angle (TTA) test of 30 degrees, and the gross vehicle weight rating (GVWR) load condition requires passing a TTA test of 24 degrees. These are the same load conditions and acceptance angles as those in the ANSI/ROHVA standard. Both TTA values must be achieved with at least one uphill-side tire in contact with the tilt platform. Second, the value of K_{st} for the vehicle at curb weight is required to be no less than 1.0. The K_{st} load condition and acceptance value are the same as the ANSI/ROHVA standard. Third, a dynamic test is required in order to demonstrate that the vehicle, in a driver-plus-passenger load condition, will complete a 20 mph drop-throttle J-turn with 180 degrees of steering in each direction without experiencing two-wheel lift.

Tilt Table and K_{st}

The tilt table test requirements and K_{st} value requirements are the same as those stated in the ANSI/ROHVA standard.

Adequacy of Dynamic Test

The ANSI/OPEI standard includes a straightforward drop-throttle J-turn test at a speed of 20 mph for all vehicles and at a steering wheel angle of 180 degrees in the right and left turning directions for all vehicles. The test is set-up as a proof test, using the same criteria for all vehicles, 20 mph and 180 degrees of steering. The loading for the test is the driver-plus-passenger loading condition, which is a total load of 430 pounds, distributed as described in the standard to be the weight distribution of a driver and a passenger aboard the vehicle. The test is performed for both right and left turns. The performance requirement is that two-wheel lift of 2 inches or more shall not occur.

CPSC staff contracted SEA to conduct J-turn testing as specified by the ANSI/OPEI standard on vehicles A, F, and J of the ROV study [13]. Table 6 shows the test results. All three of the test vehicles passed the J-turn test in both directions. Vehicle A exhibited the lowest peak lateral acceleration during the test, at just under 0.6 g turning left with slight two-wheel lift, and just over 0.6 g turning right with only rear-wheel lift. The other two vehicles tested, F and J, each passed in both directions with only rear-wheel lift.

Table 6: Summary of Drop-Throttle J-Turns With 180 degree Steering Wheel Angle Input at 500 deg./sec. [13]

Vehicle	Turn Direction	Initial Speed Required for 2 wheel lift of 2 inches or more	OPEI 20 mph test Pass/Fail Outcome
Vehicle A	Right	22 mph	Pass
	Left	21 mph	Pass
Vehicle F	Right	21 mph	Pass
	Left	22 mph	Pass
Vehicle J	Right	21 mph	Pass
	Left	23 mph	Pass

SEA used a programmable steering controller (PSC) to conduct the ANSI/OPEI J-turn testing on vehicles A, F, and J, and therefore, SEA engineers had the ability to make small changes in speed at which the execution of steering input began. Speed was increased in 1 mph increments in order to find the speed at which each vehicle failed the J-turn acceptance criteria of two-wheel lift of 2 inches or more. Vehicle A had outrigger contact turning left at 21 mph, vehicle F had outrigger contact turning right at 22 mph, and vehicle J had outrigger contact turning right at 22 mph.

The ANSI/OPEI J-turn test limits the steering angle to 180 degrees, and therefore, introduces the effects of steering ratio[8] to the outcome of the test. It is possible that an extremely poorly performing vehicle, in terms of rollover resistance, could be altered to pass the ANSI/OPEI test by changing the steering ratio. While steering ratio is an important parameter for driver comfort and control, steering ratio does not have a direct effect in terms of overall vehicle system rollover resistance. It is staff's belief the ANSI/OPEI J-turn test does not detect inadequate rollover resistance.

Handling

The ANSI/OPEI standard does not have a vehicle handling requirement.

V. STAFF RECOMMENDATION

CPSC staff recommends requiring ROVs to exhibit understeer from 0.10 g to 0.50 g of lateral acceleration when tested on a 100 ft. constant radius turn test, as described in Appendix A. Based on testing performed by SEA, CPSC staff believes that oversteer is an unstable condition that can lead to a vehicle rollover. Five of the 10 vehicles tested exhibited a desirable understeer condition, and five exhibited an undesirable oversteer condition. CPSC staff has demonstrated that 0.10 g to 0.50 g is a reasonable operating range for ROVs where reliable turn circle data can be recorded. Therefore, CPSC staff believes that ROVs can be designed to understeer with minimum additional cost, if any, and without diminishing the utility or recreational value of this class of vehicle.

CPSC staff recommends requiring ROVs to demonstrate a minimum lateral acceleration threshold at rollover of 0.70 g, or greater, in a J-turn test as described in Appendix A. The recommended test conditions and procedures were used in the testing by SEA. Four of the 10 ROVs tested by SEA exhibited lateral accelerations ranging from 0.700 to 0.785 g. Six of the 10 ROVs tested had lateral accelerations at rollover that were below 0.70 g, ranging from 0.625 to 0.690 g. The value of 0.70 g is based on the experience with the improvements made to one vehicle through a repair program negotiated with one ROV manufacturer. CPSC staff believes that with minor changes to vehicle suspension and/or track width spacing, these vehicles could achieve a minimum lateral acceleration threshold at rollover of 0.70 g or greater. Based on the SEA testing and the known SSF values, CPSC staff believes that a 0.70 g minimum value for the lateral acceleration threshold at rollover is achievable without diminishing the utility or recreational value of this class of vehicle. These improvements are illustrated in the comparison of Vehicle A at 0.670 g and Vehicle H at 0.705 g.

CPSC staff also recommends requiring manufacturers to provide information on each model vehicle's lateral acceleration threshold at rollover value, in the form of a hangtag as described in Appendix A, to allow consumers to make informed decisions when purchasing

[8] Steering ratio is the number of degrees of hand-wheel movement required to affect a 1 degree change in road-wheel steering angle. ROV steering ratios vary widely, however the most common ratios are 13 to 15 deg. /deg.

ROVs. Three ROV models tested achieved a lateral acceleration over 0.70 g. Based on NHTSA's NCAP experience, CPSC staff believes that if information on lateral acceleration threshold at rollover is required to be displayed prominently on new vehicles, consumers will be able to make informed decisions about their purchase, and manufacturers will have a competitive incentive to improve the rollover resistance of their ROVs.

Appendix A
Technical Description of Proposed Test Protocols

I. Lateral Stability

Staff recommends that the Recreational Off-Highway Vehicle (ROV) requirement for lateral stability be based on the average lateral acceleration threshold at rollover as determined by a 30 mph drop-throttle J-turn test. The lateral acceleration is measured parallel to the ground plane at the center of gravity (CG) of the loaded test vehicle and occurs at the minimum steering wheel angle required to cause the vehicle to roll over in a 30 mph drop-throttle J-turn test on a flat and level high-friction surface. Rollover is considered to be achieved when two-wheel lift is observed.

The average lateral acceleration threshold at rollover value will be the value calculated from lateral acceleration data obtained by the process described below:

1. Acceptance Limits and Requirements – The average lateral acceleration threshold at rollover value, as measured in a thirty (30) mph drop-throttle J-turn test, is required to be 0.70 g or greater. The vehicle manufacturer is required to place a hangtag on all new vehicles indicating the vehicle's rating for average lateral acceleration threshold at rollover value. The hangtag is illustrated and explained in the memorandum at Tab M.

2. Vehicle Conditions – The test vehicle shall be operated in two-wheel drive mode with all selectable differential locks disengaged during the tests. The tires shall be the manufacturer's production original-equipment tires and inflated to the manufacturer's recommended inflation pressure. The tires shall be new. Springs or shocks that have adjustable spring or damping rates shall be set to the manufacturer's recommended settings for delivery.

3. Instrumentation – At minimum, the vehicle must be instrumented to record lateral acceleration, vertical acceleration, longitudinal acceleration, forward speed, hand wheel steering angle, hand wheel steering angle rate, vehicle roll angle, pitch angle rate, roll angle rate, and yaw angle rate. Ground plane lateral acceleration shall be calculated by correcting the body-fixed acceleration value to account for roll angle. To produce uniform and comparable values, ground plane lateral acceleration shall also be corrected to reflect the value at the test vehicle center of gravity (CG) location. A roll motion inertia measurement sensor that provides direct output of ground plane lateral acceleration at the vehicle CG may also be used in lieu of manual correction to obtain ground plane lateral acceleration. Video with time display may be used for the determination of two wheel lift. Roll angle may be calculated from roll rate data.

4. Test Equipment – The test vehicle must be equipped with a programmable steering controller (PSC) capable of responding to vehicle speed that has a minimum steering angle input rate of 500 degrees per second and is accurate within $\pm$0.25 degree. The hand wheel setting for 0.0 degrees of steering angle is defined as the setting that controls the vehicle with properly aligned wheels to travel in a straight path on a level surface. The amount of steering used for each test is measured relative to the PSC reading when the vehicle steering is set to zero degrees. The test

vehicle must be equipped with outriggers capable of allowing vehicle rollover to begin, but must prevent a full vehicle rollover.

5. Test Conditions – The test surface must be dry asphalt or dry concrete that is free of contaminants that could affect test results; that has a peak braking coefficient greater than or equal to 0.90; and that has a sliding skid coefficient greater than or equal to 0.80, in accordance with ASTM E 1337 and ASTM E274, respectively. The test surface must be flat and have a grade slope equal to or less than 1 degree (1.7%). Average wind speed must be less than 20 mph. Ambient temperature must be between 32ºF and 100ºF.

6. Load Condition – The required load condition is a driver and a front seat passenger, each equivalent to a 95th percentile male. The test load condition shall be achieved by loading the vehicle with a test driver, instrumentation, outriggers, and ballast, if required. The test loading condition is required to simulate the test vehicle's center of gravity (CG) location when the vehicle is in the required load condition. Adjustable seats shall be located in most rearward position when determining the CG location for the load condition. The test vehicle CG shall be located within 1.0 inch in the x-axis and y-axis directions and may not be more than 0.5 inch below the CG location determined for the load condition.

7. Test Method –The steering controller shall be programmed to input the desired steering angle at a rate of 500 degrees per second, starting when the vehicle speed descends to 30 mph. Conduct the test by driving the vehicle in a straight path while holding the speed just above 30 mph. As the vehicle approaches the desired test location, the steering controller shall be engaged, and the throttle shall be released. The test steering angle shall be held for a minimum of 4 seconds. The parameters listed in paragraph 3 shall be recorded for the entire event.

The objective is to determine the minimum steering angle required to initiate rollover in an iterative process. To estimate the steering angle, analysis or experience may be used. A starting steering wheel angle of 90 degrees is recommended and is below the angle required to produce a violent rollover for most ROVs.

8. Test Procedure – While recording data, and starting with a 90º steering angle to produce a right turn, conduct 30 mph drop-throttle J-turns, holding steering angles for a minimum of 4 seconds before returning steering to zero. The steering rate when returning to zero may be less than 500 degrees per second. Conduct additional J-turns, increasing the steering angle in 10-degree increments, as required, until two-wheel lift is achieved. Then, decrease the test steering angle in 5 degree increments to find the lowest steering angle that will produce a two-wheel lift event. Repeat for left turns. Additional adjustments, up or down, in one degree increments may be used.

9. Verification – While recording data, conduct trials in two opposing heading directions on the test surface, using the minimum steering angle for left or right steering directions, determined in the Test Procedure to verify that the steering angle produces two-wheel lift events in both heading directions on the test surface. Conduct five trials with visually verified, successful two-

wheel lift in each steering direction and in each heading direction, while recording data for each trial. All data for each trial should be reviewed to detect trials that were not executed correctly. Any trials that do not produce two-wheel lift should be diagnosed for cause. If a cause is identified, the data may be discarded, and the trial should be repeated to replace the data. If no cause can be identified, repeat item 7, Test Procedure, to ensure that the correct steering angle has been determined. A minimum of five trials yielding two-wheel lift must be recorded for each steering direction in each heading direction on the test surface, which will result in twenty (20) total J-turns to complete the minimum data set. Addition J-turns may be added to the minimum data set in groups of four, with one for each steering direction in each heading direction on the test surface.

10. Determine Lateral Acceleration Threshold at Rollover Value – The data recorded in step 8 shall be digitally low-pass filtered to 2.0 hertz, using a phase-less, eighth order, Butterworth filter to eliminate noise artifacts on the data. Plot the data for ground plane lateral acceleration corrected to the test vehicle CG location, hand wheel steer angle, and roll angle recorded for each trial in the Verification step. Find and record the peak ground plane lateral acceleration occurring between the time of the steering input and the time of the two-wheel lift.

If a body-fixed acceleration sensor is used, correct the lateral acceleration data for roll angle using the ROHVA method described in the standard ANSI ROHVA 1 - 2011 with the equation:

$$A_y\ ground = A_y \cos Phi - A_z \sin Phi$$

Where: "*Phi*" is the vehicle body roll angle.

Calculate the lateral acceleration threshold at rollover value, which is the average of the peak values for ground plane lateral acceleration for all of the trials conducted in the verification step that produced a two-wheel lift event. The minimum value for lateral acceleration threshold at rollover for the test vehicle is required to be 0.70 g or greater.

II. Handling Performance

1. Acceptance Limits -for Recreational Off-Highway Vehicles (ROVs) as defined above, sub-limit handling performance shall be measured by the manufacturer and shall be verified to exhibit positive understeer gradients for the range of corrected ground plane lateral acceleration values from 0.10 g to 0.50 g. Negative understeer gradients, which indicate that the vehicle oversteers, shall not be exhibited by the vehicle in the ground plane lateral acceleration range from 0.10 g to 0.50 g. The measurements shall be made for the vehicle conditions and the test conditions described below.

2. Load Condition – The required load condition is a driver and a front seat passenger, each equivalent to a 95th percentile male. The test load condition shall be achieved by loading the vehicle with a test driver, instrumentation, outriggers, and ballast, if required. The test loading condition is required to simulate the test vehicle's center of gravity (CG) location when the

vehicle is in the required load condition. Adjustable seats shall be located in most rearward position when determining the CG location for the load condition. The test vehicle CG shall be located within 1.0 inch in the x-axis and y-axis directions and may not be more than 0.5 inch below the CG location determined for the load condition.

3. Vehicle Conditions – The test vehicle shall be operated in two-wheel drive mode with all selectable differential locks disengaged during the conduct of the tests. The tires shall be the manufacturer's production original equipment tires and inflated to the manufacturer's recommended inflation pressure. The tires shall be new when starting the tests, then broken-in by conducting a minimum total of ten (10) J-turns with five (5) in the right-turning direction and five (5) in the left-turning direction. The J-turns conducted for tire break-in shall be conducted at 30 mph and steering angles sufficient to cause two-wheel lift. Tires used for the full test protocol to establish the lateral acceleration threshold at rollover value for the test vehicle are acceptable for use in the handling performance test protocol. Tires with less than 65 percent of the original tread height shall not be used for handling verification testing. Tires shall be brought to operating temperature prior to the starting the test by completing 5 laps of the test radius at 20 mph in each direction. Springs or shocks that have adjustable spring or damping rates shall be set to the manufacturer's recommended settings for delivery.

4. Test Equipment - The test vehicle must be equipped with outriggers capable of allowing two-wheel lift of the inside wheels but must prevent a full vehicle rollover and have minimal effect on the loaded vehicle center of gravity location. See specification for CG location in item 2, Load Condition.

5. Test Conditions - Testing shall be conducted on a uniform hard and stable surface of asphalt or concrete. The test surface shall have a high-friction finish and shall be smooth, dry, and free of contaminates that could affect test results. The peak braking coefficient of the test surface must be greater than or equal to 0.90, and the sliding skid coefficient of the test surface must be greater than or equal to 0.80. The grade slope of the test surface shall not be greater than 1º (1.7%) in any direction. Average wind speed must be less than 20 mph. Ambient temperature must be between 32ºF and 100F.

6. Test Method - Handling performance testing shall be conducted using the constant-radius test method described in SAE Surface Vehicle Recommended Practice J266. The minimum radius for constant-radius testing shall be 100 feet. In this test method, the instrumented and loaded vehicle is driven while centered on a 100-ft. radius circle marked on the test surface, with the driver making every effort to maintain compliance of the vehicle path relative to the circle. The vehicle is operated at a variety of increasing speeds, and data are recorded for those various speed conditions to obtain data to describe the vehicle handling behavior across the prescribed range of ground plane lateral accelerations. Data shall be recorded for the speed range from 0.0 mph to 28 mph. This speed range will cover the lateral acceleration range from 0.0 g to 0.5 g.

7. Test Procedure

Method 1, Discrete Data Points - In this data acquisition method, the driver maintains a constant speed while maintaining compliance with the circular path, and data points are recorded when a stable condition of speed and steering angle is achieved. After the desired data points are recorded for a given speed, the driver accelerates to the next desired speed setting, maintains constant speed and compliance with the path, and data points are recorded for the new speed setting. This process is repeated to cover the speed range from 0.0 mph to 28 mph, which will map the lateral acceleration range from near 0.0 g to 0.50 g. Increments of speed shall be 1 to 2 miles per hour, to allow for a complete definition of the understeer gradient. Data shall be taken at the lowest speed practicable to obtain an approximation of the vehicle's Ackermann steering angle.

Method 2, Continuous Data Collection - In this data acquisition method, the driver maintains compliance with the circular path while slowly increasing vehicle speed; and data from the vehicle instrumentation is recorded continuously, so long as the vehicle remains centered on the intended radius. The rate of speed increase shall not exceed 0.93 mph per second. Initial speed shall be as low as is practicable, in order to obtain an approximation of the vehicle's Ackermann steering angle. The speed range shall be 0.0 mph to 28.0 mph, which will be sufficient to produce corrected lateral accelerations from near 0.0 g to 0.50 g.

8. Vehicle Dimension Coordinate System - The coordinate system described in SAE Surface Vehicle Recommended Practice J670 shall be used.

9. Instrumentation – At a minimum, the vehicle must be instrumented to record lateral acceleration, vertical acceleration, longitudinal acceleration, forward speed, hand wheel steering angle, hand wheel steering angle rate, roll angle, pitch angle rate, roll angle rate, and yaw angle rate. Lateral acceleration shall be corrected for roll angle and to reflect the value at the center of gravity location. Roll angle may be calculated from roll rate data. A roll-motion inertia measurement sensor that provides direct output of ground plane lateral acceleration at the vehicle CG may also be used in lieu of manual correction to obtain ground plane lateral acceleration.

10. Data Analysis - The lateral acceleration data shall be corrected for roll angle using the ROHVA method described in the standard ANSI ROHVA 1 - 2011. To provide uniform and comparable data, the ground plane lateral acceleration shall also be corrected to reflect the value at the test vehicle's center of gravity. The data shall be digitally low-pass filtered to 1.0 Hz, using a phase-less, eighth-order, Butterworth filter, and plotted with ground plane lateral acceleration on the abscissa versus hand-wheel steering angle on the ordinate. A second-order polynomial curve fit of the data shall be constructed in the range from 0.01 g to 0.5 g. The slope of the constructed plot determines the understeer gradient value in the units of degrees of hand-wheel steering angle per g of ground plane lateral acceleration (degrees/g). Using the coordinate system specified in step 8, positive values for understeer gradient are required for values of ground plane lateral acceleration values from 0.10 g to 0.50 g.

Appendix B
Literature Research on Vehicle Rollover and Handling

I. NHTSA Rollover Research

2001 Star Rating

In the late 1990s, NHTSA initiated an extensive rollover research program for light passenger vehicles, including passenger cars, SUVs, pick-up trucks, and mini vans. The result of this research was implementation, in 2001, of a "star rating" system for light passenger vehicles based on the static stability factor (SSF) of each vehicle model [18]. This rating system as part of NHTSA's New Car Assessment Program (NCAP), ranked vehicles according to the SSF of the vehicle when loaded only with a driver, as shown in Figure B1.

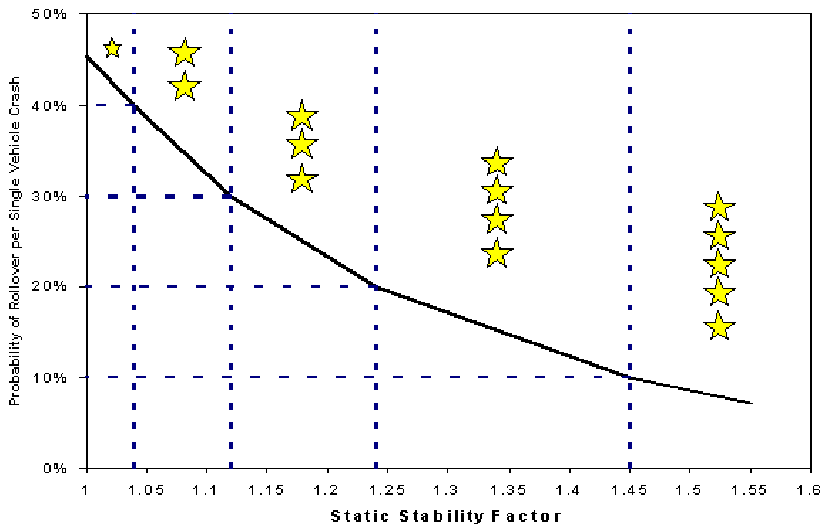


Figure B1 –2000 NHTSA Rollover Star Rating for Light Passenger Vehicles [18]

Using this original criteria, NHTSA's rating for vehicles with SSF values greater than 1.45 receive the highest rating of five stars, which indicates a high resistance to rollover and an estimated probability of rollover of 10 percent or less in a single vehicle crash. At the other extreme, light passenger vehicles rated at one star have SSF values between 1.00 and 1.04, and have an estimated probability of rollover of 40 percent to 45 percent. The NHTSA risk model used in the star rating system is based on a data set compiled from 293,000 crash incidents involving 100 vehicle groups with known SSF values and known rollover rates.

2000 TREAD Act

In 2000, Congress passed the Transportation Recall Enhancement, Accountability, and Documentation Act (TREAD Act), which required NHTSA to develop a dynamic rollover test for automobiles. NHTSA once again commenced rollover research to develop a dynamic test protocol for light passenger vehicles.

In this new round of research, NHTSA included a test method that has been used by automobile manufacturers for many years and is still used by manufacturers to gather relevant facts about the dynamic performance of new vehicle design variations, the drop-throttle J-turn. This commonly used test method is also known as the step-steer test. The test is simple: the vehicle is driven at a constant speed, and the test driver releases the throttle, and inputs the desired steering wheel angle. During the maneuver, vehicle dynamic response data are recorded continuously.

The rollover experimentation by NHTSA is detailed in SAE Technical Paper 2003-01-1008, *An Experimental Examination of J-Turn and Fishhook Maneuvers that May Induce On-Road, Untripped, Light Vehicle Rollover* [9]. The paper provides insight into the ranking criteria used by NHTSA in the evaluation of various test methods. NHTSA rated the J-turn method as excellent for repeatability and objectivity, which indicates that the method is the best regarding "whether the maneuver could be performed objectively with . . . repeatable results, for the same vehicle." Performability of the J-turn was rated excellent, indicating that the method ". . . was easiest of all of the dynamic rollover propensity maneuvers to perform." The discriminatory capability of the J-turn maneuver was rated excellent with a caveat: "When limited to vehicles with low rollover resistance and/or disadvantageous load configurations." None of the vehicles tested by NHTSA experienced a tip up in a "Nominal Load Configuration" when subjected to a simple J-turn because the rollover resistance of passenger vehicles is too high for the J-turn test to effect a rollover of the vehicle. However, the method was found to be "sensitive to the decrease in rollover resistance attributable to a decrease in SSF of 0.05" in disadvantageous load configurations.

The J-turn method did not suit NHTSA's objective for developing a dynamic rollover test for automobiles because the J-turn method was not severe enough to produce rollovers for the majority of automobiles. SSF values for automobiles are much higher than SSF values for ROVs. This difference in SSF values is the single reason that J-turn testing is appropriate for testing the rollover resistance of ROVs and not appropriate for testing the rollover resistance of automobiles.

Ultimately, NHTSA adopted a much more severe maneuver, the fishhook, to rank light passenger vehicles for rollover propensity. The fishhook maneuver starts the same as a J-turn and then at a specifically timed point in the turn, reverses the turn to the other direction. The fishhook creates much higher roll rates than the J-turn maneuver. NHTSA also modified the star rating criteria to consider the SSF value for each vehicle, plus the fishhook test performance of each vehicle, in that vehicle's rating for rollover propensity. Including the dynamic test results in the ranking has the effect of slightly changing the shape of the curve from the original year 2000 star rating chart shown in Figure B1. The revised star rating risk model, including SSF and the fishhook results is shown in Figure B2. The star ratings for rollover risk have been retained from the previous ranking criteria: a five-star rating is rollover risk of 0.1 or less; four star is 0.2 to 0.1; three star is 0.3 to 0.2; two star is 0.4 to 0.3; and one star is risk greater than 0.4 (see Figure B2).

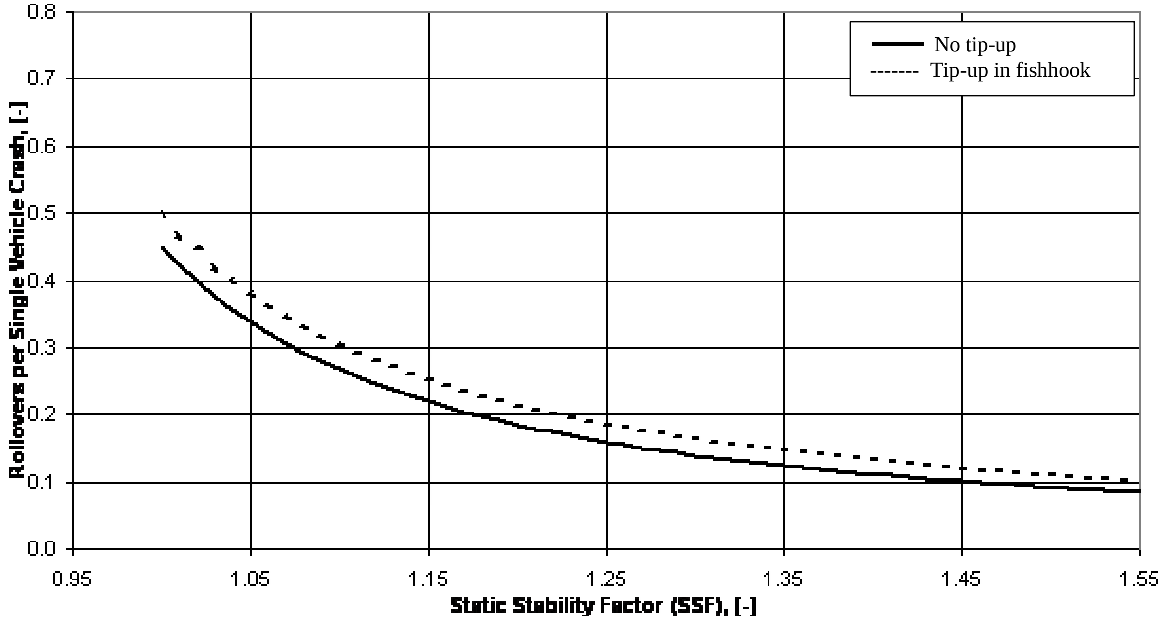


Figure B2 – 2003 Star Rating Dynamic Model [17]

II. NHTSA Handling Research

Until recently, NHTSA had not regulated the handling characteristics of automobiles. Automotive manufacturers had long recognized, researched, and developed sub-limit understeering criteria for vehicle handling before creation of the agency. However, the advance of technology has made possible a new tool for automakers to use in vehicle directional control systems. Electronic motion sensors and antilock brake technology can be employed in concert to form a new system for vehicle directional stability and control, referred to by NHTSA as Electronic Stability Control (ESC). In these ESC systems, motion-sensing devices monitor the moving vehicle and "use automatic computer-controlled braking of individual wheels to assist the driver in maintaining control in critical driving situations" [19]. Starting with model year 2012, all light passenger vehicles, including pickup trucks, SUVs, minivans, and full-size vans are required to have ESC systems in accordance with Federal Motor Vehicle Safety Standard (FMVSS) No. 126.

ESC systems allow the control of vehicle motions beyond the traditional methods associated with steering and the design characteristics of the vehicle's suspension. Using information on speed, steering wheel angle, yaw rate, and estimated sideslip, the ESC can detect the onset of limit oversteer and add corrections to the vehicle's orientation to the path of travel. The system also works to reduce or eliminate limit understeer in extremely low traction situations, such as ice, or in extreme maneuvers. Simply stated, the goal of ESC systems is to prevent, forestall, and mitigate occurrences of limit oversteer and limit understeer for light passenger vehicles in all conditions.

NHTSA has stated: "Preventing single-vehicle loss-of-control crashes is the most effective way to reduce deaths resulting from rollover crashes. This is because most loss-of-control crashes culminate in the vehicle leaving the roadway, which dramatically increases the probability of a rollover." [19] The dramatic increase in risk is due to the exposure of the vehicle to tripping mechanisms that are not encountered on the road surface. NHTSA provides examples such as soft soil, a ditch, a curb, or a guardrail. When a passenger vehicle is in or near an oversteer condition and departs the roadway, a sudden change in the surface friction will allow a severe spin, and any contact with a barrier to the sideways-sliding tire will create a trip to roll the vehicle. The tire sliding in soft soil will push the soil into a small mound which, at some point, will become sufficient to trip the vehicle.

When discussing handling of four-wheel vehicles, it is important to understand the distinction between limit oversteer and sub-limit oversteer. The light passenger vehicles (including SUVs, pickup trucks, and vans) under NHTSA's jurisdiction are designed to understeer, when operated within the limits of traction for the tires [4, 7, 15, 27]. These vehicles only experience oversteer in driving circumstances where the traction of the rear tires is lost in a turn and the rear tires slide to the side, possibly causing the vehicle to spin. For this reason, the terms "oversteer" and "spinning-out" are often used interchangeably when referring to the realization of oversteer for on-road passenger vehicles.

While the tire slip angles are realized in the tires, the automotive designer manages and controls tire slip angle in the design parameters of the suspension. In the text book, *Fundamentals of Vehicle Dynamics*, author Thomas Gillespie explains the basics of suspension design where he states: "Designers usually strive for higher front roll stiffness to ensure understeer in the limit of cornering"; and "Caution should be used when adding a stabilizer bar only to the rear because of the potential to induce unwanted oversteer." [11]

NHTSA has established a link between vehicle handling performance and single-vehicle crashes resulting in rollover. "Based on its crash data studies, NHTSA estimates that the installation of ESC systems will reduce single vehicle crashes of passenger cars by 34 percent and single vehicle crashes of sport utility vehicles (SUVs) by 59 percent. Its effectiveness is especially great for single-vehicle crashes resulting in rollover, where ESC systems were estimated to prevent 71 percent of passenger car rollovers and 84 percent of SUV rollovers in single vehicle crashes." [19].

In conjunction with the regulation requiring light vehicles to be equipped with ESC, NHTSA has developed a test to verify the performance of ESC systems on each vehicle. During development of the performance test, NHTSA staff found that consistently exercising the understeer intervention of ESC systems is impractical. Invoking the ESC understeer intervention feature on vehicles with high centers of gravity requires operation of the test vehicle on a low coefficient of friction, or slippery, test surface. Maintaining the low coefficient of friction surface in a consistent condition proved to be difficult and was not repeatable enough for the purpose. Therefore, after much experimentation, NHTSA staff adopted a severe maneuver, known as Sine with Dwell, to evaluate the performance of light vehicle ESC systems in preventing oversteer loss of control. The Sine with Dwell test only verifies the intervention capabilities of ESC systems to prevent or reduce oversteer. Research is continuing to identify a practical test for assessing the ESC understeer intervention [19].

In defining the requirements for ESC, NHTSA encountered two special cases that are of interest. First, NHTSA states: "many of the [existing ESC] systems used on vehicles with a high center of gravity only limit understeer on slippery surfaces where there is no danger that the understeer intervention could increase the possibility of tip-up." [19] This feature complicated the development of verification testing requirements. ESC systems intervene to eliminate understeer by attempting to move the vehicle's orientation toward the oversteer condition. If the system is highly successful, for a vehicle with a high center of gravity (which implies low SSF) on a high-friction surface, a worse situation may develop where the vehicle may encounter an oversteer condition, and thereby, experience a rollover. Understeer may present a collision risk but does not alone present a rollover risk. In the second case, NHTSA decided not to include Roll Stability Control (RSC) features, which are present on some high center of gravity vehicles, such as SUVs, in the requirements for ESC. Roll Stability Control uses sensors to detect excessive body roll and intervenes to reduce body roll, and thereby, prevent an impending vehicle rollover. NHTSA staff states: "roll stability control works by inducing high levels of understeer when required to prevent tip-up" [19]. High levels of understeer decrease the lateral acceleration and the associated forces attempting to roll the vehicle. Roll Stability Control may be included as part of the ECS system at the discretion of the manufacturer but is not required by regulation.

III. Vehicle Handling Research

The subject of vehicle rollover has been researched most comprehensively in recent years by NHTSA, and the issue has attracted attention because of automotive designs with higher centers of gravity. Vehicle handling, in comparison, is a more complex subject that has drawn the attention of automotive researchers since the early years of mass-produced automobiles.

In 1934, Maurice Olley produced an article regarding independent front suspension, which was a relatively new automotive design feature at the time [20]. Mr. Olley was a leading automotive researcher of the era. In describing the virtues of independent front suspension, he noted that an independent front suspension provides the designer with greater control for vehicle handling when compared to the solid front axle designs then in common use. The article states: "Let us follow out this opposite [roll steer] effect, and suppose a car turning left to roll a little to the right. If the right-hand roll produces ever so slight an increase in the left-hand turn of the front wheels, this increases the sharpness of the curve followed by the car, which increases centrifugal force [lateral acceleration] and right-hand roll, and a vicious circle of events is set up, which but for the vigilance of the driver will end up in a flat spin or an overturned car" [20]. Here, Olley seems to be describing roll steer, which is one of many possible sources of deviations in a vehicle's handling. Later, in 1938, Olley described the primary cause of deviation in a vehicle's intended path, due to tire slip angle, when he explained experimentation with wind loads acting on a vehicle while traveling straight ahead. He observed that a vehicle subjected to a side load would deviate from the straight path in different ways, depending on the relation between the front and rear tire slip angles. An understeering vehicle (more tire slip angle at the front) would deviate away from the side force, and an oversteering vehicle (more tire slip angle at the rear) would deviate toward the side force [8]. Olley effectively established that side loads cause deviations in a vehicle's path and that oversteer creates an instability that is highly undesirable.

Building on the work of Olley, Kenneth Stonex developed methods to measure objectively the vehicle characteristics affecting handling performance. Stonex published an article describing his work titled, *Car Control Factors and their Measurement,* in the SAE Journal (Transactions) in 1941 [26]. In the article, he states: "Understeer is a condition of inherent stability and, therefore, is highly desirable" [26]. By present day standards the methods of Stonex were fairly crude but were successful in measuring tire slip angles, rear axle roll steer, understeer gradient, and other parameters important to handling. Stonex developed what he called the "Skid-Pad Roadability Test," which has evolved into the steering gradient tests that are used today and are described in the current SAE J266, Surface Vehicle Recommended Practice, *Steady-State Directional Control Test Procedures for Passenger Cars and Light Trucks* [24].

During the years of World War II, a significant amount of work was done regarding vehicle handling. Researchers abroad in England, France, Germany, and Russia made contributions to the technical literature. The research before and including the war years is summarized in a paper titled, *Research in the Fundamentals of Automobile Control and Stability,* by Leonard Segel [25]. Mr. Segel provides us with a very good definition of "stability," as follows:

> "Stability . . . is the ability to maintain a given state of equilibrium. A vehicle which is stable returns to its initial state of equilibrium after the disturbance has been removed or acquires a new equilibrium state if the disturbing force is held constant."[25]

Segel collected experimental steering response data on a 1953 Buick sedan that was modified to have a variety of handling configurations and demonstrated that, for the turning vehicle, the yawing velocity for understeering configurations would reach a state of equilibrium, while oversteering configurations are directionally unstable, and at speeds above the critical speed[9], produced yawing velocities that increased unabated. Segel states: "Contrary to popular belief, the understeering vehicle is found to be the faster responding vehicle, if speed of response is taken as the time required to reach steady state." He also observes: "At [the critical speed of] 90 mph, we note that this vehicle [the oversteering Buick] is dynamically unstable. It is conceivable that a human may be able to stabilize such a vehicle by means of corrective steering action, but experience has shown that this is a very difficult task." [25]. Segel verified the conclusions made earlier by Stonex that understeer is inherently stable and oversteer is inherently unstable.

As the details of handling criteria came to be understood, automotive researchers turned their work toward understanding how to predict handling characteristics in the design stage. Walter Bergman of the Ford Motor Company published a technical paper titled, *The Basic Nature of Understeer-Oversteer* [3]. In the paper, Bergman provides a detailed assessment of the individual design factors that affect a vehicle's tendency to deviate in understeer or oversteer. Bergman's list is as follows: rear axle roll steer, toe change, dynamic camber change, weight distribution, lateral weight transfer, power application, and tread change. The author explains in fine detail how each factor operates in concert with other factors, such that the designer can relate the potential results to produce a full system arrangement. The author also states,

> "An oversteering vehicle develops an inertial force which acts in the same direction as the disturbing force, which increases the resultant lateral force at the c.g. of the vehicle, resulting in a corresponding increase of the resultant lateral tire force. The yawing moment increases, which increases the yaw of the vehicle and results in a progressively increasing curvature of the vehicle's travel. …The inertial force developed during an oversteer response of the vehicle produces instability of the vehicle and explains why an oversteering vehicle is directionally an unstable vehicle." [3]

[9] Critical speed is the lowest speed at which an oversteering vehicle will reach full dynamic instability. In addition to the speed, realization of the dynamic instability requires a directional disturbance, such as turning.

Another paper authored by R. Thomas Bundorf, titled, *The Influence of Vehicle Design Parameters on Characteristic Speed and Understeer* [7], examines methods to determine the characteristic speed and test criteria for verifying handling. Bundorf defines the characteristic speed of an understeering vehicle as: “that forward speed for an understeering vehicle at which the control sensitivity at zero lateral acceleration trim is one-half the control sensitivity of a neutral steer vehicle.” He then describes a method for designers to predict the characteristic speed using design parameters for a vehicle. This method by Bundorf seeks to create vehicle designs that will ensure understeer. This paper by Bundorf also refined the test methods for determining steering gradients and characteristic speed. These test methods are still in use today. In describing the test method, Bundorf states: “For American passenger cars, this test invariably demonstrates that the vehicles have understeer qualities well beyond the normal driving range of lateral acceleration.” Additionally, Bundorf explains the critical speed for an oversteering vehicle by stating: “The oversteer vehicle has yaw velocity gain greater than in proportion to speed and reaches an infinite value, indicating fixed control instability, at the particular speed called the critical speed.” [7]

While understanding that the individual parameters that affect steering seemed to be a logical approach for designers, the number of interrelated parameters came to be somewhat inconvenient to manage. The literature contains several works devoted to addressing this issue. R. T. Bundorf and R. L. Leffert published *The Cornering Compliance Concept for Description of Vehicle Directional Control Properties,* [8]. In this work, the authors make reference to 25 to 40 design parameters that might be used by a designer, depending on how general the analysis attempts to be. The method, known as the Cornering Compliance Concept, groups parameters together based on the effects at the front of the vehicle versus the effects at the rear of the vehicle and develops equations for compliance at the front and compliance at the rear. The goal of this work is described in the introduction where it states: “. . . the magnitude of the front sideslip angle must exceed that of the rear in order that the vehicle deviate and rotate in the appropriate direction for understeer vehicles” [8]. The Cornering Compliance Concept has been augmented and used by many designers and researchers to build vehicles with understeer handling characteristics.

At about the same time that Bundorf and Leffert were formulating the Cornering Compliance Concept, another group of researchers was developing a different method for analyzing vehicle handling properties. This method, the Moment Method, is described in a technical paper titled, *The Static Directional Stability and Control of the Automobile,* by William F. Milliken, Jr., Fred Dell’Amico, and Roy S. Rice [16]. Where most design analysis methods previously had been based on linearized approximations to model vehicle behavior, the Moment Method developed differential equations for the analysis of linear and nonlinear regimes of vehicle operation. The ability to analyze nonlinear portions of vehicle behavior is beneficial to designers because it improves the prediction of vehicle performance at higher lateral accelerations that occur just prior to breakaway (loss of tire traction) and after breakaway occurs. While the Moment Method defines a differential expression that is a “definitive measure of the directional stability,” the paper states: “. . . what was initially viewed as a steer or trim test may also be interpreted in a stability sense.” These statements refer to the fact that the steering gradient test does not measure directional stability directly but does detect the state of oversteer, which indicates that a directionally unstable condition has been achieved. The authors also state: “There is little question as to the important influence which the Under/Oversteer characteristics have upon automobile behavior. . . . Experience has further shown that from the standpoint of car development to date, changing the steer characteristics is an effective and frequently the only practical way to adjust the handling.” [16]

In work investigating the causes of vehicle rollover, R. Wade Allen and several other authors published a technical paper titled, *Characteristics Influencing Ground Vehicle Lateral/Directional Dynamic Stability* [1], which discusses links between directional stability and roll stability. The abstract for the paper states:

> Directional stability is noted to be strongly influenced by lateral load transfer distribution (LTD) between the front and rear axles. LTD influences tire side force saturation properties and should be set up so that side forces at the rear axle do not saturate before the front axle under hard maneuvering conditions in order to avoid limit oversteer and spinout. Rollover stability is shown to interact with directional stability, and to be related to center of gravity location, track width and several other characteristics that influence these variables under hard maneuvering conditions.

This study examined a diverse collection of 41 vehicles, including small, medium, and large passenger cars; vans; pick-up trucks; and sport utility vehicles; and the study ranked them for various properties. Side pull tests through the center of gravity were used to measure rollover propensity, and a validated computer simulation was used to provide dynamic properties and allow experimentation with various changes affecting handling performance [1]. A continuation of the work of Allen et al., is documented in the paper by the same authors, titled, *Computer Simulation Analysis of Light Vehicle Lateral/Directional Dynamic Stability* [2].

The literature search presented here is merely a sampling of the total body of literature on the subject of vehicle handling. The full body of work may be accessed by following the reference trail that results from the works cited here. One fact is apparent in the work reviewed: no competent research has been found that recommends sub-limit oversteer as a design objective for vehicles intended for use by the general public.

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TAB B

Draft Proposed Rule Establishing Safety Standard for Recreational Off-Road Vehicles: Preliminary Regulatory Analysis

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September 22, 2014

Draft Proposed Rule Establishing Safety Standard for Recreational Off-Road Vehicles: Preliminary Regulatory Analysis

CONTENTS

1.0 INTRODUCTION

Staff of the U.S. Consumer Product Safety Commission (CPSC) has developed a draft proposed rule for recreational off-road vehicles (ROVs). This rulemaking proceeding was initiated by an advance notice of proposed rulemaking (ANPR), published in the Federal Register on 28 October 2009. The draft proposed rule includes: (1) lateral stability and vehicle handling requirements that specify a minimum level of rollover resistance for ROVs and require that ROVs exhibit sub-limit understeer characteristics; and (2) occupant retention requirements that would limit the maximum speed of an ROV to no more than 15 miles per hour (mph), unless the seat belts of the driver and front passengers are fastened; and the rule would require ROVs to have a passive means, such as a barrier or structure, to limit further the ejection of a belted occupant in the event of a rollover.

This report provides a description of the market for ROVs and a preliminary regulatory analysis of the draft proposed rule which includes a description of the potential costs and potential benefits and a discussion of alternatives to the draft proposed rule. Each element of the draft proposed rule is discussed separately. For some elements, the benefits and costs cannot be quantified in monetary terms. Where this is the case, the potential costs and benefits are described and discussed conceptually.

2.0 MARKET INFORMATION

2.1 Products Covered

ROVs are a type of motorized, off-road vehicle. They are distinguished from all-terrain vehicles (ATVs) by the presence of a steering wheel, as opposed to handlebars, and bucket or bench seating, instead of a seat that is straddled. The throttle and brakes are operated by foot controls. ROVs are characterized by side-by-side seating for two or more occupants and have at least four wheels with off-road tires. The maximum speed is greater than 30 miles per hour (mph). The vast majority of ROVs (more than 99 percent) have gasoline-powered engines; a small number of ROVs are diesel-powered. Although ROVs have work or utility applications (*e.g.*, transporting people, equipment, or material to or from a worksite) and are frequently considered to be a type of utility vehicle, ROVs are also widely used for recreational purposes, including transportation to and from hunting and fishing sites, trail riding, and racing. Most ROVs are intended to carry two persons: a driver and a passenger to the right of the driver. However, some ROVs can carry three to six people, including the driver.

2.2 Similar or Substitute Products

There are several types of off-road vehicles that have some characteristics that are similar to those of ROVs and may be considered substitutes for some purposes.

Low-Speed Utility Task Vehicles (UTVs) **–** Although ROVs can be considered to be a type of utility vehicle, their maximum speeds of greater than 30 mph distinguish them from low-speed utility task vehicles, which have maximum speeds of less than 30 mph. Like ROVs, UTVs have steering wheels and bucket or bench seating capable of carrying two or more riders. All utility vehicles have both work and recreational uses. However, low-speed utility vehicles might not be good substitutes for ROVs in recreational uses where speed is important.

All-terrain vehicles (ATVs) **–** Unlike ROVs, ATVs use handlebars for steering and hand controls for operating the throttle and brakes. The seats on ATVs are intended to be straddled, unlike the bucket or bench seats on ROVs. Some ATVs are intended for work or utility applications, as well as for recreational uses; others are intended primarily for recreational purposes. ATVs are usually narrower than ROVs. This means that ATVs can navigate some trails that some ROVs might not be able to navigate.

Unlike ROVs, ATVs are rider interactive. When riding an ATV, the driver must shift his or her weight from side to side while turning, or forward or backward when ascending or descending a hill or crossing an obstacle. Most ATVs are designed for one rider (the driver). On ATVs that are designed for more than one rider, the passenger sits behind the driver and not beside the driver.

Go-Karts **–** Go-karts (sometimes called "off-road buggies") are another type of recreational vehicle that has some similarities to ROVs. Go-karts are usually intended solely for recreational purposes. Some go-karts with smaller engines are intended to be driven by children 12 and younger. Some go-karts are intended to be driven primarily on prepared surfaces. These go- karts would not be substitutes for ROVs. Other go-karts have larger engines, full suspensions, maximum speeds in excess of 30 mph, and can be used on more surfaces. These go-karts could be close substitutes for ROVs in some recreational applications. Most go-karts have seats for two riders, including the driver; but about 20 percent are intended for one rider only.[1]

2.3 Manufacturers and Market Shares

The number of manufacturers marketing ROVs in the United States has increased substantially in recent years. The first utility vehicle that exceeded 30 mph, thus putting it in the ROV category, was introduced in the late 1990s. No other manufacturer offered an ROV until 2003. In 2013, there were 20 manufacturers known to CPSC staff to be supplying ROVs to the U.S. market. One manufacturer accounted for about 60 percent of the ROVs sold in the United States in 2013. Another seven manufacturers, including one based in China, accounted for about 36 percent of the ROVs sold in the same year. None of these seven manufacturers accounted for more than 10 percent of the market individually. The rest of the market was divided among about

[1] "Karts Feel the Chinese Crunch," Dealer News, November 2007, p. 44(2).

12 other manufacturers, most of which were based in either China or Taiwan.[2] CPSC staff has identified more than 150 individual ROV models from these manufacturers. However, this count includes some models that appear to be very similar to other models produced by the same manufacturer but sold in the United States through different distributors.

About 92 percent of ROVs sold in in the United States are manufactured in North America. About 7 percent of the ROVs sold in the United States are manufactured in China (by 9 different manufacturers). Less than 1 percent are produced in other countries.[3]

Seven recreational vehicle manufacturers, which together account for more than 90 percent of the ROV market, established the Recreational Off-Highway Vehicle Association (or ROHVA). The stated purpose of ROHVA is “to promote the safe and responsible use of recreational off-highway vehicles (ROVs) manufactured or distributed in North America.” ROHVA is accredited by the American National Standards Institute (ANSI) to develop voluntary standards for ROVs. ROHVA members have developed a voluntary standard (ANSI/ROHVA 1-2011) that sets some mechanical and performance requirements for ROVs. Some ROV manufacturers that emphasize the utility applications of their vehicles have worked with the Outdoor Power Equipment Institute (OPEI) to develop another ANSI voluntary standard that is applicable to ROVs (ANSI/OPEI B71.9-2012). This voluntary standard also sets mechanical and performance requirements for ROVs. The requirements of both voluntary standards are similar but not identical.

2.4 Retail Prices

The average manufacturer’s suggested retail prices (MSRP) of ROVs, weighted by units sold, was about $13,100 in 2013, with a range of about $3,600 to $20,100. The average MSRP for the eight largest manufacturers in terms of market share was about $13,300. The average MSRP of ROVs sold by the smaller, mostly Chinese, manufacturers was about $7,900.[4]

The retail prices of ROVs tend to be somewhat higher than the retail prices of other recreational and utility vehicles. The MSRPs of ROVs are about 10 percent higher, on average, than the MSRPs of low-speed utility vehicles. A comparison of MSRPs for the major manufacturers of ATVs and ROVs indicates that ROVs are priced about 10 to 35 percent higher than ATVs offered by the same manufacturer.[5] Go-karts usually retail for between $2,500 and $8,000.[6]

[2] Market share is based upon a CPSC staff analysis of sales data provided by Power Products Marketing, Eden Prairie, MN (2014). Our analysis attempted to exclude those vehicles that had mostly industrial or commercial applications and were not likely to be purchased by consumers.

[3] Based upon a CPSC staff analysis of sales data provided by Power Products Marketing, Eden Prairie, MN (2014).

[4] MSRPs for ROVs were reported by Power Products Marketing, Eden Prairie, MN (2014).

[5] Based upon a CPSC staff analysis of data provided by Power Products Marketing, Eden Prairie, MN, (2014), and an examination of the suggested retail prices on several manufacturers’ Internet sites. Another source indicates that

2.5 Sales and Number in Use

Sales of ROVs have increased substantially since their introduction. In 1998, only one firm manufactured ROVs, and fewer than 2,000 units were sold. By 2003, when a second major manufacturer entered the market, almost 20,000 ROVs were sold. The only dip in sales occurred around 2008, which coincided with the worst of the credit crisis and recession that also started about the same time. In 2013, an estimated 234,000 ROVs were sold by about 20 different manufacturers.[7] The chart below shows ROV sales from 1998 through 2013.

The number of ROVs available for use has also increased substantially. Because ROVs are a relatively new product, we do not have any specific information on the expected useful life of ROVs. However, using the same operability rates that CPSC uses for ATVs, we estimate that there were about 570,000 ROVs available for use in 2010.[8] By the end of 2013, there were an estimated 1.2 million ROVs in use.

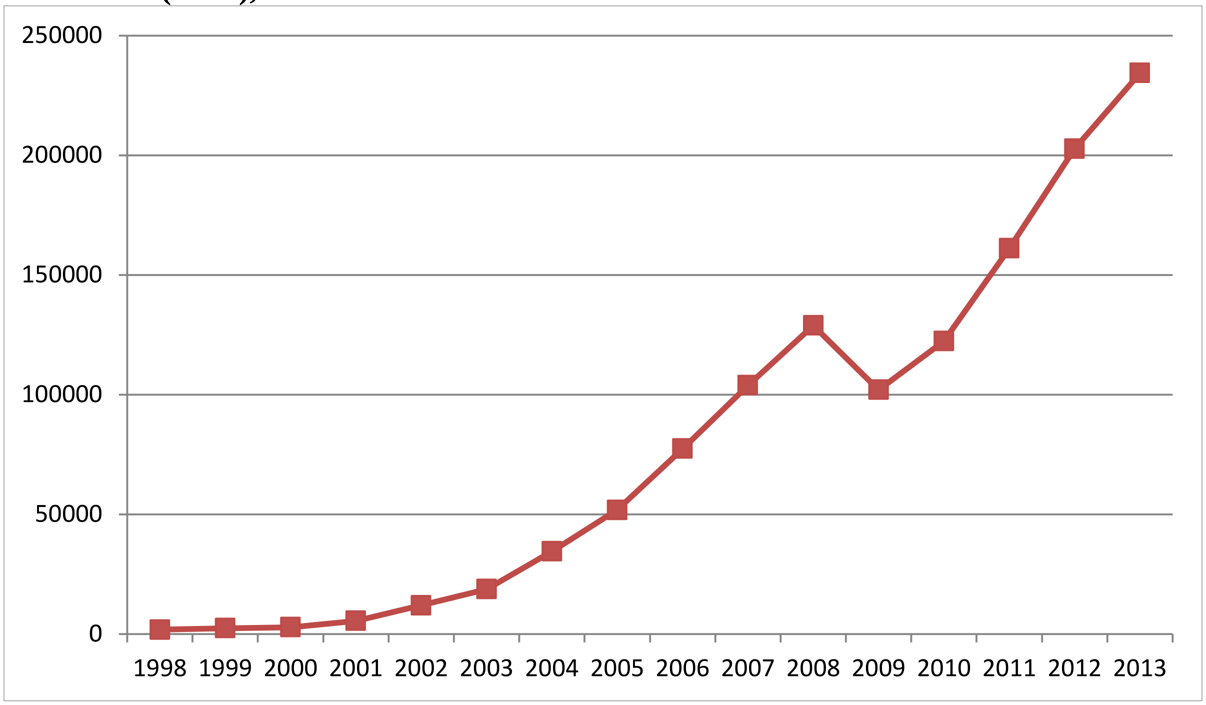
the price of one ROV or other utility vehicle is about two-thirds the price of two ATVs ("2009 Utility Vehicle Review," Southern Sporting Journal, October 2008, Vol. 14, Issue 5, pp. 58-70, accessed through: http://web.ebscohost.com on January 17, 2014).

[6] Tom Behrens, "Kart Racing: Fast times out on the prairie," The Houston Chronicle, November 27, 2008, p. 4. (accessed through http://www.chron.com on January 17, 2014)

[7] Based upon a CPSC staff analysis of sales data provided by Power Products Marketing, Eden Prairie, MN.

[8] CPSC Memorandum from Mark S. Levenson, Division of Hazard Analysis, to Susan Ahmed, Associate Executive Director, Directorate for Epidemiology, "2001 ATV Operability Rate Analysis," U.S. Consumer Product Safety Commission, Bethesda Maryland (19 August 2003). "Operability rate" refers to the probability that an ATV will remain in operation each year after the initial year of production.

ROV Sales (units), 1998 - 2013



Source: CPSC analysis of data compiled by Power Products Marketing.

Most ROVs are sold through retail dealers. Generally, dealers that offer ROVs also offer other products, such as motorcycles, scooters, ATVs, and similar vehicles. ROVs are also sold through dealers that carry farm equipment or commercial turf management supplies.

While sales of ROVs have increased over the last several years, sales of competing vehicles have leveled off or declined. Low-speed utility task vehicles have been on the market since the early 1980s. Their sales increased from about 50,000 vehicles in 1998 to about 150,000 vehicles in 2007. In 2011, however, sales fell to about 110,000 vehicles. A substantial portion of these sales were for commercial applications rather than consumer applications.[9]

After several years of rapid growth, U.S. sales of ATVs peaked in 2006, when more than 1.1 million ATVs were sold.[10] Sales have declined substantially since then. In 2012, less than 320,000 ATVs were sold, including those intended for adults as well as those intended for children under the age of 16 years.[11]

[9] Based upon a CPSC staff analysis of information provided by Power Products Marketing of Eden Prairie, MN.

[10] Mathew Camp, "Nontraditional Quad Sales Hit 465,000," Dealer New.com, (April 28, 2008). Available at: http://www.dealernews.com/dealernews/article/nontraditional-quad-sales-hit-465000?page=0,0, accessed on June 19, 2013.

[11] Estimates of ATV sales based on information provided by the Specialty Vehicle Manufacturers Association and on confidential data purchased from Power Products Marketing of Minneapolis, MN (2014).

One factor that could account for part of the decline in ATV sales is that after many years of increasing sales, the market may be saturated. Consequently, a greater proportion of future sales will likely be replacement vehicles or vehicles sold due to population growth. Another factor could be the increase in sales of ROVs. Some riders find that ROVs offer a more comfortable or easier ride, and ROVs are more likely to appeal to people who prefer the bench or bucket seating on ROVs to the straddle seating of ATVs. It is also easier to carry passengers on ROVs. Most ATVs are not intended to carry passengers, and the side-by-side seating offered by ROVs appears to be preferred over the tandem seating on the few ATVs intended to carry passengers.[12] A disadvantage of an ROV compared to an ATV is that many ROVs are too wide to travel on some trail systems intended for ATVs. However, some of the more narrow ROVs are capable of negotiating many ATV trails.[13]

Of the several types of vehicles that could be substitutes for ROVs, go-karts appear to be the smallest market segment. After increasing for several years, go-kart sales peaked at about 109,000 vehicles in 2004. Sales have since declined significantly. In 2013, fewer than 20,000 units were sold. However, many of these are aimed at young riders or intended for use on tracks or other prepared surfaces and would not be reasonable substitutes for ROVs.[14] The decline in go-kart sales may be due to the influx of inexpensive ATVs imported from China, which may have led some consumers to purchase an ATV rather than a go-kart.[15]

3.0 SOCIETAL COSTS OF DEATHS AND INJURIES ASSOCIATED WITH ROVS

The intent of the draft proposed rule is to reduce the risk of injury and death associated with accidents involving ROVs. Therefore, any benefits of the draft proposed rule could be measured as a reduction in the societal costs of injuries and deaths associated with ROVs. This section discusses the societal costs of injuries and deaths.

3.1 ROV Injuries

3.1.1Nonfatal Injuries

In order to estimate the number of nonfatal injuries associated with ROVs that were treated in hospital emergency departments, CPSC undertook a special study to identify cases that involved ROVs that were reported through the National Electronic Injury Surveillance System (NEISS) from January 1, 2010 to August 31, 2010. NEISS is a stratified national probability

[12] "UTV Sales Flatten Out in 2008," Dealer News, August 2009, p. 40(4). "2009 Kawasaki Teryx 750 FI 4x4 Sport RUV Test Ride Review," article posted on: http://www.atvriders.com, accessed 20 August 2009. Tom Kaiser, "Slowing sales: It's now a trend," Powersports Business, 12 February 2007, p. 44(1).

[13] Chris Vogtman, "Ranger shifts into recreation mode," Powersports Business, 12 February 2007, p., 46(2).

[14] "U.S. Go-Kart Market in Serious Decline," Dealer News, October, 2009, p. 38. Sales data based upon a CPSC staff analysis of information provided by Power Products Marketing of Eden Prairie, MN (2014).

[15] "Karts Feel the Chinese Crunch," Dealer News, November 2007, p. 44(2).

sample of hospital emergency departments that allows CPSC staff to make national estimates of product-related injuries. The sample consists of about 100 of the approximately 5,400 U.S. hospitals that have at least six beds and provide 24-hour emergency service.[16]

NEISS does not contain a separate product code for ROVs. Injuries associated with ROVs are usually assigned to either an ATV product code (NEISS product codes 3285–3287) or to the utility vehicle category (NEISS product code 5044).[17] Therefore, CPSC staff reviewed all NEISS cases that were coded as involving an ATV or a UTV that occurred during the first 8 months of 2010 and attempted follow-up interviews with each victim (or a relative of the victim) to gather more information about the incidents and the vehicles involved. CPSC staff determined whether the vehicle involved was an ROV based on the make and model of the vehicle reported in the interviews. If the make and model of the vehicle was not reported, the case was not counted as an ROV. Out of 2,018 NEISS cases involving an ATV or UTV during the study period, a total of 668 interviews were completed for a response rate of about 33 percent. Sixteen of the completed interviews were determined to involve an ROV. To estimate the number of ROV-related injuries initially treated in an emergency department in 2010, the NEISS weights were adjusted to account for both non-response and the fact that the survey only covered incidents that occurred during the first 8 months of the year. Variances were calculated based on the adjusted weights. Based on this work, the Directorate for Epidemiology estimated that there were about 3,000 injuries (95 percent confidence interval of 1,100 to 4,900) involving ROVs in 2010 that were initially treated in hospital emergency departments.[18]

NEISS injury estimates are limited to those injuries initially treated in hospital emergency departments. NEISS does not provide estimates of the number of medically-attended injuries that were treated in other settings, such as physicians' offices, ambulatory care centers, or those that bypassed the emergency departments and were directly admitted to a hospital. However, the Injury Cost Model (ICM), developed by CPSC for estimating the societal cost of injuries, uses empirical relationships between cases initially treated in hospital emergency departments and those initially treated in other medical settings to estimate the number of medically-attended injuries that were treated outside of a hospital emergency department.[19] According to ICM

[16] Schroeder T, Ault K. The NEISS Sample (Design and Implementation): 1999 to Present. Bethesda, MD: U.S. Consumer Product Safety Commission; 2001. Available at: http://www.cpsc.gov/neiss/2001d011-6b6.pdf.

[17] In fact, ROVs can be thought of as a subcategory of both ATVs and utility vehicles; and in the trade press and popular literature vehicles that meet the definition of an "ROV" are often referred to as "ATVs," "side-by-sides," and "utility vehicles." Consequently, even if there was a separate NEISS product code for ROVs, there might still be substantial miscoding, and some ROV incidents would be coded as ATVs or UTVs.

[18] Sarah Garland, "NEISS Injury Estimates for Recreational Off-Highway Vehicles (ROVs)," U.S. Consumer Product Safety Commission, (September 2011).

[19] For a more complete discussion of the Injury Cost Model see Ted R. Miller, et al., The Consumer Product Safety Commission's Revised Injury Cost Model, (December 2000). Available at:
http://www.cpsc.gov/PageFiles/100269/costmodept1.PDF.
http://www.cpsc.gov/PageFiles/100304/costmodept2.PDF.

estimates based on the 16 NEISS cases that were identified in the 2010 study,[20] injuries treated in hospital emergency departments accounted for about 27 percent of all medically treated injuries involving ROVs. Using this percentage, the estimate of 3,000 emergency department-treated injuries involving ROVs suggests that there were about 11,100 medically treated injuries involving ROVs in 2010 (*i.e*., 3,000 injuries initially treated in emergency departments and 8,100 other medically-attended injuries) or 194 medically-attended injuries per 10,000 ROVs in use 11,100 ÷ 570,000 x 10,000).[21]

3.1.2 Fatal Injuries

In addition to the nonfatal injuries, there are fatal injuries involving ROVs each year. As of April 5, 2013, CPSC staff had identified 49 fatalities involving ROVs that occurred in 2010, or about 0.9 deaths per 10,000 ROVs in use ((49 ÷ 570,000) x 10,000). The actual number of deaths in 2010 could be higher because reporting is still ongoing for 2010. Overall, CPSC has counted 335 ROV deaths that occurred from January 1, 2003 to April 5, 2013. There were no reported deaths in 2003, when relatively few ROVs were in use. As of April 5, 2013, there had been 76 deaths reported to CPSC that occurred in 2012.[22]

3.2 Societal Cost of Injuries and Deaths Associated with ROVs

3.2.1 Societal Cost of Nonfatal Injuries

The CPSC's Injury Cost Model (ICM) provides comprehensive estimates of the societal costs of nonfatal injuries. The ICM is fully integrated with NEISS and provides estimates of the societal costs of injuries reported through NEISS. The major aggregated components of the ICM include: medical costs; work losses; and the intangible costs associated with lost quality of life or pain and suffering.[23]

[20] Sarah Garland, Division of Hazard Analysis, "NEISS Injury Estimates for Recreational Off-Highway Vehicles (ROVs) in 2010," U.S. Consumer Product Safety Commission, Bethesda, MD 20814 (September 2011).

[21] Using the ICM estimates for all cases involving ATVs and UTVs, injuries that were initially treated in a hospital emergency department accounted for about 35 percent of all medically attended injuries. If this estimated ratio, which is based on a larger sample, but that includes vehicles that are not ROVs was used instead of the ratio based strictly on the 16 known ROV NEISS cases in 2010, the estimated number of medically-attended injuries would be about 8,600.

[22] Memorandum from Sarah Garland, Division of Hazard Analysis, "Additional ROV-related incidents reported from January 1, 2012 through April 5, 2013," U.S. Consumer Product Safety Commission, Bethesda, MD (8 April 2013).

[23]A detailed description of the cost components, and the general methodology and data sources used to develop the CPSC's Injury Cost Model, can be found in Miller et al. (2000), available at http://www.cpsc.gov//PageFiles/100269/costmodept1.PDF and http://www.cpsc.gov//PageFiles/100304/costmodept2.PDF.

Medical costs include three categories of expenditure: (1) medical and hospital costs associated with treating the injury victim during the initial recovery period and in the long run, the costs associated with corrective surgery, the treatment of chronic injuries, and rehabilitation services; (2) ancillary costs, such as costs for prescriptions, medical equipment, and ambulance transport; and (3) costs of health insurance claims processing. Cost estimates for these expenditure categories were derived from a number of national and state databases, including the National Healthcare Cost and Utilization Project – National Inpatient Sample and the Medical Expenditure Panel Survey, both sponsored by the Agency for Healthcare Research and Quality.

Work loss estimates, based on information from the National Health Interview Survey and the U.S. Bureau of Labor Statistics, as well as a number of published wage studies, include: (1) the forgone earnings of parents and visitors, including lost wage work and household work, (2) imputed long term work losses of the victim that would be associated with permanent impairment, and (3) employer productivity losses, such as the costs incurred when employers spend time juggling schedules or training replacement workers. The earnings estimates were updated most recently with weekly earnings data from the Current Population Survey conducted by the Bureau of the Census in conjunction with the Bureau of Labor Statistics.

Intangible, or non-economic, costs of injury reflect the physical and emotional trauma of injury as well as the mental anguish of victims and caregivers. Intangible costs are difficult to quantify because they do not represent products or resources traded in the marketplace. Nevertheless, they typically represent the largest component of injury cost and need to be accounted for in any benefit-cost analysis involving health outcomes.[24] The Injury Cost Model develops a monetary estimate of these intangible costs from jury awards for pain and suffering. While these awards can vary widely on a case-by-case basis, studies have shown them to be systematically related to a number of factors, including economic losses, the type and severity of injury, and the age of the victim.[25] Estimates for the Injury Cost Model were derived from a regression analysis of about 2,000 jury awards in nonfatal product liability cases involving consumer products compiled by Jury Verdicts Research, Inc.

In addition to estimating the costs of injuries treated in U.S. hospital emergency departments and reported through NEISS, the Injury Cost Model uses empirical relationships between emergency department injuries and those treated in other settings (*e.g*., physicians' offices, clinics, ambulatory surgery centers, and direct hospital admissions) to estimate the number, types, and costs of injuries treated outside of hospital emergency departments. Thus, the Injury Cost Model allows us to expand on NEISS by combining (1) the number and costs of emergency department injuries with (2) the number and costs of medically attended injuries treated in other settings to estimate the total number of medically attended injuries and their costs across all treatment levels.

[24] Rice, D.P. & MacKenzie, E.J. (1989). Cost of injury in the United States: A report to Congress, Institute for Health and Aging. San Francisco, CA: University of California and The Johns Hopkins University.
[25] Viscusi, W.K. (1988). Pain and suffering in product liability cases: systematic compensation or capricious awards? *Int. Rev. Law Econ. 8*, 203-220 and Rodgers, G.B. (1993). Estimating jury compensation for pain and suffering in product liability cases involving nonfatal personal injury. *J. For. Econ.* 6(3), 251-262.

In this analysis, we use injury data from 2010 as a baseline from which to estimate the societal cost of injuries associated with ROVs. The year 2010 is used because it is the year for which we have the most comprehensive estimates of both fatal and nonfatal injuries associated with ROVs. According to ICM, the average societal cost of a medically attended injury associated with ROVs in 2010 was $29,383 in 2012 dollars. Based on this estimate, the total societal costs of the medically-attended injuries involving ROVs in 2010 was about $326.2 million in 2012 dollars (11,100 injuries x $29,383). About 75 percent of the cost was related to the pain and suffering. About 9 percent of the cost was related to medical treatment, and about 16 percent was related work and productivity losses of the victim, caregivers, visitors, and employers. Less than 1 percent of the cost was associated with the costs of the legal and liability system.

It must be noted that these cost estimates are based on a small sample of only 16 NEISS cases. This sample is too small to reflect the full range of injury patterns (*i.e.*, the different combinations of injury diagnoses, body parts, and injury dispositions) and rider characteristics (*i.e.*, age and sex) associated with ROV injuries. In fact, because the 16 NEISS cases did not include any case in which the victim required admission to a hospital, the cost estimates are probably low. Nevertheless, this estimate will be used in this analysis with the knowledge that its use probably leads to an underestimate of the societal costs associated with ROVs and underestimates of the potential benefits of the draft proposed rule intended to reduce the risk of injury associated with ROVs.[26]

3.2.2 Societal Cost of Fatal Injuries

As discussed above, there were at least 49 fatal injuries involving ROVs in 2010. If we assign a cost of $8.4 million for each death, then the societal costs associated with these deaths would amount to about $411.6 million (49 deaths x $8.4 million). The estimate of $8.4 million is the estimate of $7.4 million (in $2006) developed by the Environmental Protection Agency (EPA) updated to $2012 and is consistent with willingness-to-pay estimates of the value of a statistical life (VSL). According to the Office of Management and Budget's (OMB) *2013 Draft Report to Congress on the Benefits and Costs of Federal Regulations and Agency Compliance with the Unfunded Mandates Reform Act*, willingness-to-pay-estimates of the VSL generally vary from about $1.3 million to $12.2 million in 2010 dollars. (In 2012 dollars, the range would be $1.3 million to 13.0 million.)[27]

[26] An alternative method for estimating the injury costs would be to assume that the patterns of injury associated with ROVs are similar to the injury patterns associated with all ATVs and UTVs. According to ICM estimates for all ATVs and UTVs (NEISS Product Codes 3285–3287 and 5044), injuries treated in hospital emergency departments accounted for about 35 percent of the medically-attended injuries. This would suggest that the number of medically-attended injuries involving an ROV was about 8,600. The average cost of a medically-attended injury involving an ATV or UTV was $42,737. Therefore, the total societal cost of medically-attended injuries would be $367.5 million.

[27] The estimate of the VSL developed by the EPA is explained EPA's *Guidelines* for Preparing Economic Analysis, Appendix B: Mortality Risk Valuation Estimates (Environmental Protection Agency, 2014) and is available at http://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0568-50.pdf/$file/EE-0568-50.pdf. The OMB's 2013 Draft Report to Congress is available at

3.2.3 Societal Cost of Injuries per ROV in Use

Based on the discussion above, the total estimated societal costs of deaths and injuries associated with ROVs were $737.8 million in 2010 (expressed in 2012 dollars). The estimate does not include the costs associated with any property damage, such as to the ROVs involved or other property, such as another vehicle or object that might have been involved in an incident.

Given the earlier estimate that about 570,000 ROVs were in use at the end of 2010, the estimated societal costs of deaths and medically-attended injuries was about $1,294 per ROV in use ($737.8 million ÷ 570,000) in 2010. However, because the typical ROV is expected to be in use for 15 to 20 years, the expected societal cost of fatalities or deaths per ROV over the vehicle's useful life is the present value of the annual societal costs summed over the ROV's expected useful life. CPSC staff has not estimated the operability rates of ROVs as they age. However, CPSC staff has estimated the operability rates for ATVs as they age based on the results of exposure surveys.[28] ROVs and ATVs are similar vehicles in that they are both off-road recreational vehicles and generally produced by the same manufacturers. If ROVs have the same operability rates as they age as ATVs, the present value of the societal cost of injuries over the expected useful life of an ROV (at a 3 percent discount rate) is $17,784.[29,30]

4.0 REQUIREMENTS OF THE DRAFT PROPOSED RULE: COSTS AND BENEFITS

The draft proposed rule would establish a mandatory safety standard for ROVs. The requirements of the draft proposed rule can be divided into two general categories: (1) lateral stability and vehicle handling and (2) occupant retention. The costs and benefits that are expected to be associated with the requirements of the draft proposed rule are discussed below. As discussed earlier, 2010 is used as the base year for this analysis because it is the only year for which we have estimates of both fatal and nonfatal injuries associated with ROVs. However, where quantified, the costs and benefits are expressed in 2012 dollars.

http://www.whitehouse.gov/sites/default/files/omb/inforeg/2013_cb/draft_2013_cost_benefit_report.pdf. Both reports were accessed on August 6, 2014.

[28] CPSC Memorandum from Mark S. Levenson, Division of Hazard Analysis, to Susan Ahmed, Associate Executive Director, Directorate for Epidemiology, "2001 ATV Operability Rate Analysis," U.S. Consumer Product Safety Commission, Bethesda MD (19 August 2003).

[29] Our choice of discount rate is consistent with research suggesting that a real rate of 3 percent is an appropriate discount rate for interventions involving public health (see Gold, Marthe R, Joanna E. Siegel, Louise B. Russell and Milton C. Weinstein, 1996, *Cost-Effectiveness in Health and Medicine*, New York: Oxford University Press).

[30] The present value of the societal cost was calculated as follows:
$(\$1{,}294/1.03) \bullet X_1 + (\$1{,}294/1.03^2) \bullet X_2 + \ldots + (\$1{,}294/1.03^i) \bullet X_i = \$17{,}784$, where X_i represents the likelihood that a ROV remains in use after i years.

In general, the cost estimates were developed in consultation with ES staff. Estimates are based on ES staff's interactions with manufacturers and knowledge related to ROV design and manufacturing process as well as direct experience with testing ROVs and similar products. In many cases, we relied on ES staff's expert judgment. Consequently, we note that these estimates are preliminary and welcome comments on their accuracy and the assumptions underlying their constructions. We are especially interested in data that would help us to refine our estimates to more accurately reflect the expected costs of the draft proposed rule as well as any alternative estimates that interested parties can provide.

4.1 Lateral Stability and Vehicle Handling Requirements

The lateral stability and vehicle handling requirement of the draft proposed rule would require that all ROVs meet a minimum level of rollover resistance and that ROVs exhibit understeer characteristics. The dynamic lateral stability requirement would set a minimum value for the lateral acceleration at roll-over of 0.70 g (unit of standard gravity), as determined by a 30 mph drop-throttle J-turn test. The greater the lateral acceleration value, the greater is the resistance of the ROV to tip or roll over. The understeer requirement would mandate that ROVs exhibit understeer characteristics in the sub-limit range of the turn circle test described in the draft proposed rule.

The draft proposed rule would also require manufacturers to place a hang tag on all new vehicles that provides the lateral acceleration at rollover value for the model and provides information to the consumer about how to interpret this value. The intent of the hang tag is to provide the potential consumer with information about the rollover propensity of the model to aid in the comparison of ROV models before purchase. The content and format of the hang tag are described in the draft proposed rule.

The draft proposed rule describes the test procedures for measuring the dynamic rollover resistance and the understeering performance of the ROV, including the requirements for the test surface, the loading of test vehicles, and the instrumentation needed for conducting the tests and for data acquisition during the tests. The test for rollover resistance would use a 30 mph drop-throttle J-turn test. This test uses a programmable steering controller to turn the test vehicle traveling at 30 mph at prescribed steering angles and rates to determine the minimum steering angle at which two-wheel lift is observed. The data collected during these tests are analyzed to compute and verify the lateral acceleration at rollover for the vehicle.

The test for vehicle handling or understeer performance involves driving the vehicle around a 100-foot radius circle at increasing speeds, with the driver making every effort to maintain compliance of the vehicle path relative to the circle. Data collected during the tests are analyzed to determine whether the vehicle understeers through the required range. The draft proposed rule would require that all ROVs exhibit understeer for values of ground plane lateral acceleration from 0.10 to 0.50 g.

4.1.1 Cost of Lateral Stability and Vehicle Handling Requirements

All manufacturers would have to conduct the tests prescribed in the draft proposed rule to determine whether their models meet the requirements and to obtain the information on dynamic lateral stability that must be reported to consumers on the hang tag. If any model fails to meet one or both of the requirements, the manufacturer would have to make adjustments or modifications to the design of the model. After the model has been modified, the manufacturer would have to conduct the tests on the modified model to ensure that the model meets the requirements.

There is substantial overlap in the conditions under which the tests for dynamic lateral stability and vehicle handling must be performed. The test surfaces are the same, and the vehicle condition, loading, and instrumentation required for both tests are virtually the same. The one difference is that the test for dynamic lateral stability also requires that the test vehicle be equipped with a programmable steering controller. Because there is substantial overlap in the conditions under which the tests must be conducted, manufacturers will likely conduct both sets of tests on the same day. This would save manufacturers the cost of loading and instrumenting the test vehicle twice and renting a test facility for more than one day.

We estimate that the cost of conducting both the dynamic lateral stability and vehicle handling tests will be about $24,000 per model.[31] This includes the cost of conducting both sets of tests, measuring the center of gravity of the test vehicle, which is required for the dynamic lateral stability test, transporting the test vehicle to and from the test site, outfitting the test vehicles with the needed equipment and instruments, and the rental of the test facility. This estimate also assumes that both tests are being conducted on the same day, and the manufacturer only needs to rent the test facility for one day and pay for loading and instrumenting the test vehicles one time.

If the model meets the requirements of both tests, the manufacturer would have no additional costs associated with these requirements. The tests would not have to be conducted again, unless the manufacturer makes changes to the model that could affect the vehicle's performance in these tests.

If the model does not meet the requirements of one or both of the tests, the manufacturer will incur costs to make adjustments in the design of the vehicle. According to Directorate for Engineering Sciences (ES) staff, engineers who specialize in the design of utility and recreational vehicles would likely have a good understanding of vehicle characteristics that influence the vehicle's stability and handling and should be able to easily modify the design of a vehicle to meet the stability and handling requirements. The Yamaha Rhino repair program demonstrated that an ROV that did not meet the lateral stability and vehicle handling requirements was

[31] This estimate is based on the rates that CPSC has most recently paid a contractor for conducting these tests. For example, see contract CPSC-D-11-0003, which provides the following cost estimates: $3,000 for static measurement to determine center of gravity location, $19,000 to perform dynamic tests, and $2,000 to ship vehicles. This amounts to approximately $24,000.

successfully modified to meet the requirements by increasing the track width and reducing the rear suspension stiffness (by removing the sway bar) of the ROV. Based on experience with automotive manufacturing, ES believes that less than 1 or 2 person-months would be required to modify an ROV model that did not comply with the requirements. A high estimate would be that a manufacturer might require as many as 4 person-months (or about 700 hours) to modify an ROV model to meet the draft proposed requirements. Assuming an hourly rate of $61.75, which is the estimated total hourly compensation for management, professional, and related workers,[32] the cost to modify the design of an ROV model to meet the stability and handling requirements, using the high estimate would be about $43,000.

CPSC staff believes that most modifications that might be required to meet the lateral stability and vehicle handling requirements will have minimal, if any, impact on the production or manufacturing costs because the assembly of an ROV already includes installation of a wheel axle and installing a longer wheel axle or wheel spacer would not change the current assembly procedure; likewise, the assembly of an ROV already includes installation of sway bars and shock absorbers and installing different variations of these suspension components would not affect the current assembly procedure.

Once an ROV model has been modified to comply with the requirements, the manufacturer will have to retest the vehicle to ensure that the model does comply with the requirements. Both the dynamic lateral stability and vehicle handling tests will have to be conducted on the redesigned model, even if the original model failed only one of the tests. This is because the design changes could have impacted the ROVs ability to comply with either requirement. Therefore, the full cost of the draft proposed lateral stability and vehicle handling requirements could range from a low of about $24,000 for a model that already met the requirements to up to $91,000 in a scenario in which the model was tested, the manufacturer required 4 person-months to modify the vehicle, and the vehicle was retested to ensure that the modified vehicle complied with the requirements.[33]

Although the plausible range for the cost of the lateral stability and vehicle handling requirement is $24,000 to $91,000 per model, CPSC staff believes that the average cost per model will be towards the low end of this range because staff tested 10 ROVs that represented the recreational and utility oriented ROVs available in 2010, and found that four out of 10 ROVs met the lateral stability requirement and five out of 10 ROVs met the vehicle handling requirements (see Tab A). As discussed above, for models that already meet the requirements, the manufacturer will incur no additional costs beyond the cost of the testing. Based upon staff examination of models that do not meet the requirements, staff believes that manufacturers should be able to bring the model into compliance with the requirements by making simple

[32] U.S. Bureau of Labor Statistics, Employer Costs for Employee Compensation, Table 9 (Management, professional, and related workers, Private Industry, goods-producing and service-providing industries), June 2012. Accessed on January 9, 2014, from http://www.bls.gov/news.release/archives/ecec_09112012.pdf

[33] If the ROV already met the lateral stability and vehicle handling requirements, the low estimate of $24,000 could overstate the incremental cost of meeting the requirements if the manufacturer was already performing the tests prescribed in the draft proposed rule.

changes to the track width or to the suspension of the vehicle. These are relatively modest modifications that probably can be accomplished in less time than the high estimate of 4 months. However, staff welcomes comments on our underlying rationale for the estimates as well as the estimates themselves.

It is frequently useful to compare the benefits and costs of a rule on a per-unit basis. Based on 2011 sales data, the average unit sales per ROV model was about 1,800.[34] ROVs are a relatively new product and the average number of years a ROV model will be produced before being redesigned is uncertain. It is often observed that automobile models are redesigned every 4 to 6 years. If a ROV model is produced for about 5 years before being redesigned, then the cost of testing the model for compliance with the dynamic lateral stability and vehicle handling requirements and, if necessary, modifying the design of the vehicle to comply with the requirements and retesting the vehicle would apply to about 9,000 units.[35] Therefore, the average per unit cost of the draft proposed dynamic lateral stability and vehicle handling requirements would be about $3 per unit ($24,000 ÷ 9,000) if the model already complies with the requirements. Using the high estimate of the time that it could take to modify a model that fails or one or both of the tests, the per-unit cost would be about $10 per unit ($91,000 ÷ 9,000).[36]

The draft proposed rule requires that the manufacturer attach a hang tag on each new ROV that provides its lateral acceleration at rollover value, which can be used by the consumer to compare the rollover resistance of different ROVs. We estimate that the cost of the hang tag, including the design and printing of the hang tag and attaching the hang tag to the vehicle will be less than $0.25 per vehicle. Our estimates are based on the following assumptions: (1) the cost of printing the hang tag and the wire for attaching the hang tag is about 8 cents per vehicle, (2) placing the hang tag on each vehicle will require about 20 seconds at an hourly rate of $26.11 and (3) designing and laying out the hang tag for each model will require about 30 minutes at an hourly rate of $61.75.[37] The estimate of 30 minutes for the hang tag design reflects that draft proposed rule provides a sample of the required hang tag and guidance regarding the layout of the hang tag for manufacturers to follow. Also, if the manufacturer has multiple models, the same template could be used across models; the manufacturer would simply need to change the lateral acceleration number and model identification. In light of these considerations, CPSC staff believes that 30 minutes per model represents a reasonable estimate of the effort involved, but

[34] In 2011, the average number of units sold per model was about 1,800. Depending on the particular model, the units sold ranged from less than 10 for some models, to more than 10,000 for others (based on an analysis by CPSC staff of a database obtained from Power Products Marketing of Eden Prairie, MN).

[35] We welcome comments on this assumption.

[36] These per unit cost estimates are an attempt to estimate the average per unit costs across all ROV models. The actual per unit cost for any ROV model would depend upon the sales volume for that model. If the sales were substantially more than 1,800 units annually, then the per-unit cost would be substantially lower than estimated above. If sales were substantially less than 1,800 units annually, then the per unit cost of the draft proposed requirements would be substantially higher.

[37] The labor rates are the total compensation for workers in the production, transportation, and material moving occupations and management, professional, and related occupations, respectively, as reported by the Bureau of Labor Statistics for all workers in goods producing industries (Employer Cost for Employee Compensation, Table 9, June 2012. Accessed on January 9, 2014, from http://www.bls.gov/news.release/archives/ecec_09112012.pdf

we welcome comments on this estimate, especially comments that will assist us in refining the estimate.

According to several ROV manufacturers, some ROV users "might prefer limit oversteer in the off-highway environment."[38] To the extent that the requirements in the draft proposed rule would reduce the ability of these users to intentionally reach limit oversteer, the draft proposed rule could have some adverse impact on the utility or enjoyment that these users receive from ROVs. These impacts would probably be limited to a small number of recreational users who enjoy activities or stunts that involve power oversteering or limit oversteer.

Although the impact on consumers who prefer limit oversteer cannot be quantified, CPSC staff expects that it will be low. Any impact would be limited to those consumers who wish to intentionally engage in activities involving the loss of traction or power oversteer. According to ES staff, the practice of power oversteer is the result of driver choices, such as the speed at which a user takes a turn. The draft proposed rule would not prevent ROVs from reaching limit oversteer under all conditions; nor would the rule prevent consumers from engaging in these activities. At most, the draft proposed rule might make it somewhat more difficult for users to reach limit oversteer in an ROV. Moreover, consumers who have a high preference for vehicles that oversteer would be able to make aftermarket modifications, such as adjustments to the suspension of the vehicle, or using different wheels or tires to increase the potential for oversteering.

4.1.2 Benefits of the Lateral Stability and Vehicle Handling Requirements

The benefit of the dynamic lateral stability and vehicle handling or understeer requirements would be the reduction of injuries and deaths attributable to these requirements. The intent of the dynamic lateral stability requirement is to reduce rollover incidents that involve ROVs. A CPSC analysis of 428 ROV incidents showed that at least 68 percent involved the vehicle rolling sideways. More than half of the overturning incidents (or 35 percent of the total incidents) occurred during a turn. There were other incidents (24 percent of the total incidents) in which the vehicle rolled sideways, but it is not known if the incident occurred during a turn.[39]

The dynamic lateral stability requirement is intended to ensure that all ROVs on the market have at least a minimum level of resistance to rollover during turns, as determined by the test in the draft proposed rule. Additionally, by requiring that consumers be informed of the rollover resistance of ROV models through the use of hang tags, the draft proposed rule would make it easier for consumers to compare the rollover resistance of ROV models before making a purchase. Manufacturers might be encouraged to develop ROV models with greater resistance to

[38] This assertion was contained in a public comment on the ANPR for ROVs (Docket No. CPSC-2009-0087) submitted jointly on behalf of Arctic Cat, Inc., Bombardier Recreational Products, Inc., Polaris Industries, Inc., and Yamaha Motor Corporation, USA.

[39] Sarah Garland, Ph.D., Analysis of Reported Incidents Involving Deaths or Injuries Associated with Recreational Off-Highway Vehicles (ROVs), U.S. Consumer Product Safety Commission, Bethesda, MD (May 2012).

rollover if consumers show a clear preference for ROVs with the higher values for lateral acceleration threshold at rollover when they purchase new ROVs. As a similar example, in 2001, NHTSA began including rollover resistance information in its new car assessment program (NCAP).[40] NHTSA believed that consumer information on the rollover risk of passenger cars would influence consumers to purchase vehicles with a lower rollover risk and inspire manufacturers to produce vehicles with a lower rollover risk.[41] A subsequent study of static stability factor (SSF) trends in automobiles found that SSF values increased for all vehicles after 2001, particularly SUVs, which tended to have the worst SSF values in the earlier years.[41]

The understeer requirement is intended to reduce the likelihood of a driver losing control of an ROV during a turn, which can lead to the vehicle rolling sideways or striking another vehicle or object. According to ES staff, oversteer is an undesirable trait because it is a directionally unstable steering response that leads to dynamic instability and loss of control. For this reason, automobiles are designed to exhibit understeer characteristics up to the traction limits of the tires. Sub-limit and limit oversteer are undesirable in off-highway environments, just as they are in on-highway environments, due to the numerous trip hazards that can cause the vehicle to roll over.[42]

Although CPSC staff believes that the dynamic lateral stability and vehicle handling requirements will reduce the number of deaths and injuries involving ROVs, it is not possible to quantify this benefit because we do not have sufficient data to estimate the injury rates of models that already meet the requirements and those that do not. Thus, we cannot estimate the potential effectiveness of the requirements in preventing injuries. However, these requirements are intended to reduce the risk of an ROV rolling sideways when making a turn. Because the estimated societal cost of deaths and injuries associated with ROVs is $17,784 over the useful life of an ROV,[43] and because at least 35 percent of the injuries occurred when an ROV rolled sideways when making a turn, these requirements would address approximately $6,224 in societal costs per ROV ($17,784 x .35). Consequently, given that the estimated cost of the lateral stability and handling requirements is about $10 per ROV, the requirements would have to prevent less than 0.2 percent of the rollover incidents ($10 ÷ $6,224) for the benefits of the requirements to exceed the costs.

4.2 Occupant Retention Requirements

The occupant retention requirements of the draft proposed rule are intended to keep the occupant within the vehicle or the rollover protective structure ROPS. First, each ROV would be

[40] 65 FR 34988 (June 1, 2000).

[41] Walz, M. C. (2005). Trends in the Static Stability Factor of Passenger Cars, Light Trucks, and Vans. DOT HS 809 868. Retrieved from http://www.nhtsa.gov/cars/rules/regrev/evaluate/809868/pages/index.html.

[42] CPSC Memorandum from Anthony Teems to Caroleene Paul, “Proposed lateral stability and vehicle handling requirements for Recreational Off-Highway Vehicles (ROVs),” U.S. Consumer Product Safety Commission, Bethesda, MD (September 19, 2014).

[43] The estimates of the societal cost of deaths and injuries were discussed in Section 3 of this report.

required to have a means to restrict occupant egress and excursion in the shoulder/hip zone defined by the draft proposed rule. This requirement could be met by a fixed barrier or structure on the ROV or by a barrier or structure that can be put into place by the occupant using one hand in one operation, such as a door. Second, the draft proposed rule would require that the speed of an ROV be limited to a maximum of 15 mph, unless the seat belts for both the driver and any front seat passengers are fastened. Additionally, a visual signal must be provided to the driver when the speed of the vehicle is limited because the seat belts are not fastened. The purpose of these requirements is to prevent deaths and injuries, especially those involving full or partial ejection of the rider from the vehicle.

4.2.1 Costs of Occupant Retention Requirements

4.2.1.1 Means to Restrict Occupant Egress or Excursion

Most ROVs already have some occupant protection barriers or structures. In some cases, these structures might already meet the requirements of the draft proposed rule. In other cases, they could be modified or repositioned to meet the requirements of the draft proposed rule. A simple barrier that would meet the requirement could be fabricated out of a length of metal tubing that is bent and bolted or welded to the ROPS or other suitable structure of the vehicle in the shoulder/hip zone of the vehicle, as defined in the draft proposed rule. ES staff believes that any additional metal tubing required to form such a barrier could be obtained for a cost of about $2 per barrier. ES also believes that the additional time that would be required to bolt or weld the barrier to the vehicle would be less than 1 minute. Assuming an hourly labor cost of $26.11, the labor time required would be less than $0.50. ES staff also believes that it would take manufacturers only a few hours to determine how an existing ROV model would need to be modified to comply with the requirement and to make the necessary drawings to implement the change. When spread over the production of the model, this cost would come to only a few cents per vehicle. Therefore, the estimated cost is expected to be less than $3 per barrier.

Based on a cost of less than $3 per barrier, the cost per vehicle would be less than $6 for ROVs that do not have rear seats and $12 for ROVs with rear seats. One exposure study found that about 20 percent of ROVs had a seating capacity of 4 or more, which indicates that they have rear seats. Therefore, if all ROV models required modification to meet the standard, the weighted average cost per ROV would be about $7 ($6 x 0.8 + $12 x 0.2). However, CPSC staff tested 10 ROVs that represented the recreational and utility oriented ROVs available in 2010, and found that four out 10 ROVs had a passive shoulder barrier that passed a probe test specified in ANSI/ROHVA 1-2011 (see Tab H). Therefore, this estimate of the average cost is high because there would be no additional cost for models that already meet the draft proposed requirement. We welcome comments on these costs and the assumptions underlying their constructions. We are especially interested in data that would help us to refine our estimates to more accurately reflect the expected costs of the this proposed requirement as well as any alternative estimates that interested parties can provide.

4.2.1.2 Requirement to Limit Speed if the Driver's Seat Belt Is not Fastened

The requirement that the speed of the vehicle be limited if the driver's seat belt is not fastened does not mandate any specific technology. Therefore, manufacturers would have some flexibility in implementing this requirement. Nevertheless, based on staff's examination of and experience with speed-limiting technology, including examination of current ROV models with this feature, most systems to meet this requirement will probably include the following components:

1. a seat belt use sensor in the seat belt latch that detects when the seat belt is fastened;
2. a means to limit the speed of the vehicle when the seat belt is not fastened;
3. a means to provide a visual signal to the driver of the vehicle when the speed of the vehicle is limited because the seat belt is not fastened;
4. wiring or other means for the sensor in the seat belt latch to send signals to the vehicle components used to limit the speed of the vehicle and provide feedback to the driver.

Before implementing any changes to their vehicles to meet the requirement, manufacturers would have to analyze their options for meeting the requirement. This process would include developing prototypes of system designs, testing the prototypes and refining the design of the systems based on this testing. Once the manufacturer has settled upon a system for meeting the requirement, the system will have to be incorporated into the manufacturing process of the vehicle. This will involve producing the engineering specifications and drawings of the system, parts, assemblies, and subassemblies that are required. Manufacturers will need to obtain the needed parts from their suppliers and incorporate the steps needed to install the system on the vehicles in the assembly line.

ES believes that it will take about nine person-months per ROV model to design, test, implement, and begin manufacturing vehicles that meet the requirements. The total compensation for management, professional, and related occupations is about $61.75 per hour.[44] Therefore, if designing and implementing a system to meet the requirement requires about nine person months (or 1,560 hours), the cost to the company would be about $100,000 per ROV model.[45]

Manufacturers would be expected to perform certification tests following the procedure described in the draft proposed rule at least once for each model the manufacturer produces to ensure that the model as manufactured meets the requirements of the rule. Additionally,

[44] U.S. Bureau of Labor Statistics, Table 9, Employer Costs for Employee Compensation (Private Industry, goods-producing and service-providing industries), June 2012. Accessed on January 9, 2014, from http://www.bls.gov/news.release/archives/ecec_09112012.pdf

[45] The estimate has been rounded to the nearest $10,000.

manufacturers would be expected to perform the certification testing again if they make any changes to the design or components used in a vehicle that could impact its compliance with this requirement. We estimate that the cost of this testing would be about $4,000 per model. This estimate assumes that the testing will require three professional employees 4 hours to conduct the testing at $61.75 per hour per person. Additionally, the rental of the test facility will cost $1,000, rental of the radar gun will cost $400, and transportation to the test facility will cost $1,400, and that the test vehicle can be sold after the testing is completed.

In addition to the cost of developing and implementing the system, manufacturers will incur costs to acquire any parts required for the system and installing the parts on the vehicles. We estimate the cost of adding a seat belt-use sensor to detect when the seat belt is fastened to be about $7 per seat belt. This estimate is based on estimates used by the National Highway Traffic Safety Administration (NHTSA) in its preliminary economic assessment of an advanced air bag rule.[46] This is a widely used technology: virtually all passenger cars have such sensors in their driver side seat belt latches to signal the seat belt reminder system in the car. The sensors and seat belt latches that would be expected to be used to meet this requirement in ROVs are virtually the same as those used in passenger cars.

There is more than one method that manufacturers could use to limit the maximum speed of the vehicle when the driver's seat belt is unfastened. One method would be to use a device, such as a solenoid, that mechanically limits the throttle opening. Based on observed retail prices for solenoid valves used in automotive applications, the cost to manufacturers of such a solenoid should be no more than about $25 per vehicle. One retailer had 24 different solenoids available at retail prices ranging from about $24 to $102. We expect that a manufacturer would be able to obtain similar solenoids for substantially less than the retail price. Thus, using the low end of the observed retail prices would suggest that manufacturers would probably be able to acquire acceptable solenoids for about $25 each.

Manufacturers of ROVs equipped with electronic throttle control (ETC or "throttle by wire") would have at least one other option for limiting the maximum speed of the vehicle. Instead of using a mechanical means to limit the throttle opening, the engine control unit (ECU) of the vehicle, which controls the throttle, could be reprogrammed or "mapped" in a way that would limit the speed of the vehicle if the seat belt was not fastened. If the ECU can be used to limit the maximum speed of the ROV, the only cost would be the cost of reprogramming or mapping the ECU, which would be completed in the implementation stage of development discussed above. There would be no additional manufacturing costs involved.

There would be at least two options for providing a visual signal to the driver that the speed of the vehicle is limited because seat belts are not fastened. One option would be to use an LCD display. Most ROV models already have an LCD display in the dashboard that could be used for this purpose. If an LCD display is present, the only cost would be the cost of the programming required for the display to show this message. This cost would be included in the

[46] NHTSA estimated the cost of a seat belt use sensor to be $2 to $5 in 1997 dollars. The cost has been adjusted to 2012 dollars using the CPI Inflation Calculator at: http://www.bls.gov/data/inflation_calculator.htm.

estimated cost of the research and development, and there would be no additional manufacturing cost.

Another option for providing a visual signal to the driver that the speed of the vehicle is limited would be to use a lighted message or icon on the dashboard or control panel of the vehicle. Both voluntary standards already require a "lighted seat belt reminder." To comply with this draft proposed requirement, the current visual reminder would have to be modified. For example, the wording or icons of the reminder would change, and the reminder would probably require a somewhat larger area on the dashboard or control panel and there could be some additional cost for an additional bulb or lamp to illuminate the larger area or icon. Based on its experience, ES staff believes that the cost of an additional bulb or lamp would be about $1 or less per vehicle.

There will be some labor costs involved in installing the components needed to meet this requirement, including installing and connecting the wires. We expect that the components installed at the stage of assembly would minimize the amount of labor required. If the amount of additional labor per vehicle was about 5 minutes, and assuming a total labor compensation rate of $26.11 an hour, the labor cost would probably amount to about $2 per vehicle.[47]

In addition to the certification testing discussed above, most manufacturers would be expected to conduct some quality assurance testing on vehicles as the vehicles come off the assembly line. Virtually all manufacturers already perform some quality control or quality assurance tests on their vehicles. The tests are intended to ensure, among other things, that the vehicle starts properly, that the throttle and brakes function properly, and that any lights function properly. Testing of the system limiting the maximum speed when the driver's seat belt is not fastened would likely be incorporated into this testing to ensure that the system is working as intended. These tests could simply involve running the vehicle once with the seat belt unfastened to determine whether speed was limited and again with the seat belt fastened to determine whether the maximum speed was no longer limited. If this testing added an additional 10 minutes to the amount of time it takes to test each vehicle the cost would be about $4 per vehicle assuming a total hourly compensation rate of $26.11.

The manufacturing costs that would be associated with meeting the seat belt reminder and speed limitation requirement of the draft proposed rule are summarized in Table 1. This includes the cost of one seat belt use sensor, the throttle or engine control, the visual feedback to the driver, and about 5 minutes of labor time and about 10 minutes for testing.

[47] Based on the total hourly compensation for workers in the *production, transportation, and material moving* subcategory under *All workers, goods producing industries* as reported by the U.S. Department of Labor, Bureau of Labor Statistics, Employer Costs for Employee Compensation – Table 9, June 2012. Accessed on January 9, 2014, from http://www.bls.gov/news.release/archives/ecec_09112012.pdf

Table 1. Estimated Manufacturing Costs of Requirement, per ROV

Component	Cost
Seat Belt Use Sensor	$7
Throttle or Engine Control	$0 to $25
Visual Signal to Driver	$1
Labor	$2
Quality Control Testing	$4
Total	***$14 to $39***

As discussed above, we estimate the upfront research, design, and implementation costs to be about $100,000 per model, and the certification testing costs to be about $4,000 per model. Assuming, as before, that the average annual sales per model are 1,800 units, and that the typical model is produced for 5 years, then the research, design, and certification testing costs would average about $12 per vehicle. The average cost for models produced at lower volumes would be higher and the average cost for models produced at higher than average volumes would be lower. Given the average cost of the research, design and development and the costs of the parts and manufacturing, we estimate that this requirement would cost between $26 ($14 + $12) and $51 ($39 + 12) per vehicle.

Unquantifiable Costs to Users – The requirement could impose some unquantifiable costs on some users who would prefer not to use seat belts. The cost to these users would be the time required to buckle and unbuckle their seat belts and any disutility cost, such as discomfort caused by wearing the seat belt. We cannot quantify these costs because we do not know how many ROV users choose not to wear their seat belts, nor do we have the ability to quantify any discomfort or disutility that they would experience from wearing seat belts. However, the draft proposed rule does not require that the seat belts be fastened unless the vehicle is traveling 15 mph or faster. This should serve to mitigate these costs because many people who would be inconvenienced or discomforted by the requirement, such as people using the vehicle for work or utility purposes or who must frequently get on and off the vehicle are likely to be traveling at lower speeds.

4.2.1.3 Requirement to Limit Speed if Seat Belts for Front Passengers Are Not Fastened

The draft proposed rule would also require that the speed of the ROV be limited to no more than 15 mph if the seat belt of any front passenger, who is seated in a location intended by the manufacturer as a seat, is not fastened. Based on conversations with ES staff, designing a system that also limits the speed of the vehicle if the seat belt of a passenger is not fastened would require only minor adjustments to the system limiting the speed if the driver's seat belt is not fastened. For example, switches could be incorporated into the system that detect the presence of a passenger and, if one is present, include the seat belt latch or use sensor for that seat in the circuit that determines whether to limit the maximum speed. ES staff believes that adding this requirement would not add any significant time to the research and design effort required to develop the system to limit the speed of the vehicle if the driver's seat belt is not fastened.

However, incorporating the front passenger seats into the requirement would require additional switches or sensors. A seat belt use sensor, like the one used on the driver's side seat belt latch, would be required for each passenger seat belt. The cost of a seat belt use sensor was estimated to be about $7. Additionally, there would likely be a sensor switch in each front passenger seat to detect the presence of a passenger. This switch could be similar to the seat switches in riding lawn mowers that shut off the engine if a rider is not detected. Similarly, in a ROV, if the presence of a passenger is not detected, the switch would not include the passenger seat belt sensor in circuit for determining whether the speed of the ROV should be limited. We estimate that the cost of this switch is $13 per seat, based on the retail price of a replacement switch for the seat switch in a riding lawn mower.

There will be some labor costs involved in installing the components needed to meet this requirement. The components would probably be installed at the stage of assembly that would minimize the amount of labor required and would probably not require more than about 5 minutes. Additionally, manufacturers will need to conduct tests of the system to ensure that it functions as required. These tests could take an additional 5 minutes per vehicle. Assuming a total labor compensation rate of $26.11 an hour,[48] the labor cost would probably amount to about $4 per vehicle. Therefore, the full cost of meeting this requirement would be about $24 per passenger seat ($7 for seat belt latch sensor + $13 for seat switch + $4 for labor). Therefore, the quantifiable cost of extending the seat belt/speed limitation requirement to include the front passenger seat belts would be $24 for ROVs with only two seating positions in the front (*i.e.*, the driver and right front passenger) and $48 for ROVs that have three seating positions in the front. According to a survey by Heiden Associates, about 9 percent of ROVs were reported to have a seating capacity of three.[49] Therefore, the average cost of extending the seat belt/speed limitation requirement per ROV would be $26 ($24 + .09 x $24).

An unquantifiable cost that should be considered is the impact that the failure of a component of the system could have on consumers. The more components that a system has, or the more complicated that a system is, the more likely it is that there will be a failure somewhere in the system. A system that limited the speed of the vehicle if a front passenger's seat belt is unbuckled would consist of more components and be more complicated than one that only limited the speed if the driver's seat belt was unfastened. Failure in one or more of the components would impose some costs on the consumer and possibly affect consumer acceptance of the requirement. For example, if the sensor in a passenger's seat belt failed to detect that the

[48] Based on the total hourly compensation for workers in the *production, transportation, and material moving* subcategory under *All workers, goods producing industries* as reported by the U.S. Department of Labor, Bureau of Labor Statistics, Employer Costs for Employee Compensation – Table 9, June 2012. Accessed on January 9, 2014, from: http://www.bls.gov/news.release/archives/ecec_09112012.pdf.

[49] Heiden Associates, Results from the 2009 ROV Exposure Survey (APPENDIX 2 to Joint Comments of Arctic Cat Inc., Bombardier Recreational Products Inc., Polaris Industries Inc., and Yamaha Motor Corporation, U.S.A regarding CPSC Advance Notice of Proposed Rulemaking-Standard for Recreational Off-Highway Vehicles: Docket No. CPSC – 2009-0087), Alexandria Virginia (December 4, 2009).

seat belt was latched, the speed of the vehicle could be limited even though the seat belts were fastened. The consumer would incur the costs of repairing the vehicle and the loss in utility because the speed was limited until the repairs were made.

4.2.2 Benefits of the Occupant Retention Requirements

The benefit of the occupant retention requirements is the reduction in the societal cost of fatal and nonfatal injuries that could be attributable to the requirements. In passenger cars, NHTSA assumes that a belted driver has a 45 percent reduction in the risk of death.[50] Research by Kahane confirms the validity of that estimate.[51] The effectiveness of seat belts in reducing the number or severity of nonfatal injuries is less certain than in the case of deaths. Nevertheless, there is evidence that the use of seat belts is associated with a reduction in injury severity. A study by Robert Rutledge et al found statistically significant decreases in the severity of injuries in belted patients versus unbelted patients admitted to trauma center hospitals in North Carolina for variables such as the trauma scores, the Glasgow coma scale, days on a ventilator, days in an intensive care unit, days in a hospital, and hospital charges.[52] This study found, for example, that the mean stay in the hospital for belted patients was about 20 percent shorter for belted patients as for unbelted patients: 10.5 days as opposed to 13.2 days. The hospital charges for belted patients were 31 percent less than for unbelted patients: $10,500 versus $15,250.[53]

In this analysis, we assume that the effectiveness estimate that NHTSA uses for seat belts in automobiles is a reasonable approximation of their effectiveness at reducing fatalities in ROVs. However, according to Kahane (2000), the effectiveness of seat belts was significantly higher in accidents involving rollover and other incidents where the potential for ejection was high.[54] A significant portion of the fatal and nonfatal injuries associated with ROVs are associated with rollovers, which suggests that a higher effectiveness estimate could be warranted.

[50] Charles J. Kahane, "Fatality Reduction by Safety Belts for Front-Seat Occupants of Cars and Light Trucks: Updated and Expanded Estimates Based on 1986 – 99 FARS Data," U.S. Department of Transportation, Report No. DOT HS 809 199, (December 2000).

[51] Memorandum from Sarah Garland, Ph.D., "Analysis of Reported Incidents Involving Deaths or Injuries Associated with Recreational Off-Highway Vehicles (ROVs)," U.S. Consumer Product Safety Commission, Bethesda, MD (May 2012).

[52] Robert Rutledge, Allen Lalor, Dale Oller, et al., The Cost of Not Wearing Seat Belts: A Comparison of Outcome in 3396 Patients," Annals of Surgery, Vol. 217, No. 2, 122−127 (1993).

[53] Note that the Rutledge study looked only at the difference in the severity of cases involving belted, as opposed to unbelted victims. It did not estimate the number of injuries that were actually prevented. It should also be noted that the Rutledge study focused only on patients that were hospitalized for at least one day. It might not be as applicable to patients who were treated and released without being admitted to a hospital.

[54] In these incidents, the researchers found the effectiveness of seat belts was 74 percent in passenger cars and 80 percent in light trucks. Incidents involving overturning of the vehicle or the ejection of the victim are associated with a larger proportion of the fatal injuries involving ROVs. At least 65 percent of the fatalities were in incidents where the vehicle rolled sideways and at least 70 percent of those injured or killed were either fully or partially ejected.

The work by Rutledge, et al, showed that mean hospital stays were about 20 percent less and hospital charges were 31 percent less for belted patients. This work provides some evidence that seat belts can reduce some components of the societal costs of nonfatal injuries by 20 to 31 percent. In this analysis we use the low end of this range, 20 percent, and assume that it applies to all components of the societal costs associated with nonfatal ROV injuries, including work losses and pain and suffering. The assumed 20 percent reduction in societal costs could come about either because some injuries were prevented entirely or because the severity of some injuries was reduced.

These assumptions are justified because the seat belts used in ROVs are the same type of seat belts used in automobiles. Additionally, the requirement that ROVs have a passive means to restrict the egress or excursion of an occupant in the event of a rollover would ensure that there would be some passive features on ROVs that will help to retain occupants within the protective structure of the ROV just as there are in automobiles. We welcome comment on the accuracy of these estimates and underlying assumptions and will consider alternative estimates or assumptions that commenters wish to provide.

A separate estimate of the benefit of the requirement for a passive means to restrict occupant egress or excursion is not calculated. The primary benefit of this requirement is to ensure that ROVs have passive features that are more effective at retaining occupants within the protective zone of the vehicle in the event of a rollover. Therefore, the passive means to restrict occupant egress or excursion acts synergistically with the seat belt requirement to keep occupants within the protective zone of the vehicle or ROPS and provides justification for applying estimates of the effectiveness of seat belts based on studies involving automobiles to the draft proposed rule for ROVs.

4.2.2.1 Benefit of Limiting Speed if Driver's Seat Belt Is not Fastened

As noted above, the benefit of the occupant retention requirements would be the reduction in the societal cost of fatal and nonfatal injuries that would be expected. The incremental benefit requiring the speed of the vehicle to be limited if the driver's seat belt is not fastened is discussed below. The incremental benefit of applying the same requirement to the front passengers is discussed separately.

4.2.2.1.1 Potential Reduction in Fatal Injuries

Table 2 shows the 231 fatality cases that CPSC staff has reviewed by the seating location of the victim and whether the victim was wearing a seat belt. Ignoring the cases in which the location of the victim or the seat belt use by the victim is unknown (and thereby erring on the side of underestimating the benefits), the data show that about 40 percent (92 ÷ 231) of the deaths were to drivers who were not wearing seat belts. If the pattern of deaths in 2010 is presumed to match the overall pattern of the deaths reviewed by CPSC, then about 20 of the reported 49 deaths associated with ROVs in 2010[55] would have been to drivers who did not have their seat belts fastened.[56]

Table 2. ROV Fatalities by Victim Location and Seat belt Use (2003 through 2011)

Location	Seat Belt Use			
	Yes	No	Unknown or N/A	Total
Driver	16	92	33	141
Right Front Passenger	10	33	6	49
Middle Front Passenger	0	6	0	6
Rear Passenger	0	3	1	4
Unknown Location	1	6	5	12
Cargo Area	1	8	1	10
Bystander or Other	0	3	6	9
Total	28	150	53	231

Source: CPSC Directorate for Epidemiology.

The requirement limiting the maximum speed would only apply to incidents involving unbelted drivers that occurred at speeds of greater than 15 mph. Of the ROV incidents that CPSC staff has reviewed, the speed of the vehicle was reported for only 89 of the 428 incidents. Therefore, estimates based on this data need to be used cautiously. Nevertheless, for those victims who are known to have been injured and for which both their seat belt use and the speed of the vehicle is known, about 73 percent of the unbelted victims were traveling at speeds of greater than 15 mph.[57] Consequently, if we assume that 73 percent of the fatalities occurred to unbelted drivers were traveling at speeds greater than 15 mph, then about 15 (20 x 0.73) of the fatalities to drivers in 2010 would have been addressed, although not necessarily prevented, by the draft proposed requirements.

As discussed above, in passenger cars, NHTSA concluded that a belted driver has a 45 percent reduction in the risk of death. If seat belts have the same effectiveness in reducing the risk of death on ROVs, the seat belt/speed limitation requirement would have reduced the number of fatal injuries to drivers of ROVs by about 7 (15 x 0.45) in 2010, if all ROVs in use at

[55] The collection of fatalities associated with ROVs in 2010 was ongoing at the time this analysis was conducted. The actual number of deaths associated with ROVs in 2010 could be higher.

[56] The actual pattern of deaths in any given year will likely be higher or lower than the overall or average pattern. In this analysis, we imposed the overall pattern to the reported fatalities in 2010 so that the results would be more representative of all reported ROV fatalities.

[57] Victims who were involved in an ROV incident but were not injured or whose injury status is not known were not included in this analysis.

the time had met this requirement.[58] This represents an annual risk reduction of 0.0000123 deaths per ROV in use (7 ÷ 570,000).

As discussed in Section 3, in this analysis we assume a value of $8.4 million for each fatality averted. However, in this analysis, we assume that each fatal injury prevented by the use of seat belts still results in a serious but nonfatal injury. The average societal cost of a hospitalized injury involving all ATVs and UTVs in 2010 was about $350,000 in 2012 dollars.[59] Subtracting this from the assumed societal cost of $8.4 million per death results in a societal cost reduction of $8.05 million per death averted. Thus, a reduction in societal costs of fatal injuries of about $99 per ROV in use (0.0000123 x $8.05 million) per year could be attributable to the seat belt/speed limitation requirement.

4.2.2.1.2 Potential Reduction in Societal Cost of Nonfatal Injuries

As discussed above, for this analysis, we assumed that the seat belt/speed limitation requirement will reduce the societal cost of nonfatal ROV injuries by 20 percent. The assumed 20 percent reduction in societal costs could come about either because some injuries were prevented entirely or because the severity of some injuries was reduced. CPSC staff has investigated several hundred nonfatal injuries associated with ROVs. Table 3 summarizes the nonfatal injuries by seating location and seat belt use.[60] Again, ignoring the cases in which the location of the victim or the seat belt use by the victim is unknown (and thereby erring on the side of underestimating the benefits), the data indicate that about 12 percent (46 ÷ 388) of the nonfatal injuries were to drivers who were not wearing seat belts. This suggests that 1,332 (11,100 x 0.12) of the approximately 11,100 medically attended injuries in 2010 would have involved unbelted drivers. Assuming, as with the fatal injuries, that 73 percent were traveling at a speed of greater than 15 mph at the time of incident, 972 (1,332 x 0.73) of the injuries in 2010 could have been addressed by the draft proposed seat belt/speed limitation requirement. These 972 injuries in 2010 represent an injury rate of about 0.00170526 (972 ÷ 570,000) per ROV in use.

[58] Alternatively, the drivers could opt to leave their seat belts unfastened and accept the lower speed. Because the risk of having an accident is probably directly related to the speed of the vehicle, this option would also be expected to reduce the number of fatal injuries.

[59] Based on the ICM estimates of the cost of a hospitalized injury using NEISS Product Codes 3285, 3286, 3287, and 5044.

[60] Cases in which the occupant was not injured or it is unknown whether the occupant was injured were not included in this analysis.

Table 3. Nonfatal ROV Injuries by Victim Location and Seat Belt Use (2003 to 2011)

	Seat Belt Use			
Location of Victim	Yes	No	Unknown or N/A	Total
Driver	23	46	51	120
Right Front Passenger	28	35	9	72
Middle Front Passenger	0	14	1	15
Rear Passenger	2	3	0	5
Unknown Location	8	21	128	157
Cargo Area	3	13	0	16
Bystander	0	0	3	3
Total	64	132	192	388

Source: CPSC Directorate for Epidemiology.

Based on estimates from the CPSC's ICM, the average societal cost of the injuries addressed is estimated to be $29,383. Applying this cost estimate to the estimated injuries per ROV that could be addressed by the standard results in an annual societal cost of about $50 per ROV in use (0.00170526 x $29,383). If wearing seat belts could have reduced this cost by 20 percent (by reducing either the number or severity of injuries), the societal benefit, in terms of the reduced costs associated with nonfatal injuries, would be about $10 per ROV in use.

4.2.2.1.3 Total Benefit Over the Useful Life of an ROV

The total benefit of the seat belt/speed limitation requirement per ROV would be the present value of the expected annual benefit per ROV in use summed over the vehicle's expected useful life. Above, using 2010 as the base year, we estimated that the annual benefit per ROV was about $99 in terms of reduced deaths and $10 in terms of reduced nonfatal injuries, for a total of $109 per ROV. Assuming that ROVs have the same operability rates as ATVs, the present value of the estimated benefit over the useful life of an ROV would be approximately $1,498 per vehicle, at a 3 percent discount rate.

The cost of the requirement to limit the speed of the vehicle if the driver's seat belt is not fastened was estimated to be between $26 and $51 per vehicle. Additionally, the cost of the requirement for a means to passively restrict occupant egress and excursion was estimated to be about $7 per vehicle. Therefore, the total cost would be between $33 and $58 per vehicle. The benefit of the requirement, estimated to be about $1,498 per vehicle, is substantially greater than the estimated cost of the requirement.

4.2.2.2 Benefit of Limiting Speed if a Front Passenger's Seat Belt Is Not Fastened

The potential incremental benefit of limiting the speed of an ROV if a front passenger's seat belt is not fastened can be calculated following the same procedure used to calculate the benefits of a requirement limiting the maximum speed when the driver's seat belt is not fastened. From the data presented in Table 2 (and ignoring the cases where the seating location of the victim or the seat belt use is unknown), there were 33 victims seated in the right front passenger position and six were seated in the middle front passenger position and were not using a seatbelt. However, some of the victims listed as being in the middle front seat were not seated in places intended to be a seat. In some cases, the victim might have been seated on a console; in other cases, the victim might have been sharing the right front seating position and not in a separate seat. Based on the available information about the incidents involved, we believe that only three of the six victims that are reported as being the "middle front passenger" were actually in positions intended by the manufacturer to be middle seats. Therefore, about 16 percent (36 ÷ 231) of the fatal injuries involved front seat passengers who were not wearing seat belts.

Applying this estimate to the fatalities in 2010 suggests that about 8 of the 49 fatalities were to front passengers who were not wearing seat belts. Assuming that about 73 percent involved vehicles traveling faster than 15 mph, about six of the fatalities would have been addressed, but not necessarily prevented, by the requirement. Assuming that seat belts reduce the risk of fatal injuries by 45 percent, about three fatalities might have been averted. This represents a risk reduction of 0.00000526 deaths per ROV in use (3 ÷ 570,000). Assuming a societal benefit of $8.05 million per death averted results in an estimated annual benefit of about $42 per ROV in use ($8.05 million x 0.00000526) in reduced fatal injuries.

Similarly, the data in Table 3 show that 35 of the victims who suffered nonfatal injuries were seated in the right front passenger location and 14 were seated in the middle front position. However, we believe that only 8 of the 14 were actually seated in a position intended by the manufacturer to be a seat. Therefore, 43 of the 388 victims (or about 11 percent of the total) with nonfatal injuries were front passengers who were not wearing seat belts. This suggests that 1,221 of the estimated 11,100 medically-attended injuries in 2010 involved unbelted front passengers. Using the assumption that 73 percent of these incidents occurred at speeds greater than 15 mph, then about 891 of the injuries might have been addressed by the requirement, or about 0.00156315 injuries per ROV in use (891 ÷ 570,000). Assuming that the average cost of a nonfatal injury involving ROVs is $29,383, the estimated societal cost of these injuries is about $46 per ROV in use. If wearing seat belts could have reduced the societal cost of the nonfatal injuries by 20 percent, then the benefits of the requirement would have been about $9 per ROV in use, per year.

Combining the benefits of the reduction in the societal cost of deaths ($42 per ROV in use) and the societal cost of injuries ($9 per ROV in use) yields an estimated benefit of $51 per ROV in use. Assuming that ROVs have the same operability rates as ATVs over time and a discount rate of 3 percent, the estimated benefit would be $701 over the expected useful life of an ROV. This is greater than the expected cost of this potential requirement of $26 per vehicle.

4.2.2.3 Impact of Any Correlation in Seat Belt Use Between Driver and Passengers

The analysis above used a simplifying assumption that the use of seat belts by the passenger is independent of the use of seat belts by the driver. Therefore, we assumed that limiting the maximum speed of the ROV if the driver's seat belt was not fastened would have no impact on the seat belt use by any passenger. However, there is some evidence that the use of seat belts by passengers is correlated with the seat belt use of the driver. In the incidents examined by CPSC staff, of the 121 right front passengers with known seat belt usage, the driver and right passenger had the same seat belt use status most of the time (about 82 percent). In other words, most of the time, the driver's and right passenger's seat belts were either both fastened or both unfastened. This suggests that if the drivers were required to fasten his or her seat belt, at least some of the passengers would also fasten their seat belts.

The implication that a correlation between seat belt use by drivers and by passengers has for this analysis is that it indicates that the benefits of requiring the driver's seat belt to be fastened were underestimated and the benefits of extending the requirement to include the right front passenger are over estimated. For example, if 80 percent of the passengers who would not normally wear their seat belts were to wear their seat belts because the driver was required to wear his or her seat belt (for the ROV to exceed 15 mph), then 80 percent of the benefit, or $561 ($701 x 0.80) attributed above to extending the speed limitation requirement to the front passengers would be rightfully attributed to the requirement that the driver's seat belt be fastened; and only 20 percent, or $140 ($701 x 0.20) would be attributable to the requirement that the front passengers' seat belts be fastened. In this example, the $140 in benefits attributed to extending the speed limitation requirement to include the front passenger's seat belts would still exceed the quantifiable cost of doing so, which was estimated to be $26.

5.0 SUMMARY OF THE COSTS AND BENEFITS OF THE DRAFT PROPOSED RULE

As described above, manufacturers would incur costs of $128,000 to $195,000 per model to test ROV models for compliance with the requirements of the draft proposed rule and to research, develop, and implement any needed changes to the models so that they would comply with the requirements. These costs would be incurred before the model is brought to market. To express these costs on a per unit basis, we assumed that, on average, 1,800 units of a model were produced annually and that a typical model is produced for 5 years. These costs are summarized in Table 4.

Table 4. Summary of Certification Testing and Research and Development Costs

Description	Cost per Model	Cost per Unit*
Lateral Stability and Vehicle Handling		
Compliance Testing	$24,000	$3
Redesign of Noncomplying Models	$43,000	$5
Retesting of Redesigned Models	$24,000	$3
Total Costs for Lateral Stability and Vehicle Handling	*$24,000 to $91,000*	*$3 to $10*
Occupant Retention		
Research, Design, Implementation	$100,000	$11
Certification Testing	$4,000	<$1
Total Costs for Occupant Retention	*$104,000*	*$12*
Total Certification Testing and Research and Development Costs	***$128,000 to $195,000***	***$14 to $22***

*Per-unit costs are rounded to the nearest whole dollar. The sums might not equal the totals due to rounding.

In addition to the testing, research, and development costs described above, manufacturers will incur some additional manufacturing costs for additional parts or labor required to manufacture ROVs that meet the requirements for the draft proposed rule. These costs are summarized in Table 5. With respect to the vehicle handling requirements, some modifications to vehicles that do not comply might increase manufacturing costs; others could decrease manufacturing costs. Therefore, we have assumed, on average, that there will not be any additional manufacturing costs required to meet the vehicle handling requirements. However, most manufacturers will incur additional manufacturing costs to meet the occupant retention requirements. These costs are expected to average between $47 and $72 per vehicle. Adding the estimated upfront testing, research, development, and implementation costs per unit from Table 4 brings the total cost of the draft proposed rule to an estimated $61 to $94 per vehicle.

Table 5. Summary of Per Unit Costs and Benefits

Description	Value Per Unit
Costs	
Manufacturing Costs	
Lateral Stability and Vehicle Handling Requirements	$0
Passive Occupant Retention Requirement	$7
Seat Belt/Speed Limitation Requirement – Driver Seats	$14 to $39
Seat Belt/Speed Limitation Requirement – Front Passenger Seats	$26
Total Manufacturing Costs	***$47 to $72***
Certification Testing and Research and Development Costs (from Table 4)	*$14 to $22*
Total Quantifiable Cost	**$61 to $94**
Benefits	
Lateral Stability and Vehicle Handling Requirements	(not quantifiable)
Occupant Retention Requirements	$2,199
Total Quantifiable Benefits	**$2,199**
Net Quantifiable Benefits	**$2,105 to $2,138**

We were able to estimate benefits for the occupant retention requirements. Applying this requirement to just the driver's seat belt would result in benefits of about $1,498 per unit. Applying the seat belt/speed limitation requirement to the front passenger seat belts could result in an additional benefit of $701 per unit. Therefore, the quantifiable benefits of the draft proposed rule would be $2,199 per unit. The benefit associated with the vehicle handling and lateral stability requirement could not be quantified. Therefore, the benefits of the draft proposed rule could exceed the $2,199 estimated above.

The fact that the potential benefits of the lateral stability and vehicle handling requirement could not be quantified should not be interpreted to mean that they are low or insignificant. It only means that we have not developed the data necessary to quantify these benefits. The purpose of the occupant retention requirements is to reduce the severity of injuries, but it is not expected to reduce the risk of an incident occurring. The lateral stability and vehicle handling requirement, on the other hand, are intended to reduce the risk of an incident involving an ROV from occurring, and therefore, prevent the injuries from occurring in the first place. At this time, however, we do not have a basis for estimating what the effectiveness of the lateral stability and vehicle handling requirement would be.

It should also be noted that to the extent that the lateral stability and vehicle handling requirements are effective in reducing the number of incidents, the incremental benefit of the occupant retention requirements would be reduced. If the lateral stability and vehicle handling requirements reduce the number of incidents involving ROVs, there would be fewer resulting injuries for which the occupant retention requirements could reduce the severity. However the resulting decrease in the incremental benefit of the occupant retention requirements would be less than the benefit that would be attributable to the lateral stability and vehicle handling requirement. Again, this is largely due to the fact that the benefit of preventing an injury from occurring in the first place is greater than the benefit of reducing the severity of harm of the injury.

While some assumptions used in this analysis would serve to reduce the estimated benefit of the draft proposed rule (*e.g.*, ignoring incidents in which the use of seat belts was unknown), the analysis also assumed that all drivers and front seat passengers would opt to fasten their seat belts if the speed of the vehicle was limited and that no driver or passenger would attempt to defeat the system, which might be done simply by passing the belt behind the rider or the seat before latching the belt. To the extent that consumers attempt to defeat the seat belt/speed limitation system, the benefits are overestimated.

The estimated cost and benefits of the rule on an annual basis can be calculated by multiplying the estimated benefits and costs per unit by the number of ROVs sold in a given year. In 2013, 234,000 ROVs were sold. If the draft proposed rule had been in effect that year, the total quantifiable cost would have been between $14.3 million and $22.0 million ($61 and $94 multiplied by 234,000 units, respectively). The total quantifiable benefits would have been at least $515 million ($2,199 x 234,000). Of the benefits, about $453 million (or about 88 percent) would have resulted from the reduction in fatal injuries, and about $62 million (or about 12 percent) of the benefits would have resulted from a reduction in the societal cost of nonfatal injuries. About $47 million of the reduction in the societal cost of nonfatal injuries would have been due to a reduction in pain and suffering.

6.0 ALTERNATIVES CONSIDERED

CPSC staff considered several alternatives to the requirements in the draft proposed rule. These included: (1) not issuing a mandatory rule, but instead relying upon voluntary standards, (2) including the dynamic lateral stability requirement or the understeer requirement, but not both, (3) requiring a more intrusive audible or visual seat belt reminder instead of limiting the speed of the vehicle if the seat belt is not fastened, (4) extending the seat belt/speed limitation requirement to include rear seats, (5) requiring an ignition interlock if the seat belts are not fastened instead of limiting the maximum speed, and (6) limiting the maximum speed to 10 mph, instead of 15 mph if the seat belts are not fastened. Each of these alternatives is discussed below. The discussion includes the reasons that staff did not include the alternative in the draft proposed rule as well as qualitative discussion of costs and benefits where possible.

6.1 No Mandatory Standard/Rely on Voluntary Standard

If CPSC did not issue a mandatory standard, most manufacturers would comply with one of the two voluntary standards that apply to ROVs. However, neither voluntary standard requires that ROVs understeer, as required by the draft proposed rule. According to the Directorate for Engineering Sciences, drivers are more likely to lose control of vehicles that oversteer, which can lead to the vehicle rolling over or to other types of accidents.

Both voluntary standards have requirements that are intended to set standards for dynamic lateral stability. ANSI/ROHVA 1-2011 uses a turn-circle test for dynamic lateral stability that is more similar to the test in the draft proposed rule for whether the vehicle understeers than it is to the test for dynamic lateral stability. The dynamic lateral stability requirement in ANSI/OPEI B71.9-2012 uses a J-turn test, like the draft proposed rule, but measures different variables during the test and uses a different acceptance criterion. However, the Directorate for Engineering Sciences does not believe that the test procedures in either standard have been properly validated as being capable of providing useful information about the dynamic stability of the vehicle. Moreover, the voluntary standards would find some vehicles acceptable even though their lateral acceleration at rollover is less than 0.70 g, which is the acceptance criterion in the draft proposed rule.

Both voluntary standards require that manufacturers include a lighted seat-belt reminder that is visible to the driver and remains on for at least 8 seconds after the vehicle is started, unless the driver's seat belt is fastened. However, virtually all ROVs on the market already include this feature, and therefore, relying only on the voluntary standards would not be expected to raise seat belt use over its current level.

The voluntary standards include requirements for retaining the occupant within the protective zone of the vehicle in the event of a rollover including two options for restraining the occupants in the shoulder/hip area. However, testing performed by CPSC identified weaknesses in the performance-based tilt table test option that allows unacceptable occupant head ejection beyond the protective zone of the vehicle ROPS. CPSC testing indicated that a passive shoulder barrier could reduce the head excursion of a belted occupant during quarter-turn rollover events. CPSC staff believes that this can be accomplished by a requirement for a passive barrier based on the dimensions of the upper arm of a 5^{th} percentile adult female, at a defined area near the ROV occupants' shoulder as contained in the draft proposed rule.

In summary, not mandating a standard would not impose any additional costs on manufacturers, but neither would it result in any additional benefits in terms of reduced deaths and injuries. Therefore, not issuing a mandatory standard was not recommended by the staff.

6.2 Removing Either the Lateral Stability Requirement or the Handling Requirement

CPSC staff considered including a requirement for either dynamic lateral stability or vehicle handling, but not both. However, ES staff believes that both of these characteristics need to be addressed. According to ES, a vehicle that meets both the dynamic lateral stability requirement and the understeer requirement should be safer than a vehicle that meets only one of the requirements. Moreover, the cost of meeting just one requirement is not substantially lower than the cost of meeting both requirements. The cost of testing a vehicle for compliance with the dynamic lateral stability and vehicle handling/understeer requirements together was estimated to be about $24,000. However, the cost of testing for compliance with just the dynamic lateral stability requirement or the just the vehicle handling requirement would be about $20,000, or only about 17 percent less than the cost of testing for compliance with both requirements together. This is because the cost of renting and transporting the vehicle to the test site, instrumenting the vehicle for the tests, and making some initial static measurements are virtually the same for both requirements and would only have to be done once if the tests for both requirements were conducted on the same day. Moreover, changes in the vehicle design that affect the lateral stability of the vehicle could also impact the handling of the vehicle. For these reasons, the draft proposed rule includes both a dynamic lateral stability requirement and a vehicle handling requirement.

6.3 Require Intrusive Seat Belt Reminder in Lieu of the Speed Limitation Requirements

Instead of seat belt/speed limitation requirements in the draft proposed rule, staff considered a requirement for ROVs to have loud or intrusive seat belt reminders. Currently, most ROVs meet the voluntary standards that require an 8-second visual seat belt reminder. Some more intrusive systems have been used on passenger cars. For example, the Ford “BeltMinder” system resumes warning the driver after about 65 seconds if his or her seat belt is not fastened and the car is traveling at more than 3 mph. The system flashes a warning light and sounds a chime for 6 seconds every 30 seconds for up to 5 minutes so long as the car is operating and the driver’s seat belt is not fastened. Honda developed a similar system in which the warning could last for longer than 9 minutes if the driver’s seat belt is not fastened. Studies of both systems found that a statistically significant increase in the use seat belts of 5 percent (from 71 to 76 percent) and 6 percent (from 84 to 90 percent) respectively.[61]

However, these more intrusive seat belt warning systems are unlikely to be as effective as the seat belt speed limitation requirement in the draft proposed rule. CPSC staff believes that the requirement in the draft proposed rule will cause most drivers and passengers that desire to exceed 15 mph to fasten their seat belts. Some research supports this position. One experiment used a haptic feedback system to increase the force the driver needed to exert to depress the gas pedal when the vehicle exceeded 25 mph if the seat belt was not fastened. The system did not prevent the driver from exceeding 25 mph, but it increased the amount of force required to depress the gas pedal to maintain a speed greater than 25 mph. In this experiment all seven participants chose to fasten their seat belts.[62]

[61] Caroleene Paul, “Proposal for Seat Belt Speed Limiter on Recreational Off-Highway Vehicles (ROVs),” CPSC Memorandum (2013).

[62] Ron Van Houten, Bryan Hilton, Richard Schulman, and Ian Reagan, “Using Haptic Feedback to Increase Seat Belt Use of Service Vehicle Drivers,” U.S. Department of Transportation, Report No. DOT HS 811 434, (January 2011).

The more intrusive seat belt reminder systems used on some passenger cars have been more limited in their effectiveness. The Honda system, for example, reduced the number of unbelted drivers by about 38 percent; the Ford system reduced the number of unbelted drivers by only 17 percent.[63] Additionally, ROVs are open vehicles and the ambient noise is likely higher than in the enclosed passenger compartment of a car. It is likely that some ROV drivers would not hear the warning and be motivated to fasten their seat belts unless the warning was substantially louder than the systems used in passenger cars.

The cost to manufacturers of some forms of more intrusive seat belt reminders could be less than the cost of the speed limitation requirement in the draft proposed rule. However, the cost of the seat belt/speed limitation requirement was estimated to be less than $72 per ROV.[64] If the experience with the Honda and Ford systems discussed above are relevant to ROVs, the benefits of a more intrusive seat belt reminder system could be less than 38 percent of the benefits estimated for the requirement in the draft proposed rule or less than $835 per ROV. Therefore, even if the cost of a more intrusive seat belt reminder system was close to $0, the net benefits would be less than the seat belt/speed limitation requirement in the draft proposed rule, which were estimated to be at least $2,105. Therefore, the alternative of a more intrusive seat belt reminder was not included in the draft proposed rule.

6.4 Extending the Seat Belt/Speed Limitation Requirement to Include Rear Seats

CPSC staff considered extending the seat belt/speed limitation requirement to include the rear passenger seats, when present. According to one exposure survey, about 20 percent of the respondents reported that their ROVs had a seating capacity of at least 4, which indicates that the ROV had rear passenger seating locations.[65] This suggests that there were about 114,000 ROVs with rear passenger seats in 2010 (0.2 x 570,000).

The cost of extending this requirement to include the rear passenger seats would be expected to be the same per seat as extending the requirement to include the right front and middle front passengers, or $24 per seat. Therefore the cost of this requirement would be $48 to $72 per ROV, depending upon whether the ROV had two or three rear seating locations.

[63] The Honda system increased seat belt use from 84 percent to 90 percent. Therefore, the percentage of unbelted drivers was reduced by about 38 percent (6 percent divided by 16 percent). The Ford system increased seat belt use from 71 percent to 76 percent. Therefore the percentage of unbelted drivers was reduced by about 17 percent (5 percent divided by 29 percent).

[64] This estimate is based on manufacturing cost estimates of $39 to apply the requirement to the driver's seat and $26 to apply the requirement to the front passenger's seat, plus $12 for research, development and certification testing.

[65] Heiden Associates, Results from the 2009 ROV Exposure Survey (APPENDIX 2 to Joint Comments of Arctic Cat Inc., Bombardier Recreational Products Inc., Polaris Industries Inc., and Yamaha Motor Corporation, U.S.A regarding CPSC Advance Notice of Proposed Rulemaking-Standard for Recreational Off-Highway Vehicles: Docket No. CPSC–2009-0087), Alexandria VA (December 4, 2009).

As shown in Table 2, three of the 231 fatalities (or 1.3 percent) involved a person in a rear seat that did not have their seat belt fastened. Using the same assumptions used to calculate the benefits of the seat belt/speed limitation for passengers in the front seats (*i.e.*, that 73 percent occurred at speeds of 15 mph or greater and seat belts would reduce the risk of death by 45 percent), extending the requirement to include the rear seats could have potentially reduced the number of fatalities in 2010 by 0.2 or about 1 death every 5 years, all other things equal. Therefore, extending the seat belt/speed limitation requirement to the rear passenger seats could reduce the annual risk of fatal injury by 0.00000175 (0.2 ÷ 114,000) per ROV in use. Assuming a societal benefit of $8.05 million per death averted results in an estimated annual benefit of about $14 per ROV in use ($8.05 million x 0.00000175) in terms of reduced fatal injuries.

As shown in Table 3, three of the 388 nonfatal injuries (or 0.8 percent) involved passengers in rear seats that did not have their seat belts fastened. This suggests that about 89 of the estimated 11,100 medically-attended injuries in 2010 may have been to unbelted rear passengers. Again assuming that 73 percent of these occurred at speeds of 15 or mph faster, about 65 medically-attended injuries might have been addressed by the seat belt/speed limitation requirement, if applied to the rear seating locations. This represents a risk of a nonfatal, medically-attended injury of 0.0005702 (65 ÷ 114,000) per ROV in use per year. The societal cost of this risk is $17, assuming an average nonfatal, medically-attended injury cost of $29,383. If seat belts could reduce the cost of these injuries by 20 percent, either by reducing the number of injuries their severity, the value of the reduction would be $3 per ROV in use per year.

Combining the benefit of $14 for the reduction in fatal injuries and $3 in terms of the reduced cost of nonfatal, medically-attended injuries yields a combined benefit of $17 per ROV in use per year. The present value of this estimated benefit over the expected useful life of a ROV is $234. This is greater than the quantifiable cost of $48 to $72. However, these estimates of the costs and benefits are probably oversimplified; the costs may have been understated and the benefits overstated. CPSC staff is hesitant to recommend this alternative for the reasons discussed below.

First, as discussed earlier, a system that included all passenger seats would include more parts than a system that only included the front passenger seats. A failure in only one of the parts could result in significant cost to the users in terms of repair costs, lost time and utility of the vehicle while it was being repaired or the vehicle could not reach its potential speed. These failures could occur because a faulty seat belt latch sensor did not detect or signal that a seat belt was latched or because a faulty seat switch incorrectly registered the presence of a passenger when one was not present. This cost cannot be quantified. However, if such failures are possible the costs of extending the seatbelt/speed limitation requirement to the rear seats would be higher than the $48 to $72 estimated above.

Second, as discussed in Section 4.2.2.3, there is some correlation between the seat belt use of the driver and other passengers. If the driver and front passengers fasten their seat belts, there is reason to believe that some rear passengers will also fasten their seat belts. If so, the benefits of including the rear seat passengers could be overestimated above. Moreover, even if there were no correlation, including only the driver and front seat passengers would still achieve about 98 percent of the total potential benefits from the seat belt/speed limitation requirement.[66]

6.5 Requiring an Ignition Interlock Instead of Limiting the Maximum Speed

CPSC staff considered whether an ignition interlock requirement that did not allow the vehicle to be started unless the driver's seat belt was buckled would be appropriate for ROVs. However, the history of ignition interlock systems to encourage seat belt use on passenger cars suggests that consumer resistance to an ignition interlock system could be strong. In 1973, NHTSA proposed requiring an interlock system on passenger cars. However, public opposition to the proposed requirement led Congress to prohibit NHTSA from requiring an ignition interlock system.[67] For this reason, CPSC staff did not recommend this alternative, but instead recommended the requirement in the draft proposed rule that would allow people to use ROVs at low speeds without having to fasten their seat belts.

6.6 Limiting the Maximum Speed to 10 mph if the Driver's Seat Belt Is Not Fastened

CPSC staff considered limiting the maximum speed of the ROV to 10 mph if the driver's seat belt was not fastened, instead of 15 mph as in the draft proposed rule. In making its recommendation, the staff had to weigh some potentially quantifiable factors against some unquantifiable factors. The expected benefits of limiting the maximum speed to 10 mph are higher than the expected benefits of limiting the maximum speed to 15 mph. Based on the injuries reported to CPSC for which the speed was reported and the seat belt use is known, about 15 percent of the people injured in ROV accidents that were not wearing seat belts were traveling between 10 and 15 mph. Therefore, decreasing the maximum allowed speed of a ROV to 10 mph if the driver's or right front passenger's seat belt is not fastened could increase the expected benefits of the requirement by up to 21 percent (0.15 ÷ 0.73). There would be no difference in the quantified costs between the two alternatives.

Although the quantified benefits would be increased and the quantified costs would not be affected by this alternative, staff believed that the unquantifiable costs would be higher if the maximum speed allowed was set at 10 mph instead of 15 mph. The staff believes that the unquantifiable costs of setting the maximum speed at 10 mph (as opposed to 15 mph) could have a negative impact on consumer acceptance of the requirement. The unquantifiable costs include

[66] The potential net benefit of the seat belt/speed limitation requirement resulting from its application to the driver and front passengers was estimated to be $2,199 per ROV. The potential net benefit resulting from its application to the rear seats was estimated to be $234 per ROV with rear seats. However, only about 20 percent of ROVs were assumed to have rear seats. Therefore, the weighted benefit over all ROVs of extending the seat belt/speed limitation requirement to include the rear seats would be about $47 per ROV ($234 x 0.2). The potential weighted benefit would be $2,246, of which about 2 percent ($47 ÷ $2,246) would be attributable to extending the requirement to the rear seats.

[67] CPSC Memorandum from Caroleene Paul, "Proposal for Seat Belt Speed Limiter on Recreational Off-Highway Vehicles (ROVs)," U.S. Consumer Product Safety Commission, Bethesda MD (2013).

the time, inconvenience, and discomfort costs to some users that would prefer not to wear seat belts. These users could include people using the ROVs for work or utility purposes who might have to get on and off the ROV frequently and who are likely to be traveling at lower rates of speed, but that could occasionally exceed 10 mph. Some of these users could be motivated to defeat the requirement, which could reduce the benefits of the draft proposed rule (and could be easily done). Allowing ROVs to reach speeds of up to 15 mph without requiring that the seat belt be fastened would mitigate some of the inconvenience or discomfort of the requirement to these users and consumers would have less motivation to attempt to defeat the requirement.

ROV manufacturers would have the option of setting the maximum speed that their own models could reach without requiring that the seat belts be fastened so long as it was no greater than 15 miles per hour. Therefore, manufacturers could set a maximum speed of less than 15 mph if they believed it was in their interest to do so. One ROV manufacturer has introduced ROV models that will not exceed 9.3 mph (15 km/hr.) unless the driver's seat belt is fastened.

7.0 CONCLUSION

We estimate the quantifiable benefits of the draft proposed rule to be about $2,199 per ROV, and we estimate the quantifiable costs to be about $61 to $94 per ROV. Therefore, the benefits would exceed the costs by a substantial margin. However, the only benefits that could be quantified were those associated with the seat belt/speed limitation requirement. The lateral stability and vehicle handling requirements would also be expected to reduce deaths and injuries and so result in additional benefits, but these were not quantifiable.

There could be some unquantifiable costs associated with the rule. Some consumers might find the requirement to fasten their seat belts before the vehicle can exceed 15 mph to be inconvenient or uncomfortable. The 15 mph threshold for the requirement was selected, as opposed to 10 mph, in order to limit the number of consumers who would be inconvenienced by the requirement and might be motivated to defeat the system. Some consumers might prefer a ROV that oversteers under more conditions than would be allowed by the draft proposed rule. However, the number of consumers that have a strong preference for oversteering vehicles is probably low.

Several alternatives to requirements in the draft proposed rule were considered including, relying on voluntary standards, and requiring more intrusive seat belt reminders (as opposed to the speed limitation requirement). However, staff determined that the benefits of the requirements in the draft proposed rule would probably exceed their costs, considering both the quantifiable and unquantifiable costs and benefits.

TAB C

Draft Proposed Rule Establishing Safety Standard for Recreational Off-Road Vehicles: Initial Regulatory Flexibility Analysis

Robert Franklin
Samantha Li
Directorate for Economic Analysis
Consumer Product Safety Commission
DRAFT September 22, 2014

Draft Proposed Rule Establishing Safety Standard for Recreational Off-Road Vehicles: Initial Regulatory Flexibility Analysis

This report provides an analysis of the impact on small businesses of a draft proposed rule that would establish a mandatory safety standard for recreational off-road vehicles (ROVs). Whenever an agency is required to publish a proposed rule, section 603 of the Regulatory Flexibility Act (5 U.S.C. 601–612) requires that the agency prepare an initial regulatory flexibility analysis (IRFA) that describes the impact that the rule would have on small businesses and other entities. An IRFA is not required if the head of an agency certifies that the proposed rule will not have a significant economic impact on a substantial number of small entities. The IRFA must contain:

(1) a description of why action by the agency is being considered;
(2) a succinct statement of the objectives of, and legal basis for, the proposed rule;
(3) a description of and, where feasible, an estimate of the number of small entities to which the proposed rule will apply;
(4) a description of the projected reporting, recordkeeping and other compliance requirements of the proposed rule, including an estimate of the classes of small entities which will be subject to the requirement and the type of professional skills necessary for preparation of the report or record; and
(5) an identification to the extent practicable, of all relevant federal rules which may duplicate, overlap or conflict with the proposed rule.

An IRFA must also contain a description of any significant alternatives that would accomplish the stated objectives of the applicable statutes and that would minimize any significant economic impact of the proposed rule on small entities. Alternatives could include: (1) the establishment of differing compliance or reporting requirements that take into account the resources available to small businesses; (2) the clarification, consolidation, or simplification of compliance and reporting requirements for small entities; (3) the use of performance rather than design standards; and (4) an exemption from coverage of the rule, or any part of the rule thereof, for small entities.

Reason for Agency Action

ROVs are a relatively new type of recreational vehicle. First introduced in the late 1990s, ROV sales increased substantially over the next 15 years. The number of deaths associated with ROVs has increased substantially over the same period, from no reported deaths in 2003, to at least 76 reported deaths in 2012. Some ROVs on the market have hazardous characteristics that could be addressed through a mandatory safety standard. [1]

[1] Memorandum from Sarah Garland, Division of Hazard Analysis "Additional ROV-related incidents reported from January 1, 2012 through April 5, 2013," U.S. Consumer Product Safety Commission, Bethesda, MD (8 April 2013).

Objectives of and Legal Basis for the Rule

The goal of the draft proposed rule is to reduce the risk of death and injury associated with the use of ROVs. The rule would be promulgated under the authority of the Consumer Product Safety Act (CPSA).

Small Entities to Which the Rule Will Apply

The draft proposed rule would apply to all manufacturers and importers of ROVs. Under criteria set by the U.S. Small Business Administration (SBA), manufacturers of ROVs are considered small businesses if they have fewer than 500 employees. We have identified one ROV manufacturer with fewer than 500 employees.

Importers of ROVs could be either wholesalers or retailers. Under the criteria set by the SBA, wholesalers of ROVs and other motor vehicles or powersport vehicles are considered small businesses if they have fewer than 100 employees; and retail dealers that import ROVs and other motor or powersport vehicle dealers are considered small if their annual sales volume is less than $30 million. We are aware of about 20 firms that import ROVs from foreign suppliers that would be considered small businesses.[2] There may be other small firms that manufacture or import ROVs of which we are not aware.

Compliance, Reporting, and Record Keeping Requirements of Draft Proposed Rule

The draft proposed rule would establish a mandatory safety standard consisting of several performance requirements for ROVs that are sold in the United States. The draft proposed rule would also establish test procedures through which compliance with the performance requirements would be determined. The draft proposed rule includes: (1) lateral stability and vehicle handling requirements that specify a minimum level of rollover resistance for ROVs and that ROVs exhibit sub-limit understeer characteristics; and (2) occupant retention requirements that would require ROVs to have a passive means, such as a barrier or structure, to restrict occupant excursion; and would limit the maximum speed of an ROV to no more than 15 miles per hour (mph), unless the seat belts of the driver and front passengers are fastened.

Manufacturers would be required to test their ROV models to determine that their models comply with the requirements of the draft proposed rule, and if necessary, to modify their ROV models to comply. The costs of these requirements are discussed more fully in the preliminary regulatory analysis.[3] Based on that analysis, we expect that the tests for lateral stability and for vehicle handling will be conducted at the same time and estimate that the cost of this combined testing would be about $24,000 per model. In many cases, we expect that this testing will be

[2] Staff made these determinations using information from Dun & Bradstreet, Reference USAGov, company websites, and regional business publications.
[3] Memorandum from Robert Franklin, Directorate for Economic Analysis, “Draft Proposed Rule Establishing Safety Standard for Recreational Off-Road Vehicles: Preliminary Regulatory Analysis,” U.S. Consumer Product Safety Commission, MD (5 August 2014).

performed by a third party engineering consulting or testing firm. If an ROV model must be modified to comply with the requirement and then retested, we estimate that the cost to manufacturers could reach $91,000 per model, including the cost of the initial testing, the cost of modifying design of the model, and the cost of retesting the model after the model has been modified. We estimate that the cost of implementing the occupant retention requirements will be about $104,000 per model. This includes the cost to research, develop, implement, and test a system that will limit the speed of the ROV when the seat belts are not fastened, as well as an occupant protection barrier or structure. Therefore, the total cost of certification testing and research and design could range from about $128,000 to $195,000.

In addition to the upfront testing and research and development costs, there will be some ongoing manufacturing costs associated with the draft proposed rule. These include the cost of the parts required to meet any of the requirements of the draft proposed rule, such as seat belt use sensors and the necessary wiring, and the cost of installing these parts on the vehicles during assembly. The ongoing manufacturing costs would be $47 to $72 per vehicle.

The draft proposed rule includes a requirement that manufacturers report the lateral acceleration at rollover value of an ROV model to potential consumers through the use of a hang tag attached to the ROV. Manufacturers would obtain the rollover resistance value when they conduct the lateral stability and vehicle handling tests to determine compliance with both requirements. The required format of the hang tag is described in the draft proposed rule. We estimate that it will cost manufacturers less than $0.25 per vehicle to print the hang tag with the rollover resistance values and to attach the hang tag to the vehicles.

Federal Rules that May Duplicate, Overlap, or Conflict with the Proposed Rule

In accordance with Section 14 of the Consumer Product Safety Act (CPSA), manufacturers would have to issue a general conformity certificate (GCC) for each ROV model, certifying that the model complies with the draft proposed rule. According to Section 14 of CPSA, GCCs must be based on a test of each product or a reasonable testing program and be provided to all distributors or retailers of the product. The manufacturer would have to comply with 16 C.F.R. part 1110 concerning the content of the GCC, retention of the associated records, and any other applicable requirement.

Potential Impact on Small Entities

One purpose of the regulatory flexibility analysis is to evaluate the impact of a regulatory action and determine whether the impact is economically significant. While the SBA gives considerable flexibility in defining “economically significant,” staff typically uses one percent of gross revenue as the threshold for determining “economic significance.” When we cannot demonstrate that the impact is lower than one percent of gross revenue, we prepare a regulatory flexibility analysis.[4]

[4] The one percent of gross revenue threshold is cited as example criteria by the SBA and is commonly used by agencies in determining economic significance (see U.S. Small Business Administration, Office of Advocacy. *A*

Impact on Small Manufacturers

The sole, small ROV manufacturer may need to devote some resources to bringing its ROV models into compliance with the draft proposed rule. This is a relatively new manufacturer of ROVs and other utility vehicles. We do not have information on the extent to which the models offered by this manufacturer would meet the requirements of the draft proposed rule or the extent to which this particular manufacturer would be impacted by the draft proposed rule.

Impact on Small Importers

A small importer could be impacted adversely by the draft proposed rule, if its foreign supplier withdraws from the U.S. market, rather than conduct the necessary testing or modify their ROVs to comply with the draft proposed rule. If sales of ROVs are a substantial source of the importer's business, and the importer cannot find an alternative supplier of ROVs, the impact could be significant. However, we do not expect a widespread exodus of foreign manufacturers from the U.S. market. The U.S. market for ROVs has been growing rapidly in recent years, and at least some foreign manufacturers will likely want to continue to take advantage of these business opportunities by maintaining a U.S. presence. In addition, most of these importers also import other products along with ROVs, such as scooters, motorcycles, and other powersport equipment, so that ROVs are not their sole source of revenue. Importers may be able to reduce any impact on revenues by increasing imports and sales of these other products.

Small importers will be responsible for issuing a GCC certifying that their ROVs comply with the draft proposed rule when it becomes final. However, importers may issue GCCs based upon certifications provided by or testing performed by their suppliers. The impact on small importers should not be significant if their suppliers provide the certificates of conformity or testing reports on which the importers may rely to issue their own GCCs.

If a small importer's supplier does not provide the GCC or testing reports, then the importer would have to test each model for conformity. Importers would likely contract with an engineering consulting or testing firm to conduct the certification tests. As discussed in the regulatory analysis, the certification testing could cost more than $28,000 per model ($24,000 for the lateral stability and vehicle handling requirements and $4,000 for the occupant retention requirement). This would exceed 1 percent of the revenue for about one-half of the small importers, assuming that they continue to import the same mix of products as in the pre-regulatory environment.

Conclusion

The draft proposed rule will not likely have a significant direct impact on a substantial number of small firms. Currently, only one manufacturer meets SBA criteria to be considered

Guide for Government Agencies: How to Comply with the Regulatory Flexibility Act and Implementing the President's Small Business Agenda and Executive Order 13272. May 2012, pp 18-20. http://www.sba.gov/sites/default/files/rfaguide_0512_0.pdf) small. However, at this time, EC staff does not recommend that the Commission certify that the rule will not have a significant impact on a substantial number of small entities due to some remaining uncertainties regarding the impacts on small importers.

Small importers may need to find alternate sources of product, if their existing supplier does not come into compliance with the draft proposed rule. However, at least some foreign suppliers will likely produce to U.S. standards due to the popularity and rising sales of ROVs. The only scenario in which small firms would likely experience a significant impact is if the importer has to conduct testing in support of a GCC. We expect that most importers, however, will rely upon certifications or testing performed by their suppliers. We welcome comments on our assessment of the likely economic impact of GCC testing for small importers.

Alternatives for Reducing the Adverse Impact on Small Businesses

Commission staff welcomes comments on this IRFA. Small businesses that believe they will be affected by the draft proposed rule are especially encouraged to submit comments. The comments should be specific and describe the potential impact, magnitude, and alternatives that could reduce the impact of the draft proposed rule on small businesses.

Several alternatives to the draft proposed rule were considered, some of which could reduce the potential impact on some small firms. These include: (1) not issuing a mandatory standard, (2) dropping the lateral stability requirement or the vehicle handling requirement, (3) requiring a more intrusive seat belt reminder instead of the speed limitation requirement, and (4) requiring an ignition interlock if a seat belt is not fastened, instead of limiting the maximum speed. For the reasons discussed below, CPSC staff did not include these alternatives in the draft proposed rule.

Not Issuing a Mandatory Standard

If CPSC did not issue a mandatory standard, most manufacturers would comply with one of the two voluntary standards that apply to ROVs and there would be no impact on the small manufacturer or small importers. However, neither voluntary standard requires that ROVs understeer, as required by the draft proposed rule. According to the Directorate for Engineering Sciences (ES staff), drivers are more likely to lose control of vehicles that oversteer, which can lead to the vehicle rolling over or to other types of incidents. Additionally, although both voluntary standards have requirements for dynamic lateral stability or rollover resistance, ES staff does not believe that the test procedures in in these standards have been properly validated as being capable of providing useful information about the dynamic stability of the vehicle.

The voluntary standards require that manufacturers include a lighted seat-belt reminder that is visible to the driver and remains on for at least 8 seconds after the vehicle is started, unless the driver’s seat belt is fastened. However, virtually all ROVs on the market already include this feature and, therefore, relying only on the voluntary standards would not be expected to raise seat belt use over its current level. Moreover, the preliminary regulatory analysis showed that the projected benefits of the seat belt/speed limitation requirement would be substantially greater than the costs.

Finally, CPSC staff believes that the occupant retention barrier in the current ROVs could be improved at a modest cost per ROV. For these reasons, CPSC staff believes that relying on compliance with voluntary standards is not satisfactory and recommends that the Commission adopt the requirements in the draft proposed rule.

Dropping the Lateral Stability Requirement or the Understeer Requirement

CPSC staff considered including a performance requirement for either lateral stability or vehicle handling, but not both. As mentioned above, the vehicle handling requirement is designed to allow ROVS to understeer. However, ES staff believes that both of these characteristics need to be addressed. According to ES staff, a vehicle that meets both the lateral stability requirement and the understeer requirement should be safer than a vehicle that meets only one of the requirements. Moreover, the cost of meeting just one requirement is not substantially lower than the cost of meeting both requirements. The cost of testing a vehicle for compliance with both the dynamic lateral stability and vehicle handling requirements was estimated to be about $24,000. The cost of testing for compliance with just the lateral stability requirement or the vehicle handling requirement would be about $20,000. Changes in the vehicle design that affect the lateral stability of the vehicle could also impact the handling of the vehicle. For these reasons, the draft proposed rule includes both the lateral stability and understeer requirements.

Require ROVs to Have Loud or Intrusive Seat Belt Reminders in Lieu of the Speed Limitation Requirements

Instead of seat belt/speed limitation requirements in the draft proposed rule, staff considered requiring ROVs to have loud or intrusive seat belt reminders. Most ROVs currently have a seat belt reminder in the form of a warning light that comes on for about 8 seconds. Most do not include any audible warning. As discussed in the preliminary regulatory analysis, staff considered requiring a more intrusive seat belt reminder, such as a loud audible warning that would sound for a minute or more. Manufacturers would incur some costs to comply with a requirement for a more intrusive seat belt reminder. For example, seat belt use sensors (estimated to cost about $7 per seat) and sensor switches (estimated to cost about $13 per seat) would still be required. However, the research and development costs to design and implement a more intrusive seat belt reminder system would probably be less than the estimated cost to develop a system that limited the maximum speed of the vehicle.

Some intrusive systems have been used on passenger cars and have been found to be effective in increasing seat belt use. One system reduced the number of unbelted drivers by 17 percent and another by about 38 percent.[5] However, a more intrusive seat belt warning system is unlikely to be as effective as the seat belt/speed limitation requirement in the draft proposed rule. ROVs are open vehicles and the ambient noise is likely higher than in the enclosed passenger compartment of a car. It is likely that some ROV drivers would not hear the warning and be motivated to fasten their seat belts, unless the warning was substantially louder than the systems used in passenger cars. CPSC staff believes that the requirement will cause most drivers and passengers who desire to exceed 15 mph to fasten their seat belts. Moreover, the analysis in the preliminary regulatory analysis showed that the societal benefits of the seat belt/speed limitation requirement in the draft proposed rule would exceed the costs by a substantial margin. Because CPSC staff does not believe that a more intrusive seat belt reminder would be effective in a ROV, and because staff believes that the seat belt/speed limitation requirement would result in substantial net benefits, this alternative was not included in the draft proposed rule.

Requiring an Ignition Interlock Instead of Limiting the Maximum Speed

CPSC staff considered whether an ignition interlock requirement that did not allow the vehicle to be started unless the driver's seat belt was buckled would be appropriate for ROVs. CPSC staff rejected making an ignition interlock system mandatory because the history of ignition interlock systems to encourage seat belt use on passenger cars suggests that consumer resistance to an ignition interlock system could be strong. [6] For this reason, CPSC staff did not recommend this alternative, but instead, staff recommended that the draft proposed rule allow people to use ROVs at low speeds without having to fasten their seat belts. However, manufacturers who believe that the cost of an ignition interlock system will be substantially lower than a system that limited the maximum speed of the vehicle, and who do not believe that consumer rejection of an ignition interlock system will be a problem, can use an ignition interlock to comply with the seat belt speed limitation requirement.

[5] Memorandum from Caroleene Paul, Directorate for Engineering Sciences, "Proposal for Seat Belt Speed Limiter on Recreational Off-Highway Vehicles (ROVs)," U.S. Consumer Product Safety Commission, Bethesda, MD (9 December 2013).

[6] Ibid.

TAB D

Analysis of Reported Incidents Involving Deaths or Injuries Associated with Recreational Off-Highway Vehicles (ROVs)*

May 2012

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Executive Summary

This report summarizes 428 ROV-related incidents resulting in at least one injury or fatality reported to the CPSC by December 31, 2011. Incidents occurred between January 1, 2003 and December 31, 2011. A summary of the observed hazard scenarios is listed below.

Overturning Events

- Most of the reported incidents indicate the vehicle rolling sideways (68 percent). More than half of these are reported to have occurred while the vehicle was in a turn (52 percent).

- The remaining categorizations of incidents include the ROV flipping forward or backward, overturning in an unknown direction, not overturning, or it is unknown whether the ROV overturned.

Severity

- A total of 826 victims are reported to have been involved in the 428 incidents.

- There are 231 reported ROV-related fatalities, of which 77 (33 percent) were children younger than 16 years of age.

- There were 388 reported injuries, ranging from minor to severe, of which 91 (23 percent) were to children younger than 16 years of age. A total of 75 injuries (19 percent) were classified as severe, of which 18 (24 percent) were children younger than 16 years of age.

- There were 207 victims involved in the reported incidents who either did not sustain any injuries or who have an unknown injury status.

Location of Victims

- Of the 619 victims reported to have been injured or killed in the 428 incidents, most (66 percent) were in a front seat of the ROV, either as a driver or passenger, when the incidents occurred.

- The majority of the remaining victims were located in an unspecified location of the ROV, the cargo bed, a rear seat(s) of the ROV, or in some other location of the ROV. A small portion (2 percent) of the victims were bystanders, drivers of other vehicles, or in an unknown location in reference to the ROV.

Occupant Retention

- A total of 610 victims were reported to be in or on the ROV and injured or killed. Of these, 282 (46 percent) were not wearing a seat belt; 92 (15 percent) were wearing a seat belt; and 236 (39 percent) have an unknown seat belt use status.

- A total of 433 (71 percent) of the 610 victims who were in or on the ROV and injured or killed are reported to have been ejected partially or fully ejected from the ROV. Of these, 269 (62 percent) were hit by the ROV during the incident.

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Introduction

Recreational off-highway vehicles (ROVs) are motorized vehicles having four or more low-pressure tires. ROVs are intended by manufacturers primarily for recreational off-highway use by one or more persons. ROVs are distinguished from all-terrain vehicles (ATVs) by the presence of steering wheels for steering control, non-straddle seats (*i.e.*, either bench seats or bucket seats) for both the ROV operator and the passenger(s), foot controls for throttle and brake, roll-over protective structures (ROPSs), and restraint systems. In addition, ROVs are designed to achieve maximum speeds greater than 30 miles per hour (mph). Although similar in configuration to some utility vehicles (UTVs), ROVs are differentiated from UTVs by their speed capability of greater than 30 mph. Utility vehicles are used primarily in farm and work applications and have maximum speeds of less than 30 mph. ROVs are more likely than UTVs to be used recreationally.

In October 2009, the Consumer Product Safety Commission (CPSC) issued an advance notice of proposed rulemaking (ANPR) for ROVs. As part of the ANPR, staff provided details for the 181 ROV-related incidents reported to the CPSC on or before August 31, 2009, which had resulted in at least one death or injury.

By December 31, 2011, CPSC staff became aware of 247 more ROV-related incidents resulting in 428 reported incidents. These 428 incidents included 231 fatalities and 388 injuries, ranging from minor to severe, occurring on or after January 1, 2003. This report details the 428 ROV-related incidents, including the 181 incidents detailed in the ANPR, and expands the amount of information studied for each incident.

Analysis Description

Incidents Included

CPSC staff searched incidents involving off-road vehicles, resulting in at least one death or injury and occurring on or after January 1, 2003, and reported to CPSC on or before December 31, 2011. ROV-related incidents were identified by the make and/or model of the vehicle involved. Once an incident was identified as ROV-related, it was included in the set of incidents to be reviewed by a multidisciplinary team. After review, the incident was included in a database that contains all reported ROV-related deaths and injuries (ROV-related death and injury database) in the given timeframe.

Notably, the summary of information in this report is based on anecdotal data collected from reports of incidents received by the CPSC. The data collected for this study are based on information reported to the CPSC through various sources, stored, and processed as given. The data are not a complete set of all incidents that have occurred; nor do the data constitute a statistical sample representing all ROV-related incidents with at least one death or injury. Additionally, reporting for ROV-related incidents occurring in the specified time frame is ongoing. CPSC staff is expecting additional reports and information of ROV-related incidents resulting in a death or injury occurring in the given time frame.

Incident Analysis Methodology

After a reported incident resulting in at least one death or injury was determined to be ROV-related, a multidisciplinary team reviewed all the documents associated with the incident. The multidisciplinary team was made up of a human factors engineer, an economist, a health scientist, and a statistician. As part of the review process, each member of the review team considered every incident and coded victim characteristics, the characteristics of the vehicle involved, the environment, and events of the incident. The coded characteristics were compared across the team, and any discrepancies were resolved by the team. After a final set of characteristics was determined, the characteristics were recorded in the ROV-related death and injury database.

Included in the ROV-related death and injury database are details of the victim(s) involved in each incident, vehicle characteristics, environmental characteristics, and events surrounding the incident. The subset of variables coded and the values each variable could assume are presented in **Appendix A**.

Analysis

All Reported Incidents Involving at Least One Injury or Fatality

The CPSC received reports of 428 ROV-related incidents by December 31, 2011, occurring on or after January 1, 2003, which resulted in at least one injury or fatality. Within the 428 ROV-related incidents, there are a total of 231 reported fatalities and 388 reported injuries, while 207 of the known individuals involved in these incidents were either not injured or their injury information was unknown. In this section, the characteristics of the victims, events, and environment of the incidents are detailed. In the first subsection, all incidents are considered, followed by a subsection that details only the incidents resulting in at least one fatality.

Characteristics of Reported Incidents by Year, State, and Driver Characteristics

This section provides an overview of all reported incidents, including the characteristics of the environment and events of the incident, as well as, the details of the victims involved in the incidents.

Table 1 lists the 428 reported ROV-related incidents resulting in at least one death or injury by the year in which the incident occurred. **Table 2** lists the states with the largest numbers of reported incidents in descending order.

Table 1: Reported ROV-Related Incidents Involving at Least One Injury or Death by Year
January 2003 – December 2011

Year of Incident*	Number of Reported Incidents
2011	*50*
2010	*59*
2009	*68*
2008	*66*
2007	101
2006	48
2005	22
2004	5
2003	1
Unknown[1]	8
Total	**428**

*Note: Reporting is ongoing for the specified time frame. Italicized entries indicate that death certificate collection from the 50 states and DC are not considered complete.

[1] The incidents with unknown dates of occurrence are known to have occurred in specified time frame based on the vehicle make and model information.

Table 2: Reported ROV-Related Incidents with at Least One Injury or Death by State January 2003 – December 2011

State of Incident	Number of Incidents
California	49
Texas	27
Missouri	16
West Virginia	15
Florida	12
Minnesota	12
Wisconsin	12
Georgia	11
Utah	11
Arizona	10
Kentucky	10
Mississippi	10
North Carolina	10
Michigan	9
Ohio	9
New York	8
Tennessee	8
Other/Unknown[2]	189
Total	**428**

The driver was known to be 16 years of age or older in 227 of the 428 incidents (**Table 3**). Of these 227 incidents where the driver was more than 16 years of age, 86 (38 percent) are known to have involved the driver consuming at least one alcoholic beverage just before the incident; 52 (23 percent) did not involve alcohol; while 89 (39 percent) have an unknown alcohol status of the driver.

[2] Other states with reported incidents (number of incidents): AK(4), AL(5), AR(6), CO(2), DE(1), IA(6), IL(7), IN(6), KS(6), LA(3), MD(1), ME(1), MT(3), ND(1), NE(4), NJ(1), NM(4), NV(3), OK(6), OR(5), PA(7), SC(3), VA(2), VT(1), WA(4), WY(2), Unknown(95).

Table 3: Age Group of the Driver at the Time of the Reported Incident
January 2003 – December 2011

Age Group of Driver	Number of Incidents
Less than 16	76
16-24	55
25-34	55
35-44	53
45-54	26
55+	38
Unknown	125
Total	**428**

Characteristics of Reported Incidents by Overturning Event and Speed

The incident review team considered overturning events in detail. If the ROV overturned, how the vehicle overturned was also studied. **Table 4** provides the details of overturning events.

Table 4: If and How the ROV Overturned in Reported Incidents
January 2003 – December 2011

Did/How did the vehicle overturn?	Number of Incidents
Flipped Forward	4
Flipped Backward	11
Rolled Sideways/Making a Turn	150
Rolled Sideways/Not Making a Turn	38
Rolled Sideways/Unknown Details	103
Overturned in an Unknown Direction	59
NA/Did Not Overturn	40
Unknown	23
Total	**428**

Of the 428 reported incidents, 291 (68 percent) rolled sideways. In 40 (9 percent) of the incidents, the ROV did not overturn.

The incident review team also considered the speed of the ROV at the onset of the incident, and whether the ROV was being used for work purposes. Of the 428 reported incidents, the speed of the ROV at the onset of the incident is unknown for 339 incidents (79 percent); 56 (13 percent) occurred at speeds of 20 miles per hour (mph) or less; and 33 (8 percent) at more than

20 mph.[3] In 207 incidents (48 percent), it is unknown whether the ROV was being used for work purposes; in 194 (45 percent), the ROV was not being used to perform work, and the ROV was being used to perform work in 27 incidents (6 percent).[4]

Injury Severity Characterized by Age Group, Location, Seat Belt Use, and Ejection Status for Reported Incidents

There were a reported 826 victims involved in the 428 incidents that have been detailed. Of these 826 victims, 619 are reported to have been injured or killed. Excluded from the victim counts are drivers and passengers of cars, trucks, vans, and trains who were involved in the incidents.

Table 5, **Table 6**, and **Table 7** identify the severity of injuries involved by age group, location of the victim in relation to the ROV, and the overturning event of the ROV, respectively. For details on the classification of injuries, see **Appendix A.**

Table 5: Injury Severity by Age Group in Reported Incidents
January 2003 – December 2011

	Injury Severity[5]							
Age Group	Minor	Moderate	Severe	Fatality	Injured (Unknown Severity)	None	Unknown	**Total**
Less than 16	45	10	18	77	18	47	2	**217**
16-24	17	12	13	33	25	29	7	**136**
25-34	22	11	13	34	22	14	5	**121**
35-44	17	15	16	25	18	17	2	**110**
45-54	13	3	8	23	9	4	0	**60**
55+	1	2	3	39	7	8	1	**61**
Unknown	17	9	4	0	20	22	49	**121**
Total	**132**	**62**	**75**	**231**	**119**	**141**	**66**	**826**

Of the 231 reported fatalities, 77 (33 percent) were children younger than 16 years of age. For the 75 injuries classified as severe, 18 (24 percent) were children younger than 16 years of age.

[3] Several incidents reported a speed similar to "low rate of speed" or "high rate of speed." Since the speed was not calculated or estimated by police or a witness, speed is counted as unknown in these cases.
[4] Work is not defined as only occupational tasks in this case. Hauling firewood or moving rocks are examples were the ROV was being used for work purposes.
[5] In several incidents, information for only one victim is reported. The numbers associated with victims in this report only represent the known victims. For example, if a report indicates that someone was injured in an ROV-related incident, but does not give the details of the location of the victim, then it is possible that they were a passenger and the driver was not mentioned in the report. The known victim would be counted, but information about the presence of other victims is unknown, so no others are included.

Reportedly, 141 victims (17 percent) involved in the reported incidents were not injured, and for 66 victims (8 percent), there is no information regarding injury status.

Table 6: Injury Severity by Location of the Victim in Reference to the ROV in Reported Incidents January 2003 – December 2011

	Injury Severity							
Location In or Around ROV[6,7]	Minor	Moderate	Severe	Fatality	Injured (Unknown Severity)	None	Unknown	**Total**
Driver	41	30	18	141	31	55	37	**353**
Right Front Passenger	32	15	11	49	14	34	3	**158**
Middle Front Passenger	9	1	1	6	4	8	4	**33**
Front Passenger (Unknown Location)	4	1	1	2	0	3	1	**12**
Rear Passenger	5	0	0	4	0	3	0	**12**
Cargo Area	6	5	1	10	4	20	1	**47**
Passenger (Unknown Location)	33	10	42	9	66	18	20	**198**
Other[8]	0	0	0	3	0	0	0	**3**
Driver-Other Vehicle (ATV)[9]	0	0	0	2	0	0	0	**2**
Bystander	2	0	1	4	0	0	0	**7**
Unknown	0	0	0	1	0	0	0	**1**
Total	**132**	**62**	**75**	**231**	**119**	**141**	**66**	**826**

Of the 826 reported victims, 353 (43 percent) were known to be driving the ROV; 203 were known to be a passenger in the front of the ROV; 12 in a rear passenger seat; 47 in the cargo area of the ROV; while 198 have an unknown location inside the ROV. These 198 are known to have been in or on the ROV at the time of the incident, but their specific location is unknown. If additional information were known, these victims could be reclassified as drivers, front passengers, rear passengers, passengers in the cargo area, or a passenger in some other location in or on the ROV.

6 In several cases, the location of the victim is unknown, and all that is known is that he/she was in or on the vehicle at the time of the incident. In these cases, the location of the victim was recorded as passenger (unknown location). Information about the driver might be known, as thus recorded, leaving the victim to be located elsewhere. However, some cases do not give any additional information other than the victim. In these cases, the victim could have been the driver or a passenger.
7 Excluded from these totals are persons located in cars, trucks, SUVs, and trains involved in some incidents.
8 Other locations include: one victim was trying to move from one location in the vehicle to another around the roll cage; one victim was standing on the rear of the vehicle, it is unclear where; one was standing on the side of the vehicle holding the roll cage.
9 Drivers of other vehicles and bystanders are not included in totals pertaining to the characteristics of riders of the ROVs, such as helmet use, seat belt use, and ejection status.

Of the 231 reported fatalities, 141 (61 percent) were to the driver of the ROV, and 49 (21 percent) were to the right front passenger in an ROV. The specific location in or on the ROV of nine fatality injured victims was not known.

Table 7: Injury Severity by Overturning Events in Reported Incidents
January 2003 – December 2011

	Injury Severity							
Overturn Event	Minor	Moderate	Severe	Fatality	Injured (Unknown Severity)	None	Unknown	**Total**
Flipped Forward	2	1	0	3	0	4	0	**10**
Flipped Backward	1	3	1	9	0	12	14	**40**
Rolled Sideways/Making a Turn	53	25	20	98	32	73	23	**324**
Rolled Sideways/Not Making a Turn	14	6	0	33	8	10	4	**75**
Rolled Sideways/Unknown Details	12	7	47	19	34	4	6	**129**
Overturned in an Unknown Direction	26	16	2	38	26	3	8	**119**
NA/Did Not Overturn	20	3	3	20	4	30	3	**83**
Unknown	4	1	2	11	15	5	8	**46**
Total	**132**	**62**	**75**	**231**	**119**	**141**	**66**	**826**

Of the 231 reported fatalities, 150 (65 percent) died in an incident where the ROV rolled sideways; 20 fatalities (9 percent) occurred in incidents where the ROV did not overturn; and it is unknown whether the ROV overturned for 11 (5 percent) fatalities.

A total of 826 victims were involved in the reported incidents; 75 (9 percent) were classified as being severely injured. Of these 75 severely injured victims, 67 (89 percent) occurred in an incident in which the ROV rolled sideways.

Table 8 details the seat belt and helmet use of the victims in or on the ROV at the time of the incident.

Table 8: Seat Belt by Helmet Use in Reported Incidents
January 2003 – December 2011

Seat Belt vs. Helmet Use (Bystanders and Drivers of Other Vehicles Excluded)				
	Helmet Use			
Seat belt Use	Unknown	No	Yes	**Total**
Unknown	282	54	4	**340**
No	43	305	0	**348**
Yes	41	72	16	**129**
Total	**366**	**431**	**20**	**817**

Of the 817 victims reported to be in or on the ROV at the time of the incident, 431 (53 percent) were not wearing a helmet. Helmet use is unknown for 366 (45 percent) of the 817 victims.

Seat belt use is known for 477 victims (58 percent) of the 817 reported victims in or on the ROV at the time of the incident. Of these 477 victims, 348 (73 percent) were not wearing a seat belt at the time of the incident.

The ejection status and whether the vehicle hit or landed on the victim are detailed in **Table 9** and **Table 10**, separated by seat belt use for each victim in or on the ROV. Excluded from both tables are bystanders and drivers of other vehicles. **Table 9** provides the summary for all victims in or on the ROV, regardless of their injury status; while **Table 10** summarizes the details for only those reported to be injured or killed while in or on the ROV. For additional information regarding ejection status, see **Appendix A**. For this report, the review team considered the victim to be “hit by the ROV,” if any part of the victim’s body made contact with an outside portion of the ROV. The category “hit by the ROV” includes injuries that occurred when a body part was pinned to the ground by the roll cage, or any other part of the surrounding environment, or the body of the ROV landed on a victim, among other scenarios.

Of the 817 victims reported to be in or on the ROV during the incident, 610 (75 percent) were known to have been injured or killed. Of these 610 victims, 433 (71 percent) are known to have been partially or fully ejected from the ROV during the incident, with 269 (62 percent) reported to have been hit by a part the ROV, such as the roll cage or a side of the ROV. The ejection status is unknown for 105 (17 percent) of these victims, while 72 (12 percent) were not ejected from the ROV.

Table 9: Seat Belt Use by Ejection Status and Whether the Victim Was Hit by the ROV for All Victims in Reported Incidents January 2003 – December 2011

	All Victims (Bystanders and Drivers of Other Vehicles Excluded)															
	Partial			Full			Ejected (Unknown Details)			Not Ejected			Unknown			
	Hit by Vehicle?			Hit by Vehicle?			Hit by Vehicle?			Hit by Vehicle?			Hit by Vehicle?			
Frequency	Unknown	No	Yes	Unknown	No	Yes	Unknown	No	Yes	Unknown	No	Yes	Unknown	No	Yes	**Total**
Seat belt Use																
Unknown	3	4	5	22	11	14	20	3	94	2	33	0	116	11	2	**340**
No	5	5	21	40	68	73	3	1	28	0	44	1	38	16	5	**348**
Yes	1	0	22	0	2	2	3	0	10	6	63	5	12	3	0	**129**
Total	**9**	**9**	**48**	**62**	**81**	**89**	**26**	**4**	**132**	**8**	**140**	**6**	**166**	**30**	**7**	**817**

Table 10: Seat Belt Use by Ejection Status and Whether the Victim Was Hit by the ROV for Those Injured or Killed in Reported Incidents January 2003 – December 2011

	Injured or Killed (Bystanders and Drivers of Other Vehicles Excluded)															
	Partial			Full			Ejected (Unknown Details)			Not Ejected			Unknown			
	Hit by Vehicle?			Hit by Vehicle?			Hit by Vehicle?			Hit by Vehicle?			Hit by Vehicle?			
Frequency	Unknown	No	Yes	Unknown	No	Yes	Unknown	No	Yes	Unknown	No	Yes	Unknown	No	Yes	**Total**
Seat belt Use																
Unknown	3	3	5	21	8	14	20	0	94	1	9	0	56	0	2	**236**
No	5	4	21	40	51	73	3	0	28	0	21	1	24	6	5	**282**
Yes	1	0	22	0	2	2	3	0	10	6	29	5	11	1	0	**92**
Total	**9**	**7**	**48**	**61**	**61**	**89**	**26**	**0**	**132**	**7**	**59**	**6**	**91**	**7**	**7**	**610**

Reported Incidents Involving at Least One Fatality

Of the 428 ROV-related incidents, 224 involved at least one death. This includes 218 incidents resulting in one fatality, 5 incidents resulting in two fatalities, and 1 incident resulting in three fatalities for a total of 231 fatalities. In this section, these 224 incidents are detailed, including the details of when the reported ROV-related incidents occurred, as well as the victim characteristics, and further breakdown of the environmental and event characteristics.

In **Table 11**, the number of reported ROV-related incidents resulting in at least one fatality is given by year of the incident. The third column lists the number of fatalities associated with the number of incidents.

Table 11: Reported ROV-Related Incidents Resulting in at Least One Death By Year and the Number of Fatalities Related to the Incidents January 2003 – December 2011

Year	Number of Reported Incidents Involving At Least One Fatality	Number of Fatalities
2011	*33*	*34*
2010	*43*	*44*
2009	*40*	*40*
2008	*41*	*43*
2007	33	35
2006	18	18
2005	13	14
2004	3	3
2003	0	0
Total	**224**	**231**

Of the 231 fatalities, 225 victims were in or on the vehicle at the time of the incident, and one was unknown to be in or on the ROV at the time of the incident. Of these 225 fatalities, four victims were wearing helmets, 171 were not wearing helmets, and the helmet use for 50 victims is unknown.

Of the 224 incidents resulting in at least one fatality, the driver of the vehicle was known to be younger than 16 years of age in 61 incidents, which involved 64 of the fatalities. The age group of each fatality can be found in **Table 5**, while the victims' locations in relation to the ROV are given in **Table 6**, and the overturning events for each fatality are detailed in **Table 7**.

In 159 incidents involving a fatality (71 percent), the driver was known to be 16 years of age or older. In 73 of these incidents (46 percent), the driver was known to have had at least one alcoholic beverage just before driving the vehicle; 45 incidents (28 percent) did not involve the driver consuming alcoholic beverages before the incident; and in 41 incidents (26 percent), the driver's alcohol status is unknown.

Characteristics of the Reported Fatal Incidents Including Overturning Events, Terrain, and Slope

In many of the reported ROV-related incidents resulting at least one death or injury, CPSC staff was able to obtain more detailed information than was originally reported on the events surrounding the incident through an in-depth investigation (IDI). The following tables summarize the environmental characteristics of the overturning event that involved at least one fatality.

Table 12 breaks down the overturning event by the type of terrain being traveled at the onset of the incident. Similarly, **Table 13** breaks down the overturning events by the type of slope being traveled at the onset of the incident.

Table 12: Terrain Surface by Overturning Event for Reported Incidents with at Least One Death January 2003 – December 2011

Incidents Involving at Least One Fatality									
	What was the surface of the terrain like at the onset of the incident?								
Overturn Event?	Dirt	Grass	Gravel	Mud	Pavement	Sand	Other[10]	Unknown	**Total**
Flipped Forward	0	0	1	0	1	1	0	0	**3**
Flipped Backward	3	0	1	0	0	1	1	3	**9**
Rolled Sideways/Making a Turn	20	22	12	5	19	5	6	8	**97**
Rolled Sideways/Not Making a Turn	13	2	6	2	4	0	3	2	**32**
Rolled Sideways/Unknown Details	3	2	1	0	3	2	1	6	**18**
Overturned in an Unknown Direction	12	2	6	0	3	3	0	10	**36**
NA/Did Not Overturn	4	1	1	1	5	0	1	7	**20**
Unknown	1	0	0	0	3	0	0	5	**9**
Total	**56**	**29**	**28**	**8**	**38**	**12**	**12**	**41**	**224**

A total of 224 incidents resulted in at least one fatality. Of these, 145 (65 percent) incidents did not occur on a paved surface, and 38 (17 percent) did occur on a paved surface. In 41 incidents, the terrain surface is unknown.

The ROV is reported to have rolled sideways in 147 (66 percent) incidents, resulting in at least one fatality. Of these 147 incidents, 105 (71 percent) did not occur on a paved surface; 26 (18 percent) did occur on a paved surface; and in 16 incidents the terrain surface is unknown.

[10] The "other" terrain surfaces described in incident reports include: rough, including trees and brush; soft sand, packed dirt, gravel with small mounds and brush; ravine of grass and dirt; freshly cut cornfield; cut soybean field; cornfield; frozen lake, ice; river bed with snow and ice; sand, mud, dirt, oil; rock pit filled with water; creek; new oil and chip resurface.

Table 13: Slope by Overturning Event for Reported Incidents with at Least One Death January 2003 – December 2011

Incidents Involving at Least One Fatality						
	Was the vehicle traveling on a slope at the onset of the incident?					
Overturn Event?	Flat	Gentle	Steep	Slope (Unknown Steepness)	Unknown	**Total**
Flipped Forward	1	1	0	1	0	**3**
Flipped Backward	0	0	7	2	0	**9**
Rolled Sideways/Making a Turn	44	12	5	9	27	**97**
Rolled Sideways/Not Making a Turn	8	6	7	5	6	**32**
Rolled Sideways/Unknown Details	4	0	2	6	6	**18**
Overturned in an Unknown Direction	3	1	7	6	19	**36**
NA/Did Not Overturn	5	0	0	5	10	**20**
Unknown	1	0	0	2	6	**9**
Total	**66**	**20**	**28**	**36**	**74**	**224**

Of the 147 reported incidents resulting in at least one fatality where it is reported that the ROV rolled sideways, it is reported that the ROV was on flat terrain in 56 incidents (38 percent), and on a sloped terrain in 52 incidents (35 percent). The slope of the terrain is unknown in 39 incidents.

In the 224 incidents resulting in at least one fatality, the speed of the ROV at the onset of the incident is unknown in 164 incidents (73 percent); 32 (14 percent) occurred at speeds of 20 miles per hour (mph) or less; 28 (13 percent) at more than 20 mph.[11] In 49 (22 percent) incidents it is unknown whether the ROV was being used for work purposes; in 157 (70 percent) the ROV was not being used to perform work; and the ROV was being used to perform work in 18 incidents (8 percent).[12]

[11] Several incidents reported a speed similar to “low rate of speed” or “high rate of speed.” Because the speed was not calculated or estimated by police or a witness, speed is counted as unknown in these cases.
[12] Work is not defined as only occupational tasks in this case. Hauling firewood or moving rocks are examples where the ROV was being used for work purposes.

Fatality Characteristics Including Seat Belt Use and Ejection Status for Reported Incidents

Table 14 details the seat belt use of the fatally injured victims who were in or on the ROV; the victim's ejection status; and whether the victim was hit by the vehicle. **Table 9** (page 14) gives this information for all victims in or on the ROV at the time of the incident, and **Table 10** (page 14) displays this information for those who were either injured or killed.

Table 14 details the 225 fatally injured victims who were in or on the ROV at the time of the incident. Of these, 194 (86 percent) were ejected partially or fully from the ROV. Of these 194 victims, 14 (7 percent) were wearing seat belts; 141 (73 percent) were not wearing a seat belt; and 39 (20 percent) have an unknown seat belt use status. It is reported that 146 of the 194 (75 percent) partially or fully ejected victims were hit by a part of the ROV, such as the roll cage or body of the vehicle.

For additional information regarding ejection status, see **Appendix A**. For this report, CPSC staff considered the victim to be "hit by the vehicle," if any part of the victim's body made contact with an outside portion of the vehicle. The category "hit by the vehicle" includes injuries that occurred when a body part was pinned by the roll cage to the ground or any other part of the surrounding environment, or the body of the vehicle landed on a victim, among other scenarios.

Table 14: Seat Belt Use by Ejection Status and Whether the Victim Was Hit by the ROV for Fatally Injured Victims in Reported Incidents January 2003 – December 2011

	For Fatalities Only (Bystanders and Drivers of Other Vehicles Excluded)															
	Partial			Full			Ejected (Unknown Details)			Not Ejected			Unknown			
	Hit by Vehicle?			Hit by Vehicle?			Hit by Vehicle?			Hit by Vehicle?			Hit by Vehicle?			
Frequency	Unknown	No	Yes	Unknown	No	Yes	Unknown	No	Yes	Unknown	No	Yes	Unknown	No	Yes	**Total**
Seat belt Use																
Unknown	0	2	1	8	2	12	0	0	14	0	0	0	7	0	1	**47**
No	0	1	19	14	17	65	2	0	23	0	2	1	2	1	3	**150**
Yes	1	0	9	0	0	2	1	0	1	2	5	3	4	0	0	**28**
Total	**1**	**3**	**29**	**22**	**19**	**79**	**3**	**0**	**38**	**2**	**7**	**4**	**13**	**1**	**4**	**225**

Sequence of Events for Reported Fatal Rollover Incidents

When considering the sequence of events for an incident, the multidisciplinary team reviewed each incident and determined up to three events, in order, that characterize the incident. The following details the events surrounding the 147 incidents resulting in one or more fatalities where the ROV was reported to roll to either the passenger or the driver side. This excludes incidents that classified the ROV as overturning, but the direction to which the ROV overturned is unknown. If additional information were available, some events classified as “overturned in an unknown direction” could change to a “rolled sideways” classification. Additionally, overturning events where the ROV flipped forward or backward are also excluded.

There were 97 incidents classified as “rolled sideways/making a turn.” These incidents are listed in **Table 15** in descending order by the frequency of the initial event of the incident, then by the frequency of the second and third events.

Table 15: Event Sequence for Reported Fatal Incidents Where the ROV Rolled Sideways While Making a Turn January 2003 – December 2011

Initial Event	Second Event	Third Event	Count
Turn	Overturn		45
	Vertical Impact	Overturn	9
	Turn	Overturn	8
	Collision	Overturn	4
	Other	Overturn	8
	Grade/Slope	Overturn	2
	Other	Collision	1
	Overturn	Collision	1
	Vertical Impact	Turn	1
Grade/Slope	Turn	Overturn	9
	Turn	Collision	1
	Turn	Vertical Impact	1
Vertical Impact	Turn	Overturn	2
	Grade/Slope	Turn	1
	Overturn		1
Failed to Turn	Turn	Overturn	1
Collision	Turn	Overturn	1
Unknown	Overturn		1
Total			**97**

Of the 97 reported fatal incidents classified as rolled sideways while making a turn, the most common initiating event was turning, which occurred in 79 (81 percent) of the incidents.

There were 32 incidents classified as “rolled sideways/not making a turn.” These incidents are listed in **Table 16** in descending order by the frequency of the initial event of the incident, then by the frequency of the second and third events.

Table 16: Event Sequence for Reported Fatal Incidents Where the ROV Rolled Sideways Not Making a Turn January 2003 – December 2011

Initial Event	Second Event	Third Event	Count
Vertical Impact	Overturn		5
	Collision	Overturn	1
	Grade/Slope	Overturn	1
	Vertical Impact	Overturn	1
	Other	Overturn	1
Collision	Overturn		2
	Grade/Slope	Overturn	2
	Vertical Impact	Overturn	2
	Collision	Overturn	1
Grade/Slope	Overturn		4
	Collision	Overturn	1
	Vertical Impact	Overturn	1
	Overturn	Collision	1
Other	Grade/Slope	Overturn	2
	Collision	Overturn	1
	Overturn		1
Turn	Vertical Impact	Collision	1
	Vertical Impact	Overturn	1
Unknown	Other	Overturn	1
	Overturn		1
Failed to Turn	Vertical Impact	Overturn	1
Total			**32**

Of the 32 reported fatal incidents classified as rolled sideways not making a turn, the most common initiating event was vertical impact, representing a total of nine incidents (28 percent).

There were 18 incidents classified as “rolled sideways/unknown details.” These incidents are listed in **Table 17** in descending order by the frequency of the initial event of the incident, then by the frequency of the second and third events.

Table 17: Event Sequence for Reported Fatal Incidents Where the ROV Rolled Sideways but the Details of the Roll are Unknown January 2003 – December 2011

Initial Event	Second Event	Third Event	Count
Unknown	Overturn		5
Turn	Collision	Overturn	2
	Other	Vertical Impact	1
	Vertical Impact	Other	1
Grade/Slope	Overturn		3
Vertical Impact	Grade/Slope	Overturn	1
	Other	Overturn	1
	Overturn		1
Collision	Grade/Slope	Overturn	1
	Overturn		1
Other	Grade/Slope	Overturn	1
Total			**18**

Turning was the most common known initiating event, representing four incidents.

Conclusion

By December 31, 2011, the CPSC received reports of 428 ROV-related incidents occurring on or after January 1, 2003. Of these 428 incidents, there are 231 reported fatalities and 388 reported injuries ranging from minor to severe. Of the 231 reported fatalities, 77 were children under 16 years of age (33 percent). Seventy-five of the 388 reported injuries (19 percent) not resulting in death could be classified as severe, that is, the victim has lasting repercussions from the injuries received in the incident, based on the information available. (**Table 5**)

Of the 428 reported ROV-related incidents, it is reported that the ROV overturned in 365 of the incidents. Of these, 150 incident reports stated that the ROV rolled to a side while making a turn, and 97 of these 150 incidents resulted in at least one fatality. Ninety-eight fatalities (42 percent of all fatalities) occurred in incidents where the ROV was classified as rolling sideways while making a turn. Forty-four of these incidents (45 percent of fatal incidents where the ROV rolled sideways while making a turn) were reported to occur on flat terrain. (**Table 4**, **Table 7**, and **Table 13**)

While the seat belt status is unknown for 340 victims who were in or on the vehicle at the time of the incident, 348 victims were not wearing their seat belt. One hundred twenty-nine victims in or on the ROV at the time of the incident were wearing their seat belts. For the 129 victims reported to be wearing their seat belt at the time of the incident, it is reported that 40 were ejected from the vehicle either partially or fully (31 percent); 74 were not ejected (57 percent); and 15 (12 percent) have an unknown ejection status. (**Table 9**)

Of the reported 225 fatalities where the victim was either in or on the ROV at the time of the incident, 28 victims (12 percent) are reported to have been wearing a seat belt at the time of the incident. Of the 28 victims reported to be wearing their seat belt, 14 are reported to have been ejected either partially or fully from the ROV, with 12 being hit by the ROV. (**Table 14**)

Notably, the summary of information in this report is based on anecdotal data collected from reports of incidents received by the CPSC. The data collected for this study are based on information reported to the CPSC through various sources, stored, and processed as detailed in the **Appendix A**. The data are not a complete set of all incidents that have occurred; nor are the data a statistical sample representing all ROV-related incidents with at least one death or injury resulting. Additionally, reporting for ROV-related incidents occurring in the specified time frame is ongoing. CPSC staff is expecting additional reports and information of ROV-related incidents resulting in a death or injury occurring in the given time frame.

Appendix A: Incident Coding Conventions

Included in the ROV-related death and injury database are details of the victim(s) involved in each incident, vehicle characteristics, environmental characteristics, and events surrounding the incident. This section describes several variables and how they were recorded in the database. Although the information for each variable in the database may not be provided in the available documents, whenever possible, the variables recorded for each victim are: age, gender, height, weight, injury severity, date and cause of death (if applicable), alcohol use (for those 16 or more years of age), seat belt and helmet use during the incident, ejection status from the vehicle, whether the vehicle hit the victim, what part of the vehicle hit the victim and the body part(s) hit (if applicable and known), the victim's location in the vehicle, race, and ethnicity.

The injury severity was considered for each person involved in an incident (excluding involved persons in a car, truck, SUV, van, or train). Each was classified as one of the following:

No injury:	The victim did not sustain any injuries.
Minor injuries:	Injuries described as scratches, bruises, etc. This also includes injuries described as minor injuries in documents, or treated and released from the hospital.
Moderate injuries:	Injuries requiring one or more surgeries, but the injuries were fully recoverable. Injuries requiring hospitalization and/or recovery time, but without permanent effects. Includes reports of fractured bones, torn ligaments, etc.
Severe Injuries:	Injuries resulting in one or more surgeries with lasting repercussions such as amputations, deglovings, severe head injuries, etc.
Injured (Unknown Details):	It is known that a victim was injured, but there was not sufficient information to classify the injury as minor, moderate, or severe.
Fatality:	Injuries sustained in the incident lead to the victim's death.
Unknown:	No information regarding the victim's injuries was provided in the documents available to CPSC staff.

The ejection status of each victim in or on the ROV at the time of the incident was considered, and recorded as:

Not ejected:	No part of the victim's body exited the vehicle.
Partial ejection:	Part of the victim's body left the vehicle as a result of a voluntary or involuntary action, while part of the victim's body remained inside the vehicle.
Full ejection:	All of the victim's body exited the vehicle involuntarily. If the victim jumped out, it is not considered an ejection.

Ejected (Unknown Details): It was known that at least part of the victim's body exited the vehicle, but it cannot be ascertained from the information provided if the victim was partially or fully ejected.

Unknown: It is not known if the victim was ejected.

The location of the victim was recorded as one of the following: driver, right front passenger, middle front passenger, front passenger (unknown location), right rear passenger, left rear passenger, middle rear passenger, rear passenger (unknown location), cargo area, passenger (unknown location, but known to be located in or on the ROV), other (persons located in/on the ROV not included in another choice), driver-other vehicle (ATV), bystander, or unknown.

The characteristics of the vehicle recorded whenever possible included: make, model, model year, engine size in cubic centimeters (cc), whether the driver was the owner of the vehicle, rental status, any aftermarket modifications, whether the vehicle was being used for work at the time of the incident, and the load (if any) at the time of the incident.

The environmental characteristics of the incident, recorded whenever possible, are: the general terrain type, slope, the direction of travel on the slope (if applicable), the type of terrain surface, the condition of the terrain, any other vehicles involved (if applicable), and the weather conditions at the time of the incident.

The general type of terrain was recorded as up to three of the following: field/pasture/farmland/ranchland, yard/lawn, forest/woods, off-highway vehicle park/ATV trail/snowmobile trail, desert, paved road (including public and private roads), paved surface/not a road (for example, driveway, parking lot, etc.), paved surface/nothing else known, unpaved road (including public and private roads), road/nothing else known, unpaved surface (unknown details), other, or unknown. Slope where the vehicle was traveling at the onset of the incident was classified as flat, gentle, steep, a slope with unknown steepness, or unknown. The direction of travel on the slope was recorded for gentle, steep, and slopes where the details are unknown. The direction of travel on the slope was recorded as up, down, across, crest, other, or unknown. The type of terrain surface being traveled on at the time of the incident was recorded as one of the following: dirt, grass, gravel, mud, pavement, sand, other, or unknown. The condition of the terrain was captured as dry, ice, snow, wet, other, or unknown. Other information regarding the terrain not captured in these variables was recorded in comment fields relating to the terrain.

The characteristics recorded about the event include: the date, state, and city or county of the incident; the initial event, second and third event (if applicable) in the sequence of events; if and how the vehicle overturned; speed at the time of the incident, which was recorded as a range.

An overturning event was recorded as one of the following:

Flipped Forward: The rear of the ROV left the ground toward the location where the front of the ROV was located.

Flipped Backward: The front of the ROV left the ground toward the location of where the back of the ROV was located.

Rolled Sideways/Making a Turn: The ROV overturned to either the driver's or passenger's side while the ROV was making a turn.

Rolled Sideways/Not Making a Turn:	The ROV overturned to either the driver's or passenger's side; however, the ROV was not turning at the time of the rollover.
Rolled Sideways/Unknown Details:	The ROV overturned to either the driver's or passenger's side; however, the details are unknown as to whether the vehicle was in a turn.
Overturned in an Unknown Direction:	It is known that the ROV overturned during the incident, but the details as to the direction of the overturning are unknown.
NA/Did Not Overturn:	The ROV did not overturn during the incident.
Unknown:	It is unknown if the ROV overturned during the incident.

If an overturning event occurred, then the final position in which the vehicle landed was recorded as driver side, passenger side, back of the vehicle, front of the vehicle, top of the vehicle, upright, other, or unknown. Also recorded for overturning events was the degree of the overturning: 90 degrees, 180 degrees, 270 degrees, 360 degrees, 90 degrees or more, more than 360, or unknown. If the ROV was turning as part of the overturning event, then the direction of the turn was also recorded.

As the multidisciplinary team reviewed an incident, the sequence of events was recorded, up to three events. At each point in the sequence of events, the choices used to record the event were: collision with tree/pole/etc., collision, the ROV hit another vehicle, another vehicle hit the ROV, failed to turn, grade/slope, overturn, turn, vertical impact (for example, a jump or a hole), other (mechanical, occupant hit surrounding environment, etc.), or unknown. In this report, events classified as collision with a tree/pole/etc., collision, ROV hit other vehicle, other vehicle hit ROV are classified as a collision.

TAB E

NEISS Injury Estimates for Recreational Off-Highway Vehicles (ROVs)*

September 2011

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Executive Summary

This report summarizes the analytical methodologies employed and the results obtained for the estimated number of emergency department-treated Recreational Off-Highway Vehicle (ROV)-related injuries occurring in the United States between January 1, 2010 and August 31, 2010. The report is based on a National Electronic Injury Surveillance System (NEISS) special study using follow-up telephone surveys to all records classified as an All-Terrain Vehicle (ATV) or Utility Vehicle (UTV).

<u>The Study</u>

- A total of 2,018 ATV and UTV-related injuries were recorded in the NEISS between January 1, 2010 and August 31, 2010.

- For each injury, a survey was attempted to obtain additional information on the vehicle involved, the victim(s) of the incident, and the characteristics of the incident.

- At total of 668 surveys were completed; the remaining 1,350 surveys were not completed because CPSC staff was unable to contact the patient; CPSC staff was not provided contact information by the treating hospital, or the patient refused to participate. The response rate is 33 percent for this survey.

<u>Methodology</u>

- The sample balancing (raking methodology) was chosen to compensate for the nonresponses to the survey, allowing CPSC staff to draw conclusions from the survey data.

- To estimate the variance of the raked estimate, a bootstrap algorithm was created that was based on the structure of the study and the raking method employed.

<u>Results</u>

- Of the 668 competed surveys, 16 were identified as involving ROVs. Notably, ROVs were identified by make and model of the vehicle involved. Thus, it is possible that some ROV-related injuries could not be identified due to missing information on make and model. This could lead to an underestimate of ROV-related injuries.

- The estimated number of emergency department-treated, ROV-related injuries occurring in the United States between January 1, 2010 and August 31, 2010, is 2,200. The estimated standard deviation, using the bootstrapped methodology detailed in this report, is 695.713. Thus, the 95 percent confidence interval is 800 to 3,600.

- The estimated total number of emergency department-treated ROV-related injuries for the year 2010 was determined by linearly extrapolating the data that were obtained between January 1, 2010 and August 31, 2010. The resulting estimate is 3,000, with a corresponding 95 percent confidence interval of 1,100 to 4,900.

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Introduction

Recreational off-highway vehicles (ROVs) are motorized vehicles that have four or more low-pressure tires. ROVs are distinguished from all-terrain vehicles (ATVs) by the presence of steering wheels for steering control, non-straddle seats (*i.e.*, bench seats or bucket seats) for the ROV operator and the passenger(s), foot controls for throttle and brake, roll over protective structures (ROPS), and occupant restraint systems. In addition, ROVs are designed to achieve maximum speeds greater than 30 miles per hour (mph). Although similar in configuration to some utility vehicles (UTVs), ROVs differ from UTVs by their speed capability. UTVs are used primarily in farm and work applications and have maximum speeds of less than 30 mph. ROVs are more likely than UTVs to be used recreationally.

In October 2009, the Consumer Product Safety Commission (CPSC) issued an advance notice of proposed rulemaking (ANPR) for ROVs. When the ANPR published, data were not available to estimate the number of emergency department-treated, ROV-related injuries. Since then, CPSC staff performed a special study of data from the National Electronic Injury Surveillance System (NEISS), in which the estimated number of emergency department-treated ROV-related injuries could be determined. This report summarizes the design, analysis methodology, and the results of the special study.

Background

NEISS is a national stratified probability sample of hospitals in the United States and its territories. There are five strata in the NEISS: (1) children's hospitals, (2) small hospitals, (3) medium hospitals, (4) large hospitals, and (5) very large hospitals. Within each stratum is a sample of hospitals that make up the primary sampling units (PSUs) of the NEISS. For each hospital in the sample, every emergency department visit that is associated with a consumer product is recorded. To facilitate injury estimates associated with a product or product group, each injury has a product code that identifies the type of product involved. Other product-specific information, such as the name of the manufacturer, is not recorded in NEISS. Other information recorded for each injury includes gender, age, diagnosis, disposition, and body part, among other information. The information on stratum, hospital, age, and gender of the patient is known for all observations in this study. Additional information about NEISS can be found online at: http://www.cpsc.gov/library/neiss.html.

For ROVs, incidents can be identified only by the make and model of the vehicle involved. Because the NEISS does not record product-specific information, identifying ROVs uniquely from ATVs and UTVs is difficult in most situations. ROVs are recorded in NEISS as an All-Terrain Vehicle (ATV) or a Utility Vehicle (UTV), depending upon how the vehicle was described by the victim and recorded in the emergency department record at the time of treatment. Therefore, directly calculating the estimated number of emergency department ROV-related injuries is not possible based on the information generally available in NEISS.

When resources allow, follow-up special studies are performed from the NEISS data collected. These special studies are often focused on a product or group of products and are used to gather more specific information about the product(s) involved and the hazard scenario surrounding the incident. Special studies use telephone surveys to collect information about the incident from the patient, or someone closely associated with the patient, who knows details of the incident, such as a family member.

A NEISS special study was implemented in 2010, to consider the data collected on ATVs and UTVs. One of the goals of the study was to determine whether ROV-related injury estimates could be calculated. As with other NEISS special studies conducted by the CPSC, a telephone survey was developed to follow-up on injuries associated with ATVs and UTVs. ROVs are identified within completed surveys by the make and model of the vehicle reported. The purpose of the survey was to gain additional information on the type of vehicles involved and the incident scenarios. An attempt was made to follow-up on all injuries recorded in the NEISS database that involved an ATV or UTV that occurred between January 1, 2010 and August 31, 2010. Estimated injuries were calculated using the information available from the surveys, which identified ROVs by make and model of the vehicle. The following sections summarize the results of the survey concerning ROVs, as well as the methods used to obtain the results.

This special study was also used to examine and update the correction factor that is applied to ATV-related estimates. Vehicles that are not considered ATVs, such as ROVs and UTVs, sometimes are coded as ATV-related in the NEISS. To account for such misidentification, a correction factor is applied to ATV-related injury estimates to estimate more accurately the number of ATV-related injuries. This study was used to update the correction factor to exclude vehicles that are not considered ATVs. The methodology and results of this analysis are included in the 2011 CPSC staff memorandum [1].

Results

This section gives the results of the analysis of the special study. The first section summarizes the response rates of the survey. The second section summarizes the estimates obtained by applying the raking method of handling the nonresponse. For a detailed description of the methods used to obtain the estimates, see the Methodology section.

Survey Design and Response Rates

Follow-up surveys were attempted for all injuries reported to involve an ATV or UTV in NEISS from January 1, 2010 through August 31, 2010. Of the 2018 injuries recorded in NEISS as ATV- or UTV-related injuries, 668 follow-up surveys were completed by CPSC contractors. The response rate of this survey is 33 percent. Appendix A provides additional details for the calculation of response rates.

Of the 668 completed surveys, a majority were identified to have involved ATVs (87 percent), while 16 involved ROVs (2 percent), 18 involved UTVs (3 percent), and 50 (7 percent) involved vehicles other than ATVs, UTVs, or ROVs. The completed surveys were categorized into one of four categories: ATV, UTV, ROV, or Other. ROVs were identified by reported make and model of the vehicle. If the make and model of the vehicle was unknown, they were not categorized as an ROV but included in an ATV, UTV, or Other category, as appropriate, based on the answers to survey questions. This could lead to underestimation of the number of ROV-related injuries in the given timeframe.

Unit nonresponse, which occurs when a sampled subject cannot be reached or refuses to participate, is the first consideration when analyzing survey results. Auxiliary information for every injury recorded in NEISS is available. The auxiliary information includes gender and age of the patient, as well as which hospital treated the patient and the stratum into which the hospital falls. Using this data, nonresponse was handled through the raking technique. The resulting estimates are given in the Estimates section. The details on how the raking technique was implemented and how estimates were calculated are in the Methodology section.

Estimates

Table 1 gives the estimated number of ROV-related injuries and their estimated variances using the techniques discussed in the Methodology section. Before estimates can be calculated, unit nonresponse must be considered. The raking technique was employed to handle nonresponse to obtain the estimated number of ROV-related emergency department-treated injuries. The corresponding variance estimate was calculated by a bootstrap technique (see the Methodology section for details). The sample weights were raked to match population marginal totals; then, the injury estimate was derived by adding the weights associated with ROVs. The resulting estimate is indicated in Table 1. The variance of this estimate was calculated by creating and independently raking 500 bootstrap samples by resampling hospitals with replacement in each stratum, then applying the Monte Carlo approximation of variance to each stratum. A detailed description of this method is given in the Methodology section.

Table 1: Summary of the Estimates of the Number of Emergency Department-Treated Injuries Associated with ROVs from January 1, 2010 to August 31, 2010

Nonresponse Technique	Injury Estimate	Variance Estimation Method	Estimated Standard Deviation	Estimated Coefficient of Variation (CV)[1]	95% Confidence Interval
Raking	2,200	Bootstrap of PSUs	695.713	0.3162	800-3,600

As noted in the Survey Design and Response Rates section, ROVs were identified by make and model in the completed surveys. If the make and model were unknown, the survey could not be classified as associated with an ROV. This could lead to an underestimate of the number of ROV-related, emergency department-treated injuries occurring from January 1, 2010 to August 31, 2010.

The estimated number of emergency department-treated, ROV-related injuries is 2,200, with an estimated standard deviation of 695.713, and a 95 percent confidence interval of 800 to 3,600. The estimated number of ROV-related, emergency department-treated injuries for 2010 can be extrapolated from these estimates and by considering the average number of ATV-related injuries during the months in question. Analyzing the numbers of ATV-related injuries from 2006 to 2010, on average, 73 percent (98,580 of 135,940) of ATV-related, emergency-department treated injuries occurred from January to August. Using the partial year estimate of 2,200, and assuming that ROV-related injuries follow the same seasonal pattern as ATVs, then the estimated number of ROV-related emergency department-treated injuries for 2010 is 3,000 (2,200/0.73). The CV is not expected to change for the annual estimate. Thus, the CV estimate of 0.3162 will be used, making the 95 percent confidence interval 1,100 to 4,900.

Methodology

As with most surveys, there are several considerations that must be addressed to perform analyses. Two of these considerations involve the nonresponse within the survey and the estimation techniques, which are based on the study design. This section summarizes the nonresponse and estimation techniques that are implemented in this study to handle the nonresponse and generate estimates of injuries.

[1] The CV is not a bootstrapped estimate. Instead, the CV is calculated by using the estimated standard deviation obtained via bootstrapping. See the Methodology section for additional details.

Nonresponse

Nonresponse in a survey is a well-established problem within the field of survey design and analysis. As such, there are many techniques available to deal with nonresponse. There are two types of nonresponse that must be addressed: item nonresponse and unit nonresponse. Item nonresponse occurs when the sampled subject is reached, agrees to participate, but refuses to answer a question in the survey, or does not know the answer to a question. For the completed surveys in this study, several questions in each survey were considered by the analyst, and the survey was categorized into one of four groupings of vehicle type involved: ATV, UTV, ROV (identified by make and model), or Other. Thus, item nonresponse is not an issue in this analysis.

The other type of nonresponse is unit nonresponse, which occurs when a sampled subject cannot be reached or refuses to participate. In this case, no information is collected from the subject. In calculating the number of emergency department-treated, ROV-related injuries, based on the results of this study, the biggest area of concern is unit nonresponse. Unit nonresponse occurred due to a victim's refusal to participate in the survey, CPSC staff being unable to collect contact information for the patient, or CPSC staff's inability to make contact with the patient when contact information was known.

Although there are many techniques for dealing with unit nonresponse in a survey, the methodology chosen to calculate ROV-related, emergency department-treated injuries is the raking technique, with a bootstrap estimator for the variance of the injuries estimates. However, other techniques were considered and tested for this survey. The techniques considered were raking and multiple imputation. Within raking, the determination of the variance estimate considered bootstrapping and the Taylor Series method of estimation. Raking and multiple imputation, as well as other techniques, are discussed at length in statistical literature. For a discussion on the analysis of the methodologies considered for this study, see [2].

Raking

A popular method of dealing with unit nonresponse is raking, also known as raking ratio estimation, or sample balancing. This method uses an iterative proportional fitting algorithm to adjust weights to known population marginal totals to handle unit nonresponse within the survey. This technique is attributed to Deming and Stephan's 1940 paper [3]. Additional information can be found in [4] and [5].

Raking and ROV Injury Estimates

From January 1, 2010 to August 31, 2010, CPSC staff conducted a special study with the NEISS for injuries related to ATVs and UTVs. Any injury that had a corresponding product code of 3285 (3-wheel ATV), 3286 (4-wheel ATV), 3287 (ATV, unknown number of wheels), or 5044 (UTV), was a candidate for a follow-up survey. Many surveys were not completed because the subject's contact information was lacking; staff was unable to make contact with a subject that had contact information available, or the subject refused to participate. Raking was implemented to handle this nonresponse. Basically, the weights recorded for nonresponding subjects are distributed among the subjects with completed surveys. That is, raking adjusts the weights of the completed surveys to compensate for the nonresponse.

To account for the nonresponse in this study via raking, the variables used to rake must be chosen, population marginal totals for those variables must be obtained, and then the sample can be raked. Finally, estimates for ROV-related, emergency department-treated injuries can be determined based on the vehicle classification for each completed survey. The following summarizes this process.[2]

Raking variables were chosen following a logistic regression analysis on the completed surveys to determine what variables might have an impact on the vehicle type associated with the injuries. Although this does not necessarily give a picture of what is happening in the population, it does narrow down the choices for variables to be considered for raking. The variables considered are variables that are available in the NEISS without the use of a special study, which include age, gender, stratum, disposition, diagnosis, race. Age was used to create five age groups: less than 16 years, 16-25, 26-35, 36-45, and 46 or more years of age. Race was considered, but it was not ultimately used, due to the amount of missing data in the original NEISS data. Gender and stratum, along with age group, were the variables considered in the analysis used to determine the variables that were used in raking. The nonhierarchical logistic model fit to determine which variables to use in raking is (where the parameters to estimate and subscripts are not displayed for simplicity):

$$\begin{gathered} vehicle = stratum + stratum * gender + stratum * agegroup \\ + stratum * gender * agegroup + \varepsilon rror\ term \end{gathered}$$

where $vehicle$ can take one of four values: ATV, UTV, ROV, or Other; $stratum$ can take one of five values: children's, small, medium, large, or very large; $gender$ can take one of two values: male of female; $agegroup$ can take one of five values: less than 16 years, 16-25, 26-35, 36-45, and 46 or more years of age.

Hospitals (PSUs) were not included because they would be excluded in the raking technique. This was done on the assumption that the distribution of vehicles in one hospital within a stratum has the same distribution as another hospital within the same stratum. For example, suppose Hospital A and Hospital B were in the same stratum. Hospital A had 25 injuries recorded as ATV- or UTV-related and a survey was completed for all 25. Hospital B had 15 injuries but did not provide contact information; thus, no surveys were completed for Hospital B's injuries. If the assumption holds, then the distribution of vehicle types for Hospital B, if known, would look like the distribution of vehicles in Hospital A.

This model was considered with the original weights and also with unweighted observations. The resulting Type III p-values for each of the effects in both models were all <0.0001. Thus, age and gender in each stratum were used in raking the dataset. This model was used to explore possible variables that would be used to rake the sample to population totals.

Once the variables used for raking are chosen, the next stage of raking is obtaining the population marginal totals for those variables. For this study, the population marginal totals were generated through the NEISS database using the data known for all attempted surveys. For every injury recorded in each hospital (PSU) from January 1, 2010 to August 31, 2010, a survey was attempted for any that involved an ATV or UTV; that is, each injury that had a corresponding product code of 3285 (3-wheel ATV), 3286 (4-wheel ATV), 3287 (ATV, unknown number of wheels), or 5044 (UTV) was a candidate for a completed follow-up survey. Using the

[2] Note that all population data, sample data, and estimates are associated with the January 1, 2010, to August 31, 2010, timeframe.

full sample attempted for this study and each observation's weights recorded in NEISS, the population marginal totals can be obtained. Thus, the weighted set of all injuries recorded in NEISS, where the injury is reported to be associated with an ATV or UTV from January 1, 2010 to August 31, 2010, provide the population totals for each age group and gender in each stratum.

To illustrate, let w_{hij} be the original weight recorded in the NEISS database for an injury, where $h = 1, \ldots, 5$ indicates stratum, $i = 1, \ldots, n_h$ indicates hospital (PSU) in stratum h, and $j = 1, \ldots, m_i$ indicates the injury record. Thus, w_{hij} indicates the j^{th} injury record from the i^{th} hospital in stratum h. Each ATV and UTV-related injury recorded in NEISS has weight w_{hij} associated with it. When referring to w_{hij} in this study, only ATV and UTV-related injuries from the NEISS are being considered. Thus, the population marginal total for females in the medium hospital stratum ($h = 3$) that received an ATV- or UTV-related injury is defined as

$$Y_3^F = \sum_{i=1}^{n_3} \sum_{j=1}^{m_i} w_{3ij} \, I_F = 5{,}293.09$$

where Y_3^F is the population marginal total for females in the medium hospital stratum, and

$$I_F = \begin{cases} 1 & if\ gender = female \\ 0 & if\ gender = male \end{cases}$$

is an indicator variable for gender. All other marginal population totals are calculated similarly. Throughout this section, exemplar data are provided for marginal totals and for the results of raking. This section describes the methodology of the analysis and does not report individual results throughout the analysis process.

Table 2 and Table 3 provide the population marginal totals used for the medium hospital stratum. The marginal population total for medium-sized hospitals for females, 5,293.09, represents the sum of all the observations' weights associated with a product code of ATV or UTV, where the observed gender is female in the stratum of medium hospitals. The completed surveys from the medium hospital stratum were raked to match these totals.

Table 2: Population Marginal Totals for Gender in the Medium Hospital Stratum

Stratum=Medium (h=3)	
Gender	**Population Marginal Total**
Male	13,233.40
Female	5,293.09

Similarly, the population marginal totals for age groups in the medium stratum are calculated by summing the weights of observations that fall into each age group in the medium hospital stratum, where the injury was associated with all ATV and UTV-related injuries recorded in NEISS from January 1, 2010 to August 31, 2010.

Table 3: Population Marginal Totals for Age Group in the Medium Hospital Stratum

Stratum=Medium (h=3)	
Age Group	**Population Marginal Total**
<16	4,065.83
16-25	4,795.80
26-35	5,062.30
36-45	2,377.45
45+	2,225.45

The survey weights were raked to match the population marginal totals for gender and age group within each stratum. The raking macro created for SAS®[3] [5] was used to generate the raked weights.

Let w'_{hij} be the raked weight of stratum h, hospital (PSU) i, and injury k, where the injury here is an ATV or UTV-related injury. To define further, w'_{hij}, let

$$w'_{hij} = a_{hij} \cdot w_{hij} \cdot I_C \quad (1)$$

where

$$I_C = \begin{cases} 1 & if\ survey = completed \\ 0 & if\ survey = not\ completed\ \ (i.e., nonresponse) \end{cases}$$

is an indicator variable for a survey being completed or not, and a_{hij} is a simplification showing that the weight is adjusted based on the raking process for that observation within stratum h. That is, basically a_{hij} is an adjustment factor for the completed surveys that is based on raking to age group and gender marginals within the stratum. Although a_{hij} contains the i subscript, as described above, PSUs were not used in the raking process. The i subscript in combination with the j subscript simply identifies the observation that is being adjusted. The weights of the surveys categorized as a nonresponse are adjusted to zero, and their weight is distributed accordingly among the completed surveys within the stratum. Thus, only the completed surveys with the adjusted weights (w'_{hij}) are used in any further analysis.

To describe the raking process for this study, the example of the medium hospital stratum will be continued. The completed surveys' original weighted sums for age group and gender in the medium hospital stratum are given in Table 4. The weights are raked so that the sample weighted sums in Table 4 match the population totals given in Table 2 and Table 3. The resulting weighted sum totals after raking are given in Table 5.

[3] SAS® 9.2, Cary, NC, Licensed to the U.S. Consumer Product Safety Commission.

Table 4: Sample Weight Sum Totals Prior to Raking in the Medium Hospital Stratum

Stratum=Medium (h=3)						
	Age Group					
Gender	< 16	16-25	26-35	35-45	45+	Total
Male	1,303.88	768.05	1,074.51	651.47	1,035.97	4,833.87
Female	498.71	843.24	459.69	192.25	0	1,993.89
Total	1,802.59	1,611.29	1,534.20	843.72	1,035.97	6,827.77

Note that the adjusted totals provided in Table 5 sum to match the population marginal totals provided in Table 2 and Table 3.

Table 5: Sample Weight Sum Totals After the Raking Procedure to Match Marginal Totals in the Medium Hospital Stratum

Stratum=Medium (h=3)						
	Age Group					
Gender	< 16	16-25	26-35	35-45	45+	Total
Male	3,033.30	2,425.67	3,666.36	1,882.93	2,225.17	13,233.40
Female	1,032.52	2,370.12	1,395.94	494.52	0	5,293.09
Total	4,065.83	4,795.79	5,062.30	2,377.45	2,225.17	18,526.50

The a_{hij} in equation (1) is the adjustment factor obtained at the end of the raking process for the nonresponse in the age group and gender within the stratum. For example, the adjustment factor for females less than 16 years of age in the medium hospital stratum is $a_{3ij} = \left(\frac{1032.52}{498.71}\right) = 2.0704$. The resulting w'_{3ij} for females less than 16 years of age with a completed survey would be obtained by multiplying their original weight (w_{hij}) by 2.0704 to adjust for the nonresponse. Each observation within each stratum follows the same process according to the stratum's population marginal totals.

For each completed survey, the analyst categorized the survey into one of four groupings based on the answers to the survey questions: ATV, UTV, ROV, and Other. Since a goal of this study was to understand what types of vehicles were recorded in the NEISS ATV and UTV product codes, the product codes originally recorded in the NEISS were not considered in this classification. ROVs were identified here—where they cannot be identified in the NEISS—by make and model, based on the survey participant's response. The estimates generated for this report correspond to the ROVs identified by the respondents.

Once the weights have been raked and the surveys classified according to the vehicle type involved, the number of ROV-related, emergency-department treated injuries occurring between January 1, 2010 and August 31, 2010, can be estimated by

$$\hat{\theta} = \sum_{h=1}^{5} \hat{\theta}_h$$

where

$$\hat{\theta}_h = \sum_{i=1}^{n_h} \sum_{j=1}^{m_i} w''_{hij}$$

and $\hat{\theta}$ is the estimated total number of ROV-related injuries, and w''_{hij} is the raked (adjusted) weight associated with the j^{th} completed survey of hospital (PSU) i in stratum h when the vehicle type was identified as an ROV. Mathematically, w''_{hij} is defined as

$$w''_{hij} = w'_{hij} \cdot I_{ROV}$$

where

$$I_{ROV} = \begin{cases} 1 & if\ vehicle = ROV \\ 0 & if\ vehicle = not\ an\ ROV. \end{cases}$$

$\hat{\theta}_h$ and $\hat{\theta}$ are obtained solely through the original sample that has been raked to match the population marginal totals. No bootstrap resampling was applied to obtain this estimate. A bootstrap method was implemented to obtain the variance of $\hat{\theta}$. A corresponding bootstrap estimate $\hat{\theta}^*$ was calculated, as well as the bootstrap variance estimates associated with $\hat{\theta}$ and $\hat{\theta}^*$. The following section provides the details of how the bootstrap methods were implemented and used.

Variance of the Raked ROV-Related Injury Estimate

The variance of the estimated number of ROV-related injuries from raking is complicated, and no consistent methodology is available to calculate it. Different sources of variation need to be considered in the case of raked data. When the weights associated with a survey are raked, the resulting adjusted weights were calculated based partially on the sample available. Therefore, the adjusted weights are subject to sampling error. The typical Taylor Series method of calculating the variance of the estimate does not account for the possibility of sampling error associated with the raked weights, leading to a possible biased estimate of the variance. It is also possible that the variables chosen for the raking process, and thus the adjustments to the sample weights via raking, do not affect the variance. However, it is difficult, at best, to determine if this is the case before raking and creating estimates. Therefore, the suggested technique is to employ a sample reuse method [6].

For this study, a bootstrap sample reuse method was created to estimate the variance of the raked ROV-related injury estimate. This method accounts for different types of possible sampling error. It assumes additional variance created by a pattern of nonresponse within strata is negligible, or basically that there is no specific pattern. The units chosen to resample are the PSUs (hospitals) of the NEISS. The PSUs can be considered as the first stage of the sampling process for the surveys. For every injury recorded in each PSU, a survey was attempted for any involving an ATV or UTV; that is, any injury that had a corresponding product code of 3285 (3-wheel ATV), 3286 (4-wheel ATV), 3287 (ATV, unknown number of wheels), or 5044 (UTV) was a candidate for a completed follow-up survey. This can be considered the second phase of

sampling. Because the hospitals are the PSUs in the case of this study, the bootstrap samples created use the hospitals within a stratum as the units to resample.
The bootstrap methodology used in this analysis is described as follows:
Let $S_h = \{i|i = 1, \dots, n_h\}$ be the hospitals (PSUs) within stratum h, where $h = 1, \dots, 5$ and n_h is the number of PSUs in each stratum (size of the stratum). Let $S_h^{*(b)} = \{i^{*(b)}|i = 1, \dots, n_h\}$ be the b^{th} bootstrap sample created by sampling with replacement the PSUs from S_h where $b = 1, \dots, B$.

(1) Generate a bootstrap sample, $S_h^{*(1)}$, of size n_h by sampling with replacement from S_h. All completed surveys within each chosen PSU (hospital) in $S_h^{*(1)}$ are a part of the bootstrap sample.

(2) Rake the bootstrap sample to the age group and gender population marginal totals for the stratum.

(3) Calculate the estimated number of ROV-related injuries by stratum for the bootstrap sample

$$\theta_h^{*(b)} = \sum_{i=1}^{n_h} \sum_{j=1}^{m_i} w''_{hij}$$

where n_h is the number of PSUs in each stratum (size of the stratum) and m_i is the number of completed surveys in each PSU, w''_{hij} is the raked (adjusted) weight associated with the j^{th} completed survey of the i^{th} PSU in stratum h when the vehicle type was identified as an ROV.

(4) Step 1 and 2 are repeated B times, generating B bootstrap samples for stratum h, and the corresponding B estimated number of ROV-related injuries for each bootstrap sample.

(5) Repeat steps 1 through 4 for each stratum, $h = 1, \dots, 5$.

(6) The Monte Carlo approximation of the variance is

$$Var(\hat{\theta}) = \frac{1}{B-1} \sum_{h=1}^{5} \sum_{b=1}^{B} \left(\theta_h^{*(b)} - \hat{\theta}_h\right)^2$$

For this study, B was chosen to be 500. The estimated standard deviation is the square root of the variance estimate, $s = \sqrt{Var(\hat{\theta})}$ for $\hat{\theta}$. The coefficients of variation (CV) are $CV(\hat{\theta}) = \frac{s}{\hat{\theta}}$. In this case, CV is not calculated using the bootstrap method but instead calculated by using the bootstrap variance estimate. The 95 percent confidence intervals are then calculated using the assumption of normality ($\hat{\theta} \pm 1.96 \times s$).

The bootstrap samples for this study were generated using the bootstrap macro provided by SAS® [7]. In calculating the estimated number of ROV-related injuries and the estimated variance, both the raked and bootstrapped raked methods of calculating the estimates were used. The results are presented in Table 1.

In 12 bootstrap samples, 10 in the children's hospital stratum and 2 in the large hospital stratum, there were sampling zeros that caused non-convergence in the raking algorithm. Thus, these 12 samples were replaced by different bootstrap samples. It is not suspected that the sample replacement affects the estimated variance of the estimate.

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Appendix A

Response Rate Methodology

The formulas used to calculate the response rates associated with this survey were based on the formulas from “Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys,” published by The American Association for Public Opinion Research (AAPOR) in 2000 [8].

The following represents the formula for the minimum response rate (given as Response Rate 1 by AAPOR):

$$RR1 = \frac{Completed\ Interviews}{Completed\ Interviews + Refusals + No\ Contact + No\ Contact\ Information}$$

Follow-up surveys were attempted for all injuries recorded in NEISS from January 1, 2010 to August 31, 2010, reported to involve an ATV or UTV. A total of 668 follow-up surveys were completed (there were no partially completed surveys) by CPSC contractors of the 2,018 injuries recorded in NEISS in the specified time frame. Therefore, the response rate of this survey is 33 percent. Surveys were not completed for the patients where contact information was not provided to CPSC staff; contact was not established when contact information was known; or the patient refused to complete the survey. A total of 504 surveys (25 percent) did not have contact information; contact was not established in 653 surveys (32 percent); and the survey was refused in 193 cases (10 percent). Thus, the response rate is

$$RR1 = \frac{668}{668 + 193 + 653 + 504} = 0.3310$$

Appendix B

Summary of the ROV Survey Questionnaires

Table 6 through **Table 10** summarize the survey responses where the involved vehicle was identified as an ROV. Notably, some questions were omitted based on the confidentiality of the questions (such as make and model of the vehicle) or lack of responses, while some questions were combined to aid the display of the responses.

Table 6: Summary of ROV-Related Surveys (Part 1)

Incident Number	*Treatment Date*	*Task Number*	*Stratum*	*ROV Model Year*	*Modifications to ROV?*	*Vehicle Use at the Time of Incident*	*Summary of Events (From Interviews)*[4]
1	05MAR10	100309HEP4081	M	2010	No	Recreational	Victim was a passenger on an ATV. The driver was making a sharp turn and driving too fast on a public road so the ATV rolled over. The victim fractured several ribs when he fell off. The driver was ok.
2	14MAR10	100319HEP5041	S	2010	No	Recreational	38 year old male was riding in the cargo bed of a *** ROV. His relatives were driving and in the passenger seat, both with seatbelts. They were riding out in the field. The victim had been squatting down and holding the rear bar. The driver took a jump and the victim's body was thrown out of the vehicle. He maintained his grip on the bar. His foot struck the top of the tailgate. He was wearing steel toed boots.
3	01FEB10	100408HEP9043	V	2009	Nerf Bars added and front bumper push bar	Recreational	36 year old female was a right side passenger on an ROV. They were riding on a motor cross trail on private property when the ROV went up and over a jump and landed nose first. Both were wearing seatbelts and both sustained injuries. Drive-broken knee cap, passenger-neck sprain. The chest restraint did not hold her back. She was treated and released from the emergency room.
4	01FEB10	100408HEP9044	V	2009	No	Recreational	Hit a jump way too fast and landed nose first. The front end of the ATV hit the ground and both passengers' seatbelts failed to lock. The vehicle went straight up in the air and landed on all four wheels.
5	07JAN10	100408HEP9055	S	Unknown	Unknown	Recreational	The victim was the passenger and they were driving in the snow when the ATV tipped and landed on the victim's foot
6[5]	07APR10	100415HEP8942	S		.	.	.
7	01MAY10	100515HEP8722	V	2009	No	Recreational	"I don't remember what happened. I was told that I was involved in an accident. I was in the street at the time that the vehicle rolled-over and I had lacerations on my face and forehead. I don't remember what occurred."
8[6]	06MAY10	100516HEP6903	S	2010	No	Recreational	"We were riding the vehicle when we stopped on a flat dirt area in the rec park. My husband then decided to start doing donuts. We may have lost control because we flipped and I landed on my head."

[4] This column represents what the interviewer recorded based on the narrative provided by the respondent. Thus, the term "ATV" is based on the terminology used by the respondent, not the final vehicle classification chosen by the analyst.

[5] The survey associated with incident number 6 was not fully completed due to the logic within the survey after the respondent was not able to identify the vehicle as an ROV. The only questions that were answered were questions concerning type of vehicle involved. Based on the interviewee's response to the type of vehicle involved, the analyst was able to identify the vehicle involved as an ROV; however, no additional information was obtained on the incident. Thus, an "." is used to identify the remainder of the questions in the tables for this incident.

[6] Incident numbers 9 and 10 represent the same incident. Two victims were treated in the emergency department for this incident. Only one survey is completed for incidents where more than one victim is treated in the emergency department. The survey is repeated in the analysis and counted as separated completed surveys.

9	06MAY10	100516HEP6903	S	2010	No	Recreational	“We were riding the vehicle when we stopped on a flat dirt area in the rec park. My husband then decided to start doing donuts. We may have lost control because we flipped and I landed on my head.”
10	07MAY10	100517HEP4241	S	Unknown	No	Recreational	“All I know is that he was on a UTV and it somehow overturned. I don’t know how it happened. When it overturned it hit is right foot and it fractured his foot. I was not there.”
11	13MAY10	100529HEP6721	V	2009	No	Recreational	“I was a passenger on the back of the vehicle. The rear end slid and hit or grabbed a rock. The rear of the vehicle went to the right. I tried to turn to the left. I lost control and the vehicle flipped over.”
12	24JUN10	100625HEP0001	S	Unknown	No	Chores	“She accidently hit a tree when she hit the gas instead of the brake.”
13	26JUN10	100702HEP5443	C	Unknown	No	Chores	“A lot of young people were going to the dump. They wanted to get rid of the garbage at the camp ground. They were having a water gun fight at the time. My son, while riding as a passenger in the ROV, turned to use his water gun. As he turned, he lost his balance and he fell out of the ROV and hit his head.”
14	28JUL10	100729HEP8101	V	2009	No	Recreational	“I was riding the ROV but I was not being careful. I was going too fast. When I tried to turn I was going too fast and the ROV tipped over on me. I hit my head against the frame.”
15	01AUG10	100818HEP6503	M	2009	No	Recreational	Patient was a passenger with his father as the driver on their recreational off-highway vehicle. As they were going down a slight decline, the ROV slightly leaned to the right and the patient put his right arm out. The father went to grab the patient’s arm and when he leaned to the right to het his son’s arm, the ROV went over. The patient lacerated his finger.
16	22AUG10	100831HEP5762	L	Unknown	No	Recreational	“I was a passenger on the ROV. Something (I don’t know what) ran into the road and she, the driver, tried to avoid it. When she attempted to swerve out of the way the ROV flipped over and wound up on its side.”

Table 7: Summary of ROV-Related Surveys (Part 2)

Incident Number	*Initiating Event*	*Direction of Turn*[7]*	*Degree of turn**	*Object Vehicle Hit**	*Did the ROV overturn?*	*To which side was the overturn?**	*Degree of vehicle roll?**	*NEISS Injured Party Location in ROV*	*Specific Location of Passenger**	*Number of Passengers*
1	Making a turn	Unknown	Sharp		Yes		Unknown	Passenger		1
2	Making a jump				No			Passenger	Cargo bed	2
3	Jumping a dirt ramp				No			Passenger	Right front passenger	1
4	Hit a jump way too fast				No			Driver		1
5	Overturn						Unknown	Passenger	Unknown	0
6	.	.	.	.	.	.	.	.	.	.
7	Unknown				Unknown			Driver		0
8	Making a turn	Left	Sharp		Yes	Passenger	90	Passenger	'I was on the right side.'	2
9	Making a turn	Left	Sharp		Yes	Passenger	90	Passenger	'I was on the right side.'	2
10	Unknown				Yes	Passenger	Unknown	Passenger	'Right passenger side'	1
11	Making a turn	Left	Sharp		Yes	Passenger	90	Passenger	Right front passenger	1
12	Collision			Stationary object	No			Driver		0
13	“Turning to shoot a water gun”				No			Passenger	‘Front passenger.'	1
14	Failed to turn				Yes	Driver	90	Driver		0
15	ROV tilted to right and father leaned to right to grab son’s outreached arm & the ROV went over				Yes	Passenger	90	Passenger	Right front passenger	1
16	“Something ran out (don’t know what) in front of ROV”				Yes	Driver	90	Passenger	'Front, left side.'	3

[7] “*” indicates a question in the survey that is asked or not asked based on the respondent’s answer to a previous question. If the cell is blank, the respondent was not asked the question because the question was determined not to apply.

Table 8: Summary of ROV-Related Surveys (Part 3)

Incident Number	*Age of driver*	*Gender of driver*	*Driver's weight*	*Driver's height (inches)*	*Was the driver injured?*	*Driver injured details**	*Was the driver ejected?*	*Did the ROV hit the driver?**	*What part of ROV hit the driver?**	*Did the ROV come to rest on driver?**	*Was the driver wearing a seatbelt?*	*Was the driver wearing a helmet?*
1	40	Male	215	72	No		Unknown	No				Yes
2	Unknown	Female	110	71	No		No	No			Yes	No
3	34	Male	190	67	Yes	Broken kneecap	No	Yes	Bolt that holds the tilt steering wheel	No	Yes	No
4	33	Male	175	39	Yes	Ruptured discs in back; broke kneecap in half	No	Yes	Unknown	No	Yes	Yes
5	Unknown	Male	Unknown	Unknown	No		Unknown	No				Unknown
6	.	.			.	.	.	.	.	.	.	.
7	79	Male	130	73	Yes	"Lacerations to the face and forehead"	Unknown	Unknown			Unknown	No
8	56	Male	190	70	Yes	"He had a pulled muscle in his right shoulder."	No	No			No	No
9	56	Male	190	70	Yes	"He had a pulled muscle in his right shoulder."	No	No			No	No
10	Unknown	Refused	Unknown	Unknown	Refused		Refused	Refused			Refused	Refused
11	38	Male	175	73	Yes	Torn rotator cuff	No	No			Yes	No
12	84	Female	172	65	Yes	"Injured (Cuts) to her fingers"	No	No			No	No
13	35	Male	135	66	No		No	No			No	No
14	37	Male	270	72	Yes	Head injury	Partial[8]	No			No	No
15	32	Male	150	71	No		No	No			Yes	Yes
16	52	Female	136	66	Yes	Bruises all over shoulder area and hip."	Partial	No			No	No

[8] This partial ejection was identified by the respondent as a voluntary action, by answering yes to the question: "Did *the driver* voluntarily put part of his/her body outside of the vehicle, for example, sticking out an arm or leg to break a fall?"

Table 9: Summary of ROV-Related Surveys (Part 4)

Incident Number	*Age of Passenger**	*Gender of Passenger**	*Passenger's height (inches)**	*Passenger's weight**	*Was the passenger injured?**	*Passenger injury details**	*Was the passenger ejected?**	*Did the ROV hit the passenger?**	*Location of ROV that hit the passenger**	*Did the ROV come to rest on the passenger?**	*Was the passenger wearing a seatbelt?**	*Was the passenger wearing a helmet?**
1	38	Male	76	225	Yes	Passenger had 3 broken ribs	Unknown	No		.	Unknown	Yes
2	38	Male	71	170	Yes	Sprain to top of foot	Full	No	Cargo area	No	No	No
3	36	Female	62	150	Yes	Severe whiplash, chest contusion	No	Yes	The handlebar at steering wheel height	No	Yes	No
4	Unknown	Female	62	155	Yes	Sprains to back and chest and whiplash to her neck	No	Yes	Handlebar in front of her. Passenger sits beside the driver	No	Yes	Yes
5	19	Male	Unknown	Unknown	Yes	The victim sustained a foot contusion.	Unknown				Unknown	Unknown
6	.	.	.	.	.	.	.	.	.	.	.	.
7												
8	55	Female	67	170	Yes	"I had a head injury."	No	No			No	No
9	55	Female	67	170	Yes	"I had a head injury."	No	No			No	No
10	10	Male	Unknown	Unknown	Yes	"Fractured right foot."	Unknown	Yes	Unknown	Unknown	Unknown	Unknown
11	32	Male	71	240	Yes	"Laceration to the ear, fractured skull and swelling to the brain."	Partial	No			Yes	No
12												
13	10	Male	60	99	Yes	"Head injury. Bump to the back of his head."	Full	No			No	No
14												
15	6	Male	52	60	Yes	Laceration to right finger	No	No			Yes	Yes
16	49	Female	69	136	Yes	"Fractured left arm."	Partial	No			No	No

Table 10: Summary of ROV-Related Surveys (Part 5)

Incident Number	*Did the driver own the ROV?*	*How did the driver learn to drive the ROV?*	*How many years of experience did the driver have with ROVs?*	*Where did the incident occur?*	*Was the ROV travelling on a slope?*	*What was the direction of travel on the slope?**	*Surface Type*	*Terrain Condition*	*Speed(mph)*	*Cargo*	*Cargo Location**	*Weight of Cargo**	*Did the driver have an alcoholic beverage prior to incident?*
1	Yes	Friend/Relative	More than 5	Paved road	Flat		Pavement	Dry	25 or more	No			No
2	Yes	Self-taught	More than 5	Field	Flat		Fill dirt	Loose dirt, not hard packed	5 to 9	No			No
3	Yes	Friend/Relative	1 to 5	Motor cross track on private property	Gentle	Up	Dirt	Dry	25 or more	No			No
4	Yes	Self-taught	More than 5	Field	Flat		Dirt and grass	Dry	25 or more	Yes	Back	10-50 lbs.	No
5	Yes	Unknown	Unknown	Unknown	Unknown		Unknown	Snowy	Unknown	Unknown			Refused
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	Yes	Friend/Relative	1 to 5	Paved road	Gentle	Unknown		Dry	Unknown	Yes	Back	10-50 lbs.	No
8	Yes	Self-taught	More than 5	Field	Flat		Dirt	Dry	5 to 9	No			No
9	Yes	Self-taught	More than 5	Field	Flat		Dirt	Dry	5 to 9	No			No
10	Unknown	Refused	Refused	Paved road	Flat		Pavement	Unknown	Unknown	No			Unknown
11	No, borrowed	Friend/Relative	More than 5	Field	Flat		Grass	Wet	10 to 14	No			No
12	Yes	Self-taught	More than 5	Yard	Flat		Grass	Dry	5 to 9	No			No
13	Yes	Training Course	More than 5	Non-paved road	Flat		Gravel	Dry	5 to 9	No			No
14	Yes	Self-taught	More than 5	Field	Flat		Grass	Dry	25 or more	No			No
15	Yes	Friend/Relative	More than 5	Other	Gentle	Down	Sand	Dry	Unknown	No			No
16	Yes	Unknown	More than 5	Paved road	Flat		Pavement	Dry	15 to 19	No			No

View the 2010 NEISS ATV/UTV data

TAB F

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
4330 EAST WEST HIGHWAY
BETHESDA, MD 20814

Memorandum

Date: April 8, 2013

TO : Caroleene Paul
ROV Project Manager
Directorate of Engineering Sciences

THROUGH : Kathleen Stralka
Associate Executive Director
Directorate for Epidemiology

Steve Hanway
Director
Division of Hazard Analysis

FROM : Sarah Garland, Ph.D.
Mathematical Statistician
Division of Hazard Analysis

SUBJECT : Additional ROV-related incidents reported from January 1, 2012 through April 5, 2013*

Introduction

ROV-related incidents reported to CPSC staff from January 1, 2003 to December 31, 2011 are analyzed in detail in two May 2012 reports included in the ROV NPR briefing package: *Analysis of Reported Incidents Involving Deaths or Injuries Associated with Recreational Off-Highway Vehicles (ROVs)* and *Supplemental Analysis of Reported Incidents Involving Deaths or Injuries Associated with Recreational Off-Highway Vehicles (ROVs)*. These reports summarize 428 ROV-related incidents resulting in at least one injury or fatality reported to the CPSC by December 31, 2011. A multidisciplinary team reviewed all the documents associated with the incident. Details regarding the victims' characteristics, incident scenarios, and vehicle characteristics were analyzed extensively. Among the 428 ROV-related incidents, there are a total of 231 reported fatalities.

Since December 31, 2011, CPSC staff has received additional reports for the timeframe of the detailed reports and also incidents occurring in the time period from January 1, 2012 to April 5, 2013. Hazard patterns, victim characteristics, and incident scenarios are fully detailed in the other reports, while this memorandum provides a summary of the additional reports received. Staff does not expect that these additional incidents change the hazard patterns identified in the other reports; thus, full details for the victim, incident, and vehicle characteristics are not provided.

*This analysis was prepared by CPSC staff. It has not been reviewed or approved by, and may not reflect the views of, the Commission.

Summary of ROV-related incidents reported from January 1, 2012 through April 5, 2013

As of April 5, 2013, CPSC staff is aware of 122 additional ROV-related incidents that were reported on, or after, January 1, 2012. **Table 1** summarizes the year the incidents occurred. Combining all reported incidents from January 1, 2003 through April 5, 2013, there are a total of 550 reported ROV-related incidents resulting in at least one death or injury.

Table 1: Reported ROV-related Incidents Involving at Least One Injury or Death by Year January 1, 2003—April 5, 2013

Year of Incident*	Number of Additional Reported Incidents (1/1/2012-4/5/2013)	Total Number of Reported Incidents (January 1, 2003-April 5, 2013)
2013	*12*	*12*
2012	*88*	*88*
2011	*13*	*63*
2010	*5*	*64*
2009	4	72
2008	0	66
2007	0	101
2006	0	48
2005	0	22
2004	0	5
2003	0	1
Unknown	0	8
Total	***122***	***550***

*Note: Reporting is ongoing for the period 2010-2013. Italicized entries indicate that death certificate collection from the 50 states and DC are not considered complete. However, it is possible to receive additional reports of ROV-related incidents for any year.

Table 2 provides the number of incidents by state for incidents reported by April 5, 2013. The additional reports between January 1, 2012 and April 5, 2013, are in the second column, while the total numbers of reported incidents by state are in the third column. Rows are ordered in decreasing order by total number of reported incidents.

Table 2: Reported ROV-Related Incidents with at Least One Injury or Death by State
January 1, 2003 – April 5, 2013

State of Incident	Number of Additional Reported Incidents (1/1/2012-4/5/2013)*	Total Number of Reported Incidents (1/1/2003-4/5/2013)*
California	6	55
Texas	13	40
Missouri	8	24
Minnesota	7	19
West Virginia	4	19
Florida	6	18
Utah	6	17
Georgia	5	16
Wisconsin	3	15
North Carolina	3	13
Arizona	2	12
Arkansas	6	12
Kentucky	2	12
Indiana	6	12
Ohio	3	12
Pennsylvania	5	12
Michigan	2	11
Mississippi	1	11
Illinois	3	10
Oklahoma	4	10
Tennessee	2	10
Other/Unknown[1]	25	190
Total	**122**	**550**

*Reporting is ongoing for the years 2010–2013.

[1] Other states with reported incidents (number of incidents): AK(5), AL(5), CO(4), DE(1), IA(9), ID(1), KS(7), LA(5), MD(1), ME(1), MT(7), ND(4), NE(5), NJ(1), NM(5), NV(3), NY(9), OR(6), SC(4), SD(3), VA(2), VT(1), WA(4), WY(2), Unknown(95).

Of the 122 additional ROV-related incidents resulting in at least one death or injury, 98 included at least one fatality. **Table 3** summarizes the number of reported incidents resulting in at least one fatality by year. There have been 104 additional ROV-related fatalities reported to CPSC staff between January 1, 2012 and April 5, 2013, for a total of 335 reported ROV-related fatalities from January 1, 2003 through April 5, 2013. An additional 118 ROV-related injuries have also been reported from January 1, 2012 through April 5, 2013, making 506 the total number of reported ROV-related injuries from January 1, 2003 through April 5, 2013 (not shown in the tables).

Table 3: Reported ROV-Related Incidents Resulting in at Least One Death By Year and the Number of Fatalities Related to the Incidents January 1, 2003–April 5, 2013

Year*	Number of Additional Reported Incidents Involving At Least One Fatality (1/1/2012-4/5/2013)	Number of Additional Fatalities (1/1/2012-4/5/2013)	Total Number of Reported Incidents Involving at Least One Fatality (1/1/2003-4/5/2013)	Total Number of Fatalities (1/1/2003-4/5/2013)
2013	*6*	*7*	*6*	*7*
2012	*72*	*76*	*72*	*76*
2011	*11*	*12*	*44*	*46*
2010	*5*	*5*	*48*	*49*
2009	4	4	44	44
2008			41	43
2007			33	35
2006			18	18
2005			13	14
2004			3	3
2003			0	0
Total	***98***	***104***	***322***	***335***

*Reporting is ongoing for the years 2010−2013, indicated by italics in the table.

TAB G

(Removed)

Restricted Memorandum

TAB H

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
BETHESDA, MD 20814

Memorandum

Date: September 22, 2014

TO : Caroleene Paul
Project Manager, ROVs
Division of Mechanical Engineering
Directorate for Engineering Sciences

THROUGH: Andrew Stadnik
Associate Executive Director
Directorate for Laboratory Sciences

Gregory K. Rea
Division Director
Division of Mechanical Engineering
Directorate for Laboratory Sciences

FROM : Ian B. Hall
Mechanical Engineer
Division of Mechanical Engineering
Directorate for Laboratory Sciences

SUBJECT : Staff's Recommended Occupant Protection Requirements for the Proposed CPSC Regulation of Recreational Off-highway Vehicles.

I. BACKGROUND

A. Introduction

Recreational Off-Highway Vehicles (ROVs) were first introduced in the late 1990s. As late as 2003, fewer than 20,000 ROVs were sold annually, but sales have increased rapidly since then. In 2011, the most recent year for which sales data are available, more than 160,000 ROVs were sold. At the end of 2013, CPSC staff estimates there were more than 1 million ROVs in use. Yamaha, Polaris, Kawasaki, CanAM, Honda, Arctic Cat, and John Deere account for over 90 percent of ROV sales.[1]

CPSC staff reviewed 428 ROV-related incidents that resulted in 231 ROV-related fatalities and 388 injuries occurring between January 2003 and December 2011. Additionally, nonfatal injuries are significant in nature, often resulting in amputation, degloving, or other severe injuries of the extremities. CPSC staff's analysis of the injury data and preliminary test and evaluation of the vehicles indicate that lateral rollover of ROVs is a significant hazard. In particular, evidence suggests that occupants are partially ejected from the vehicle and that the vehicle roll cage– intended to protect the occupants–crushes the occupants instead.

As of April 5, 2013, CPSC staff is aware of 335 reported fatalities that occurred from January 1, 2003 to April 5, 2013, and staff is aware of 506 reported injuries that occurred during the same time period. To analyze hazard patterns related to ROVs, a multidisciplinary team of CPSC staff reviewed incident reports that CPSC received by December 31, 2011 and that concerned incidents that occurred between January 1, 2003 and December 31, 2011.

The U.S. Consumer Product Safety Commission (CPSC) published an advance notice of proposed rulemaking (ANPR) in October 2009, stating that CPSC does not believe the proposed voluntary standard adequately addresses vehicle rollover or occupant protection during a rollover. The ANPR additionally states: "occupant retention for ROVs is imperative because the vehicles are used in an off-road environment and at a relative high rate of speed." CPSC staff continues to believe that robust requirements can improve occupant retention, and therefore, ultimately reduce the injury rate.

This memorandum will review the current voluntary standards requirements that address occupant protection and provide staff's recommendations.

B. Definition of a Recreational Off-Highway Vehicle (ROV)

"ROVs" are defined as motorized vehicles designed for off-highway use, with the following features: four or more pneumatic tires designed for off-highway use; side-by-side seating for two or more occupants; automotive-type controls for steering, throttle, and braking; and maximum vehicle speed greater than 30 mph (48.3 kph). ROVs are equipped with Rollover Protective Structures (ROPS), seat belts, and other restraints for the protection of occupants (see Figure 1).

[1] Franklin, R. "Draft Proposed Rule Establishing Safety Standard for Recreational Off-Road Vehicles: Preliminary Regulatory Analysis," August 5, 2014.

Figure 1: Typical Recreational Off-Highway Vehicle (ROV)

The open compartment configuration of ROVs is intentional and allows for easy ingress and egress, but the design also increases the likelihood of complete or partial ejection of the occupants in a rollover event. In some vehicles, there are no occupant protection devices, such as full-size doors or windows, to keep occupants' limbs and torsos within the vehicle, other than a seat belt that occupants must actively engage.

C. Incident Hazard Review

Reported Incidents

CPSC staff reviewed 428 ROV-related incidents from the Injury and Potential Injury Incident (IPII) and In-Depth Investigation (INDP) databases, occurring between January 1, 2003 and December 31, 2011, and reported by December 31, 2011. From the 428 reported incidents, there were 388 injured victims and 231 fatalities. Children younger than 16 years of age made up 23 percent of the injured victims and 33 percent of the fatalities. Of the 619 victims who were injured or killed, most (66 percent) were in a front seat of the ROV as a driver or passenger when the incidents occurred.

In many of these reported ROV-related incidents resulting in at least one death, CPSC staff was able to obtain more detailed information on the events surrounding the incident through an in-depth investigation (IDI). Of the 428 ROV-related incidents, 224 involved at least one death. This includes 218 incidents resulting in one fatality, five incidents resulting in two fatalities, and one incident resulting in three fatalities, for a total of 231 fatalities.

Lateral Rollover

Of the 428 reported ROV-related incidents, 291 (68 percent) involved lateral rollover of the vehicle. From the 428 ROV-related incidents reviewed by CPSC staff, 817 victims were reported to be in or on the ROV during the incident, and 610 (75 percent) were known to have been injured or killed. Of the 610 fatally and non-fatally injured victims known to be in or on the ROV at the time of the incident, 433 (73 percent) were known to have been partially or fully ejected from the ROV, and

269 (62 percent) of these victims were hit by a part of the vehicle, such as the roll cage or side of the ROV.

Occupant Ejection and Seat Belt Use

In addition, of the 817 victims in or on the ROV at the time of the incident, seat belt use is known for 477 victims, and 348 (73 percent) were not wearing a seat belt at the time of the incident. Of the 231 reported fatalities, 77 (33 percent) victims were children younger than 16 years of age. Of the 231 fatalities, 225 were in or on the ROV at the time of the incident, and 194 (86 percent) victims were ejected partially or fully from the vehicle. Of these 194 ejected victims, 141 (73 percent) were not wearing a seat belt, 14 (7 percent) were wearing seat belts, and 39 (20 percent) have an unknown seatbelt use status.

Due to the large proportion (68 percent of 428 reported incidents) of lateral rollovers in the incident dataset, the high ejection rate (86 percent of the 225 fatally-injured victims and 73 percent of the 610 non-fatally injured and fatally injured victims), and the low seat belt usage rate (9 percent of 155 fatally injured ejected victims were wearing seatbelts in incidents where seat belt usage was known), CPSC staff believes that improving occupant protection performance is imperative to reduce injuries and deaths associated with ROV use.

II. DISCUSSION

A. Review of Mandatory and Voluntary Standards

1. ROHVA Voluntary Standard

ANSI/ROHVA 1-2010

The Recreational Off-Highway Vehicle Association (ROHVA) first published a standard for ROVs, ANSI/ROHVA 1-2010,[2] on March 5, 2010. The scope of the standard covered ROVs and specifically excluded vehicles that are covered by other standards, like golf carts and automobiles. According to the definition in ROHVA 1-2010, “ROVs” are motorized off-highway vehicles with four tires and a steering wheel for steering control. ROVs have a maximum speed of 35 mph or greater, in addition to other vehicle characteristics. The ROHVA standard included several sections that are specifically related to occupant crash safety performance: § 4.6 *Handholds*, § 4.7 *Roll-Over Protective Structure (ROPS)*, and § 4.8 *Occupant Restraints*.

ANSI/ROHVA 1-2010: § 4.6 Handholds

[2] American National Standard for Recreational Off-Highway Vehicles (ANSI/ROHVA 1-2010). (2010). Irvine, CA: Recreational Off-Highway Vehicle Association (ROHVA).

The handhold requirement in § 4.6 requires each seating position have at least one handhold. Additionally, each handhold shall be able to withstand upward and downward forces exceeding 224 pound force (lbf), applied quasi-statically.

ANSI/ROHVA 1-2010: § 4.7 Roll-Over Protective Structure (ROPS)

In § 4.7 *Roll-Over Protective Structure (ROPS)*, the standard states that ROPS shall tolerate various levels of force without deforming into the occupant's space, and the ROPS shall not fully separate from the vehicle. Partial separation is acceptable, assuming that the ROPS meets the force and deflection requirements.

ANSI/ROHVA 1-2010: § 4.8 Occupant Restraints

In § 4.8 *Occupant Restraints*, the standard states that each seating position shall have a 3-point seat belt that meets a seat belt consensus standard, SAE J2292. [3] Should manufacturers decide voluntarily to include a seat belt reminder warning system with their vehicle, the system must meet the warning requirements in a federal automotive crash safety regulation.[4]

ANSI/ROHVA 1-2011

On July 11, 2011, ROHVA published a revised version of the standard, ANSI/ROHVA 1-2011.[5] ROHVA expanded the scope of the standard by decreasing the maximum vehicle speed from 35+ mph down to 30+ mph. This allowed vehicles with maximum speeds between 30+ mph and 35+ mph to be covered by the revised version of the standard. In addition, the new standard modified multiple sections relating to occupant crash safety.

ANSI/ROHVA 1-2011: § 4.6 Handhold

In ANSI/ROHVA 1-2011 § 4.6 *Handhold*, the severity of the test was reduced by allowing permanent deformation to the handhold and decreasing the applied load by 50 percent, from 1000 N (224 lbf) to 500 N (112 lbf). The appendix, which usually provides explanations for changes in a voluntary standard, did not mention the change or the justification for the change.

ANSI/ROHVA 1-2011: § 4.7 Roll Over Protective Structure (ROPS)

[3] Combination Pelvic/Upper Torso (Type 2) Operator Restraint Systems for Off-Road Work Machines (SAE J2292-2006). (2006). Warrendale, PA: Society of Automotive Engineers International (SAE).
[4] "Occupant Crash Protection," 49 C.F.R. § 571.208.
[5] American National Standard for Recreational Off-Highway Vehicles (ANSI/ROHVA 1-2011). (2011). Irvine, CA: Recreational Off-Highway Vehicle Association (ROHVA).

The ROPS requirements, listed in ANSI/ROHVA 1-2011 § 4.7, also changed. A second test method was added, which allowed the ROV to meet the original International Organization for Standardization (ISO) roof crush requirement or a new methodology defined by the Occupational Health and Safety Administration (OSHA). [6] [7] The newly incorporated OSHA methodology was designed to establish test methodologies and performance requirements for wheeled agricultural tractors. According to the appendix in ANSI/ROHVA 1-2011, ROHVA wished to include the new methodology because some ROVs are used in work applications and could potentially be covered by OSHA requirements.

ANSI/ROHVA 1-2011: § 4.8 Occupant Retention System (ORS)

ROHVA also significantly updated § 4.8 *Occupant Retention System (ORS)*, which included modifications to two different sub-requirements: § 11.2 *Seat Belt Reminder*, and § 11.3 *ORS Zones*.

In the revised standard, the seat belt warning system addressed in § 11.2 *Seat Belt Reminder* is now mandatory, but the severity of the requirements was reduced significantly. In the original standard, ANSI/ROHVA 1-2010, manufacturers could voluntarily add a seat belt warning system. If they did add a seat belt reminder system, then the system was required to warn the driver through a combination of seat belt reminder lights and audible chimes for a minimum of 60 seconds. In the latest revision, each vehicle is required to have a seat belt reminder system, but the reminder lights and audible chimes are required to last for only 8 seconds.

ROHVA also added new requirements to the latest revision to address occupant safety across specific regions of the occupant's body. The standard defines four zones: Zone 1–Leg/Foot; Zone 2–Shoulder/Hip; Zone 3–Arm/Hand; and Zone 4–Head/Neck.

Zone 1 focuses on reducing the likelihood that an occupant's lower leg would be ejected from the vehicle.[8] To reduce lower extremity ejections, the standard defines an area next to the vehicle's foot well that must have a physical barrier to restrain the occupant's foot. As seen in Figure 2, the protected area is comprised of the area that is 9 inches forward from the seat cushion and at least 4 inches from the floor of the vehicle. The shaded area must withstand a 50 lbf load

[6] Earth-moving machinery -- Roll-over protective structures -- Laboratory tests and performance requirements (ISO 3471:2008). (2008). Geneva, Switzerland: International Organization for Standardization (ISO).
[7] "Protective enclosures for wheel-type agricultural tractors-test procedures and performance requirements," 29 C.F.R. § 1928.53.
[8] Yager, T. (2011) Letter to Caroleene Paul. 18 Apr. 2011. Recreational Off-Highway Vehicle Association (ROHVA) written response to CPSC staff's ballot on proposed American National Standard ANSI/ROHVA 1-201X.

located at the center of the barrier while not sustaining any permanent damage. Additionally, the standard specifies that there be no openings larger than 3 inches in diameter.

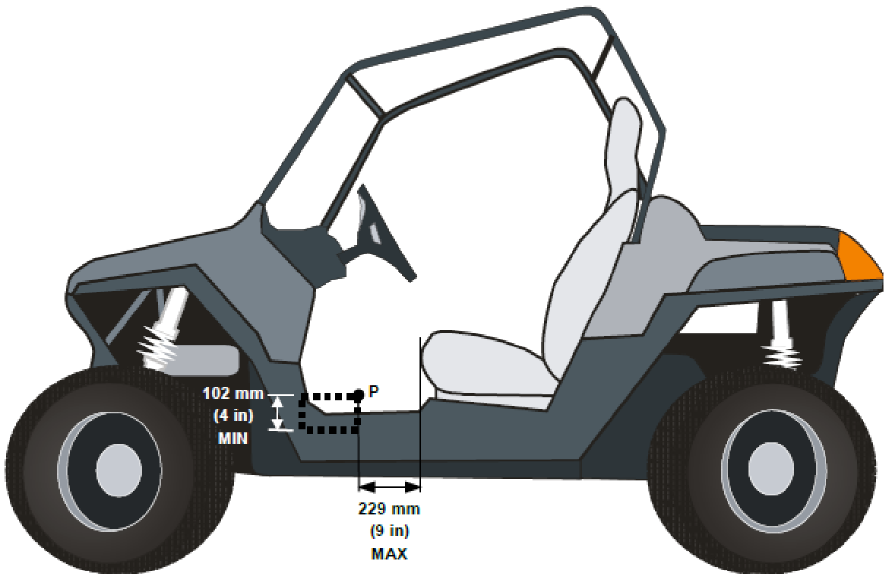

Figure 2: Zone 1

Zone 2 requirements address occupant torso and pelvis excursion during a roll-over event. The standard allows a vehicle to be tested against one of two methods at the choice of the manufacturer.

The first method for Zone 2, defined by the ROHVA standard as a construction-based method, requires that a barrier be present at the approximate location of a small-stature female's shoulder. As seen in Figure 3, Point R is 17 inches from the intersection of the seat back and the seat cushion and 6 inches perpendicular to the seat back. At Point R, the standard requires that the barrier withstand a laterally outward force of 163 lbf while not permanently deflecting more than approximately 1 inch.[9]

[9] The ROHVA and OPEI standards both use SI units with the English approximate equivalents listed as reference. For simplicity, this memorandum refers to the approximate English equivalents, when applicable.

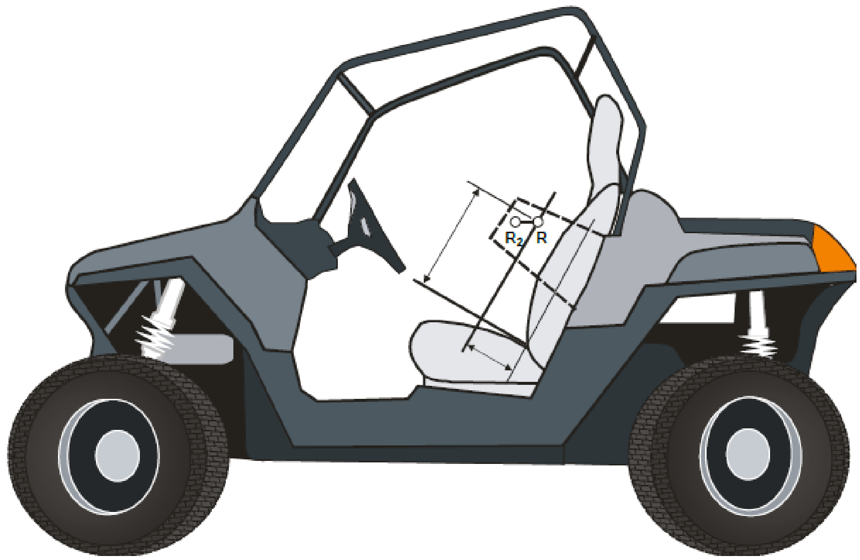

Figure 3: Point R and Zone 2 area

The second method for Zone 2, defined by the ROHVA standard as a performance-based method, is a quasi-static, tilt-table test that measures the occupant excursion of a properly belted 50th-percentile adult male Hybrid III (AM50 HIII) dummy.[10] In the test, the ROV is secured to the tilt table so that the major axis of the vehicle, *i.e.*, from front to back, is parallel to the tilt-table's rotational axis so that the vehicle experiences pure roll as the vehicle is tilted. The vehicle seat that is closest to the tilt table hinge, *i.e.*, the downhill seat, is set to the as-delivered condition; an AM50 HIII test dummy is placed in the downhill seat and then is belted in place, following the vehicle manufacturer's recommended seat belt-use instructions. The tilt table is quasi-statically raised to 45 degrees. As the vehicle tilts to 45 degrees, the dummy pivots towards the outside of the vehicle. The standard requires that the AM50 HIII's torso excursion not exceed 5 inches beyond the maximum width of the vehicle. According to the appendix § A11.3.1.2, any device or barrier may be used to restrain the occupant in the tilt table test.

Zone 3 requirements address occupant arm and hand excursion during a rollover event. The standard allows a vehicle to be tested against one of three methods, at the choice of the manufacturer.

The first method for Zone 3, defined by the ROHVA standard as a construction-based method, defines an area that must be covered by a permanent barrier. As seen in Figure 4, the barrier is comprised of the area that is bounded by the seat edge, the line from point S extending forward and downward no more than 25 degrees from horizontal for a distance of 19.7 inches. Each vehicle must have a

[10] "Hybrid III Test Dummy," 49 C.F.R. part 572 Subpart E.

permanent barrier that covers the area in Figure 4. There are no physical tests associated with the construction-based method.

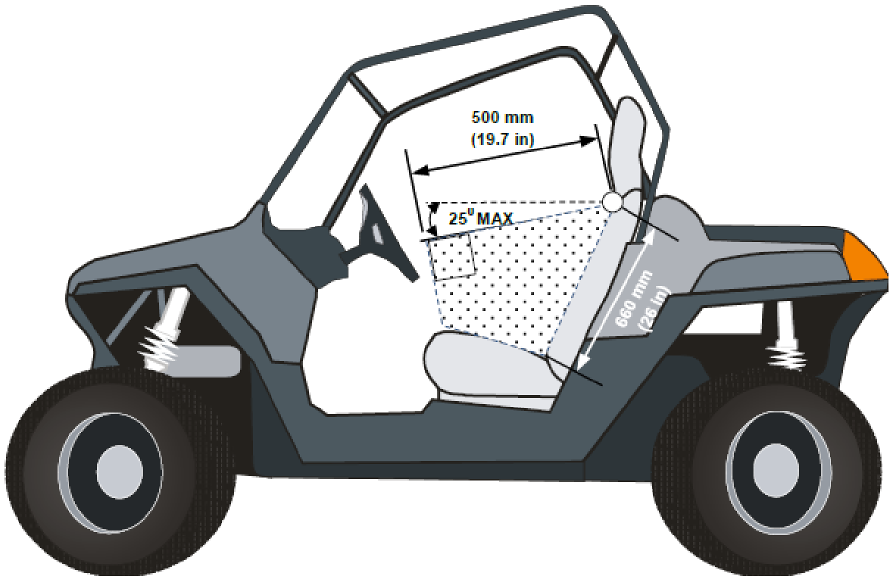

Figure 4: Zone 3 area

The second and third methods for Zone 3 are defined by the ROHVA standard as performance-based methods. The second method requires that the permanent barrier that covers the Zone 3 area be able to absorb a 50 lbf load placed at the center of the area.

The third Zone 3 methodology is a quasi-static tilt table test that measures the occupant excursion of a properly belted 50th-percentile adult male Hybrid III (AM50 HIII) dummy. In the test, the vehicle is placed on a tilt table with an AM50 dummy in the outboard downhill seating position. The dummy's hands are affixed to appropriate handholds, and the test dummy's joints are set to simulate the occupant's grip on the handhold. Although not stated in the test procedure, the standard's appendix specifies that the dummy's joint tension shall be similar to an occupant who is in the initial stages of a rollover. The tilt table is quasi-statically raised to 45 degrees. The standard requires that the AM50 dummy's hand/arm excursion must not exceed 7 inches beyond the maximum width of the vehicle.

Zone 4 requirements address injuries to the occupant's head. The standard requires that all manufacturers recommend that each occupant be seated, belted, and wearing a helmet.

2. <u>OPEI Standard.</u>

On March 6, 2012, the Outdoor Power Equipment Institute (OPEI) published a standard, ANSI/OPEI B71.9-2012, for off-highway vehicles. The standard introduced requirements for § 5.1.2 *Occupant Protective Structure*, § 5.1.3 *Occupant Restraints*, and § 5.1.4 *Occupant Side Retention Devices*.

The Occupant Protective Structure requirement, § 5.1.2, specifies that the overhead structure shall not deflect more than 5 inches when subjected to 1.5 times the curb weight of the vehicle, unless the curb weight is less than 3,333 lbs. If the curb weight is less than 3,333 lbs., then the test device shall be loaded to a minimum of ~5000 lbf. The OPEI standard defines "curb weight" as the weight of the vehicle, plus the maximum volume of consumable fluids, but without occupants. The load shall be applied at each of the four corners of the vehicle's overhead structure.

The Occupant Restraints requirement, § 5.1.3, includes requirements on seatbelts, seat belt warning systems, and handholds. Specifically, the requirement specifies that the vehicle shall be equipped with 3-point belts for each seating position. Each belt must also meet requirements in various SAE standards. [11] [12] [13] [14]

In addition, the standard requires that there be a seat belt reminder system (§ 5.1.3.2). The system must flash a warning light for a minimum of 8 seconds once the key moves to the key-on or key-start position. The standard allows the 8-second warning to be reduced if the system determines that the driver's belt is fastened within 8 seconds.

Handholds are specified in § 5.1.3.2. The standard requires that there be at least one handhold for each designated seating position; and the handhold must be contained inside of the overhead protective structure. There are no test methodologies or performance requirements listed for handholds.

Occupant Side Retention Devices are required in § 5.1.4. The standard states that occupant side retention devices shall be provided to reduce the probability of ejection and entrapment between the vehicle and the terrain, but the OPEI standard does not list any performance requirements or test methodologies.

B. CPSC Testing

CPSC staff conducted physical tests so that staff could understand the vehicle crash environment and the occupant kinematics within that environment. Occupant kinematics is defined as the occupant's motion during a crash event,

[11] Operator Restraint System for Off-Road Work Machines. (SAE J386-200602). (2006). Warrendale, PA: Society of Automotive Engineers International (SAE).
[12] Motor Vehicle Seat Belt Anchorages--Design Recommendations. (SAE J383-199506). (1995). Warrendale, PA: Society of Automotive Engineers International (SAE).
[13] Motor Vehicle Seat Belt Anchorages-Test Procedure. (SAE J384-199406). (1994). Warrendale, PA: Society of Automotive Engineers International (SAE).
[14] Seat Belt Hardware Performance Requirements. (SAE J141-199506). (1995). Warrendale, PA: Society of Automotive Engineers International (SAE).

including the relative motion between various body parts. When testing required specialized equipment, CPSC staff contracted two firms to conduct multiple physical test series. Based on the epidemiological data, CPSC staff chose to focus on improving occupant containment within the vehicle during 90-degree rollovers.

1. Acceleration Sled Test Series #1

CPSC staff initiated a pilot study to evaluate potential test methodologies that could be used to investigate protection strategies in ROV rollovers. CPSC staff contracted Active Safety Engineering (ASE) to conduct the pilot study. CPSC staff provided ASE with two ROVs that represented the two most popular vehicles on the market in 2009. One vehicle, Vehicle A, was associated with the highest number of reported injuries and deaths that CPSC staff was aware of at the time. Conversely, the other vehicle, Vehicle B, was used by a similar demographic of users under similar conditions yet was associated with very few reported injuries and deaths. In the first test series, ASE investigated two different methodologies: a quasi-static roll and a dynamic acceleration sled rollover. ASE also studied the ROV environment to develop baseline knowledge about rollovers, to determine which test dummies to use, and to understand the performance benefit of certain types of occupant restraints. [15]

Vehicle A had a conventional 3-point belt system, a small passive pelvic barrier restraint, and a partial door that contacted the occupant's knee and outboard lower leg. Vehicle B had a 3-point belt system, an inertial spool lock on the seat belt retractor, a passive shoulder barrier restraint, and a passive pelvic barrier restraint.

A major part of the study was to compare and contrast the differences between the quasi-static roll test and the dynamic acceleration sled test. The quasi-static roll test was based on the Federal Motor Vehicle Safety Standard (FMVSS) 301 fuel system integrity test.[16] In this test, the vehicle was mounted to a tilting platform and quasi-statically tilted to 90 degrees. As the vehicle tilted, the test dummy occupants were pulled by gravity towards the ground, and the occupant excursion relative to the ROPS structure near the occupant was measured.

[15] Active Safety Engineering. "Pilot Study of Recreational Off Highway Vehicles (ROV)," June 21, 2010.
[16] "Fuel system integrity," 49 C.F.R. § 571.301 Subpart B.

Figure 5: Quasi-static roll machine

Figure 6: Quasi-static roll test at 90-degrees.

The dynamic test method used an acceleration sled system, otherwise known as a HYGE™ system. The HYGE™ system simulates the deceleration conditions of a lateral rollover, but in reverse. In an ROV rollover event, lateral forces at the tire-surface interface create a large enough roll moment about the vehicle's center of gravity for a sufficient length of time for the vehicle to roll over. This roll motion can be simulated by using the HYGE™ sled to apply lateral forces to the tire-road interface of the ROV. The HYGE™ system uses compressed gas to push a piston that is connected to the test sled. The shape and length of the piston determines the acceleration input to the sled. To eliminate variability due to tire flexion, the tip-side wheels of the test ROV were removed from the vehicle and replaced with hinged brackets mounted to the sled so that the vehicle could roll freely while remaining attached to the sled. As the sled accelerated towards the passenger's side, the pivoting brackets allowed the vehicle to roll towards the driver's side. Once the vehicle started to roll, the occupants moved within the rotating cabin of the ROV.


Figure 7: HYGE™ sled test set-up.


Figure 8: Vehicle roll during event.

The results of the roll tests and HYGE™ sled tests indicated that both test methodologies were repeatable. The benefit of the quasi-static test methodology is its simplicity. However, without more study, it was difficult to confirm that the static test methodology could adequately simulate a dynamic crash event. Therefore, staff decided to continue to explore dynamic test methodologies that more accurately simulate the kinematics of a lateral rollover of an ROV.

The benefit of the HYGE™ sled test is its dynamic simulation of a rollover event with repeatable input lateral acceleration. However, a fundamental limitation of the HYGE™ sled is the length and shape of the piston used to generate the input acceleration. The shape of the piston orifice determines the acceleration profile, and the length of the piston determines the duration of input. Most pistons are designed for the high acceleration/short duration impacts associated with passenger automobile crashes. ROV rollovers can occur at low acceleration levels (below 1g) over longer durations of time than the HYGE piston lengths can allow. Therefore, for additional occupant protection studies, staff decided to explore different dynamic test methods that were not pulse-distance limited.

The results of the HYGE™ sled tests indicated that the female 5th-percentile hybrid III (AF05) dummy and the male 50th-percentile hybrid III (AM50) dummy exhibited similar occupant kinematics. In addition, there was little interaction between the driver and passenger dummies during the tests. The results suggest that future occupant protection tests, to limit test complexity and costs, can be reduced to an analysis of a male 50th percentile hybrid III dummy.

The HYGE™ sled tests results also showed the potential for a passive torso side barrier restraint to reduce occupant excursion significantly. Vehicle A was tested in the unbelted state in the original vehicle condition, and in a modified vehicle condition with an added passive torso side restraint. Without the passive torso side restraint, the maximum unbelted occupant head excursion was 28 inches. With the passive torso side restraint, the unbelted occupant's head did not leave the vehicle's cabin, yielding zero inches of ejection.

2. Acceleration Sled Test Series #2

After the initial screening series, CPSC contracted ASE to conduct a second sled series to explore an alternate method to the HYGE™ sled to impart dynamic roll motions to the ROV. [17] In the second sled series, ASE used a deceleration sled system to gently accelerate a sled containing the ROV to a constant velocity, and then decelerate the sled at a controlled rate causing the ROV to roll. The system is comprised of a sled that moves along a center rail that runs the length of the test track. The sled is pulled by a cable to accelerate the sled to the desired velocity. A system of brakes causes the sled to decelerate, and the inertial load acting on the vehicle's center of gravity causes it to tip. To eliminate variability due to tire flexion, the tip-side wheels of the test ROV were removed from the vehicle and replaced with hinged brackets mounted to the sled so that the vehicle could roll freely, while remaining attached to the sled. The goal of this series was to measure the occupant kinematics under un-tripped rollover conditions, near 0.7 g

[17] Active Safety Engineering. "Pilot Study — Phase II of Recreational Off-Highway Vehicles (ROV)," November 15, 2010.

lateral acceleration and to study the effect of different occupant restraint systems. [18]

Figure 9: Deceleration Sled

The sample ROVs used in the second pilot study were the same vehicles used in the first pilot study, namely Vehicle A and Vehicle B. Vehicle A had a conventional 3-point belt system, a small passive pelvic barrier restraint, and a half door that prevented the occupant's knee and outboard lower leg from exiting the vehicle. Vehicle B had a 3-point belt system, an inertial spool lock on the seat belt retractor, a passive shoulder barrier restraint, and a passive pelvic barrier restraint.

The results of the deceleration sled tests indicate that a passive shoulder barrier restraint was effective at limiting occupant ejection at un-tripped rollover conditions for both belted and unbelted occupants.

For belted occupants, the deceleration sled tests results indicate that the passive shoulder bolster significantly reduced occupant excursion and the resulting

[18] Staff also investigated using a Euro-SID II dummy, which will not be discussed here. The occupant head and arm kinematics were significantly different from the AM50 dummy. Staff decided not to pursue further testing with the Euro-SID II dummy. See the ASE report for more information on the Euro-SID II dummy testing and results.

occupant ejection. [19] In all tests with Vehicle B, a vehicle with a passive shoulder barrier, the maximum occupant head excursion did not exceed the protective zone of the ROPS. In all tests with Vehicle A, a vehicle without a passive shoulder barrier, the maximum occupant head excursion exceeded the protective zone of the ROPS.

For unbelted occupants, the deceleration sled tests results also indicate that the passive shoulder barrier significantly reduced occupant excursion. Three tests were conducted with unbelted occupants: (1) Vehicle A in original configuration without a passive shoulder barrier; (2) Vehicle B in original configuration with a passive shoulder barrier; and (3) Vehicle A in modified configuration with a prototype passive shoulder barrier.

The unbelted occupant in Test 1, Vehicle A without a passive shoulder barrier, was partially ejected from the vehicle, with only the legs remaining inside the cabin. The unbelted occupant in Test 2, Vehicle B with a passive shoulder barrier, contacted the passive shoulder barrier early in the event and remained inside the protective zone of the ROPS. [20] The unbelted occupant in Test 3, Vehicle A modified with a passive shoulder barrier, contacted the shoulder restraint, coupled to the vehicle early in the event, and remained inside the protective zone of the ROPS.

3. <u>Roll Simulator</u>

In 2011, SEA Limited (SEA) designed and built a roll simulator to measure and analyze occupant response during quarter-turn roll events of a wide range of machines, including ROVs. The SEA roll simulator employs a cable-drawn sled and brake system to reproduce lateral acceleration profiles and a motor on the sled body to rotate the platform to reproduce desired roll rate profiles. [21] CPSC contracted SEA to conduct a study of the rollover performance of multiple vehicles within the ROV market. [22]

Before testing vehicles on the rollover simulator, SEA conducted autonomous full-vehicle rollover tests to measure rollover characteristics on multiple vehicles. During those full-vehicle autonomous rollover events, SEA measured the lateral

[19] ASE conducted one run in Vehicle B with the Euro-SID II. The dummy was partially ejected, but the results are not comparable to the results with the AM50 dummy, due to dummy construction differences and the resulting changes in occupant kinematics.
[20] The vehicle was tethered to the sled to limit vehicle roll and the subsequent damage to the vehicle and to the laboratory. Staff does not believe that the tether forces are consistent with most real-world events. Therefore, staff ignored vehicle and occupant kinematics after the tether jerk.
[21] Yoder et al., (2012). Establishing Occupant Response Metrics on a Roll Simulator. SAE Technical Paper 2012-01-0099.
[22] SEA Limited. "Test and Evaluation of Recreational Off-Highway Vehicles (ROVs) Dynamic Occupant Protection Performance Tests," September 2012.

acceleration and the roll rate for two distinct types of rollover crashes: un-tripped rollovers and tripped rollovers.

Figure 10: Autonomous Vehicle Start

Figure 11: Autonomous Vehicle Two-Wheel Lift

Figure 12: Autonomous Vehicle Rolling

Figure 13: Autonomous Vehicle at Rest

An un-tripped rollover occurs when the vehicle rolls solely as a result of the lateral frictional forces created at the tire-surface interface. This typically occurs when a vehicle with low lateral stability is driven fast enough in a curve to generate enough force through friction with the pavement to roll the vehicle. A tripped rollover occurs as a result of forces at the tire, created by contact with an object, as when a vehicle slides laterally into a curb or berm of soil. Tripped rollovers on ROVs are more severe than un-tripped rollovers because the lateral accelerations created by impact with an object are higher than the un-tripped lateral acceleration range, 0.6 g to 0.8 g, of these vehicles.

After measuring the lateral acceleration and roll rate of several real-world vehicles within the ROV market as they conducted 90-degree rollovers, SEA developed two sets of roll characteristics simulating the two main types of rollover events: the un-tripped rollover and the tripped rollover. Subsequently, SEA conducted validation tests to confirm the simulated vehicles' motion against the real-world target kinematics.[23] [24] [25] As seen in Figure 14, Figure 15, and Figure 16, the simulator roll characteristics in black are comparable to the target full-vehicle roll characteristics in blue, which resulted in comparable occupant kinematics.

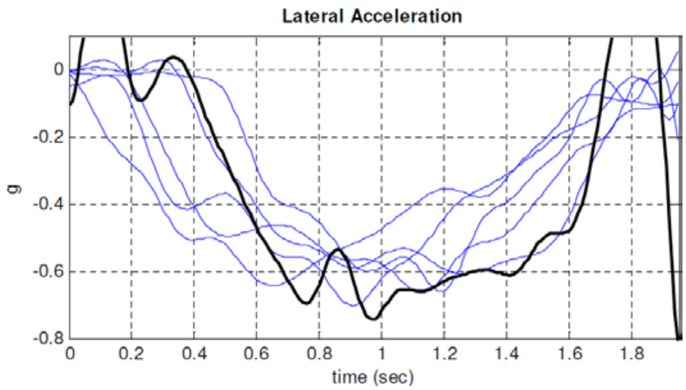

Figure 14: Roll Simulator vs. Autonomous Vehicle Lateral Acceleration.

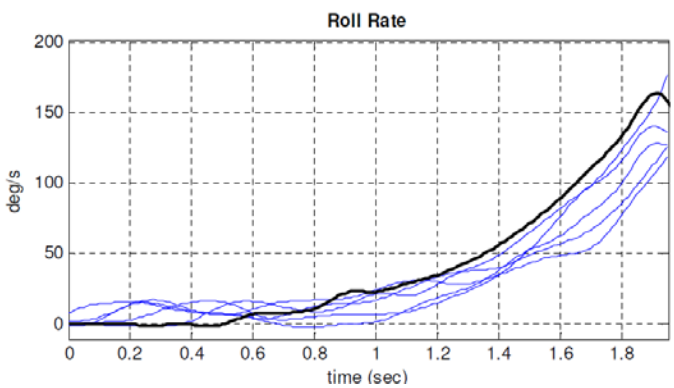

Figure 15: Roll Simulator vs. Autonomous Vehicle Roll Rate

[23] IMECE2011-62603 "Modeling and Validation of a Roll Simulator for Recreational Off-Highway Vehicles." By Zagorski et al.

[24] IMECE2011-62601 "Control Strategies for a Roll Simulator for Recreational Off-Highway Vehicles." By Zagorski et al.

[25] Zagorski, et al., (2012) Validation of a Roll Simulator for Recreational Off-Highway Vehicles. SAE Technical Paper 2012-01-0241.

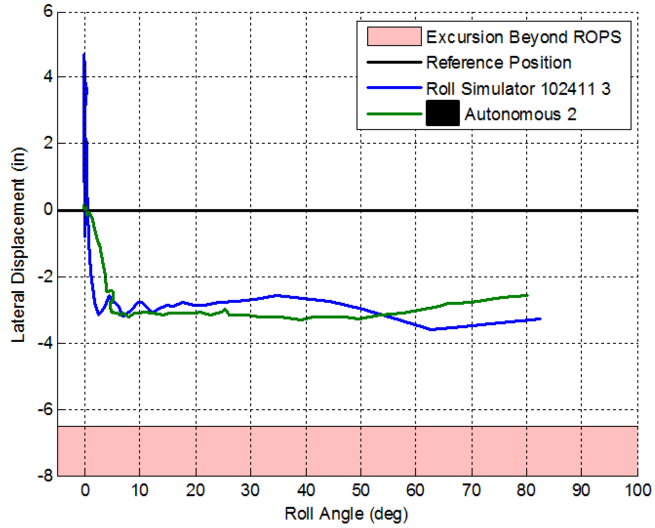

Figure 16: Roll Simulator vs. Autonomous Vehicle Occupant Head Kinematics.

Once the system had been validated, SEA placed a male 50th percentile Hybrid III dummy in the test ROVs and dynamically rolled the vehicles, using the un-tripped and rollover characteristics from the autonomous full-vehicle tests. The occupant kinematics in the simulator rollover matched the occupant kinematics in the autonomous real-world rollovers.

For each vehicle, SEA conducted un-tripped tests and tripped tests, each with a belted and instrumented Hybrid III 50th percentile male dummy in the driver's seat.[26] All roll events were driver-side leaning; thus, the dummy was a belted nearside occupant. After the conclusion of the belted occupant tests, SEA conducted an un-tripped test with an unbelted and un-instrumented Hybrid II 50th percentile male dummy to obtain qualitative information on unbelted occupant protection performance of the vehicle. An older and un-instrumented Hybrid II dummy was used for the unbelted tests due to cost considerations for a test that involved a high potential for damage to the test equipment.

Occupant head kinematics were calculated through analysis of high-speed video data. Markers were placed on the Hybrid dummy head and torso, as well as on the vehicle, and the motion of each marker was digitized. This method provides accurate and repeatable measurements of head and torso displacement during the simulated rollover event.

[26] Morr, P.E. (2012) Test and Evaluation of Recreational Off-Highway Vehicles (ROVs) Dynamic Occupant Protection Performance Tests. www.cpsc.gov.

Unbelted Occupants

The SEA roll simulator test results indicate that unbelted occupants are partially or fully ejected from all vehicles, regardless of the presence of other restraint components, including side pelvic and shoulder barrier restraints.

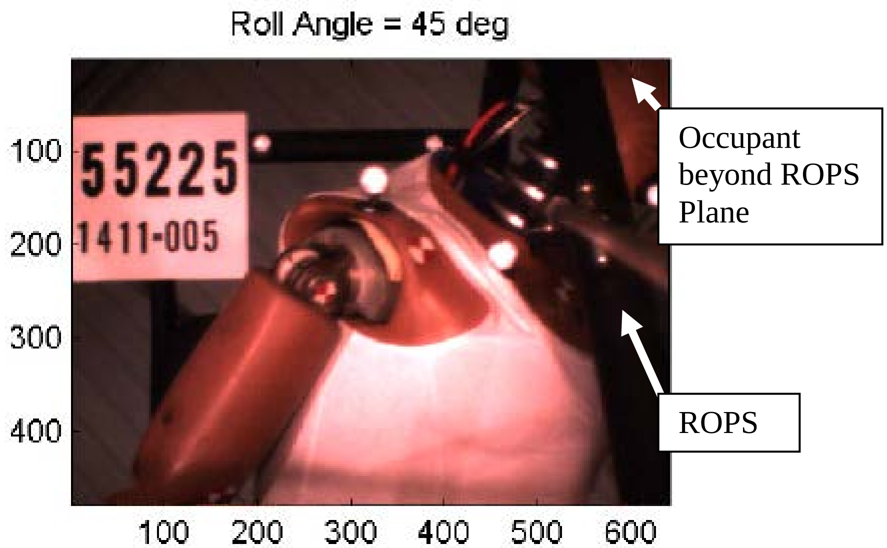

Figure 17: Example of partially-ejected occupant during test.

Figure 18: Example of an Unbelted Occupant Partially-Ejected from the Vehicle.

In prior test series conducted by ASE on the deceleration sled, unbelted occupants remained inside the vehicle when restrained solely with a passive shoulder barrier. CPSC staff believes that the discrepancy between the ASE deceleration sled and SEA roll simulator results is due to differences in the input acceleration profiles and roll rates experienced by the test vehicles. Staff believes that the vehicle kinematics on the SEA rollover simulator represent more accurately real-world events because SEA validated the sled kinematics against full-vehicle real-world rollover events.

While passive shoulder barriers may not provide substantial benefit for occupant protection in unbelted rollovers, the SEA roll simulator test results indicate they significantly improved occupant containment when used in conjunction with a seat belt.

Belted occupants

The SEA roll simulator results indicate that the belted occupants of certain vehicles remain contained within the ROPS. See the results below in Table 1.

The SEA roll simulator test results indicate that Vehicle B and Vehicle C were the only vehicles that restrained the belted occupants within the protective zone of the ROPS during un-tripped and tripped rollover events. Vehicle D restrained the belted occupant within the ROPS during the un-tripped rollover event but not during the higher-energy tripped rollover event. Vehicle F, Vehicle G, Vehicle H, and Vehicle K failed to restrain the belted occupants within the protective zone of the ROPS during both the un-tripped and tripped rollover events. Vehicle H and Vehicle K are the same model vehicle, but Vehicle H is model year 2011, while Vehicle K is model year 2007. Table 1, Figure 19, and Figure 20 illustrate further analysis of the occupant head excursion of each vehicle compared to the plane of that vehicle's ROPS.

Table 1: Belted Occupant Results on Roll Simulator

BELTED TEST RESULTS					
Vehicle	**Event Type**	**Head Excursion (inches)**			
		Y-Avg	**Y-Max**	**Z-Avg**	**Z-Max**
B	Threshold	-3.8	-4.0	-1.8	-3.0
B	Trip	-5.6	-5.7	-2.1	-2.3
C	Threshold	-3.9	-4.2	-0.9	-1.4
C	Trip	-5.5	-6.4	-1.8	-2.1
D	Threshold	-9.3	-9.5	-2.8	-1.7
D	Trip	-13.0	-16.1	-5.1	-7.8
F	Threshold	-8.7	-12.0	-6.0	-6.1
F	Trip	-13.1	-14.3	-6.9	-7.3
G	Threshold	-16.0	-16.8	-3.1	-3.9
G	Trip	-14.0	-14.1	-3.1	-3.2
H	Threshold	-16.8	-18.9	-3.2	-4.0
H	Trip	-14.3	-14.4	-2.5	-3.0
K	Threshold	-15.6	-16.2	-0.6	-1.0
K	Trip	-14.0	-14.7	-2.2	-2.3

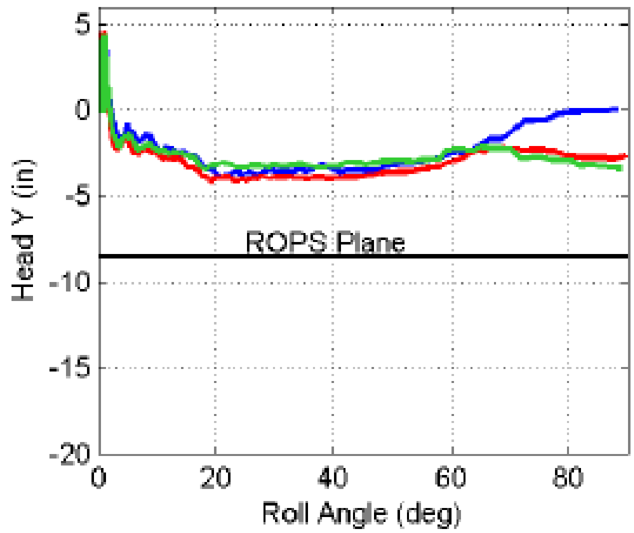

Figure 19: Example of Head Excursion Within ROPs Plane.

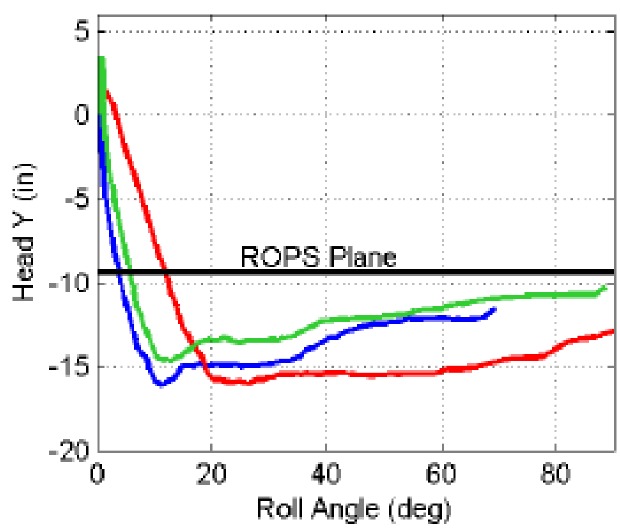

Figure 20: Example of Head Excursion Outside ROPs Plane.

Vehicle B

Vehicle B has a 3-point seat belt and a passive shoulder barrier restraint. The 3-point seat belt is equipped with an inertial locking mechanism that locks the seat belt upon rapid deceleration or rollover of the vehicle. CPSC staff measured the angle at which the seat belt on Vehicle B locks, and test results indicate that the seat belt locks at approximately 56 degrees (see appendix B for seat belt test data).

During un-tripped rollovers and tripped rollovers, the shoulder restraint on Vehicle B interacted with the occupant's shoulder so that the occupant coupled to the vehicle early in the event. This resulted in the occupant remaining inside the ROPS throughout the rollover event.

Figure 21: Vehicle B Side View

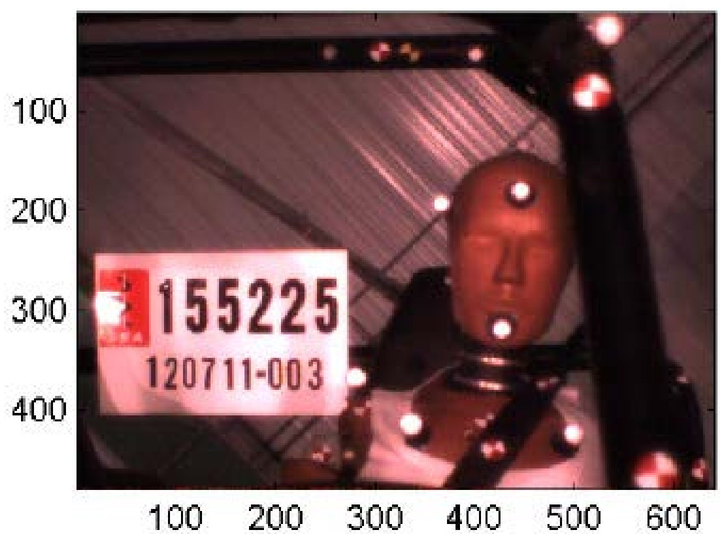

Figure 22: Occupant B at 45° Roll

Vehicle C

Vehicle C has a 3-point seat belt but does not have a passive shoulder barrier. The 3-point seat belt is equipped with an inertial locking mechanism that locks the seat belt webbing when the vehicle experiences a certain acceleration level or roll angle. CPSC staff measured the angle at which the seat belt on Vehicle C locks, and test results indicate the lock angle is approximately 53 degrees (see appendix B).

During both un-tripped rollovers and tripped rollovers, the occupant in Vehicle C remained inside the protective zone of the ROPS.

Figure 23: Vehicle C Side View

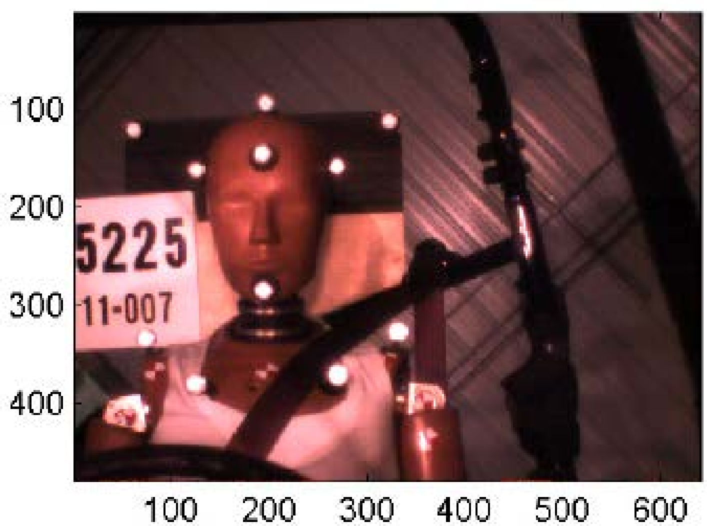

Figure 24: Occupant C at 45° Roll

Vehicle D

Vehicle D has a two-point seat belt but does not have a passive shoulder barrier. This vehicle has a large hip restraint that extends into the lower abdominal region of the AM50 dummy. Vehicle D also has the widest vehicle cabin protective zone provided by the ROPS compared to the other vehicles tested.

During un-tripped rollovers, the lap belt and hip restraint of Vehicle D coupled with the occupant, and the occupant remained within the protective zone of the ROPS. However, during higher-energy tripped rollovers, the occupant partially decoupled from the vehicle, and the head exited the ROPS plane.

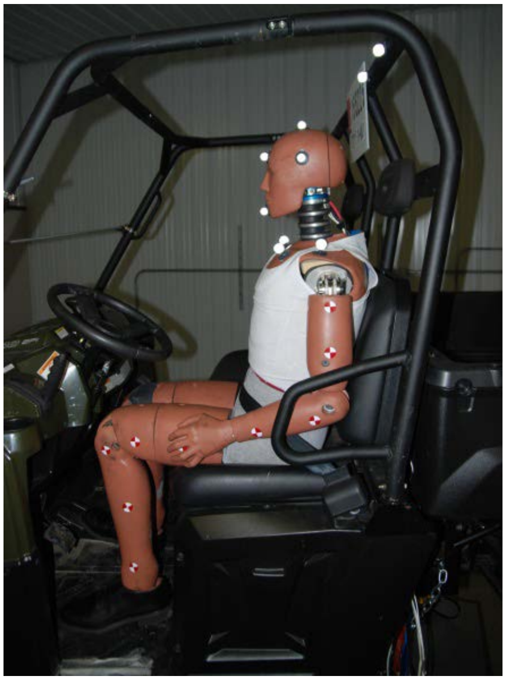

Figure 25: Vehicle D Side View

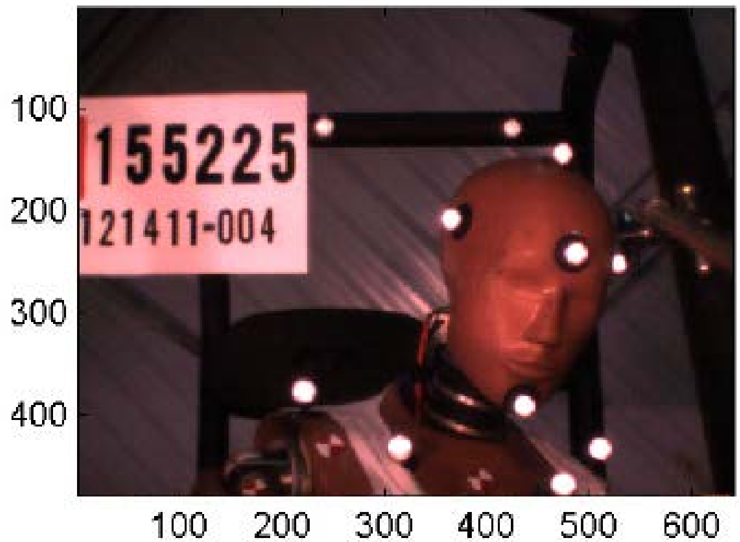

Figure 26: Occupant D at 45° Roll

Vehicle F

Vehicle F has a 2-point seat belt but does not have a passive shoulder barrier. This vehicle has a low-profile hip restraint and the narrowest vehicle cabin protective zone provided by the ROPS compared to other vehicles tested.

During un-tripped rollovers and tripped rollovers, the occupant decoupled from the vehicle, and the head exited the side of the vehicle's ROPS plane in 2 out of 3 un-tripped tests. The occupant decoupled from the vehicle, and the head exited the side of the vehicle's ROPS plane in 3 out of 3 tripped tests.

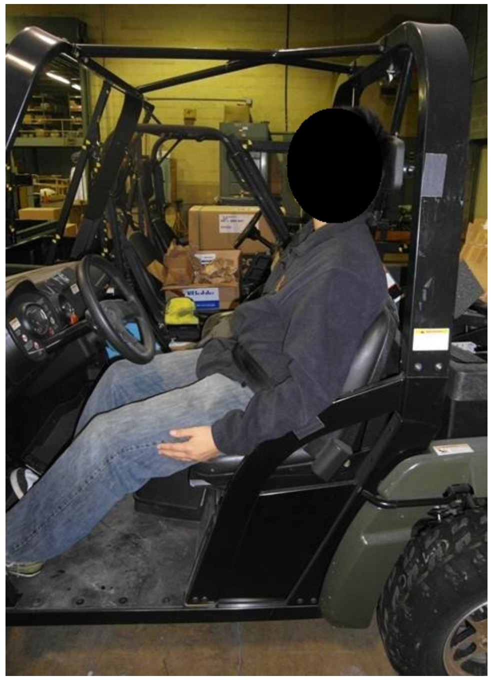

Figure 27: Vehicle F Side View

Figure 28: Occupant F at 45^{o} Roll

Vehicle G

Vehicle G has a 3-point seat belt but does not have a passive shoulder barrier. The 3-point seat belt is equipped with a locking mechanism based on a centrifugal clutch that is activated by rapid pulling of the webbing from the spool. CPSC staff measured the angle at which the seat belt on Vehicle G locks, and test results indicate that the seat belt does not lock throughout a 90-degree angle range (see appendix B).

In all un-tripped rollovers and tripped rollover tests, the occupant's head exited Vehicle G's ROPS plane.

Figure 29: Vehicle G Side View

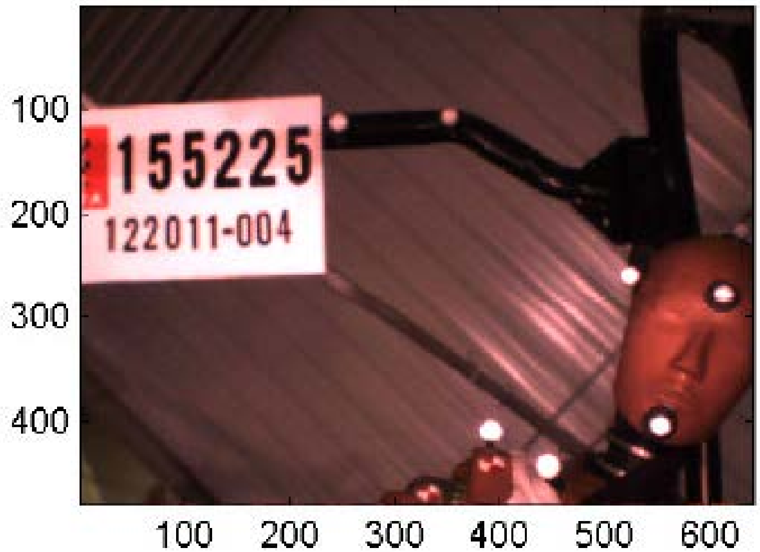

Figure 30: Occupant G at 45^{o} Roll

Vehicle H

Vehicle H has a 3-point seat belt but does not have a passive shoulder barrier. The 3-point seat belt is equipped with a locking mechanism based on a centrifugal clutch that is activated by rapidly pulling the belt webbing from the spool. CPSC staff measured the angle at which the seat belt on Vehicle H locks, and the test results indicate that the seat belt does not lock throughout a 90-degree range (see appendix B).

In all un-tripped rollovers and tripped rollover tests, the occupant's head exited the side of Vehicle H's ROPS plane.

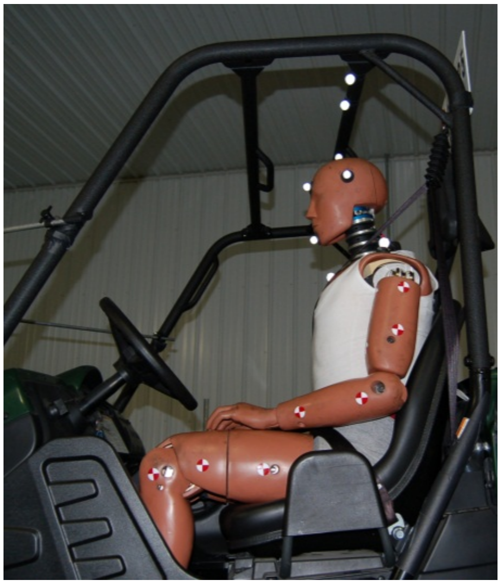

Figure 31: Vehicle H Side View

Figure 32: Occupant H at 45^{o} Roll

Vehicle K

Vehicle K has a 3-point seat belt but does not have a passive shoulder barrier. The 3-point seat belt is equipped with a locking mechanism based on a centrifugal clutch that is activated by rapid pulling of the webbing from the spool. CPSC staff measured the angle at which the seat belt on Vehicle K locks, and the test results indicate that the seat belt does not lock throughout a 90-degree angle range (see appendix A).

In all un-tripped rollovers and tripped rollover tests, the occupant's head exited the side of Vehicle K's ROPS plane.

Figure 33: Vehicle K Side View

Figure 34: Occupant K at 45^{o} Roll

CPSC Staff Discussion of SEA Roll Simulator Test Results

Only two vehicles had occupants that remained inside the protective ROPS structure during both un-tripped and tripped events.

The occupant in Vehicle B contacted the passive shoulder guard early in the event. Because the occupant contacted the passive shoulder guard early in the event, the occupant had not moved significantly by the time the inertial spool lock activated. By limiting the relative movement of the occupant, the occupant had not pulled significant slack out of the seat belt retractor by the time the seat belt inertial spool locked. An inertial spool lock is a feature on a seat belt retractor that locks the seat belt spool and limits seat belt payout when the vehicle experiences a certain level of vehicle acceleration or vehicle roll. By locking the seat belt early in the event, the restraint system is able to significant reduce occupant motion relative to the ROPS later in the event. In terms of Vehicle B's performance, the early and significant restraint resulted in low occupant excursion and no occupant ejection outside the ROPS plane.

Vehicle C did not have a passive shoulder guard, yet Vehicle C's restraint system was able to limit occupant excursion and eliminate occupant ejection outside of the ROPS plane. CPSC staff believes the occupant kinematics may have been related to the seat belt in conjunction with other unknown factors.

The seat belt anchorage points had been placed to minimize belt slack. In particular, the seat buckle was located rearward and below the AM50's hip. By placing the seat buckle rearward and below the dummy's hip point, the belt hugged the curvature of the dummy's pelvis and limited seat belt slack. By limiting seat belt slack in the lap belt, an occupant would have loaded the lap belt early in the rollover simulation. As the occupant loaded the lap belt, the seat belt tongue lock would have activated early in the event and locked the lap belt, which restrained the occupant's pelvis.

In addition to the lap portion of the seat belt, the shoulder portion also had features designed to increase restraint in a dynamic event. In particular, Vehicle C also had an inertial lock. By cross-referencing the lateral acceleration seen in the SEA sled tests with the acceleration associated with the locking angle of the inertial seat belt, the inertial spool lock engaged at approximately 10 degrees of vehicle roll. It's possible that the combination of the belt routing, the inertial spool lock, and other unknown features interacted to limit occupant excursion.

Although the SEA Roll Simulator is the most advanced test equipment viewed by CPSC staff to date, staff did notice several instances of unexplained variation in the vehicle and occupant kinematics. Due to the unexplained variation, the data are too preliminary to make any detailed recommendations regarding dynamic testing. Without additional testing, CPSC staff does not feel confident in basing a rule on the roll simulator, and staff would recommend focusing on static component tests. Staff is confident that passive shoulder barriers and seat belts will keep occupants contained within the vehicle. Therefore, until further testing can be completed, staff recommends focusing on passive shoulder barrier component tests.

Staff also recommends continuing to study dynamic crash events with the roll simulator. Additional testing may show higher levels of repeatability, because staff expects that SEA has continued to develop the roll simulator since CPSC's last test series was conducted in late 2011 and early 2012. An additional test series will allow CPSC staff to develop a dynamic test procedure. A dynamic test procedure would give manufacturers flexibility to develop restraint systems that are not based on a passive shoulder barrier and may incorporate novel restraint designs like the one in Vehicle C.

4. Testing to the ROHVA Standard

To analyze the adequacy of the ROHVA standard, CPSC staff tested multiple vehicles to the occupant protection procedures listed in the ROHVA standard.

Zone 1

CPSC staff began with Zone 1. Staff applied a 50 lbf load at the centroid of the shaded area identified in Figure 2. Seven vehicles passed the test by absorbing the applied load without any damage. Two vehicles did not pass, because there was no foot barrier in the required zone.

Table 2: Zone 1 results summary.

Vehicle	Zone 1	Comment
A / K	Pass	
B	Pass	
C	Pass	
D	N/T	Not Tested.
E	Pass	
F	Fail	There is no foot barrier in the required zone.
G	Fail	There is no foot barrier in the required zone.
H	Pass	
I	Pass [27]	
J	Pass	

Zone 2

CPSC staff tested vehicles against the performance requirements in Zone 2. The ROHVA standard allows manufacturers to choose one of two methods of compliance: the "construction-based method," listed in § 11.3.1.2(A), or the "performance-based method," listed in § 11.3.1.2 (B).

CPSC testing indicated that the performance-based method was less severe than the construction-based test method. Four of 10 vehicles passed the construction-based requirements, while eight of 10 passed the performance-based requirements. CPSC staff is concerned that multiple vehicles passed the performance-based method while failing the construction-based method's requirements.

In addition, CPSC staff tested two vehicles with substantially similar restraint systems according to the current Zone 2 performance-based test method. One vehicle passed the performance test while the second vehicle failed. The root cause of the difference is unknown, but the difference may be related to how the seat belt supported the occupant's weight, perhaps due to changes in the frictional characteristics at the seat belt and D-ring interface.[28] The differences may also be

[27] Test results for Vehicle I are applicable to the front seats only.
[28] The D-ring is the metal ring located above the occupant's shoulder through which the seatbelt passes.

due to changes in the seat belt retractor spool spring. Further testing indicated that small changes in the seat belt restraint force caused the occupant to move laterally towards the outside of the vehicle, leading CPSC staff to believe that the seat belt was the main source of occupant retention for that particular vehicle.

Table 3: Zone 2 Results summary.

Vehicle	Zone 2 Construction Criterion	Zone 2 Performance Criterion	Overall	Comment
A / K	Fail	Fail	Fail	
B	Pass	Pass	Pass	
C	Pass	Pass	Pass	
D	Fail	Pass	Pass	
E	Fail	Pass	Pass	
F	Fail	Fail	Fail	
G	Fail	Pass	Pass	
H	Fail	Pass	Pass	
I	Pass [29]	Pass	Pass	
J	Pass	Pass	Pass	

<u>Zone 3</u>

CPSC staff tested vehicles against the requirements listed for Zone 3. Zone 3 allows for three separate methods of compliance: one construction-based method listed in § 11.3.1.3(A) or one of two performance-based methods referenced in §11.3.1.3(B).

CPSC staff noted some inconsistencies in the ROHVA standard. The ROHVA construction-based method, §11.3.1.3(A), specifies that the retention requirements for Zone 3 shall be met by a permanent barrier that covers a specific area, but the standard does not reference any test method. CPSC staff assumed that the Zone 3 construction-based method was intended to reference the first Zone 3 test procedure listed in §11.3.2.3(A). That test procedure adds an additional requirement, which states that the barrier shall have no opening that allows a 3-inch probe to pass through the barrier.

[29] Test results for Vehicle I are applicable to the front seats only.

The results of the construction-based test indicate that only one vehicle passed the requirements. Even the vehicles with a net system had openings near the seatback. Only one vehicle had a net system where the opening near the seat back was marginally smaller than 3 inches.

The second method of compliance with the Zone 3 requirements was the performance-based method defined in § 11.3.1.3(B). As stated above, CPSC staff assumed that the test method § 11.3.2.3(A) was intended to be the construction-based test method, and thus, the second test method, listed in § 11.3.2.3(B) would be the performance-based test procedure. In the performance-based method, the vehicle is mounted to a tilt table and quasi-statically tilted to 45 degrees. The tilt table results indicate that only two vehicles did not pass the performance-based test methodology.

In addition, CPSC staff conducted multiple tests on several vehicles to identify potential sources of variability in the test method, and CPSC staff noted that the results were not repeatable. In particular, CPSC staff conducted a total of four Zone 2 performance-based tests on Vehicle A. In two of the four tests, the dummy's hand detached from the hand-hold. The change in retention yielded a significant difference in the ejection distance of the hand and arm, such that the standard deviation was 5.4 inches.

The ROHVA standard allows manufacturers to comply with the standard by meeting the construction-based method or the performance-based method. Because the performance-based method is less severe, staff would expect to see most manufacturers certifying through the performance-based method.

Table 4: Zone 3 Results summary.

Vehicle	Zone 3 Construction	Zone 3 Performance	Zone 3 Overall
A / K	Fail	Fail	Fail
C	Pass [30]	Pass	Pass
D	Fail	Pass	Pass
E	Fail	Pass	Pass
F	Fail	Fail	Fail
G	Fail	Pass	Pass
H	Fail	Pass	Pass
I	Fail	Pass	Pass
J	Fail	Pass	Pass

Zone 4

The ROHVA standard requires that manufacturers recommend that each occupant be seated, belted, and wearing an appropriate helmet. The standard does not require any specific physical testing.

C. Adequacy of voluntary standards

1. ROHVA Standard

Through testing and analysis, CPSC staff identified multiple issues with the current ANSI/ROHVA 1-2011 test methodologies. CPSC staff began by testing 10 vehicles to the occupant restraint requirements listed in the current ROHVA standard. Out of 10 vehicles, eight met the ROHVA standard's performance requirements. Even those vehicles associated with high reported injury and death rates in the EPI database met the performance requirements. Staff discusses the specific issues starting with Zone 1.

Zone 1

Zone 1 requirements were written to restrict leg and foot excursion and currently allow complicated net systems. CPSC staff believes that some consumers,

[30] The result was a marginal pass. The edges of the net covered the probe's exit path out of the vehicle. Applying a small outward force would likely allow the probe to exit the vehicle.

particularly the elderly, mobility-restricted, or dexterity-restricted, may choose to forego the protection of a net system if it is too cumbersome to use, and the difficulty may create a disincentive to use the net system. Additionally, consumers who enter and exit the vehicle regularly may find complex net systems frustrating. As stated above, those consumers may also decide to forego the protection of a net system if the system is too cumbersome to use.

Zone 2

Zone 2 requirements allow manufacturers to meet construction-based or performance-based requirements to address shoulder/hip excursion. CPSC staff has several concerns regarding the construction-based method and the performance-based method. These concerns can be grouped into three major areas: requirements, test methodology, and results.

Zone 2 requirements issues

CPSC staff noted several issues with the Zone 2 performance-based requirement. The current ROHVA 5-inch ejection requirement for Zone 2 is based on the maximum vehicle width, not the width of the ROPS near the occupant. CPSC staff measured the difference between the outermost point of the ROV and the outermost point on the ROPS near the occupant's head. On one vehicle, the vehicle's maximum width location was 6-¾ inches outside the maximum ROPS width near the occupant. Because the requirement is based on the maximum vehicle width, the occupant's torso could be 5 inches beyond the 6-¾ inches or 11-¾ inches outside of the ROPS and still meet the current ROHVA requirement. Because of the significant discrepancy between the maximum vehicle width and the ROPS width near the occupant on some vehicles, CPSC staff believes that using the maximum vehicle width allows occupant excursion that is inappropriate.

In addition to the maximum width, CPSC staff has concerns regarding the 5-inch torso requirement. During performance-based testing, the vehicle is quasi-statically rotated to an angle of 45 degrees. As the vehicle tips, the occupant rotates in his or her seat towards the ground and out of the vehicle. As the occupant rotates out of the vehicle, staff found the maximum occupant head ejection could exceed the torso ejection by up to 3 inches. Allowing 5 inches of torso ejection could allow 8 inches of head ejection. CPSC staff believes that a test that allows 8 inches of head ejection is inappropriate.

Zone 2 test methodology issues

The current Zone 2 construction-based test method only requires that the barrier withstand a load at a single point. The ROHVA standard's 3-inch diameter probe does not accurately represent the contact between the occupant and the vehicle during many real-world, 90-degree rollover events. CPSC staff recommends changing the 3-inch diameter probe to a probe that simulates the upper arm of a small-stature female. Increasing the size of the probe and mandating a flexible joint connection to the probe will create an incentive for manufacturers to protect a larger area, instead of allowing manufacturers to focus on a single point. A protective area, as opposed to a single point, would provide more coverage and could protect a larger proportion of the human population.

Figure 35: Structure protecting a single point

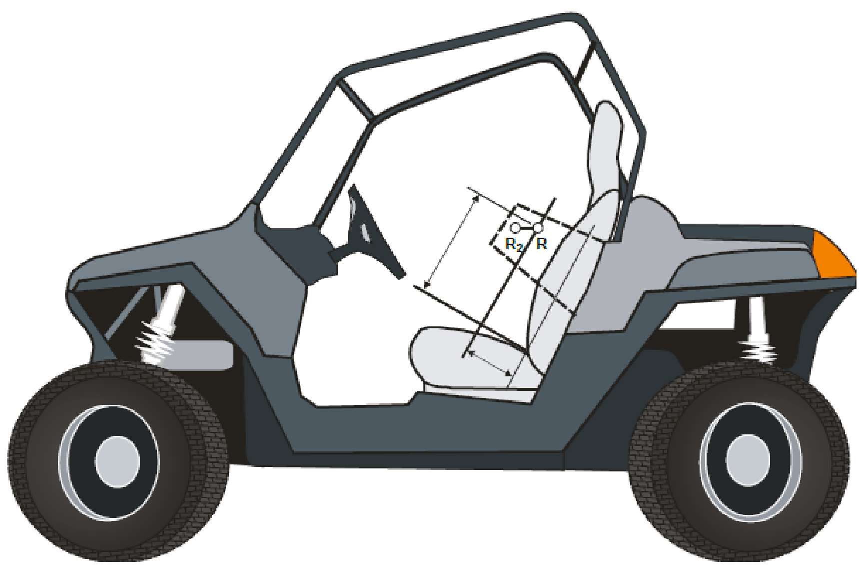

Figure 36: Structure protecting a zone

CPSC staff also noted that the current ROHVA standard does not specify how to position the dummy and leaves significant room for interpretation. In §11.3.2.2(B)(4), the ROHVA standard states: “The test dummy shall be positioned in an upright and centered posture.” In contrast, other crash safety regulations, like FMVSS 208, clearly describe how to position each body region of the dummy. For example, the dummy positioning procedure in FMVSS 208

S10 uses more than 900 words. [31] Dummy positioning is important because if the dummy is in a different initial position, the contact areas and resulting forces between the dummy and the vehicle change. This is especially important in a quasi-static test, where small changes in forces can significantly alter the overall movement of the occupant. In total, the dummy positioning procedure is not defined clearly and leaves significant room for interpretation, especially compared to other dummy positioning procedures developed and used by other federal regulations.

As ROVs evolve, vehicle designs may start to incorporate other adjustable components, and the current ROHVA standard does not address adjustable features, except for a short statement regarding the seat. The standard currently states that the seat shall be in the as-delivered condition. This could pose a problem for a test lab that does not receive the ROV directly from an assembly plant, because the laboratory may receive a vehicle where the seat had been moved during transportation or through consumer use. The standard also does not address other vehicle components, like a tilt/telescoping steering wheel or a seat belt D-ring positioning aid. If the standard does not describe the position of the seat and other adjustable components clearly, the dummy at one laboratory may interact with a vehicle environment that is fundamentally different from the vehicle environment at a different laboratory.

Finally, the standard does not specify other important factors that contribute to a repeatable test. Although the joint stiffness is discussed in the appendix relative to the Zone 3 performance-based test methodology, that discussion is conspicuously absent for Zone 2. Joint stiffness can have a significant effect on how the dummy interacts with the vehicle's interior, particularly in a quasi-static test. Additionally, the standard makes no mention of clothing. Without a description of the clothing required, some test laboratories may use ATV/ROV riding jackets, pants, and boots. Other laboratories may default to the clothing defined in automotive regulations; *i.e.*, a cotton shirt, cotton pants, and MIL-spec shoes. Without clear and specific test methodologies, different laboratories may produce different results.

[31] "Occupant Crash Protection," 49 C.F.R. § 571.208.

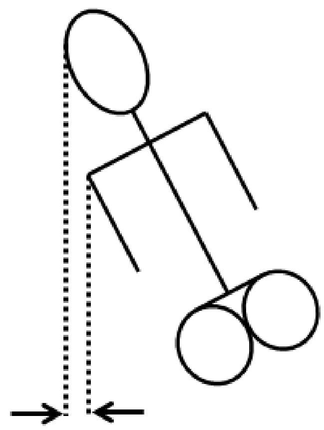

Figure 37: Front View of Vehicle Occupant Showing the Difference Between Head Excursion and Torso Excursion

Zone 2 results issues

CPSC staff is concerned that the ROHVA Zone 2 performance test method, as currently written, is not repeatable. As noted above, CPSC staff tested two vehicles with substantially similar restraint systems according to the Zone 2 performance method listed in the ROHVA standard. Vehicle A did not meet the requirements of the performance method because the dummy's torso exceeded the 5-inch ejection requirement; while Vehicle H did meet the requirement. CPSC staff believes that vehicles with substantially similar restraint systems should behave comparably; however, the ROHVA test yielded significantly different results. CPSC staff is not recommending incorporating the Zone 2 performance requirement into the mandatory standard.

Zone 3

Zone 3 requirements allow manufacturers to meet construction-based or performance-based requirements to address arm/hand excursion. CPSC staff identified several issues, and these issues may be grouped into three main areas: requirements, test methodology, and results.

Zone 3 requirements issues

The Zone 3 construction-based requirement is not currently linked to a test method that measures a force, a displacement, or another engineering-related characteristic. CPSC staff assumes that the ROHVA standard intended to measure Zone 3 construction-based method, using the test method in the ROHVA standard § 11.3.2.3(A).

Zone 3 test methodology

The current Zone 3 performance-based method allows complicated net systems. As stated above, some mobility-constrained or dexterity-constrained consumers may forgo the protection of a net, if the system is too cumbersome to use.

In the Zone 3 performance-based test method, the test personnel measure the excursion of the dummy's hand and arm, relative to the maximum width of the vehicle. CPSC staff noted several of the same issues in Zone 3 that also were seen in Zone 2 and discussed above.

The appendix does mention dummy joint stiffness and rigidity but only in general terms. The appendix in section A11.3.2.3 states that the automotive standard of "barely restraining the weight of the limb when extended horizontally are applicable to automobiles in a level, non-accelerating condition." [32] CPSC staff disagrees with that assertion. FMVSS 208, FMVSS 213, FMVSS 214, and other standards use the 'barely restraining' language to ensure test-to-test and laboratory-to-laboratory repeatability.[33] [34] [35] The tests involve a vehicle or surrogate vehicle crashing into various types of barriers at various speeds. The crash tests, by definition, are both dynamic and accelerating events. The ROHVA standard's appendix is incorrect in stating that the "barely restraining" language is for non-accelerating events.

In addition to the joint stiffness, the standard does not adequately describe the grip force. According to the standard, the dummy shall grip the steering wheel or handhold, simulating an occupant who is in the early stages of a rollover. Neither the actual grip force requirement, nor the methodology necessary to apply that grip force are defined or discussed. Without adequate description, each test lab would independently have to create a joint stiffness requirement and measurement method. CPSC staff is concerned that the lack of specificity will significantly degrade the test-to-test and laboratory-to-laboratory repeatability.

As in the Zone 2 performance test, the Zone 3 performance-based method does not address other adjustable features within the vehicle, like a tilting/telescoping steering wheel or an adjustable seat belt D-ring. The standard does state that the seat shall be in the as-delivered position, but CPSC staff believes that the current language is insufficient to describe accurately a specific orientation of an adjustable seat that may have lumbar, vertical cushion height, and seatback angle adjustments. Because the standard does not adequately describe the seat positioning methodology, test operators and test labs may interpret the language differently, leading to significant test-to-test and laboratory-to-laboratory variation.

<u>Zone 3 results issues</u>

CPSC staff is concerned that the ROHVA Zone 3 performance test method, as currently written, is not repeatable. As noted above, CPSC staff conducted

[32] American National Standard for Recreational Off-Highway Vehicles (ANSI/ROHVA 1-2010). (2010). Irvine, CA: Recreational Off-Highway Vehicle Association (ROHVA).
[33] "Occupant crash protection," 49 C.F.R. § 571.208.
[34] "Child restraint systems," 49 C.F.R. § 571.213.
[35] "Side impact protection," 49 C.F.R. § 571.214.

repeated tests on multiple vehicles to measure the variability in the test method. The level of variability measured is not consistent. For this reason, CPSC staff is not recommending incorporating the Zone 3 performance requirement into the mandatory standard

2. OPEI Standard

   CPSC staff does not believe the ANSI/B71.9 requirements for occupant protection are adequate because there are no tests that simulate occupant excursion in a dynamic crash event. Therefore, staff does not recommend basing a rule on the OPEI standard.

D. Public Comments

The agency received multiple comments from the public concerning the proposals in the ANPR. One comment, from Arctic Cat, Bombardier, Polaris, and Yamaha, was of particular interest to CPSC staff. The joint industry comment stated that the current voluntary standard was adequate and that modifications to the current standard or any additional regulatory requirements were unnecessary.

First, CPSC staff reviewed the report referenced by the joint industry comment, and found the analysis lacking in multiple respects.[36] Therefore, CPSC staff disagrees with multiple conclusions in the referenced report. A summary of the areas of disagreement follows.

- The joint comment's conclusions based on the commenters' analyses of the NEISS utility vehicle data are not technically sound.
- CPSC staff does not agree that comparing ROV risk to risk associated with ATVs produces a valid argument that ROVs are safe.
- The joint industry comment is incorrect in stating that the CPSC did not sort the IDIs according to factors that could contribute to a rollover crash event.
- In the analysis provided in the joint comment, it was assumed that an occupant was not wearing a seatbelt because the victim was ejected, which CPSC staff considers an invalid indicator of seatbelt use because belted occupants can still be ejected from the ROV.
- The joint comment analyses and exposure study also show that there is a pattern of foreseeable misuse, which is not mentioned in the joint comment and that staff finds to be an important factor in determining the requirements outlined in the NPR.

[36] Garland, S. "CPSC Staff's Response to Industry Joint Comment Regarding IDI, NEISS, and Exposure/Risk Analyses for ROVs," July 26, 2013.

Second, the joint comment stated that the voluntary standard was adequate. CPSC staff conducted the occupant safety tests in the ANSI/ROHVA 2011-1 standard. CPSC staff's testing indicated that 8 of 10 vehicles passed the torso ejection requirements listed in the ROHVA standard, including vehicles associated with high injury and death rates.

During testing, CPSC staff noted that some test methods defined in the ROHVA standard lacked specificity. For example, the ROHVA standard does not adequately address adjustable features within the vehicle, and the standard does not sufficiently describe how the dummy shall be placed in the vehicle in the performance-based test methods. Without clear and specific test procedures, significant test-to-test and laboratory-to-laboratory variation could result, which limits the effectiveness of a standard.

CPSC staff does not believe that some of ROHVA standard's requirements will improve occupant safety in a rollover crash event. As an example, in the Zone 2 performance-based method, the ROHVA standard allows for 5 inches of torso ejection outside of the maximum width of the vehicle. One vehicle had a maximum width location that was 6-¾ inches outside the ROPS near the occupant. Because the ROHVA standard references the maximum width of the vehicle and not the width of the ROPS, the occupant's torso could be ejected 11-¾ inches outside of the ROPS and still pass the requirement in the ROHVA standard. CPSC staff does not believe that this is appropriate.

In comparison, CPSC staff and CPSC's contractors simulated and validated dynamic rollover crash events. As stated above, the SEA belted-occupant test results showed that only 2 of 7 vehicles had occupants whose heads remained inside the vehicle's cabin. In the remaining 5 vehicles, the occupants' heads passed through the plane created by the side of the vehicle, even when the occupant was restrained with the available seat belt.

For the reasons explained above, CPSC staff can not recommend using an unmodified version of the ROHVA standard as the baseline for the proposed federal regulation.

III. STAFF RECOMMENDATIONS FOR THE PROPOSED SAFETY STANDARD FOR ROVs

Below is a discussion of the three main technical requirements that staff recommends to address occupant protection performance during a lateral rollover in the notice of proposed rulemaking (NPR) for ROV safety. Appendix A provides the exact language staff recommends.

A. Seat Belt Reminder.

In the ROHVA 1-2010 revision, seat belt reminder systems were not mandatory. For manufacturers who included a seat belt reminder in their vehicles, the seat belt reminder systems were required to be compliant with FMVSS 208 §7.3. FMVSS 208 § 7.3 requires that the seat belt reminder system have a warning light and a warning chime for at least 60 seconds when the key moves to the key-on or key-start position and the belt is not in use. Within FMVSS 208, the manufacturer also had the option to use a continuous or intermittent warning chime until the driver uses his/her belt.

In ROHVA 1-2011, a seat belt reminder system became mandatory, but the standard significantly degraded the severity of the performance requirements. In the current 2011 version, the seat belt reminder system is only required to illuminate a warning light and sound a reminder chime for a total of 8 seconds.

CPSC staff does not believe that an 8-second warning light and chime will be sufficient to change drivers' behavior.[37] Therefore, CPSC staff recommends proposing a performance requirement to limit the ROV maximum speed to no more than 15 mph if the seat belt of the driver and front passenger(s), if present, are not buckled.

C. Occupant Retention System.

1) Zone 2 – Shoulder/Hip.

The current Zone 2 construction-based test method in ROHVA 1-2011 only requires that the barrier withstand a 163 lbf. load at a single point. CPSC staff recommends applying the force through a universal joint, incentivizing manufacturers to protect a larger area, instead of a single point. CPSC staff also recommends updating the probe dimensions.

The new probe is based on the dimensions of the upper arm of a fifth-percentile adult female.[38] [39] [40] [41] Staff chose the dimensions of an adult fifth-percentile female, because multiple automotive crash safety regulations use a dummy based on the dimensions of an adult fifth-percentile female. During testing, Point Q on the probe shall be placed such that it is coincident to Point R on the vehicle. Additionally, the major axis of the probe shall be parallel to the angle of the

[37] Paul, Caroleene. "Proposal for Seat Belt Speed Limiter on Recreational Off-Highway Vehicles (ROVs)," Aug 2013.
[38] National Aeronautics and Space Administration. (1978). Anthropometric Source Book Volume II: A Handbook of Anthropometric Data. Retrieved from: http://archive.org/details/nasa_techdoc_19790005540.
[39] Humanetics Innovative Solutions. (2013). External Dimensions of Hybrid III 5th Female Dummy - 880105-000-H. Plymouth, MI: Retrieved from: http://www.humaneticsatd.com/crash-test-dummies/frontal-impact/hybrid-iii-5th.
[40] Humanetics Innovative Solutions. (2013). External Dimensions of SID-IIs Small Side Impact Dummy. Plymouth, MI: Retrieved from: http://www.humaneticsatd.com/crash-test-dummies/side-impact/sid-iis.
[41] Kulwicki, Michael. Personal communications. Tue 3/5/2013 4:16 PM.

seatback, measured 17 inches up the intersection of the seatback from the seat cushion. A probe connected to a rotational joint will allow the probe to pivot past a barrier, unless the probe is adequately supported on both sides of the rotational joint. Due to these changes, the torso barrier size must increase beyond the current requirement in the ROHVA standard.

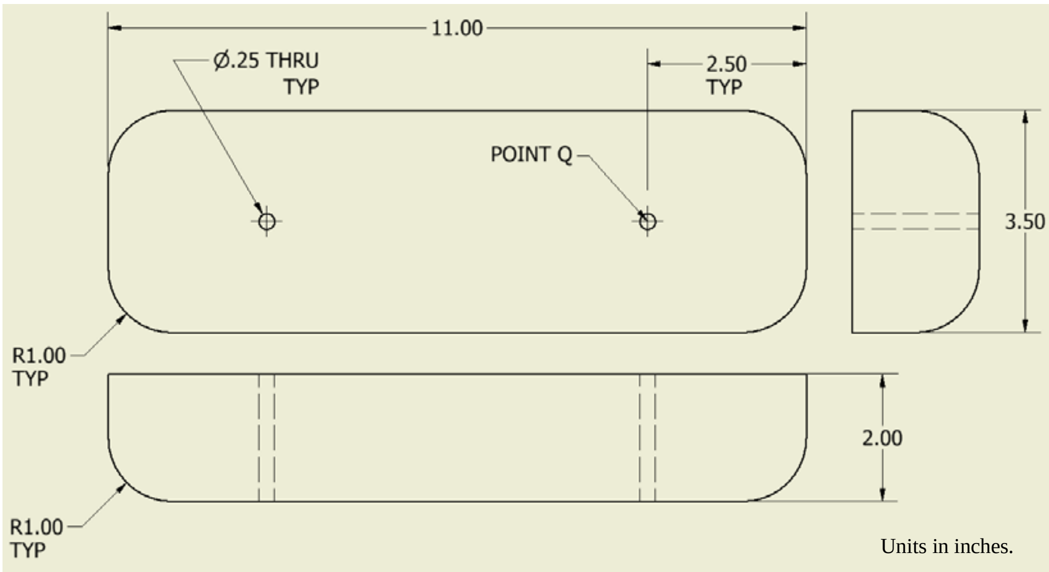

Figure 38: Shoulder/Hip Probe.

Appendix A – Proposed Occupant Protection Performance Requirements.

A.1 Occupant Retention System. Each vehicle shall restrict occupant egress and excursion in order to restrain occupants under crash conditions.

A.1.1 General Test Conditions.

(1) Probes shall be allowed to rotate through a universal joint.

(2) Forces shall be quasi-statically applied and held for 10 seconds.

A.1.2 Shoulder/Hip Performance Requirement. The vehicle structure or restraint system must absorb the force specified in A.1.5 with less than 25 mm (1 inch) of permanent deflection along the horizontal lateral axis.

A.1.3 Location of Applied Force. Locate point R on the vehicle, as shown in Figure 2. All measurements for the point shall be taken with respect to the base of the seatback. The base of the seatback lies on the surface of the seat cushion along the centerline of the seating position and is measured without a simulated occupant weight on the seat. Point R is located 432 mm (17 inches) along the seat back above the base of the seatback. The point is 152 mm (6 inches) forward of and perpendicular to the seatback surface as shown in the figure. For an adjustable seat, Point R is determined with the seat adjusted to the rear-most position. Point R2 applies to an adjustable seat and is located in the same manner as Point R except that the seat is located in the forward-most position.

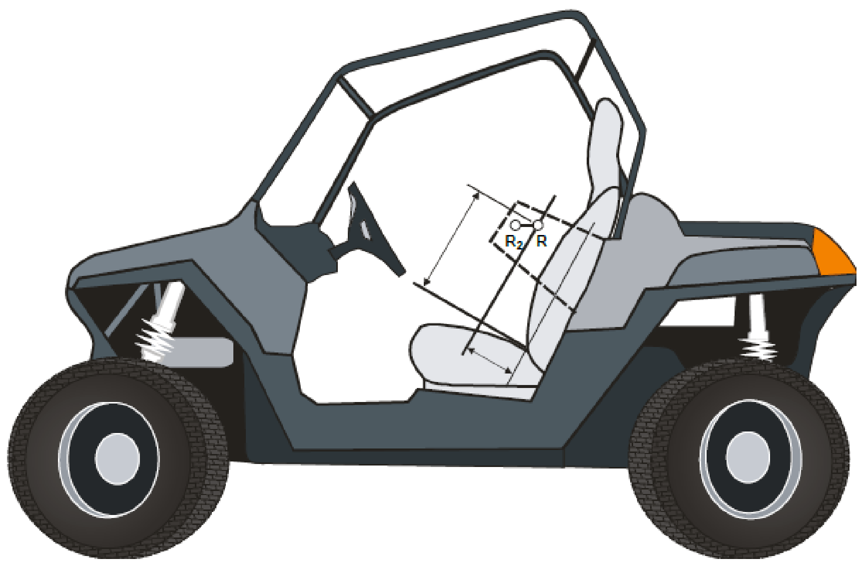

Figure 2. Point R in Shoulder/Hip Area[42]

A.1.4 Barriers. Remove all occupant protection barriers that require action on the part of the consumer to be effective (i.e. remove nets). Passive barriers that do not require any consumer action are allowed to remain.

A.1.5 Shoulder/Hip Test Method. Apply a horizontal, outward force of 725 N (163 lbf.). Apply the force through the upper arm probe shown in Figure 3. The upper arm probe shall be oriented so that Point Q on the probe is coincident with Point R for a vehicle with a fixed seat, or Point Q shall be coincident with any point between R and R2 for a vehicle with an adjustable seat. The probe's major axis shall be parallel to the seatback angle at a point 17 inches along the seat back above the base of the seatback

[42] American National Standard for Recreational Off-Highway Vehicles (ANSI/ROHVA 1-2011). (2011). Irvine, CA: Recreational Off-Highway Vehicle Association (ROHVA).

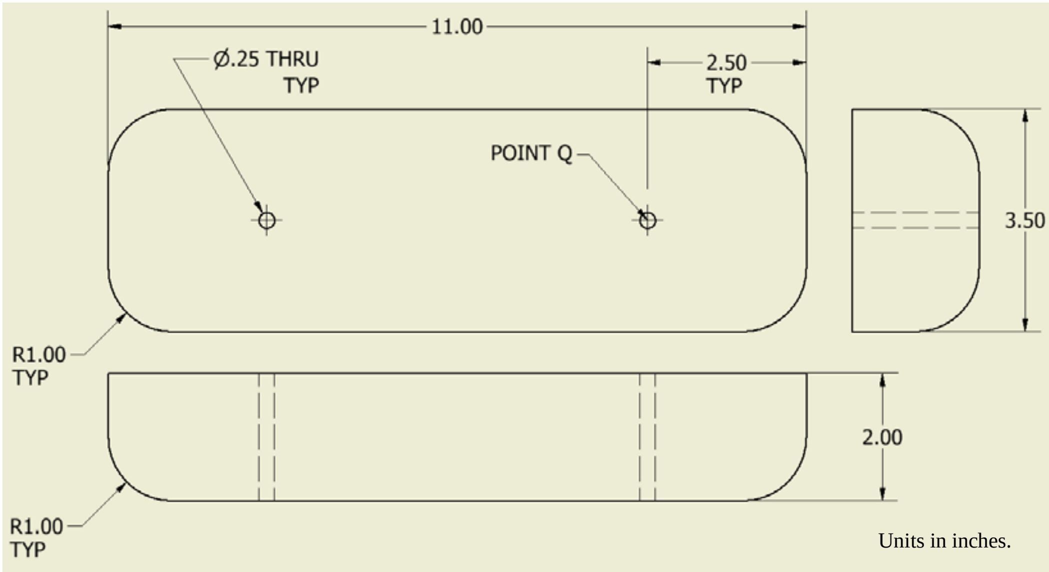

Figure 3. Shoulder/Hip Zone Probe

Appendix B – Seat Belt Inertial Lock Testing

August 17, 2012

TO: Mark Kumagai, Director
Division of Mechanical Engineering
Directorate for Engineering Sciences

FROM: Michael Arensmeier, Engineering Trainee
Division of Mechanical Engineering
Directorate for Engineering Sciences

SUBJECT Seat Belt Inertial Lock Testing

I. Introduction

The goal of this test series is to identify the inertial locking capabilities of five Recreational Off-Highway Vehicle (ROV) seat belt systems. ROVs are motorized vehicles that can exceed 30 mph, having four or more low-pressure tires designed for off-road use and intended by the manufacturer primarily for recreational use by one or more persons, as shown in Figure 1.

Seat belts are designed to lock automatically under different conditions, such as exceeding a seat belt payout speed, exceeding a tip angle, or by accelerating beyond a certain level. In this study, CPSC staff investigated the presence of a seat belt inertial lock, which is intended to lock the seat belt spool reel when the ROV tips beyond a certain angle or when the lateral acceleration exceeds a tolerance. Locking the seat belt spool can reduce seat belt payout and can help to restrain an occupant under certain crash conditions.

Figure 1: Recreational Off-Highway Vehicle (ROV)

II. Samples

The five seat belt systems shown in Figures 2 through 6 were from ROV Vehicles A, B, C, H, and I. The seat belt systems are from the front passenger side seat of each test vehicle. Each seat belt system was comprised of a retractor, D-ring, and buckle. The retractor, generally located below the occupant, and the D-ring, which is located above the occupant's shoulder, were used as reference points for inertial lock testing.

Figure 2: Vehicle A Belt System

Figure 3: Vehicle B Belt System

Figure 4: Vehicle C Belt System

Figure 5: Vehicle H Belt System

Figure 6: Vehicle I Belt System

III. Testing

The purpose of the test was to determine the presence of an inertial locking system on each of the five samples. The test fixture, shown in Figure 7, was designed to simulate a conventional seat belt configuration found in an ROV. The test fixture included a location to mount the retractor and the D-ring. CPSC staff attached an inclinometer to the side of the structure so that staff could measure the angle.

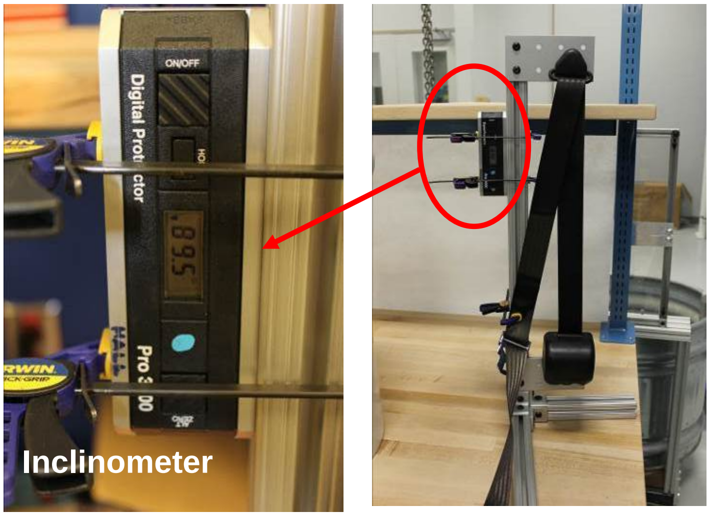

Figure 7. Seat Belt Inertial Lock Test Set-up

First, CPSC staff attached the sample to the fixture with the retractor on the bottom bracket and the D-Ring on the top bracket, as shown in figure 7. Then, staff gradually rotated the fixture from a vertical towards a horizontal position, while lightly pulling on the shoulder belt segment, as shown in Figure 8. Once the belt stopped, staff determined that the inertial lock system had activated, and staff recorded the angle from horizontal and calculated the angle to the vertical plane.


Figure 8: Test in process.

After completing the tests, staff carefully disassembled the seat belt system to identify the mechanics behind the inertial locking features. Figures 9 and 10 show one inertial lock in the engaged and disengaged positions.

In this particular system, a cup on the locking lever rests on top of a metallic ball. If the retractor experiences a tipping event, the metallic ball will move relative to the cup. As the metallic ball moves from the center of the cup towards the edge, the locking lever moves upward and engages against a saw-tooth feature on the external spool gear, which subsequently locks the belt spool reel inside the retractor.

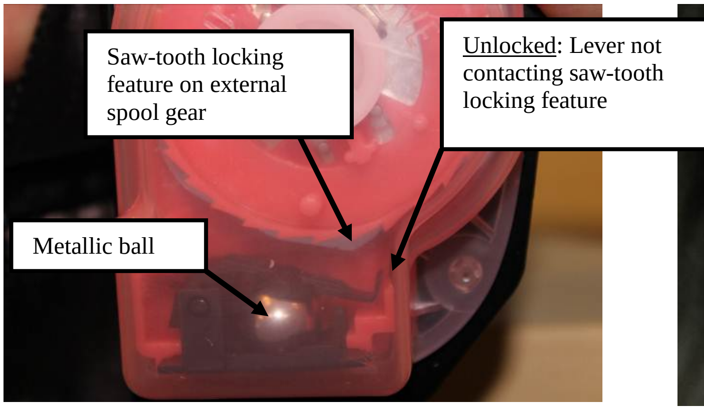

Figure 9: Inertial Lock System - Unlocked

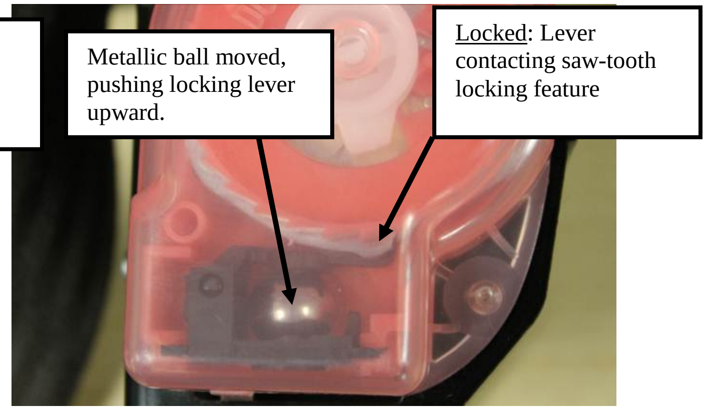

Figure 10: Inertial Lock System - Locked

IV. Results and Discussion

The results, as seen in Table 1, indicate that three retractors had inertial locking systems, while two retractors did not. Vehicle B locked at 56.0 degrees, while Vehicle C locked at 53.2 degrees, and Vehicle I locked at 54.3 degrees. The remaining two vehicles, Vehicle A and Vehicle H, did not lock. CPSC staff disassembled the two non-locking retractors and confirmed that the designs did not incorporate inertial spool locking features.

Table 1. Seat Belt Inertial Lock Angle Test Data

Model	Test #	Angle of Lock Deg from Vert
Vehicle B	1	57.9
	2	55
	3	55.5
	4	53.8
	5	56.7
	6	56.8
	7	57.2
	8	54.9
	9	55.9
	10	56.6
	Average	**56.0**
	St Dev	**1.2**
Vehicle I	1	54.7
	2	54.8
	3	53.9
	4	54.5
	5	54.5
	6	53.7
	7	53.7
	8	54.4
	9	55.5
	10	53.5
	Average	**54.3**
	St Dev	**0.6**
Vehicle C	1	54.3
	2	53.6
	3	54
	4	53.3
	5	52.2
	6	50.2
	7	54.5
	8	53.3
	9	53.9
	10	52.8
	Average	**53.2**
	St Dev	**1.3**
Vehicle A	1	DID NOT LOCK
	Average	**#DIV/0!**
	St Dev	**#DIV/0!**
Vehicle H	1	DID NOT LOCK
	Average	**#DIV/0!**
	St Dev	**#DIV/0!**

VI. Conclusions

The testing separated the seat belt systems into two distinct groups: those with and those without inertial locking systems. Vehicle B, Vehicle C, and Vehicle I, all had inertial locking features. Vehicle A and Vehicle H did not.

TAB I

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
4330 EAST WEST HIGHWAY
BETHESDA, MD 20814

Memorandum

Date: December 9, 2013

TO : George Borlase, Assistant Executive Director
Office of Hazard Identification and Reduction

THROUGH: Mark Kumagai, Division Director
Division of Mechanical Engineering

FROM : Caroleene Paul, ESME
Directorate for Engineering Sciences

SUBJECT : Proposed Performance Requirements for Seat Belt Speed Limiter on Recreational Off-Highway Vehicles (ROVs)

I. Background:

Product

Recreational off-highway vehicles (ROVs) are motorized vehicles designed for off-highway use and have the following features: four or more pneumatic tires designed for off-highway use; side-by-side seating for two or more occupants; automotive-type controls for steering, throttle, and braking; and a maximum vehicle speed greater than 30 miles per hour (mph). Additionally, ROVs are designed with narrow track widths and high ground clearance for use on off-road trails. A negative consequence of this tall and narrow configuration is low vehicle lateral stability and a high risk of rollovers. ROVs are equipped with rollover protective structures (ROPS), seat belts, and other restraints for the protection of occupants in the event of a rollover. However, the vehicles are also designed with an open-compartment configuration that increases the likelihood of complete or partial ejections of the occupants in a rollover event.

Seat belts are the primary safety device that prevents ejection of an occupant from an ROV during a rollover event. A three-point seat belt restrains the upper and lower part of a person to the seat of a vehicle to prevent ejection of that person during a vehicle crash.[1] Federal Motor Vehicle Safety Standards (FMVSS) 208 *Occupant Crash Protection* and FMVSS 209 *Seat Belt Assemblies* stipulate requirements for seat belts in passenger vehicles and specify performance requirements for seat belts to restrain passengers in crash simulations.[2]

Incident Data

Lateral rollover

[1] US patent 3,043,625. Retrieved at: http://www.google.com/patents/US3043625.
[2] 49 CFR § 571.208 Standard No. 208; Occupant crash protection and § 571.209 Standard No. 209; Seat belt assemblies.

CPSC staff reviewed 428 ROV-related incidents from the Injury and Potential Injury Incident (IPII) and In-Depth Investigation (INDP) databases occurring between January 1, 2003 and December 31, 2011, and received by December 31, 2011 (Garland, 2012). Of the 428 reported incidents, 291 (68 percent) involved lateral rollover of the vehicle. Of the 224 fatal incidents, 147 (66 percent) involved rollover of the vehicle.

Seat Belt Use

From the 428 ROV-related incidents reviewed by CPSC staff, 817 victims were reported to be in or on the ROV at the time of the incident and 610 (75 percent) were known to have been injured or killed. Seatbelt use is known for 477 of the 817 victims; of these, 348 (73 percent) were not wearing a seatbelt at the time of the incident.

Of the 610 fatal and nonfatal victims who were in or on the ROV at the time of the incident, 433 (71 percent) were ejected partially or fully from the ROV, and 269 (62 percent) of these victims were struck by a part of the vehicle, such as the roll cage or side of the ROV, after ejection. Seat belt use is also known for 374 of the 610 victims; of these, 282 (75 percent) were not wearing a seat belt.

Of the 225 fatal victims who were in or on the ROV at the time of the incident, 194 (86 percent) were ejected partially or fully from the vehicle, and 146 (75 percent) were struck by a part of the vehicle after ejection. Seat belt use is known for 155 of the 194 ejected victim; of these, 141 (91 percent) were not wearing a seat belt.

Front seat occupants

A total of 826 victims were involved in the 428 ROV-related incidents reviewed by CPSC staff. Of these victims, 353 (43 percent) were known to be driving the ROV and 203 (24 percent) were known to be a passenger in the front seat of the ROV. Of the 231 reported fatalities, 141 (61 percent) were the driver of the ROV, and 49 (21 percent) were the right front passenger in an ROV.

Recreational Off-Highway Vehicle Association (ROHVA)'s Analysis

The Recreational Off-Highway Vehicle Association (ROHVA) performed an analysis of hazard and risk issues associated with ROV-related incidents and determined that lack of seat belt use is the top incident factor (Heiden, 2009). Additionally, ROHVA stated: "Based on the engineering judgment of its members and its review of ROV incident data provided by the CPSC, ROHVA concludes that the vast majority of hazard patterns associated with ROV rollover would be eliminated through proper seat belt use alone" (Yager, 2011).

II. Occupant Protection Testing by CPSC staff

To explore occupant protection performance testing with a new product for which no standard test protocol exists, CPSC staff contracted with Active Safety Engineering (ASE) to perform exploratory pilot studies to evaluate test methodologies that could be used to investigate occupant protection performance in ROV rollovers (Monk, 2010). ASE used a HYGE™ accelerator sled to conduct dynamic rollover simulations on sample ROVs, occupied by a Hybrid III 50th percentile male anthropomorphic test device (ATD).[3] The HYGE™ system causes a stationary vehicle, resting on the test sled, to roll over by imparting a short-duration lateral acceleration to the test sled. As shown in Figure 1, the torso of an unbelted ATD ejected partially from the ROV during a simulated rollover (see Figure 1). In comparison, the torso of a belted ATD remained in the ROV during a simulated rollover (Figure 2). The tests demonstrated that use of a seat belt prevented full ejection of the ATD's torso.

Figure 1. Unbelted occupant test using HYGE™ sled test device.

Figure 2. Belted occupant test using HYGE™ sled test device.

In a follow-up pilot study, ASE used a deceleration platform sled rather than a HYGE™ accelerator sled to impart the lateral acceleration to the test vehicle (Monk, 2010). The deceleration sled is more accurate than the HYGE™ sled in re-creating the lower energy rollovers associated with ROVs.

As shown in Figure 3, an unbelted ATD ejected fully from the vehicle during tests conducted at the rollover threshold of the ROV. In comparison, a belted ATD partially ejected from the vehicle during tests conducted at the same lateral acceleration (Figure 4). These exploratory tests with belted and unbelted occupants indicate the importance of using seat belts to prevent full ejection of the occupant during a rollover event.

[3] HYGE Inc. manufactures crash simulation systems that simulate the effects of a collision in an acceleration rather than a deceleration mode. HYGE™ systems are used by automobile manufacturers to test passenger safety devices such as seats, seat belts, child restraints, and air bags.

Figure 3. Unbelted occupant test using deceleration sled test device.

Figure 4. Belted occupant test using deceleration sled test device.

After completion of the pilot studies, CPSC staff contracted with SEA, Limited (SEA) to conduct more advanced occupant protection performance evaluations of ROVs using the SEA roll simulator (Morr, 2012). An ROV experiences both lateral acceleration and lateral roll during a rollover event; therefore, an accurate simulation of an ROV rollover must recreate both values. The SEA roll simulator produces lateral accelerations using a deceleration sled and produces roll rates using a motor to rotate the test sled (Figure 5).[4] The SEA roll simulator is able to perform multiple tests of a test ROV at set values of acceleration and roll rate.

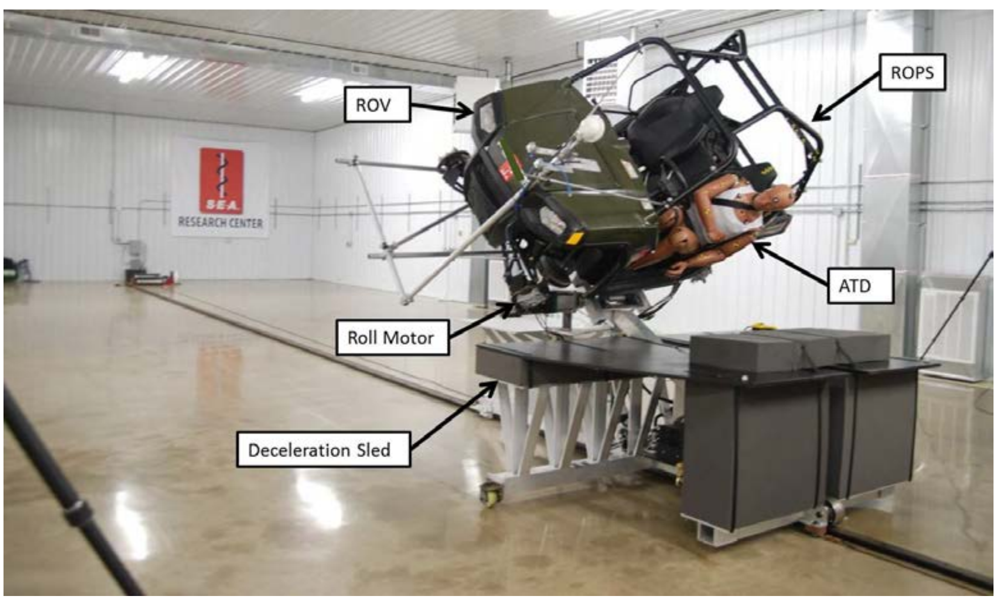

Figure 5. SEA Roll Simulator

[4] Zagorski, S. B., Heydinger, G. J., Sidhu, A., Guenther, D.A., and Andreatta, D. A. (2011). Modeling and Validation of a Roll Simulator for Recreational Off-Highway Vehicles. IMECE 2011-6203.

To measure the range of lateral accelerations and roll rates of actual ROV rollovers, SEA conducted autonomous full-vehicle rollovers of instrumented ROVs, under tripped and untripped conditions (Yoder et al., 2012). [5] SEA validated the roll simulator as an accurate simulation of ROV rollover and occupant kinematics by comparing roll rates, lateral accelerations, and ATD ejections that were created by the simulator with actual values measured during autonomous rollover. Results show that the roll simulator accurately re-creates the conditions of an ROV rollover.

Results of ROV roll simulation tests, with belted and unbelted ATDs, indicate that seat belt use prevents full ejection of an occupant during a rollover. An unbelted ATD ejected fully from the ROV in tests that simulated untripped vehicle rollover (Figure 6). In comparison, belted ATDs remained within the ROV in test runs under the same conditions (Figure 7). Although the head of some belted ATDs moved outside the ROPS in some model ROVs, none of the belted ATDs were ejected fully from the vehicle.

Figure 6. SEA roll simulator test of unbelted ATD.

Figure 7. SEA roll simulator test of belted ATD.

Summary

Results of CPSC staff's exploratory testing of belted and unbelted occupants in simulated ROV rollover events showed that the forces during a rollover event eject unbelted occupants from the vehicle, while belted occupants remain within the vehicle. This observation corresponds with the incident data for ROV rollovers, where 91 percent of the fatal victims who were partially or fully ejected from the vehicle were not wearing seat belts. Of those incidents that involved occupant ejection, many occupants were killed when struck by the vehicle after they were ejected.

[5] Untripped rollovers occur when a vehicle is turning and lateral forces created by friction between the vehicle's tires and the ground cause the vehicle to rollover. Tripped rollovers occur when a vehicle is sliding sideways and strikes an object, such as a curb, which causes the vehicle to roll over.

III. Literature Review

Seat Belt Reminders (Automotive)

Using seat belts is one of the most effective strategies for avoiding death and injury in motor vehicle crashes (Dinh-Zarr et al. 2001, 48). The National Highway Traffic Safety Administration (NHTSA) has shown a 45 percent reduction of fatality risk in automobiles with the use of 3-point belts (NHTSA, 2001). However, the safety belt restraint system is only effective if it is used.

Strategies for increasing seat belt use in passenger vehicles date to January 1, 1972, when the National Highway Traffic Safety Administration (NHTSA) required all new cars to be equipped with passive restraints or with a seat belt reminder system that used a visual flashing light and audible buzzer that activated continuously for one minute if the vehicle was placed in gear with occupied front seat belts not belted (Robertson, 1975). Most automobile manufacturers opted for the seat belt reminder system. Analysis of observed seat belt use in vehicles with and without a continuous visual-audible reminder system showed no statistical increase in seat belt use (Robertson and Haddon, 1974). In 1973, NHTSA required that all new cars be equipped with an ignition interlock that allowed the vehicle to start only if the driver was belted. The ignition interlock was meant to be an interim measure until passive airbag technology matured, but public opposition to the technology led Congress to rescind the legislation and to prohibit NHTSA from requiring either ignition interlocks or continuous audible warnings that last more than 8 seconds (TRB, 2003; 15 U.S.C. Section 1410 (b)). To comply with the legislation, NHTSA revised the Federal Motor Vehicle Safety Standard (FMVSS) to require a seat belt reminder with warning light and audible buzzer that lasts 4 seconds to 8 seconds when front seat belts are not fastened at the time of ignition. This standard still applies today (TRB, 2003; 15 U.S.C. section 1410 (b)).

After 1975, the U.S. federal government turned to legislating safety belt use, and in the 1980s states were urged to pass laws that required safety belt use. Although these laws were initially unpopular, there is clear evidence that these laws have been successful in increasing safety belt use over the years, from nationwide rates of 14 percent seat belt use in 1983, to 84 percent seat belt use in 2011 (Perkins et al, 1983; Chen, 2011). Jurisdictions with stronger seat belt enforcement have higher use rates (Chen, 2011).

Seat Belt Users (Automotive)

Seat belt users can be loosely separated into three categories: full-time users, part-time users, and nonusers. Approximately 88 percent of drivers can be considered full-time seat belt users, although 6 percent of those full-time seat belt users immediately admitted to part-time use in the past week (Boyle and Lampkin, 2008). Of the drivers who do not regularly wear a seat belt, part-time users substantially outnumber nonusers. Accordingly, a greater increase in seat belt use may be achieved by targeting part-time users rather than nonusers (Bradbard et al., 1998). Part-time users and nonusers give different reasons for not wearing seat belts. Part-time seat belt users consistently cite forgetfulness and perceived low risk, such as driving short distances or on familiar roads, as reasons for not using seat belts (Block, 1998; Bradbard et al., 1998; Harrison and Senserrick, 2000; Bentley et al., 2003; Boyle and Vanderwolf, 2003; Eby et al., 2005; Boyle and Lampkin, 2008). Nonusers tend to cite negative personal reasons, such as discomfort and freedom of choice, as reasons for not using seat belts.

Observational studies indicate that seat belt use is consistently lower among males, drivers ages 16 to 24, drivers in rural areas, and pickup truck drivers (Perkins et al., 1983; Block, 1998; NHTSA MVOSS, 2000; Boyle and Vanderwolf, 2003; NHTSA MVOSS, 2004; Boyle and Lampkin, 2008; Pickerall and Ye, 2010).

Seat Belt Reminders – Effectiveness

One approach to increasing vehicle occupant seat belt use is to provide in-vehicle reminders to encourage occupants to fasten their seat belts. However, possible systems vary considerably in design, intrusiveness, and, most importantly, effectiveness.

Observational studies of cars equipped with the original NHTSA-required seat belt reminders found no significant difference in seat belt use between vehicles equipped with the continuous one minute visual-audio system and vehicles not equipped with the reminder system (Robertson and Haddon, 1974; Robertson, 1975). After NHTSA adopted the less stringent 4-second to 8-second visual and audio reminder system requirements, NHTSA conducted observational and phone interview studies and concluded that the less intrusive reminder system was also not effective in increasing seat belt use (Westefeld and Phillips, 1976).

Observational studies found that ignition interlocks were more effective than visual-audio reminders, and ignition interlocks more than doubled seat belt use rates from 28 percent to 67 percent (Westefeld and Phillips, 1976). However, over time, many motorists eventually bypassed the system and seat belt use rates in cars with the ignition interlock systems decreased by 29 percentage points in cars manufactured in 1974 and by 20 percentage points in cars manufactured in 1975 (Westefeld and Phillips, 1976). Despite the effectiveness of the ignition interlock, the feature was not well accepted by the public in terms of being forced to fasten their seat belts. Many individuals sent letters of complaint to their Congressmen, and in the 1974 Motor Vehicle and School Bus Amendment passed by Congress, NHTSA was prohibited from having a standard which required an interlock system (Westefeld and Phillips, 1976).

The relationship between seat belt reminder intrusiveness and effectiveness was seen in focus group studies that found low-annoyance reminders are ineffective and high-annoyance reminders are effective but are more likely to be unacceptable and deactivated (Bradbard et al., 1998). In fact, the interlock was the most effective reminder but was also the most unacceptable. Similarly, a study of injured drivers in Europe found no increase in seat belt use in vehicles fitted with only a visual reminder compared to increased seat belt use in cars with visual *and* audible reminders (Bylund, 2001). Interviews conducted in Sweden (Dahlstedt, 1999) and focus groups in Australia (Harrison et al., 2000) found that visual-audio reminder systems that increase in intensity with speed were generally acceptable to drivers.

Ford Motor Company was the first U.S. manufacturer to introduce vehicles equipped with enhanced seat belt reminders (ESBR) with visual and audio reminders that exceeded the 4-second to 8-second time requirement in FMVSS 208 (TRB, 2003). The Ford BeltMinder™

system flashes and chimes intermittently for up to 5 minutes if drivers or front passengers fail to buckle their seat belts. This system is substantially more intrusive than an 8-second reminder. The Ford BeltMinder™ system increased driver seat belt use by 5 percent, and was well received by drivers (Williams et al., 2002).

American Honda Motor Company (Honda) introduced an enhanced seat belt reminder system with an intermittent flashing light and chime that lasts for at least 9 minutes if the driver or front passenger fails to buckle their seat belts. Honda's seat belt reminder system increased drivers' seat belt use by 6 percent and was also well received by drivers (Ferguson et al., 2006).

NHTSA conducted focus groups studies comparing four types of ESBR systems: (1) the Ford BeltMinder™; (2) a visual and audio reminder system that increased in intensity with vehicle speed; (3) an entertainment interlock system; and (4) a transmission interlock system that prevents the transmission from being put in gear (Bentley et al., 2003). The study found that the more intrusive systems were perceived to be more effective but also more unacceptable (Bentley et al., 2003). Nonusers rated the most intrusive transmission interlock system to be the most effective. However, many nonusers and full-time users had the strongest negative reaction to the system because the system infringed on their decision to wear their seat belt (Bentley et al., 2003).

A national research project by the University of Michigan Transportation Research Institute endeavored to promote safety belt use in the United States by developing an effective in-vehicle safety belt reminder system. The project authors performed literature reviews and conducted surveys and focus groups to design an optimal safety belt reminder system. The authors concluded that principles for an optimal safety belt reminder system include the following (Eby et al., 2005):

1. The full-time safety belt user should not notice the system.
2. It should be more difficult to cheat on the system than to use the safety belt.
3. Permanent disconnection of the system should be difficult.
4. The system should be reliable and have a long life.
5. Crash and injury risk should not be increased as a result of the system.
6. System design should be based on what is known about the effectiveness and acceptability of system types and elements.
7. System design should be compatible with the manufacturer's intended purpose/goals for the system.

The project authors acknowledge that seat belt users range from those who always wear seat belts to those who never wear seat belts, and the behavior of each category of users is motivated by different factors. Figure 7 shows the recommended guidelines for seat belt reminder systems, depending on the range in intrusiveness and type of user. The authors conclude that nonusers require the most intrusive system to change behavior and will buckle the seat belt or disconnect the system (Eby et al., 2005).

Intrusiveness				
Safety Belt Use Group	**Full-time user**	**Part-time user: cognitive/personal**	**Part-time user: low perceived risk**	**Full-time nonuser**
System Goals	**System invisible to driver**	**Effectiveness and user acceptability are maximized**	**Effectiveness is maximized; acceptability is minimized**	**Acceptability is minimized**
Type of System Engaged	**No system engaged**	**Reminder system**	**Annoyance system**	**Interlock system**

Figure 7. System goals and acceptable in-vehicle safety belt promotion technology [Source: Eby et al., 2005]

NHTSA conducted a study of ESBR effectiveness that compared results of controlled experiments with field observations of actual seat belt use. Among the findings of the ESBR effectiveness report are:

1) systems with only visual reminders are not effective;
2) ESBR systems, in general, promote greater seat belt use by 3 to 4 percentage points;
3) more annoying systems are more effective, but that creates the challenge of designing an effective system that is acceptable;
4) potential gains in seat belt use come not from simply reminding users but also from motivating users, such as tying seat belt use to elimination of an annoyance; and
5) the positive effects of ESBRs on belt use were more pronounced for the low belt use propensity groups (Lerner et al., 2007; Freedman et al., 2009).

Seat Belt Reminder – Innovative Technologies in Passenger Vehicles

Despite public education and enforcement efforts, and the presence of enhanced seat belt reminders, seat belt use rates in the United States have increased dramatically but have not reached 100 percent (Van Houten et al., 2011; Chen and Ye, 2011).

Researchers seeking to develop more innovative in-vehicle technology beyond visual and audible warnings looked at delaying the ability of a driver to shift a vehicle into gear if the seat belt is not buckled (Van Houten et al., 2005; Van Houten et al., 2009). The system allowed unbuckled drivers to start the vehicle but the vehicle could only be placed into gear after a delay of several seconds. While the technology significantly increased seat belt use among the commercial fleet drivers studied, some drivers consistently bypassed the system, and many drivers reported that the system would be more acceptable if it did not force drivers to buckle when reversing and when moving vehicles at slow speeds for a short distance (Van Houten et al., 2009).

Building on the gear-shift delay technology, researchers developed a haptic feedback system (a system that recreates the sense of touch by applying force or vibration to the user) that made it more difficult for drivers to depress the gas pedal when the vehicle exceeded 25 mph if the driver's seat belt was not buckled (Van Houten et al., 2011). Although the drivers could continue to drive unbelted and exceed 25 mph by pressing harder on the throttle pedal, they needed to exert constant mental and physical effort to do so. The feedback disappeared once the driver's seat belt was buckled. The pilot study found that that the haptic feedback technology was associated with 100 percent seat belt use on the seven commercial drivers who participated in the study (Van Houten et al., 2011). Occasionally drivers would forget to buckle during a trip and, in all instances, they buckled up within 25 seconds of the pedal counter-force being applied. The participants' comments were overwhelmingly positive, in part, because the system was a consistent and forceful motivator to buckle up without affecting the general operation of the vehicle (Van Houten et al., 2011).

A follow-up study on the haptic feedback study focused on 20 young drivers ranging in age from 18 to 21, and a feedback force set at 20 mph instead of 25 mph (Hilton, 2012). The study results showed that the mean seat belt use increased from 54.7 percent to 99.7 percent, and the few instances where seat belts were not worn were on trips of 2 minutes or less. Most significantly, participants rated the system as very acceptable and agreeable (9 out of a 10 point scale).

The Insurance Institute for Highway Safety (IHHS) conducted a national telephone survey of 1,218 adult drivers and passengers to collect information about attitudes towards seat belt use and in-vehicle technologies to encourage seat belt use (Kidd et al., 2013). Part-time users and nonusers were targeted for opinions about different types of reminders and reminder strategies. Driving a short distance (67 percent), forgetting (60 percent), and comfort (47 percent) were common reasons why part-time seat belt users do not wear seat belts. Comfort (77 percent), not needing a seat belt (54 percent), and disliking being told what to do (50 percent) were common reasons why nonusers do not wear seat belts.

The IHHS survey asked respondents if they would support the following seat belt interlocks to increase seat belt use if the driver is not buckled:

- an ignition interlock that prevents the vehicle from starting,
- a speed interlock that limits the vehicle speed to 15 mph,
- a transmission interlock that prevents the vehicle from being placed in gear,
- an entertainment system interlock that prevents use of the entertainment system.

The study also compared respondent attitudes towards other seat belt reminders like accelerator pedal feedback, auditory chimes, and visual lights or text displays. Results of the survey indicate respondents opinions to verbal descriptions of various situations and not actual experience with the described technologies. Nevertheless, results indicate that:

- Ignition interlocks would be most effective at changing part-time users and nonuser habits, but would be least acceptable to all drivers.
- Speed interlocks would encourage 56 percent of part-time users and 33 percent of nonusers to buckle up, but the described technology is not acceptable to 45 percent of full time users, 61 percent of part-time users, and 80 percent of nonusers.
- Technologies that activate after the vehicle is moving would be the least intrusive to full-time users and part-time users.

- Auditory and haptic belt reminders would be more effective than visual reminders, and are more acceptable to all drivers.

Seat Belt Reminder – Innovative Technologies in ROVs

In 2010, Bombardier Recreation Products (BRP) introduced the Can-Am Commander 1000 ROV with a seat belt speed limiter system that restricts the vehicle speed to 9 mph if the driver's seat belt is not buckled. CPSC staff performed dynamic tests to verify that the vehicle's speed was limited when the driver's seat belt was not buckled. On level ground, the vehicle's speed was limited to 6 to 9 mph when the driver was unbelted, depending on the ignition key and transmission mode selected (Lee, 2012).

In 2013, BRP introduced the Can-Am Maverick vehicle to the market as a sport oriented ROV that also includes a seat belt speed limiter system. CPSC staff did not test the Maverick vehicle because a sample vehicle was not available for testing.

In 2014, Polaris Industries (Polaris) announced that 2015 Ranger and RZR models will offer an interlocking seatbelt system that limits the speed of the vehicle to 15 mph if the seatbelt is not engaged.[6] CPSC staff has not tested these vehicles because they are not yet available on the market.

User Acceptance of Innovative Technologies in ROVs

CPSC staff believes studies of seat belt reminder systems on automobiles are an appropriate foundation for ROV analysis because ROVs are typically driven by licensed drivers and the seating environment is similar to an automobile.[7] However, staff believes data on ROV users' experience and acceptance of seat belt reminders is necessary to validate the analysis.

CPSC staff was not aware of any studies that provide data on the effectiveness of seat belt reminder systems on ROVs or user acceptance of such technologies. Therefore, staff contracted with Westat, Inc. (Westat) to conduct focus groups with ROV users to explore their opinions of seat belt speed limitation systems on ROVs. Phase 1 of the effort conducted focus groups of ROV users and asked questions about ROV use and user opinions of the Can-Am speed limitation system that were shown in a video to the participants. Results of Phase 1 were used to develop the protocol for Phase 2, in which participants drove an ROV equipped with a seat belt speed limitation system. Phase 2 of the effort conducts focus groups of ROV users who provide feedback after driving and interacting with an ROV that is limited at 10 mph, 15 mph, and 20 mph.

Results of Phase 1 of the Westat study indicate that the ROV user participants (Newens, 2014):

[6] Retrieved at: http://www.weeklytimesnow.com.au/machine/sidebyside-vehicles-soon-to-get-safety-improvements/story-fnkerd6b-1227023275396
[7] Owner's manuals and warning labels on ROVs state that ROV operators should be 16 or older with a valid driver's license (ANSI/ROHVA 1-2011).

- admit to being part-time seat belt users,
- cite familiarity and low-risk perception as reasons for not wearing seat belts,
- value easy ROV ingress and egress over seat belt use,
- generally travel around 5 mph when driving on their own property and overall drive 15 to 30 mph for typical use,
- had negative personal and positive parental reactions to the speed limitation technology at 10 mph,
- were more accepting of the speed limitation technology if the speed was raised to 15 mph or if the system was tied to a key control.

Phase 2 of the Westat study is ongoing and a report of the results is expected by December 2015. The results will provide data on ROV users' acceptance of a seat belt speed limitation technology with a threshold speed of 10 mph, 15 mph, and 20 mph. Staff believes the results will provide additional rationale for determining a threshold speed for a seat belt speed limitation technology that balances users acceptance (as high a speed as possible) with safe operation of the ROV without seat belt use (as low a speed as possible).

IV. Voluntary Standards

ANSI/ROHVA 1-2011, *American National Standard for Recreational Off-Highway Vehicles,* is the voluntary standard that was developed for ROVs by members of ROHVA. The latest revision of the standard was published in July 2011.

ANSI/OPEI B71.9-2012, *American National Standard for Multipurpose Off-Highway Utility Vehicles,* is the voluntary standard that was developed for ROVs by members of the Outdoor Power Equipment Institute (OPEI). The latest revision of the standard was published in March 2012.

ANSI/ROHVA 1-2011 and ANSI/OPEI B71.9 - 2012 specify that ROV manufacturers provide a visual seat belt reminder that remains active for at least 8 seconds after the vehicle is started (ROHVA, 2011; OPEI, 2012) . ANSI/OPEI B71.9 additionally specifies that the 8-second duration may be reduced if the driver's seat belt is latched during that time. The ROV seat belt reminder requirements are similar to the 4-second to 8-second visual and audio seat belt reminder requirements for automobiles specified in FMVSS 208. However, automobile manufacturers have long since exceeded such minimal seat belt reminder requirements because, as explained above, numerous studies have proven that effective reminder systems have to be more intrusive to motivate users to buckle their seat belts. The more intrusive reminders are more effective at changing user behavior, as long as the reminder is not so intrusive that users bypass the system.

CPSC staff believes the ANSI/ROHVA 1-2011 and ANSI/OPEI B71.9 - 2012 requirement for an 8-second seat belt reminder light is not adequate to meaningfully increase seat belt use rates in ROVs because the seat belt reminder system is not intrusive enough to motivate drivers and passengers to wear their seat belts. Results from past studies on automotive seat belt reminders concluded that the FMVSS 4-second to 8-second visual light and audio buzzer reminder system is ineffective. Additionally, an audible warning is not practical in the open environment of an

ROV, where the user's ability to hear a warning will be hindered by helmet use and vehicle-generated noise. ANSI/ROHVA 1-2011 limits ROV sound levels to 96 decibels (dB) and protection against the effects of noise exposure start at 90 dB according to Occupational Safety and Health Administration (OHSA) standard 1910.95.

V. **Proposed Requirements**

Overview

Using seat belts is one of the most effective strategies for avoiding death and injury in motor vehicle crashes (Dinh-Zarr et al. 2001, 48). Similarly, recommendations from ROV manufacturers and CPSC staff's occupant protection testing indicate that using seat belts is the most effective strategy to restrain occupants within an ROV during rollover, and to reduce deaths and injuries associated with occupant ejection. As with other motor vehicles, however, the safety belt restraint system is only effective if it is used.

Results of a literature review by CPSC staff (see Section III) indicate that:

- automobile seat belt reminders are more effective when the reminders are more aggressive or annoying but not so much so that users will reject or bypass the system
- visual-only reminders are not effective
- technologies that link vehicle performance to seat belt use are effective at changing user behavior to wear seat belts

The voluntary standards for ROVs (ANSI/ROHVA 1-2011 and ANSI/OPEI B71.9 – 2012) require an 8-second reminder light to motivate users to buckle seat belts; however, numerous automotive studies have already proven that visual-only reminders are not effective (Robertson and Haddon, 1974; Robertson, 1975, Westefeld and Phillips, 1976; Freeman et al., 2009). Therefore, CPSC staff believes the voluntary standard requirement does not adequately reinforce occupant seat belt use to provide maximum occupant protection during a rollover.

Based on CPSC staff's testing and literature review, and the low seat belt use rates in ROV-related incidents, staff believes a seat belt speed limiting system that restricts the maximum speed of the vehicle to 15 mph if any occupied front seats are not buckled, is the most effective method to increase seat belt use rates in ROVs. The system consistently motivates occupants to buckle their seat belts if the occupants want to travel faster than 15 mph; but the system is transparent to occupants who use the ROV at speeds below 15 mph and occupants who are already wearing their seatbelt.

Acceptance/Effectiveness

CPSC staff believes that in-vehicle technology that limits the speed of the ROV if the front occupied seats are not buckled will be accepted by ROV users because the speed limitation does not interfere with the operation of the ROV below the threshold speed, and users will be motivated to wear seat belts to exceed the threshold speed. This belief is based on automotive studies that showed drivers accepted an accelerator pedal haptic feedback system tied to seat belt use because the system did not interfere with the operation of the vehicle below a threshold speed, and drivers were willing to buckle their seat belts to access un-hindered speed capability of the vehicle (Van Houten, et al., 2011; Hilton, 2012).

In 2010, Bombardier Recreation Products (BRP) introduced the Can-Am Commander 1000 vehicle to the ROV market with a seat belt reminder system that limits the speed of the vehicle to approximately 9 mph if the driver's seat belt is not buckled. The Commander vehicle sold well in its first year on the market and has continued to make gains in the ROV market share.[8] BRP then introduced the Can-Am Maverick vehicle to the market in 2013 as a sport oriented ROV that also includes a seat belt speed limiter system. The Maverick vehicle has been reviewed positively by several publications with no negative reaction or rejection of the seat belt speed limitation system.[9] CPSC staff believes the continued sales and popularity of the Can-Am Commander and Can-Am Maverick vehicles indicate that users will accept a seat belt speed limiter system and that manufacturers are able to bring this technology successfully to market.

In 2014, Polaris announced that 2015 Ranger and RZR models will offer an interlocking seatbelt system that limits the speed of the vehicle to 15 mph if the seatbelt is not engaged. CPSC believes this decision by the leading ROV manufacturer also supports staff's conclusion that ROV users will accept limitation of the vehicle's speed that is tied to seat belt use.

<u>Speed Limit</u>

CPSC staff's literature review concludes that intrusive reminders are effective at changing user behavior, as long as the reminder is not so intrusive that users bypass the system. Limitation of vehicle speed is the intrusive reminder for ROV users to buckle their seat belt; therefore, staff believes that the threshold speed for a seat belt speed limitation system should be as high as possible to gain user acceptance (and reduce bypass of the system), but low enough to allow relatively safe operation of the vehicle.

CPSC staff believes 15 mph is the appropriate speed threshold for a seat belt speed limitation system for the following reasons:

Relatively Safe Operation of the ROV at 15 mph

- ANSI/NGCMA Z130.1 – 2004, *American National Standard for Golf Carts – Safety and Performance Specifications*, specifies the maximum speed for golf carts at 15 mph. This standard establishes 15 mph as the maximum acceptable speed for unbelted drivers and passengers (golf carts do not have seat belts or ROPS) in vehicles that are often driven in off-road conditions.
- SAE J2258 *Surface Vehicle Standard for Light Utility Vehicles* specifies a speed of 15 mph as acceptable for a vehicle, with a lateral stability of at least 25 degrees on a tilt table

[8] Market share is based upon a CPSC staff analysis of sales data provided by Power Products Marketing, Eden Prairie, MN (2014).
[9] Reviews retrieved at: http://utvguide.net/can_am_maverick_1000r_review.htm, http://atvillustrated.com/content/first-look-2013-canam-maverick-1000r, and http://www.outdoorlife.com/articles/gear/2013/10/sxs-review-2013-can-am-maverick-1000-full-line-model.

test, without seat belts or ROPS. This standard also establishes 15 mph as the maximum acceptable speed for unbelted drivers and passengers in vehicles that are driven in off-road conditions.

- Polaris Ranger and RZR model year 2015 ROVs will be equipped with a seat belt speed limiter that limits the vehicle speed to 15 mph if the driver's seat belt is not buckled. The decision by the largest manufacturer of ROVs establishes 15 mph as the maximum acceptable speed for unbelted ROV drivers.
- The fundamental relationship between speed and lateral acceleration is (Halliday, D. and Resnick, R., 1974):

$$A = V^2/R$$

where A = lateral acceleration
V = velocity
R = radius of turn

The minimum proposed lateral acceleration threshold at rollover for ROVs is 0.70 g (Teems, 2012), and the typical turn radius of an ROV is 16 feet[10]. Therefore, without any additional effects of tire friction, the speed at which rollover would occur during a turn on level ground is 13 mph.[11] In reality, friction at the tires would increase the speed at which rollover occurs above 13 mph.

User Acceptance of 15 mph

- Results of Westat's focus group study of ROV users indicate that ROV users value easy ingress and egress from an ROV and generally drive around 15 mph to 30 mph during typical use of the ROV. Users had a negative personal and positive parental reactions to a speed threshold of 10 mph and were more accepting of a speed limitation technology if the threshold speed was 15 mph.
- There are many situations where an ROV is used at slow speeds, such as mowing or plowing, carrying tools to jobsites, and checking property. CPSC staff believes a speed limitation threshold of 15 mph allows the most latitude for ROV users to perform utility tasks where seat belt use is often undesired.
- CPSC staff believes ROV user acceptance of a seat belt speed limitation system will be higher at 15 mph than the speed threshold of 9 mph on the Commander ROV. Although BRP continues to sell the Commander and Maverick ROVs with speed limitations set around 10 mph, preliminary focus group responses indicated that many ROV users believe 10 mph is too low a speed limit to be acceptable. The 15 mph threshold is 50 percent higher than a 10 mph threshold, and staff believes the difference will significantly increase user acceptance of the system. Staff believes Polaris's decision to include seat belt speed limiters with a 15 mph threshold speed in 2015 model year Rangers and RZRs supports staff's belief that user acceptance of a speed limitation system will be higher at 15 mph than 10 mph.

[10] Turn radius values retrieved at http://www.atv.com/features/choosing-a-work-vehicle-atv-vs-utv-2120.html and http://www.utvunderground.com/2014-kawasaki-teryx-4-le-6346.html.
[11] Staff recognizes that on a slope, the lateral acceleration due to gravity can cause ROV rollover at speeds below 15 mph. However, staff believes it is appropriate to use level ground as a baseline.

Passenger Seat Belt

Results of CPSC staff's review of 428 ROV-related incidents from the IPII and INDP databases indicate the following (Garland, 2012):

- the majority of victims were not wearing seat belts
- 24 percent of all victims were front passengers on the ROV
- 21 percent of fatal victims were front passengers on the ROV
- 64 percent of nonfatal front passenger victims were not wearing seat belts
- 80 percent of the fatal front passenger victims were not wearing seat belts

Based on this information, CPSC staff believes seat belt use would reduce the severity of injuries and the number of deaths of front passengers who were ejected from the ROV during rollover. Staff's economic analysis of the benefits of a seat belt speed limitation system on front passengers estimates an annual net benefit of $51 per ROV in use from reduced deaths and reduced injuries (Franklin, 2014). This is greater than the $26 per vehicle expected cost of this potential requirement.

Recommended Requirement

CPSC staff recommends that the Commission propose the following performance requirement for ROVs:

Seat Belt Speed Limitation System. An ROV shall not be capable of exceeding 15 mph when the seat belt of the driver seat and any occupied front passenger seat is not buckled. Visible feedback shall inform the driver that vehicle speed is limited until the seat belts of occupied seats are buckled.

Test Condition 1. Test conditions shall be as follows:

(1) The test ROV shall be a representative production vehicle. The ROV shall be in standard condition.
(2) ROV test weight shall be the vehicle curb weight, plus the test operator only. If the test operator weighs less than 215 lbs. (98 kg), then the difference in weight shall be added to the vehicle to reflect an operator weight of 215 lbs. (98 kg).
(3) Tires shall be inflated to the pressures recommended by the ROV manufacturer for the vehicle test weight.
(4) The test surface shall be clean, dry, smooth asphalt or concrete of less than a 1-degree (1.7%) grade.
(5) The driver's factory-installed seat belt shall not be buckled; however, the driver shall be restrained by a redundant restraint system for test safety purposes.

Test Condition 2. Test conditions shall be as follows:

(1) ROV test weight shall be the vehicle curb weight, plus the test operator and a passenger surrogate that will activate the seat occupancy sensor. If the test operator weighs less than 215 lbs. (98 kg), then the difference in weight shall be added to the vehicle to reflect an operator weight of 215 lbs. (98 kg).

(2) Tires shall be inflated to the pressures recommended by the ROV manufacturer for the vehicle test weight.
(3) The test surface shall be clean, dry, smooth asphalt or concrete of less than a 1-degree (1.7%) grade.
(4) The driver's seat belt shall be buckled. The front passenger's seat belt(s) shall not be buckled.

Test Procedure. Measure the maximum speed capability of the ROV under Test Condition 1 and Test Condition 2, using a radar gun or equivalent method. The test operator shall accelerate the ROV until maximum speed is reached and shall maintain maximum speed for at least 15 m (50 ft.). Speed measurement shall be made when the ROV has reached a stabilized maximum speed. A maximum speed capability test shall consist of a minimum of two measurement test runs conducted over the same track, one each in opposite directions. If more than two measurement runs are made, there shall be an equal number of runs in each direction. The maximum speed capability of the ROV shall be the arithmetic average of the measurements made.

Performance Requirement. The maximum speed capability of a vehicle with an unbuckled seat belt of any occupied front seat shall be 15 mph or less.

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TAB J

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
4330 EAST WEST HIGHWAY
BETHESDA, MD 20814

Memorandum

Date: August 11, 2014

TO : Joel Recht, Associate Executive Director
Office of Hazard Identification and Reduction

THROUGH : Mark Kumagai, Division Director
Division of Mechanical Engineering

FROM : Caroleene Paul, ESME
Directorate for Engineering Sciences

SUBJECT : Yamaha Rhino Incidents

I. Background:

In 2008, CPSC staff began investigating ROVs following reports of serious injuries and fatalities associated with the Yamaha Rhino vehicle, manufactured by Yamaha Motor Corporation, USA (Yamaha or firm). Staff investigated more than 50 incidents, including 46 driver and passenger deaths associated with the Yamaha Rhino model vehicle. More than two-thirds of the incidents involved rollovers, and many involved unbelted occupants. Of the rollover-related deaths and hundreds of reported injuries, many appeared to have involved turns at relatively low speeds on level terrain.

Through Engineering Sciences (ES) staff, CPSC contracted the U.S. Army's Aberdeen Test Center (ATC) to conduct static and dynamic tests to characterize the Yamaha Rhino vehicle and to identify factors that contribute to rollover. Results of the static and dynamic tests showed that the Yamaha Rhino vehicle exhibited low lateral stability, transitioned from understeer to severe oversteer, and exhibited poor occupant protection during simulation of a rollover event. Rollover in an ROV begins when the lateral acceleration builds to a point that the vehicle can no longer counterbalance the roll generated by the lateral acceleration.[1] ATC vehicle engineers suspected that the Rhino's low lateral stability and oversteer handling may have contributed to rollover incidents.

ATC modified a Yamaha Rhino vehicle and conducted vehicle handling tests of the ROV in several configurations to evaluate the effects of a wider track width and stiffer front suspension. The vehicle handling test is a constant radius test performed in accordance with SAE J266 *Steady-State Directional Control Test Procedures for Passenger Cars and Light Trucks*. The modifications increased the vehicle's track width by adding 2-inch spacers to the front and rear wheels, and increased the front suspension stiffness by removing the rear sway bar. The results of the vehicle handling test on a 50-foot radius circle are shown in Figure 1, where the changes in steering wheel angle required to keep the vehicle on a circular path are

[1] Gillespie, T. (1992). Fundamentals of Vehicle Dynamics. Society of Automotive Engineers, Inc. p. 309−311.

plotted against the lateral acceleration of the vehicle as it increases in speed around the circle. All versions of the Yamaha Rhino (modified and unmodified) initially exhibit understeer─the vehicle steers less into the turn than the driver steers with the steering wheel. However, as the speed of the vehicle around the circle increases, the unmodified Rhino vehicle transitions to oversteer─the vehicle steers more into the turn than the driver input at the steering wheel. In Figure 1, plot lines to the right indicate oversteer, and plot lines to the left indicate understeer.

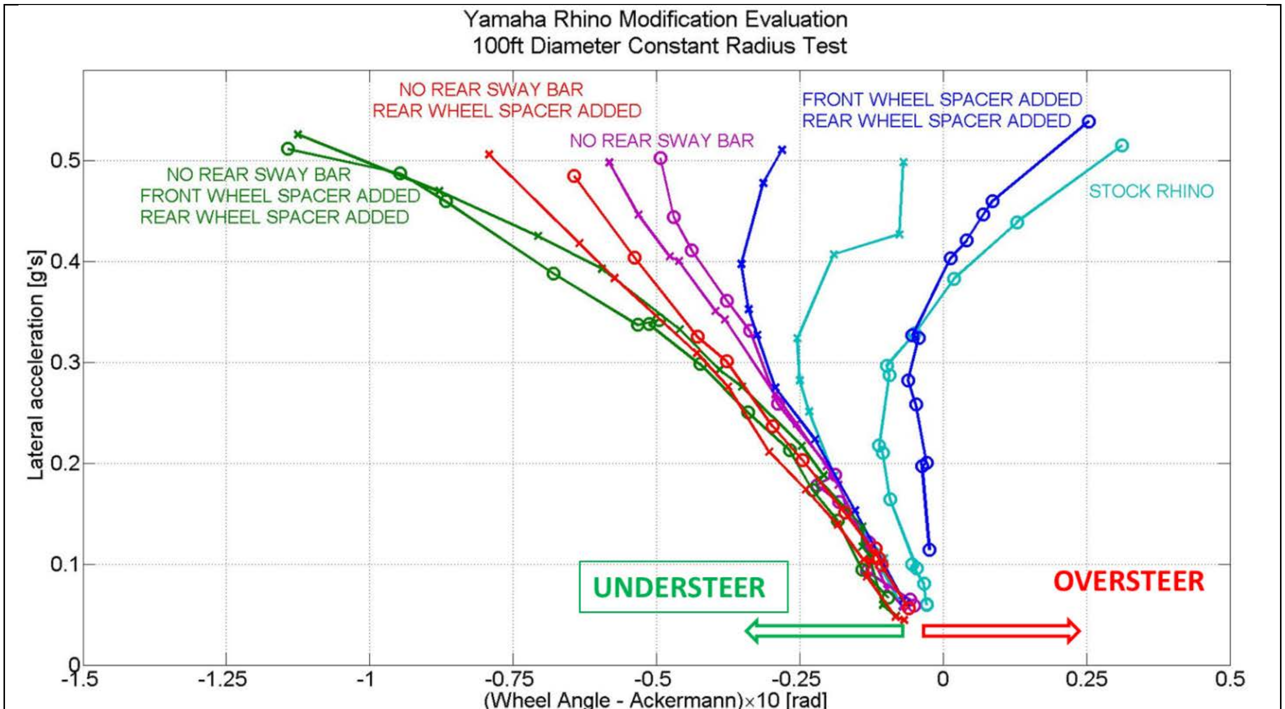

Figure 1. Constant radius test results of stock and modified Yamaha Rhino (conducted on 50-foot radius circle)

Results of the vehicle handling tests indicate that removing the rear sway bar changes the oversteer in the unmodified vehicle to understeer. In addition, adding spacers to the rear wheels increased the understeer, and adding spacers to the front and rear wheels increased the understeer even further.

On March 31, 2009, the CPSC, in cooperation with Yamaha, announced a free repair program for all Rhino 450, 660, and 700 models to improve safety.[2] The repair program included the following:

- Installation of a 50-mm spacer on each rear wheel
- Removal of the existing rear anti-sway bar
- Installation of half doors (if not previously installed)
- Installation of an additional hand hold (if not previously installed), and

[2]CPSC Release #09-172, March 31, 2009, Yamaha Motor Corp. Offers Free Repair for 450, 660, and 700 Model Rhino Vehicles.

- Free helmet (when vehicle brought in for repair).

In addition, Yamaha agreed to:

- Suspend sale of all affected models until repaired;
- Notify all Yamaha dealers of the suspension of sales, instruct consumers to stop use, repair the ROVs in accordance with the firm's corrective action plan (CAP);
- Notify all consumers to stop using all affected vehicles until repaired;
- Notify all consumers with affected vehicles of the free repair and corrective action plan ;
- Include/produce a training video;
- Include a warning placard reminding drivers and occupants of safe driving practices;
- Issue a joint CPSC/Yamaha press release announcing the free repair program on March 31, 2009;
- Post the repair program on its website; and
- Distribute information related to safe operating practices to operators and occupants at the time repairs are made.

Yamaha also agreed to implement the repairs on all future Rhino models. Yamaha's repair program addressed CPSC staff's concerns with low lateral stability and undesirable oversteer in the Rhino vehicle by: (1) increasing the track width of the vehicle by adding 50-mm spacers on the vehicle's rear wheels; and (2) correcting the steering and handling characteristic by removing the rear sway bar.

II. Incident Data:

The repair program resulted in two types of RHINO ROVS with the following different characteristics:

1. Oversteer with a lower lateral stability (unrepaired)
2. Understeer with an increased lateral stability (repaired)

This unique situation allowed the staff to evaluate the effectiveness of increasing the rollover resistance and changing the vehicle performance from oversteer to understeer by comparing the incident data before and after the Rhino repair.

CPSC staff reviewed reports of ROV-related incidents from the IPII, DTHS, and INDP databases that occurred between January 1, 2003 and May 31, 2012, and identified 242 Yamaha Rhino-related incidents.[3] Of the 242 total incidents involving a Yamaha Rhino vehicle reported to CPSC during this time period, 187 incidents occurred before the Yamaha Rhino repair program was announced on March 31, 2009. After the repair notice, 55 incidents occurred. The number of incidents that occurred by quarters of a year are shown below in Figure 2.

[3] The data are only those reported to CPSC staff and are not representative of all incidents.

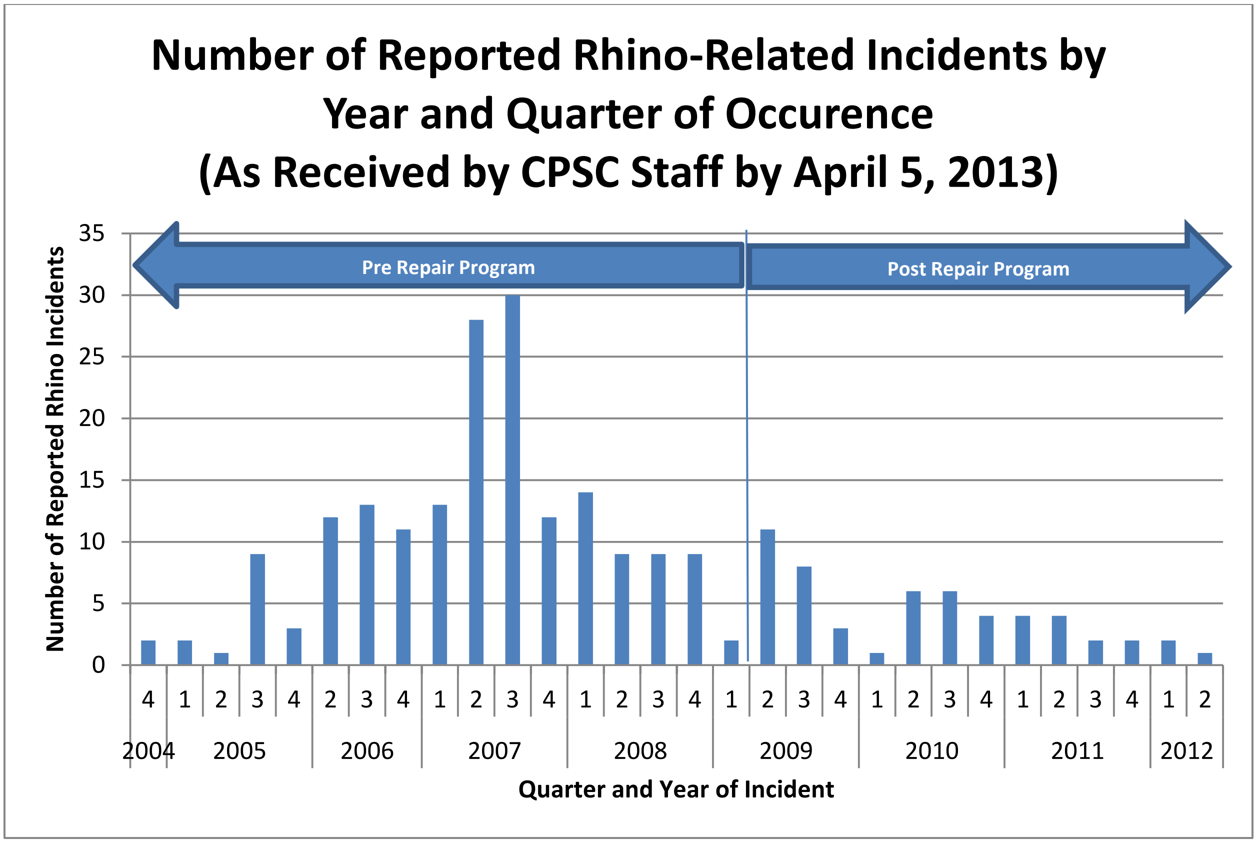

Figure 2. Number of Reported Yamaha Rhino Incidents from January 2003 to May 2012.

As shown in Figure 2, the number of Rhino-related incidents consumers and others reported to CPSC decreased noticeably after the repair program was started.

CPSC staff also analyzed incidents in which a Yamaha Rhino vehicle rolled over during a turn on level ground. ROV rollover during a turn on level ground is caused by the lateral acceleration generated during the turn, as opposed to rollovers on slopes, where the slope contributes to the rollover. Uncorrected oversteer can cause a sudden and unexpected increase in lateral acceleration, which causes rollover, or causes the vehicle to slide and roll over.[4]

Of the 242 Yamaha Rhino-related incidents reported to CPSC, staff identified 46 incidents in which a Yamaha Rhino vehicle rolled over during a turn on flat or gentle terrain. Forty-one of the 46 incidents involved an unrepaired Rhino vehicle and two incidents involved a repaired Rhino vehicle (both incidents with a repaired Rhino vehicle occurred on terrain with a 5 to 10 degree slope). Staff did not find incidents involving repaired Rhino vehicles rolling over on flat terrain during a turn.

[4] Teems, A. (2014). Memorandum to Caroleene Paul. Proposed lateral stability and vehicle handling requirements for Recreational Off-Highway Vehicles (ROVs). (Tab A)

III. Conclusion:

In 2008, CPSC staff investigated the Yamaha Rhino ROV and determined that the vehicle had low lateral stability, incorrect oversteer handling, and poor occupant protection performance. Yamaha announced a repair program on March 31, 2009 and agreed to: (1) install rear spacers on the ROV to increase the effective track width and increase lateral stability; (2) remove the rear sway bar to correct the handling during a turn from oversteer to understeer; and (3) install half doors and additional hand holds to improve occupant protection.

CPSC staff reviewed reports of ROV-related incidents involving Yamaha Rhino model vehicles that were reported to CPSC by consumers and others between January 1, 2003 and May 31, 2012. After the repair program was initiated in March 2009, the number of reported incidents by consumers and others to CPSC involving a Yamaha Rhino ROV decreased noticeably.

In addition, staff analysis of reported ROV-related incidents indicates at least 41 incidents in which an unrepaired Rhino vehicle rolled over during a turn on flat or gentle terrain. In comparison, staff identified only two incidents in which a repaired Rhino vehicle rolled during a turn, and each incident occurred on a slope of up to 10 degrees. There were no incidents involving repaired Rhinos rolling over on flat terrain during a turn.

CPSC staff believes the decrease in Rhino-related incidents after the repair program was initiated can be attributed to the vehicle repairs. Specifically, correction of oversteer and improved lateral stability can reduce rollover incidents by reducing the risk of sudden and unexpected increases in lateral acceleration during a turn, and increasing the amount of force required to roll the vehicle over. Staff believes that lateral stability and vehicle handling have the most effect on rollovers during a turn on level terrain because the rollover is caused primarily by lateral acceleration generated during the turn. Staff's review of rollover incidents during a turn on level ground indicates that repaired Rhino vehicles are less likely than unrepaired vehicles to roll over. Staff believes this is further evidence that increasing lateral stability and correcting oversteer to understeer contributed to the decrease in Yamaha Rhino incidents.

In conclusion, the Yamaha Rhino investigation provided the staff with the background and understanding of the following vehicle characteristic that contribute to rollover incidents and injuries:

1. lateral rollover resistance
2. steering characteristics
3. occupant protection

Comparing the incident data before and after the Rhino repair allowed the staff to evaluate the effectiveness of increasing the rollover resistance and changing the vehicle performance from oversteer to understeer. The repair program provided staff an understanding of the feasibility to implement an ROV repair to address lateral stability and steering characteristic. The experience gained from the Yamaha Rhino investigation became the basis for staff's approach in developing technical requirements for a proposed rule.

TAB K

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
4330 EAST WEST HIGHWAY
BETHESDA, MD 20814

Memorandum

Date: September 11, 2014

TO : Caroleene Paul, Project Manager
Directorate for Engineering Sciences

THROUGH: Mark Kumagai, Division Director
Division of Mechanical Engineering

FROM : Kevin Lee, ESME
Directorate for Engineering Sciences

SUBJECT : Speed Test Results of Can-Am Commander 1000 with Seat Belt Speed Limitation Feature

I. Introduction

Recreational off highway vehicles (ROVs) are motorized vehicles designed for off-highway use and have the following features: four or more pneumatic tires designed for off-highway use; side-by-side seating for two or more occupants; automotive-type controls for steering, throttle, and braking; and a maximum vehicle speed greater than 30 miles per hour (mph). ROVs are also equipped with roll over protective structures (ROPS), seat belts, and other restraints such as doors, nets and shoulder barriers for the protection of occupants. Reports of ROV-related fatalities and injuries prompted the U.S. Consumer Product Safety Commission (Commission) to publish an advance notice of proposed rulemaking (ANPR) in October 2009 to consider whether there may be unreasonable risks of injury and death associated with ROVs.[1]

CPSC staff reviewed 428 ROV-related incidents from the Injury and Potential Injury Incident (IPII) and In-Depth Investigation (INDP) databases occurring between January 1, 2003 and December 31, 2011, and received by December 31, 2011.[2] From the 428 ROV-related incidents reviewed by CPSC staff, 817 victims were reported to be in or on the ROV during the incident and 610 (75 percent) were known to have been injured or killed. Of the 610 fatal and non-fatal victims who were in or on the ROV, 433 (71 percent) were partially or fully ejected from the ROV and 269 (62 percent) of these victims were struck by a part of the vehicle, such as the ROPS or side of the ROV. Seat belt use or non-use is known for 374 of the 610 fatal and non-fatal victims who were in or on the ROV, 282 (75 percent) were not wearing a seat belt. Of the 225 reported fatalities, 194 (86 percent) victims were ejected partially or fully from the vehicle. Of these 194 ejected fatalities, 141 (73 percent) were not wearing a seat belt, 14 (7 percent) were wearing seat belts, and 39 (20 percent) have an unknown seatbelt use status.

[1] 74 FR 55495 Standard for Recreational Off-Highway Vehicles.
[2] Analysis of Reported Incidents Involving Deaths or Injuries Associated with Recreational Off-Highway Vehicles (ROVs) *Sarah Garland, Ph.D.* May 2012.

In 2010, Can-Am entered the ROV market with the Commander vehicle (Figure 1). The Commander has a unique seat belt speed limitation safety system that prevents the vehicle from exceeding 10 mph when the driver's seat belt is unbuckled. CPSC staff is interested in this technology given the high percentage of injuries and deaths associated with unbelted ROV victims. This memo summarizes the Directorate for Engineering Sciences (ES) staff's test and evaluation of the Commander 1000 vehicle speed limiting system.

Figure 1. Commander 1000 ROV

II. Test Vehicle

ES staff purchased a Can-Am Commander 1000 ROV in January, 2011 (sample number 11-440-9741) at a cost of approximately $13,000.

The Commander has several features that regulate vehicle speed and acceleration sensitivity through the use of electronic throttle control technology (ETC). ETC is a technology that replaces the conventional cable/linkage connection between a vehicle's accelerator pedal and engine throttle body, with a throttle pedal position sensor that controls a motor driven actuator at the throttle body through the engine control unit (ECU).

The Commander's ECU is programmed to control the engine throttle response to provide smooth and consistent power delivery even if the driver's foot bounces up and down on the accelerator pedal due to rocky or uneven terrain. This ECU program is referred to as standard mode. A sport mode switch (Figure 2) changes the ECU program for engine throttle response. When the sport mode is engaged, the throttle response is unfiltered, resulting in a quick and sensitive throttle response. The sport mode is desirable on smooth and open terrain where there are limited bumps to cause unintended throttle input.

Figure 2. Headlight, 2WD/4WD, and Sport and Standard Controls

Ignition key

The Commander can be operated by three different ignition keys (Figure 3). Each ignition key contains an encoded electronic chip that transmits a pre-programmed maximum speed to the ECU. The orange "work" key reduces the ROV's overall performance by limiting engine torque to 50 percent of the maximum available, and limits the maximum vehicle speed to 25 miles per hour (mph).[2] A gray "normal" key reduces the ROV's overall performance by limiting engine torque to 70 percent of the maximum available, and limits the maximum vehicle speed to 43 mph.[2] A black "performance" key does not limit the engine torque or maximum speed capability of the vehicle. The Commander was tested with the black key, and the average maximum speed was 66 mph.[3]

Figure 3. Orange, Gray, and Black ignition keys

Driver seat belt latch status

The Commander is equipped with a seat belt latch sensor in the driver's seat belt. If the seat belt is not latched, the seat belt indicator lamp will flash with the following message: "ENGINE LIMITATION ENGAGED. FASTEN SEATBELT." In addition, according to the owner's manual, the vehicle speed is limited to approximately 9 mph on flat ground.

[2] Maximum speeds for the orange key and gray key are cited from the 2011 Commander 1000 owner's manual.
[3] Maximum speed for the black key is cited from a report by SEA Ltd on test results for vehicle characteristics of ROVs; http://www.cpsc.gov/library/foia/foia11/os/rovj.pdf.

III. Test methodology and results

CPSC staff evaluated the Commander's seatbelt safety system between March 7, 2012 and July 12, 2012, at the National Emergency Training Center (NETC) located at 16825 S. Seton Ave., Emmitsburg, MD 21727. All the tests were performed in the driver-only condition, *i.e.*, no passengers or cargo other than the data acquisition system, on a level grassy field (Figure 4).

Figure 4. Grassy test field at NETC

Instrumentation that was fixed to the vehicle body measured speed via global positioning system (GPS) technology. The instrumentation used during the dynamic testing is shown in Figure 5.

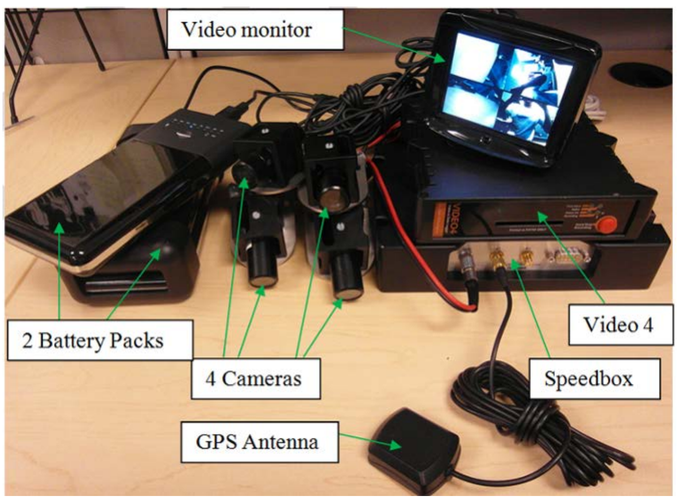

Figure 5. Dynaic testing instrumentation

The longitudinal acceleration, speed, and time pulse (used for calculating date and time of day using GPS satellite information) were measured using the Race Technology Speedbox. The Speedbox is a combination GPS and inertial measurement system (IMS) instrument that uses data from GPS and a three-axis accelerometer to provide vehicle speed updates at a rate of 200Hz. The Race Technology Speedbox was mounted near the center of gravity (CG) of the vehicle (Figures 6 and 7).

Figure 6. Side view of instrumented vehicle

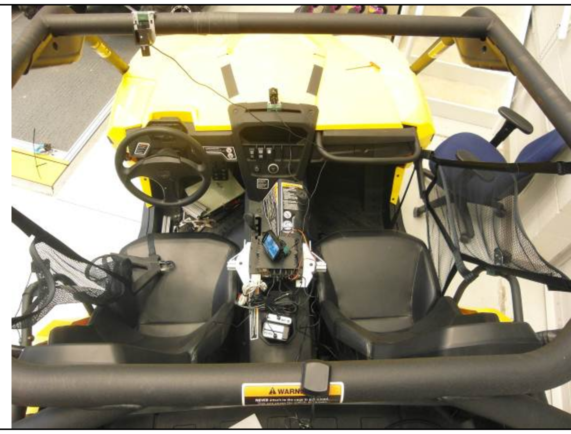

Figure 7. Top view of instrumented vehicle

Vehicle Testing

CPSC staff tested the Commander by driving it along a straight-line path, unbelted, and while varying the vehicle conditions. Specifically, the Commander was driven with three ignition keys (orange, gray, and black), with and without the sport mode engaged, and with the driver's seat belt unbuckled. The vehicle was also driven in 2-wheel-drive and 4-wheel-drive modes. Table 1 summarizes the results of the tests for all the keys:

Table 1: Vehicle Speed **Unbelted**
Data Summary of Commander 1000

Key Type	Vehicle Condition		Maximum Speed (mph)
Orange Key	Standard	2WD	7.74
		4WD	6.83
	Sport	2WD	6.71
		4WD	9.07
	Average		7.58
Gray Key	Standard	2WD	8.08
		4WD	8.54
	Sport	2WD	8.63
		4WD	9.63
	Average		8.72
Black Key	Standard	2WD	7.65
		4WD	7.95
	Sport	2WD	8.06
		4WD	8.4
	Average		8.01

The results show that the Commander limits the vehicle speed to below 10 mph while the driver's seat belt is not latched. Appendix A provides the graphical representation of Table 1.

IV. Summary

ES staff measured the maximum speed of the Commander 1000 when the driver's seat belt was unlatched. The average maximum unbelted speed of the Commander using the optional orange key was 7.58 mph. The average maximum unbelted speed of the Commander using the gray key was 8.72 mph. The average maximum unbelted speed of the Commander using the black key was 8.01 mph. ES staff's evaluation of the BRP Commander 1000 showed that the seat belt speed limitation safety system performs as intended by the manufacturer. The evaluation informed the staff that a seat belt speed limitation safety system is feasible, manufacturable and should be considered to address seat belt use in ROVs.

Appendix A

Figures 8 to19 show the speed profiles for each of the various combinations of mode, ignition key, and drive train condition. Each test was conducted with the driver's seatbelt unlatched and the transmission in high gear.[3] From a stopped position, the driver releases the foot brake and fully depresses the accelerator pedal. The test is concluded when the vehicle maintains a steady maximum speed.

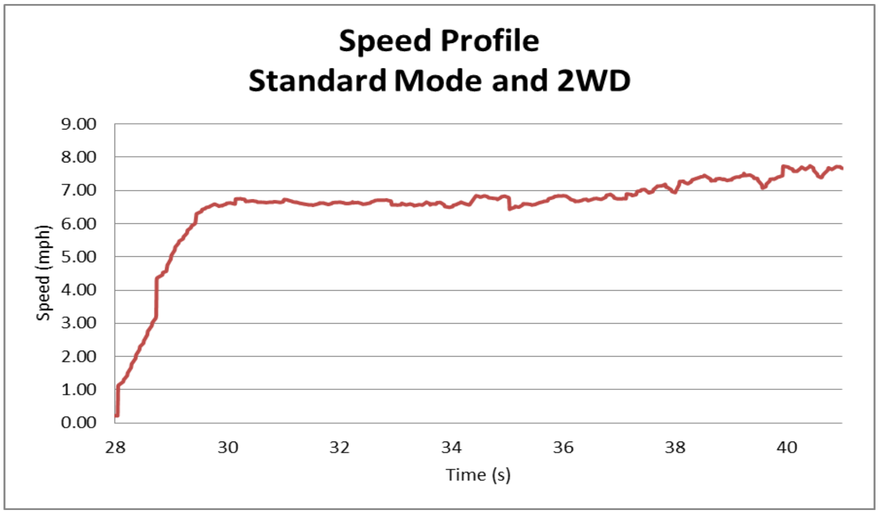

Figure 8. Speed Profile for Orange Key in Standard Mode with 2WD, Unbelted

Figure 8 shows that the maximum speed is 7.74 mph.

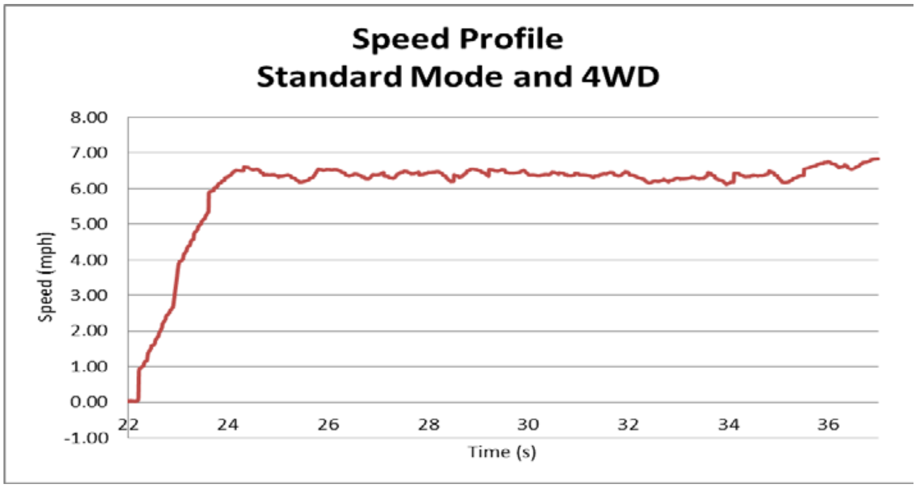

Figure 9. Speed Profile for Orange Key in Standard Mode with 4WD, Unbelted

Figure 9 shows that the maximum speed is 6.83 mph.

[3] Low gear is used for high torque situations. High gear is used for "normal" torque situations. The test conditions on level ground were appropriate for high gear.

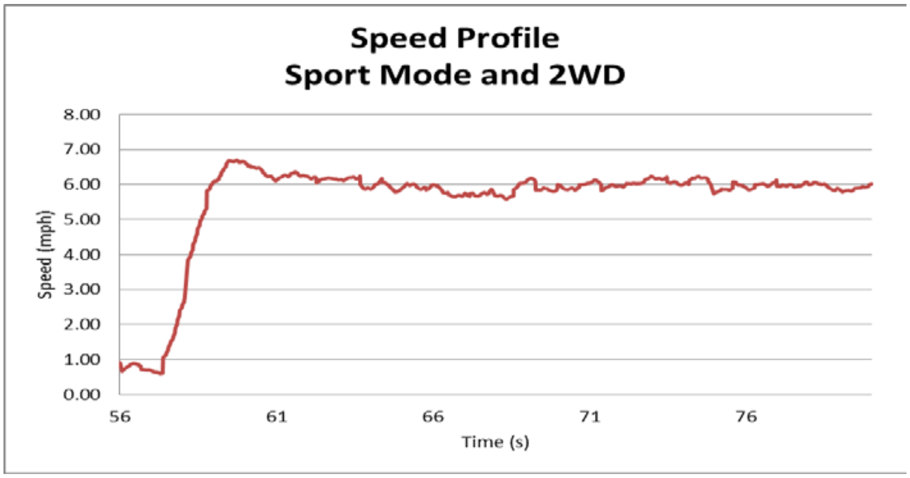

Figure 10. Speed Profile for Orange Key in Sport Mode with 2WD, Unbelted

Figure 10 shows that the maximum speed is 6.71 mph.

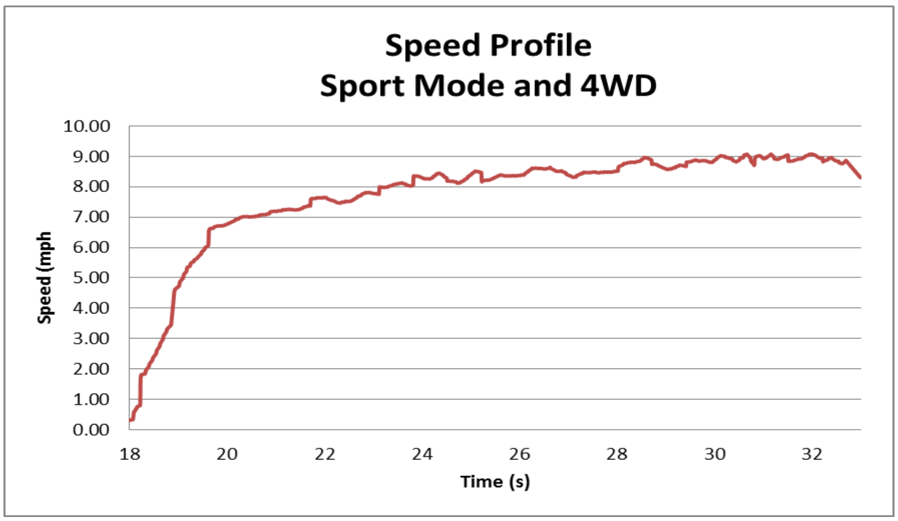

Figure 11. Speed Profile for Orange Key in Sport Mode with 4WD, Unbelted

Figure 11 shows that the maximum speed is 9.07 mph.

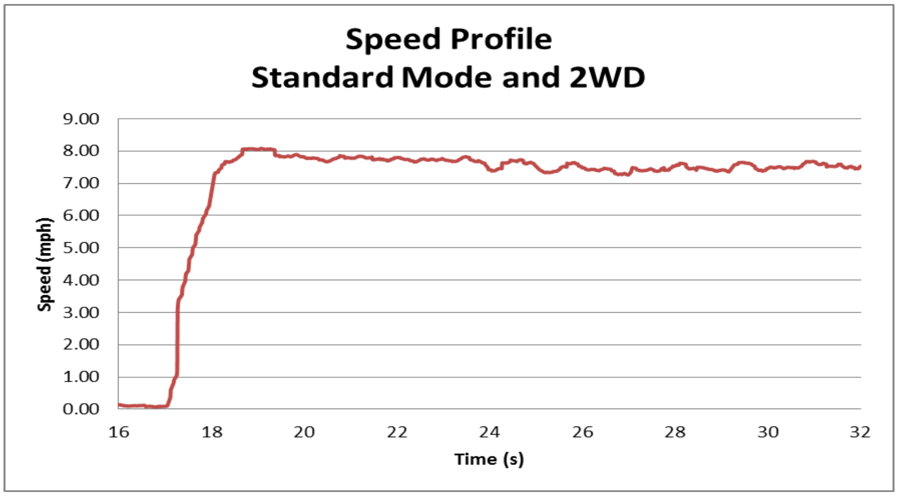

Figure 12. Speed Profile for Gray Key in Standard Mode with 2WD, Unbelted

Figure 12 shows that the maximum speed is 8.08 mph.

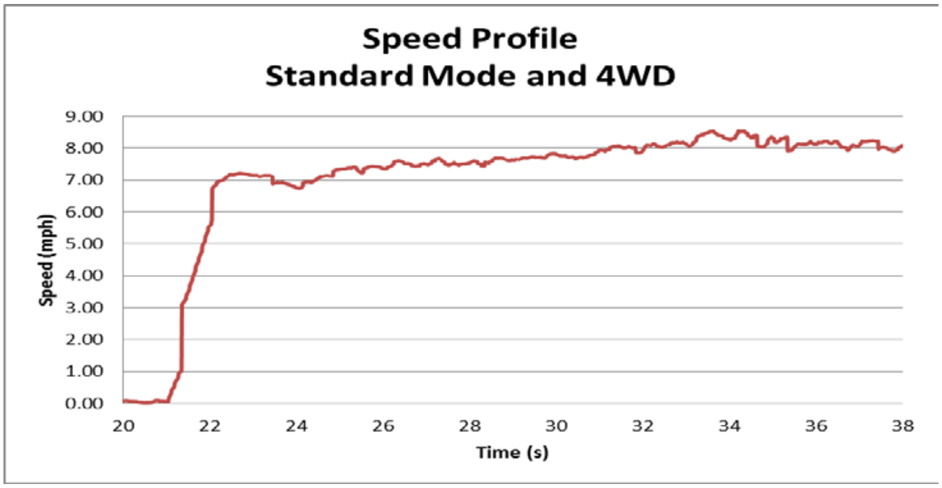

Figure 13. Speed Profile for Gray Key in Standard Mode with 4WD, Unbelted

Figure 13 shows that the maximum speed is 8.54 mph.

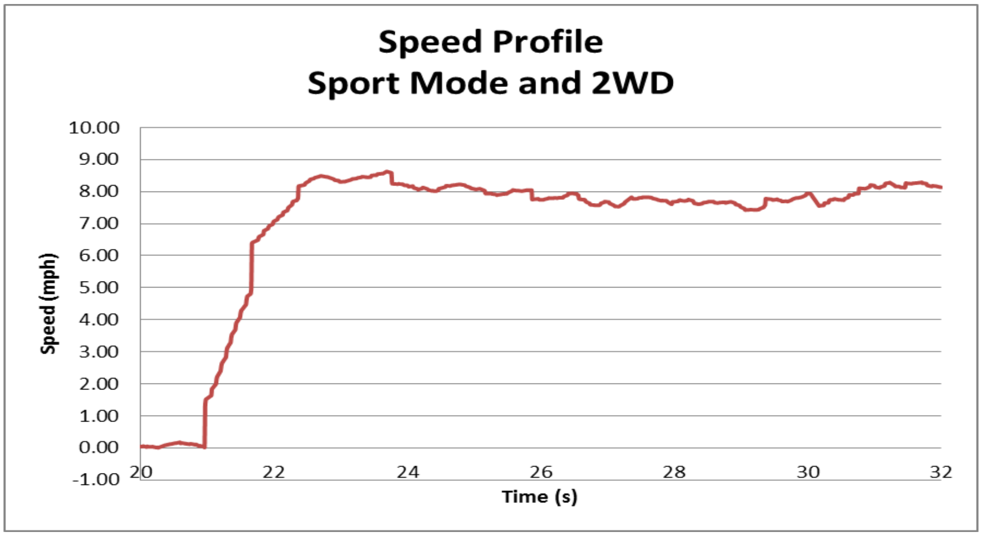

Figure 14. Speed Profile for Gray Key in Sport Mode with 2WD, Unbelted

Figure 14 shows that the maximum speed is 8.63 mph.

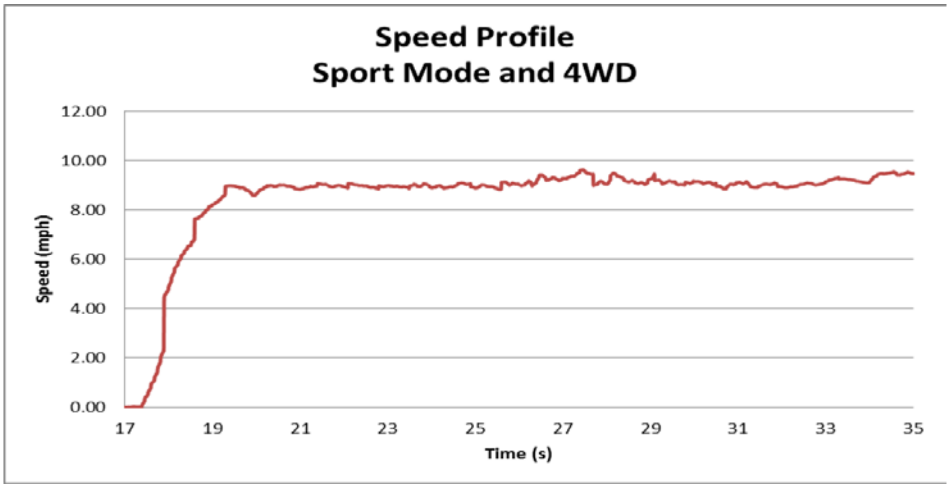

Figure 15. Speed Profile for Gray Key in Sport Mode with 4WD, Unbelted

Figure 15 shows that the maximum speed is 9.63 mph.

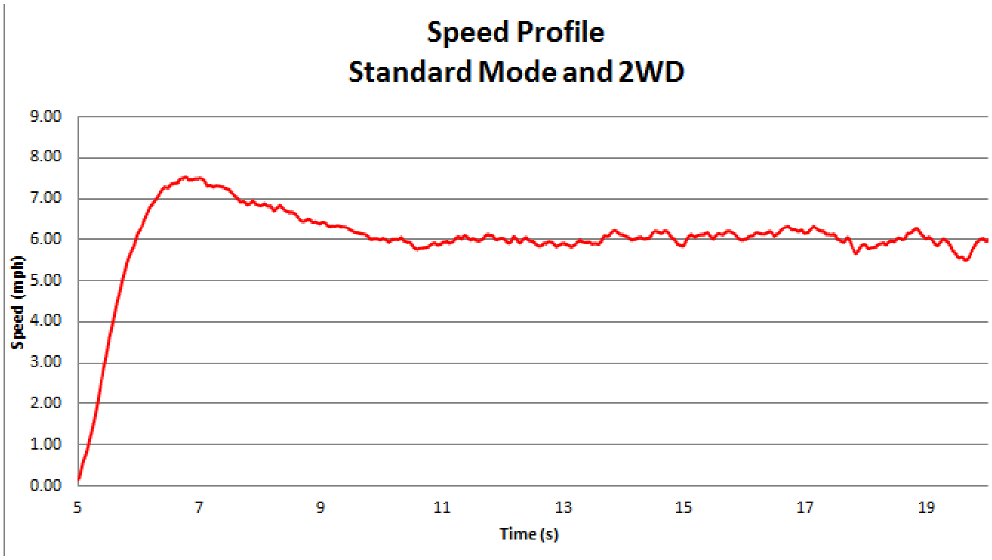

Figure 16. Speed Profile for Black Key in Standard Mode with 2WD, Unbelted

Figure 16 shows that the maximum speed is 7.65 mph.

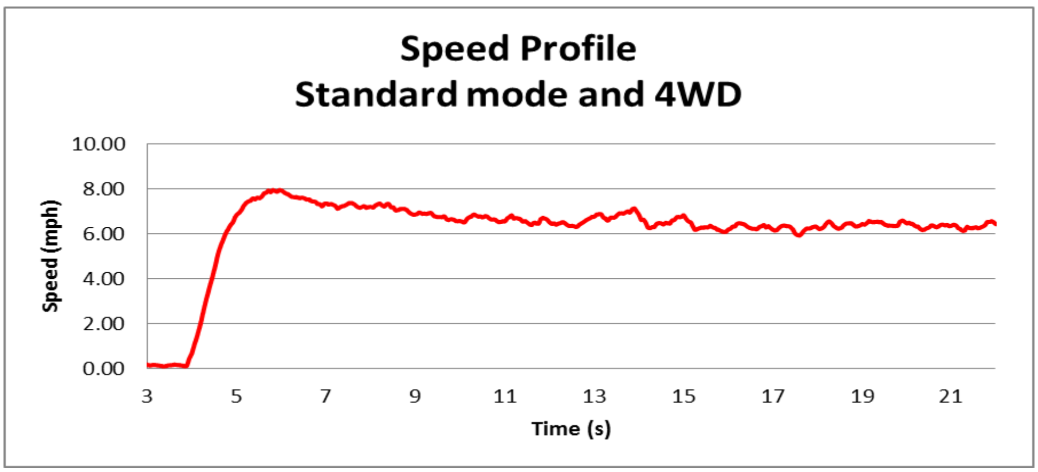

Figure 17. Speed Profile for Black Key in Standard Mode with 4WD, Unbelted

Figure 17 shows that the
maximum speed is 7.95 mph.

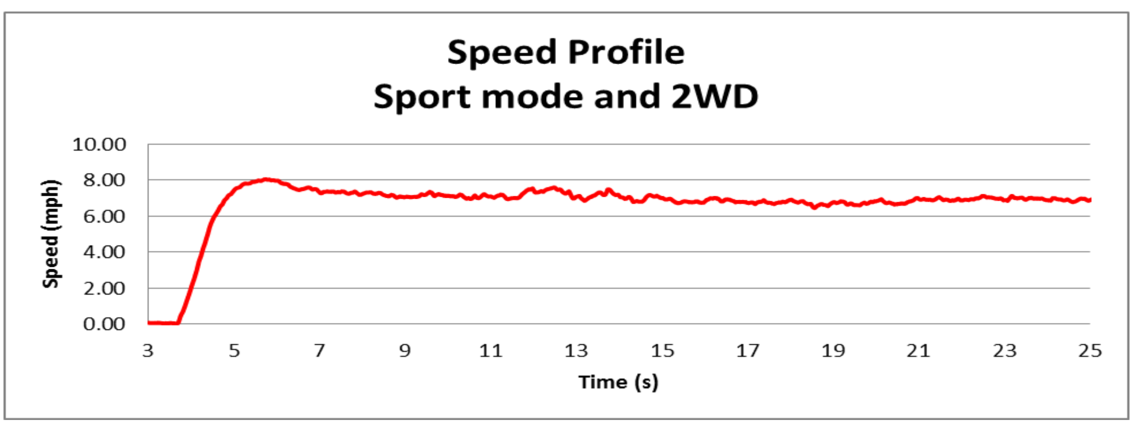

Figure 18. Speed Profile for Black Key in Sport Mode with 2WD, Unbelted

Figure 18 shows that the maximum speed is 8.06 mph.

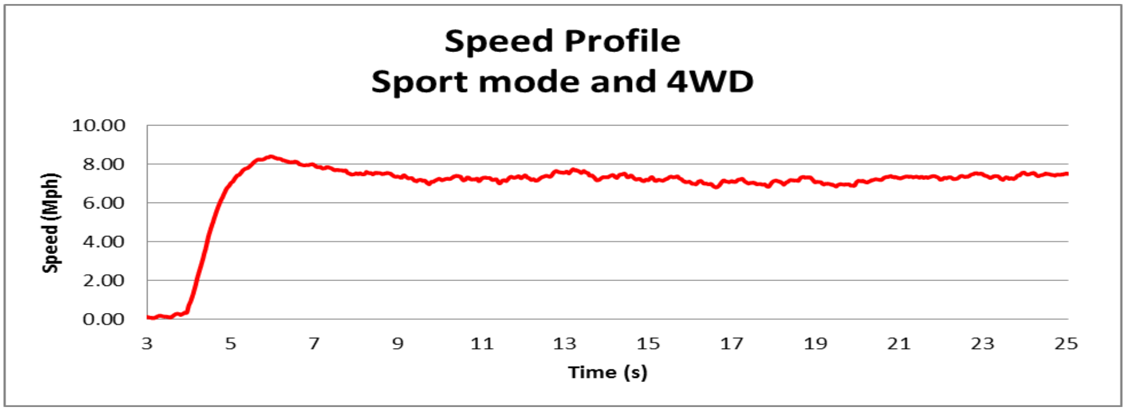

Figure 19. Speed Profile for Black Key in Sport Mode with 4WD, Unbelted

Figure 19 shows that the maximum speed is 8.4 mph.

TAB L

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
4330 EAST WEST HIGHWAY
BETHESDA, MD 20814

Memorandum

Date: July 26, 2013

TO : Caroleene Paul
ROV Project Manager
Directorate for Engineering Sciences

THROUGH : Kathleen Stralka
Associate Executive Director
Directorate for Epidemiology

Steve Hanway
Director
Division of Hazard Analysis

FROM : Sarah Garland, Ph.D.
Mathematical Statistician
Division of Hazard Analysis

SUBJECT : CPSC Staff's Response to Industry Joint Comment Regarding IDI, NEISS, and Exposure/Risk Analyses for ROVs*

Comments to the U.S. Consumer Product Safety Commission's (CPSC's) advance notice of proposed rulemaking (ANPR) for recreational off-highway vehicles (ROVs) from Arctic Cat Inc., Bombardier Recreational Products Inc., Polaris Industries Inc., and Yamaha Motor Corporation, U.S.A. were submitted as a joint comment and address several points of the ANPR. In this memorandum, CPSC staff responds to issues presented in the joint comment concerning ROV-related incidents in the National Electronic Injury Surveillance System (NEISS) and other CPSC databases, and ROV exposure and risk estimates.

NEISS Estimates

The joint comment discusses CPSC staff's use of the NEISS, or the lack thereof, in preparing the ANPR. Additionally, the joint comment presents the analytical results and conclusion using the NEISS provided by Heiden and Associates (Heiden). Some excerpts from the joint comment on the NEISS include, but are not limited to:

The comment asserts that CPSC did not include certain information in the ANPR. The comment states: "the ANPR omits any analyses of ROV-related incident data from the National Electronic Injury Surveillance System ("NEISS") … For example, only 5% of the UTV accidents reported in NEISS resulted in hospitalizations; 95% of vehicle operators or occupants were treated and released. In contrast to the predominately severe injuries described in the IDIs, 64% of the NEISS UTV injuries were minor (involving contusions, abrasions, strains, and sprains)."

*This analysis was prepared by CPSC staff. It has not been reviewed or approved by, and may not reflect the views of, the Commission.

The comment provides an analysis of NEISS data. Some of the results provided in the comment include: Appendix 11, Page 12: "NEISS injuries associated with utility vehicles (UTVs) are estimated to have risen somewhat during the period from 2005 (when the first significant ROV sales were made) through 2007, but remained below the 1,000-mark until 2008."

Other results provided in the comment include: Appendix 12, page 8: "Through the review process, a total of 20 NEISS records, producing an estimated 1049 ER treated injuries associated with side-by-side UTVs were identified. Thirteen of these records were identified within the product category for utilities vehicles. An additional seven records were found in the product categories for ATVs, golf carts, and motorized vehicles, not elsewhere classified (three or more wheels) in which a record references a known brand of UTV (e.g., Mule, Gator, Ranger, Rhino). In total, fifteen of the 20 records (75% of records, 83% of the estimate injuries) referenced a particular brand of utility vehicle…Sensitivity analyses were performed by adding possible in-scope cases to the analysis. Possible in-scope cases are NEISS cases that are not clearly in-scope UTV's but for which the narrative mentions a roll bar, roll cage, 'rowbar,' enclosed vehicle, stepping on the gas, dash, restraint, 4-seater vehicle, steering wheel or cases with 5 or more passengers on a 'ATV or golf cart.' This resulted in an additional 44 records and a total estimate of 2,965 ER treated injuries associated with in-scope or possible in-scope UTVs in the period 2003-2007."

<u>CPSC Staff's Response</u>

The joint comment's conclusions based on the commenter's analyses of the NEISS utility vehicle data are not technically sound.

Consumer product-related injuries treated in emergency departments of the NEISS member hospitals are coded from the medical record. Information about the injury is extracted, but specifics about the product and the product's use often are not available. Moreover, hospital staff usually cannot distinguish between ATVs, UTVs, and ROVs; nor does NEISS have separate codes for each of these products, *i.e.*, ROVs are not a separate product category from UTVs or ATVs.

Product codes that identify ATVs within the NEISS data set are 3285 (3-wheel ATVs), 3286 (4-wheel ATVs), and 3287 (ATVs, unknown number of wheels). In 2005, CPSC added the product code 5044, utility vehicles, to the NEISS. Any attempt to identify UTVs in the NEISS prior to this date could not produce valid results. Even after this product code was added, there are many records coded as 5044 that were not UTVs; and still, a considerable proportion of UTVs are being coded as ATVs. CPSC staff considers an ATV to be an off-road, motorized vehicle having three or four low-pressure tires, a straddle seat for the operator, and handlebars for steering control. UTVs have bench or bucket seats, a steering wheel, and foot controls for acceleration and braking. UTVs may or may not have rollover protective structures (ROPS), while ROVs always have ROPS. In addition, to be classified as an ROV, the vehicle must have a maximum speed above 30 miles per hour. Many official entities and news media refer to UTVs and ROVs as ATVs. This creates several problems in creating reliable estimates for UTVs and or ROVs or both. At a minimum, ROVs can be thought of as a subset of UTVs or ATVs or both. ROVs cannot be identified consistently through the NEISS case records because ROV identification requires the knowledge of the make/model of the vehicle, which is not coded in the NEISS for any product. Occasionally, the NEISS narrative contains make/model identification, but this cannot be used to identify ROVs accurately and consistently.

Estimates for the individual years of 2005–2008 and 2010 for the product code 5044 are not usable for reasons provided in the online NEISS database documentation: "CPSC considers a national estimate unstable and potentially unreliable when: the estimate is less than 1,200 or the number of records used is less than 20, or the CV exceeds 33%."[1] All estimates for Utility Vehicles in these years fail at least one of these qualifications. For 2005 through 2007 and 2010, the estimates without the removal of out-of-scope records do not meet these qualifications. Therefore, they also fail when out-of-scope records are removed. Similarly, estimates from 2008 fail to meet the qualifications when out-of-scope records are removed.

In the years 2005 through 2008 (the years cited in the joint comment document), the 5044 product code had mostly out-of-scope records, with a large number of utility trailers and similar records. After these are removed, the only viable estimate is obtained by aggregating the cases across 2005 through 2008 to get an estimated 1,300 emergency department-treated injuries related to UTVs. Refer to Table 1. This estimate is considerably less than the estimate reported by Heiden in the joint comment. However, the estimated 1,300 UTV-related injuries in this type of analysis would not capture all UTV-related injuries because most NEISS incidents involving UTVs were recorded in the ATV product codes. Note, in addition, that these are not ROV-related injuries, but UTV-related injuries, which is a broader category than ROVs. ROVs are a subcategory of UTVs, distinguished from other UTVs by a maximum speed greater than 30 mph and always having a ROPS. Heiden notes that the distribution of the types of injuries is not severe when considering the estimates associated with the dispositions available in the NEISS. Moreover, there was an increase in estimated injuries during the time frame of 2005 through 2008. To these two points, valid estimates of the distributions of the types of injuries cannot be made because the sample sizes are too small. Even if these were valid estimates, they would be for a range of vehicles, not just UTVs because many different products were recorded in this category when the category was first used. Additionally, Heiden does not use the associated variances with the estimates, nor does Heiden use the statistical structure of the NEISS in gauging any trend.

CPSC staff believes that the only valid way to use the NEISS to estimate ROV injuries is to gather additional information on the cases to classify the products involved more accurately. Therefore, CPSC staff conducted a special study in 2010 to obtain information about ROV-related incidents. In the 2010 NEISS special study conducted by CPSC staff, all cases coded as ATV-related (product codes 3285, 3286, and 3287) or UTVs (product code 5044) were selected for telephone interviews to gather information about the product involved and the use of the product. Sixteen of the 668 completed surveys had responses that identified the vehicle as an ROV. Of these, 12 were originally coded as ATVs. And of those, 11 would not be identified as even possibly UTVs or ROVs through the NEISS narrative. Only 4 of the 16 were originally coded as UTVs, based on information available from the emergency department's medical records. Also, there were 18 UTVs (not ROVs) identified in the special study, all of which were originally coded as ATVs. Only 3 of these 18 would have been identifiable as possible UTVs

[1] https://www.cpsc.gov/neiss/webestimates.html#cvar.

based on the NEISS narrative. This shows that the miscoding rate for these vehicles based on medical record narratives is still high. This is most likely due to what consumers report their vehicles to be when they are in the emergency department. Estimates for UTVs would certainly increase if more information was known about the incident vehicles that were recorded as ATVs in the NEISS. Attempting to identify UTV-related injuries in the ATV product codes via the NEISS narrative, then adding them to the 5044 product code, still will not result in a full picture of UTV-related injuries.

If the product code 5044 were used for analysis of the broader UTV category, because it cannot be used for the ROV subcategory, then the following results would be statistically valid results, but still not create a full picture of UTV-related injuries, as previously discussed. If all out-of-scope records are removed, such as utility trailers and their related parts, then from 2005 through 2008, there are an estimated 1,300 emergency department-treated, UTV-related (not just ROV-related) injuries, with 95.0 percent being treated and released. However, CPSC staff believes that the majority of UTV-related injuries were coded in ATV product codes during these years.

As the years have passed and the product code is being used more as intended, a completely different picture is seen for UTVs. From 2009 through 2012, there were an estimated 6,200 emergency department-treated, UTV-related injuries. This larger number of reported incidents can be attributed to an increase in the number of UTV-related injuries, a larger portion of injuries being identified in NEISS as UTVs, there being a larger number of UTVs in use, combinations of all or some of these, or other factors not identified. Of these estimated 6,200 injuries, only 80.2 percent are treated and released. The proportion of treated and released for UTV-related injuries is significantly below (p-value=0.0009) the proportion of treated and released for all consumer product-related injuries (92.0% of estimated consumer product-related, emergency department-treated injuries were treated and released from 2009 through 2012). This illustrates that more severe injuries are associated with UTVs. Table 1 summarizes the results of CPSC staff's analysis of product code 5044 for the years 2005 through 2008, the years for which the joint comment provides their analysis. Table 1 also summarizes the subsequent years 2009 through 2012 for product code 5044.

In conclusion, data are insufficient to support the arguments from the ANPR joint comment that UTV injuries are not as severe as those associated with other products. As more data have become available in recent years, it appears that about 80 percent of the injuries have been treated and released, compared to about 92 percent of the injuries associated with all consumer products. It should be noted that even in the more recent years, CPSC staff still expects there are many records in the ATV product codes that would be re-categorized to the UTV product code if more information about the vehicle were known (see the summary of the ATV/UTV special study records above). Thus, the product code 5044 continues to represent a minimum of UTV-related injuries. Additionally, these are UTV-related, not ROV-related injuries, although ROVs are included in the larger class of UTVs. CPSC staff used NEISS only when information was available to identify ROVs specifically, which was obtained through a special study performed in 2010.[2]

[2] Garland, S. "NEISS Injury Estimates for Recreational Off-Highway Vehicles (ROVs) in 2010," September 2011.

Table 1: Estimated UTV-Related Emergency Department-Treated Injuries for Product Code 5044, (With Out-of-scope Records Removed), for All Dispositions and for Treated and Released, 2005-2012

	Product Code=5044 (records that were not related to UTVs removed)					
	All Dispositions			Disposition of Treated and Released		
Year	n	Estimate	CV	n	Estimate (percent of total estimate†)	CV
2005	4	*	*	4	*	*
2006	5	*	*	5	*	*
2007	3	*	*	3	*	*
2008	13	*	*	11	*	*
Total (2005-2008)	**25**	**1,300**	**0.30**	**23**	**1,300 (95.1%)**	**0.30**
2009	25	1,300	0.26	18	*	*
2010	21	*	*	20	*	*
2011	34	1,300	0.26	25	*	*
2012	46	1,400	0.25	35	1,200 (84.8%)	0.27
Total (2009-2012)	**126**	**4,800**	**0.17**	**98**	**3,900 (80.2%)**	**0.20**
Total	**151**	**6,200**	**0.17**	**121**	**5,100 (83.4%)**	**0.18**

*Indicates estimates that are considered unstable, thus not reportable.
†Percentages are based on unrounded estimates. Estimates are rounded to the nearest hundred.

Exposure

In the joint comment, the commenters use a summary of an exposure study to argue that risk is lower for ROVs than for other products. The details of the exposure study, performed by Heiden Associates (Heiden), are summarized in Appendix 2 of the joint comments. The following summarizes some points from the joint comment about exposure and also some points not considered in the joint comment, but that were provided in Appendix 2 of the comment.

The joint comment makes conclusions about exposure and risk based on the exposure study performed by Heiden. For example, on page 37, the joint comment states: “The Exposure Survey shows that the potential risks associated with ROV usage are comparable to or lower than the potential risks associated with many of other types of vehicles. From 2005 to 2007, ROV fatality rates ranged from approximately 1.0 to 1.2 fatalities per 10,000 vehicles. At this basic level, the ROV fatality rate is equivalent to the fatality rate per 10,000 vehicles associated with ATVs, and is lower than the fatality rare per 10,000 vehicles associated with passenger cars, SUVs, and other light trucks. Vehicle-associated risks can also be measured based on exposure hours, rather than by numbers of vehicles. For example, ROVs have an exposure-adjusted rate of 0.16 fatalities per million hours of riding time, whereas ATVs have an exposure-adjusted rate of 0.33 fatalities per million hours of riding rime.”

Appendix 2 provides some details to the findings of the exposure study completed by Heiden. The following are some excerpts from those reported results. Appendix 2, Page 3: “4-5. The median ROV driver drove an estimated 102 hours annually, and the median amount of estimated riding time as a passenger as 18 hours annually. The average hours of use estimates were much higher-326 hours per year for driving, and 46 hours as a passenger. 4-6. These averages may be overstated because some survey respondents may have over-reported the extent of their riding. The driving time estimates for many individuals show very high levels of use, with 12 percent of drivers estimated to have driven more than 1,000 hours in the past year.”

Appendix 2, Page 15-16: “Surveyed ROV drivers were asked if they carried passengers at all and if they ever carried more than one passenger at a time, as well as the percentages of time that they carried one or more passengers and more than one passenger at a time. Most ROV drivers (72 percent) reported carrying passengers, and almost half (45 percent) reported carrying more than one passenger at a time. The reported share of time spent carrying only one passenger was only slightly higher than for carrying multiple passengers, however. Of the drivers who carried one or more passengers, nearly half (47 percent) reported carrying passengers at least half of the time they were driving. Of those who reported carrying more than one passenger at a time, 37 percent indicated that they did so at least half the time they were driving.”

Appendix 2, Page 17: “Finally drivers were asked whether and how often they drove ROVs in five selected locations, including ATV/off-road vehicle trails, sand/desert areas, and public roads. Most drivers (86 percent) reported frequently or sometimes riding on ATV or off-road vehicle trails; somewhat fewer (69 percent) reported frequently or sometimes riding on paved roads or other surfaces. Half reported riding at least sometimes on public roads, and 41 percent indicated they frequently or sometimes drove on sand dunes or in desert areas.”

CPSC Staff's Response

CPSC staff does not agree that the ROV risk presented in the joint comment is a reliable number to associate with ROVs based on the information provided on exposure. ROVs present specific hazard patterns that CPSC staff is addressing in the NPR package.

The mean exposure (millions of hours) was used in risk calculations in the joint comment. Heiden's exposure study summary (Appendix 2) notes that these values are likely high. Heiden provides the much lower exposure using the median (millions of hours), which if used for risk calculations, shows a much different picture for risk. Using the median number of hours of use,[3] the annual exposure for ROV riders is 130 million hours, a much smaller exposure number than the 340 million annual hours using the mean.

Heiden's exposure study (Appendix 2) does not provide any mathematical justification for the validity of the sample size, and what can and cannot be extrapolated from the study. For the estimates provided in the joint comment, there are no variance estimates reported. Given that the median and the mean exposure, in millions of riding hours, have such a large difference, a highly skewed distribution is suggested. It is likely that the variance, and thus, the associated confidence intervals, are large. If these are accounted for in the analysis of risk, an entirely different conclusion is possible than the conclusion provided by the analysis in the joint comment. CPSC staff would recommend a rigorous statistical analysis before any conclusions are reached in the area of risk.

If the results of the exposure study are used as provided in Appendix 2 of the joint comment without further statistical calculations, CPSC notes that there are significant reported numbers of drivers in this survey who report operating their vehicles on paved and public roads. In addition, note the large number of drivers who carry more than one passenger. The study does not mention the number of passengers the vehicle was intended to carry. Are these numbers above the recommended number of passengers for the vehicle? These are not mentioned in the joint comment, but they are part of Appendix 2.

Seat belt-use patterns were not part of Heiden's exposure study. Because it cannot be determined what the typical usage pattern is, CPSC staff must rely on information on seat belt use from the incidents reported to CPSC staff. CPSC's data show that there is a set of users not wearing seat belts who incur injuries at rates that justify standards to increase seat belt use. CPSC staff has developed the requirements in the draft NPR that address incidents involving the use and foreseeable misuse of the product.

[3] Some extrapolation was necessary for median numbers not provided (passenger hours for drivers).

Reported ROV-Related Incidents

The joint comment provides a summary of the analyses performed on CPSC's ROV-related reported incidents from staff's analysis provided in the ANPR. The following summarizes some points made in the joint comment, which was based on an analysis of a subset of reports available from the ANPR.

The joint comment asserts that CPSC staff has not considered the reported incidents with view of the circumstances surrounding the incidents. Page 13 of the joint comment: "Furthermore, CPSC has not sorted the IDIs and correlated them against vehicle performance indices according to the key factors that would be expected to influence rollover rate, including: specific types of accident, surface types (e.g., gravel, mud, hard dirt, two-layer soil, etc.), surface conditions (dry, moist, wet, frozen, etc.), terrain (grade, cross-slope, obstacle-size), loading conditions (occupants, cargo), accident mechanism and causations (e.g., control inputs and sequence, attempted task, etc.), misuse factors (e.g., non-use of helmets, belts, improper maintenance, tire pressures, etc.), operator age and gender, or make-model-year of ROV."

The joint comment utilizes the analysis completed by Heiden which is based on the number of warned against behaviors acting in incidents and other reported feature of the incident. For example, on page 39, the joint comment states: "Heiden analyzed these completed IDIs for the presence of eight behavior patterns that are specifically enumerated and warned against by ROHVA and its members. These warned-against behavior patterns include: (1) doing stunts; (2) riding at excessive speeds; (3) riding on public or paved roads; (4) operation by a driver under the age of 16; (5) the use of alcohol or drugs while driving (6) passengers riding in improper seating configurations; (7) riders failing to wear a helmet; (8) riders failing to wear a seatbelt. Heiden found that at least one warned against behavior was present in 98% of the IDI-reported accidents, and that multiple warned-against behaviors were present in 88% of these accidents."

And on page 40, the joint comment states: "For example, among the 86 IDI-reported accidents that involved a rollover or overturn, 22 occurred when the driver was making a sharp turn or turning at an excessive rate of speed, 20 occurred when the driver was operating the vehicle on a steep grade, and 11 occurred when the driver was attempting a dangerous maneuver."

<u>CPSC Staff's Response</u>

As previously mentioned, hazard patterns associated with ROVs are not identifiable in the NEISS records, which are based on the victim's medical records. As such, CPSC staff considered the incidents reported through other collection methods, such as news clippings, death certificates, medical examiner's reports, among others, and when possible, the CPSC In-Depth Investigation (IDIs) associated with the reported incident.

CPSC staff's analysis of incidents for the ANPR was a preliminary review of reported incidents, which was performed to understand the overall hazard patterns. For the NPR, staff conducted an extensive multidisciplinary review of 428 reported ROV-related incidents with at least one death or injury. The results of this study are summarized in the report in the NPR briefing package, with analyses of victim characteristics, hazard patterns, environmental characteristics, and make and model characteristics.[4] The approach taken in the joint comment to remove reports from the analysis because there is unknown information is not CPSC staff's approach in analyzing ROV-related incidents or incidents involving any consumer product. Unknowns from all reports are reported along with the knowns from all reports to demonstrate that the full picture is seen because every report will have at least one piece of unknown information, and every report will have at least one piece of known information. The unknowns are reported in all tables, if any unknowns were recorded for the variables used.

The analysis of IDIs summarized in the joint comment does not define what was meant by "excessive speed" or by "dangerous maneuver" or "sharp turn." In other places the joint comment states: "There is also no evidence suggesting that speed is an important factor in preventing accidents" (page 27). In addition: "Tight steering turn capability is an important feature in certain ROVs, particularly those for trail use, because of the need to respond quickly to avoid obstacles and trail-edge drop-offs, and otherwise navigate in these off-highway terrains" (page 29). Thus, there is ambiguity in what the definitions could mean in the analysis of the IDIs (*e.g.,* When is the vehicle at an excessive speed? When is a turn too sharp? When is a maneuver dangerous?). CPSC staff's approach to analyzing the 428 incidents summarized in the report available in the NPR briefing package is to consider the sequence of events, the vehicle, the driver, passenger characteristics, and environment characteristics across all incidents. All definitions needed are used consistently by the multidisciplinary review team to understand the hazard patterns and incident characteristics across all incidents, not to set responsibility in one place or another.

In the analysis provided in the joint comment, the analyst assumed that an occupant was not wearing a seat belt because the victim was ejected, which CPSC staff considers an invalid indicator of seat belt use. In CPSC staff's analysis, there were 34 victims wearing a seat belt and partially or fully ejected (Table 9, Tab H: "Analysis of Reported Incidents Involving Deaths or Injuries Associated with Recreational Off-Highway Vehicles (ROVs)"). An unknown status is appropriate when the seat belt use is not reported. This provides the reader with a clearer picture of what could be occurring, or not, in the reported incidents and can identify the hazards associated with wearing and not wearing a seat belt. CPSC staff's analysis of seat belt use, ejection status, and injuries are provided in CPSC staff's reports of the analysis of 428 ROV-related incidents.

CPSC staff's analysis of incidents, the summary of which is provided in the NPR package, provides all hazard patterns and victim characteristics in a more rigorous approach than the analyses provided in the joint comment.

[4] Garland, S. "Analysis of Reported Incidents Involving Deaths or Injuries Associated with Recreational Off-Highway Vehicles (ROVs)," May 2012.

TAB M

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
4330 EAST WEST HIGHWAY
BETHESDA, MD 20814

Memorandum

Date: August 25, 2014

TO : Caroleene Paul
ROV Project Manager
Division of Mechanical Engineering
Directorate for Engineering Sciences

THROUGH : Joel Recht, Ph.D.
Associate Executive Director
Directorate for Engineering Sciences

Bonnie B. Novak, Director
Division of Human Factors
Directorate for Engineering Sciences

FROM : Sarah B. Newens
Human Factors Engineer
Division of Human Factors
Directorate for Engineering Sciences

SUBJECT : Staff's Recommendation for ROV Hang Tag Providing J-turn Test Results (Lateral Acceleration) to Consumers

Introduction and Background

Consumer Product Safety Commission (CPSC) staff is recommending that the Commission issue a notice of proposed rulemaking (NPR) that would require Recreational Off-Highway Vehicle (ROV) manufacturers to provide technical information for consumers on a hang tag at the point-of-purchase. Section 27(e) of the Consumer Product Safety Act (CPSA) authorizes the Commission to require, by rule, that manufacturers of consumer products provide to the Commission performance and technical data related to performance and safety as may be required to carry out the purposes of the CPSA, and to give notification of such performance and technical data at the time of original purchase to prospective purchasers and to the first purchaser of the product.[1] Section 2 of the CPSA provides that one purpose of the CPSA is to "assist consumers in evaluating the comparative safety of consumer products."[2] A hang tag provided on the ROV will offer comparative information based on a specific J-turn testing protocol that staff recommends as part of a proposed rule.

[1] Section 27(e) of the Consumer Product Safety Act, 15 U.S.C. 2076(e).
[2] 15 U.S.C. § 2051(b)(2).

In Tab A, technical staff recommends that the Commission propose to require ROVs to meet a minimum lateral acceleration of 0.70 g at rollover, as identified by J-turn testing.[3] This memo lays out the rationale for the staff recommendation that a hang tag on each ROV state the actual measured lateral acceleration at rollover of each ROV model and the elements for inclusion on such hang tag. The proposed sample ROV hang tag, see Figure 1 at right, shows rollover resistance in terms of lateral acceleration. By providing product information at point-of-purchase, staff believes that the hang tag will assist consumers in making buying decisions.

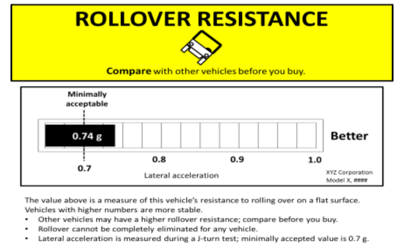

Figure 1. Sample ROV Hang Tag

Note: larger hang tag sample is found in Appendix A

History of product labels and hang tags

Several U.S. federal government agencies and counterparts outside the U.S. currently implement and require on-product labels to help consumers with buying decisions. In 1975, The Federal Trade Commission (FTC) was directed to develop and administer a mandatory appliance energy label; the EnergyGuide label was required on certain products beginning in 1980.[4] The National Highway Traffic Safety Administration (NHTSA) introduced a New Car Assessment Program (NCAP) star-rating system for automobiles in 1978, to provide comparative information on vehicle crashworthiness. The NCAP is a five star-rating system for the level of increased safety for frontal crashes, side crashes as of 1997, and rollover assessments as of 2001 (Hershman, 2001).

Point-of-purchase hang tags are a common mode of communication on off-road vehicles, such as all-terrain vehicles (ATVs). In 1988, the Commission entered into consent decrees with companies that were the major distributors of ATVs at that time. Among the provisions of the consent decrees was agreement that the ATV distributors would provide hangtags on ATVs at the point of sale.[5] The ATV action plans, which came out of the consent decrees and the most recent ANSI/SVIA voluntary standard for ATVs, which the Commission has mandated as a CPSC standard,[6] also contain hang tag requirements. The ATV hang tags are required to include general warning information regarding operation and operator and passenger requirements, as well as warned-against behaviors.[7]

[3] Draft CPSC Memorandum from Tony Teems, Division of Mechanical Engineering, to Caroleene Paul, "Proposed lateral stability and vehicle handling requirements for Recreational Off-Highway Vehicles (ROVs)" U.S. Consumer Product Safety Commission, Bethesda, MD.
[4] 16 C.F.R. part 305
[5] CPSC Approves Consent Decrees for All-Terrain Vehicles. 1988. Retrieved from http://www.cpsc.gov/en/Newsroom/News-Releases/1988/CPSC-Approves-Consent-Decrees-for-All-Terrain-Vehicles/.
[6] 16 C.F.R. part 1420.
[7] The voluntary standard for ATVs ANSI/SVIA 1-2010, Section 4.24 addresses the requirements for the ATV hang tags.

Product label communication

"The objective of hazard warnings is to change behavior, whereas the purpose of information provisions is to inform purchase decisions" (National Research Council, 1996). In other words, a product label, or information provided at point-of-purchase, has a different objective than a warning, which is used to communicate hazards, convey information on how to avoid the hazard, and describe the consequences of not avoiding the hazard. The hang tag proposed is to convey product information only, and is distinct from a warning label.

After the introduction of the NCAP rating system, NHTSA found that the scores improved steadily with the largest improvements soon after inception (Kahane, 1994), which suggests that requiring ROV test results on a hang tag may motivate manufacturers to increase the performance of their ROVs to achieve a higher reportable lateral acceleration

Linear scale graph

With regard to the appliance energy label, a survey conducted in the 1980s by the FTC, measured consumer awareness of energy information presented at the time of purchase. This study indicated that the energy label did increase consumer awareness of energy efficiency as an important purchasing criterion (National Research Council, 1996). Therefore, CPSC staff believes that ROV users may use the lateral acceleration in a J-turn test presented as the resistance to rollover as an important purchase criterion when presented on a hang tag.

When initially released to the public in 1980, the EnergyGuide label presented the energy consumption of products as the primary disclosure as a linear scale graph. Beginning in 2005, the FTC conducted a 2-year review of the label that included a public workshop, consumer research, and public comments.[8] The FTC found that there was a high level of reported recognition and usefulness of the existing label; the FTC also found that respondents preferred the operating cost as the primary disclosure rather than the energy consumption (Newsome, Hampton. 2008). In 2007, the EnergyGuide label maintained the use of a linear scale, changing the primary disclosure from energy consumption to operating cost with the lowest and highest yearly operating cost for similar models so that consumers can compare products.[9] CPSC staff recommends that the ROV hang tag present the lateral acceleration in a graph on a linear scale because the linear scale on the EnergyGuide provides almost 35 years of support, which was upheld as recently at 2007, for consumer comprehension of linear scales for comparing products using information labels.

Since the linear scale discussed above is a graphical representation of the information, it is important to include labels so that the data can be understood. Graphs, such as the linear scale proposed, should have a unique title and the axes should be fully labeled with the units of measurement. Graphs should also be distinguished from the text by adding white space or

[8]FTC. (2007). Retrieved from: http://www.ftc.gov/news-events/press-releases/2007/08/concluding-two-year-rulemaking-ftc-announces-new-energyguide.
[9] FTC. Retrieved from: https://www.consumer.ftc.gov/articles/0072-shopping-home-appliances-use-energyguide-label.

enclosing the graphs in a box and technical communication that includes graphs should also include text to paraphrase the importance of the graphic and explain how to interpret the information presented (Markel, M. 2001). CPSC staff believes that placing the label "better" at the right side of the scale identifies for the consumer that the higher value equates to better or higher rollover resistance.

Icons

In addition to research on product labels, there are some aspects of warning label research that are applicable in the development of the informational ROV hang tag. Specifically, human factors research on icons and symbols typically appears in warning research literature, and while creating an information provision is a different objective than creating a warning, the research from warnings icons is applicable when creating the information label. For example, research has shown that pictorial symbols and icons make warnings more noticeable and easier to detect than warnings without such symbols and icons (Wogalter, Dejoy, & Laughery, 1999). Additionally, including a graphic before introducing text may serve as a valuable reference for consumers, by maintaining attention and encouraging further reading (Smith, 2003). Therefore, CPSC staff recommends an ROV icon on the hang tag to identify the product. The same icon on a slight angle may help consumers readily identify the label as addressing the ROV rollover characteristics.

The proposed sample ROV hang tag, shown in Appendix A, presents information graphically and textually, to help clarify the range of performance that consumers should be aware of during their purchasing process. Presenting information in this manner offers a better chance of comprehension by a wide range of users, such as non-English-literate users (Smith, 2003).

Size and shape of ROV hang tag

Most of the ROV manufacturers are also manufacturers of ATVs. Accordingly, they are already familiar with the hang tag requirements for ATVs. CPSC staff recommends that the size, placement, and attachment specifications for ROV hang tags be similar to the hang tags used for ATVs; the ANSI/SVIA 1-2010 voluntary standard requires ATVS to be sold with a hang tag that is to be removed only by the initial purchaser of the ATV and replaced by the retailer if lost or damaged. The ANSI/SVIA 1-2010 voluntary standard requires the ATV hang tags to be 6-inches tall x 4-inches wide; CPSC staff recommends the ROV hang tags to be 6-inches wide x 4-inches tall. The ATV hang tags are presented in portrait orientation to accommodate text and several warnings; in contrast, the recommended ROV hang tags are presented in landscape orientation to accommodate a graph and minimal text.

Summary hang tag recommendations

In the discussion above, staff laid out the basis and support for the recommendations on (1) the use of the hang tag to communicate product information, (2) a linear scale graphical representation of rollover resistance, (3) titled ROV icon, and (4) size and shape of the hang tag. In summary, staff recommends that the ROV hang tag content and format include the same elements as those in the example hang tag (Appendix A). The staff recommends the following ROV hang tag requirements:

Every ROV shall be offered for sale with a hang tag that provides the lateral acceleration threshold at rollover, graphically and textually. The hang tag shall be attached to the ROV and lost or damaged hang tags should be replaced at point-of-sale. The hang tags may be removed only by the first purchaser.

Size. Every hang tag shall be at least 15.24 cm (6 inches) wide by 10.16 cm (4 inches) tall.

Attachment. Every hang tag shall be attached to the ROV and be conspicuous to a person sitting in the driver's seat, and the hang tag shall be removable only with deliberate effort.

Format. The hang tag shall provide all the elements as shown in the example hang tag.

The proposed hang tag should include a heading of "Rollover Resistance" with an ROV icon at a slight angle directly below the heading.

Specifically for the linear scale recommendations, as explained previously, consumers are familiar with a linear scale rating, which is used on the EnergyGuide rating system found on several appliances to communicate energy consumption information to consumers which supports the CPSC staff recommendations that the ROV hang tag also provide information using a linear scale rating. The ROV hangtag presents a linear graph ranging from 0.65 g to the upper end of 1.0 g.[10] The recommended range allows for a shaded area for ROVs that meet the minimally acceptable lateral acceleration; the range also allows consumers to compare across models using the same scale. A vertical dotted line on the linear graph identifies the minimally accepted value of 0.7 g. Within the shaded region on the graph, the actual measured lateral acceleration will be given. A graph presented on the ROV hang tag will present the quantitative results from the J-turn test, with the label "better" presented at the right to identify the ROVs with larger values to have a higher resistance to rolling over.

Another similarity to the EnergyGuide label, staff recommends that the ROV hang tag state the manufacturer and model. Lastly, a text summary, shown in item 4 of Appendix A, is given below the graph to help explain the lateral acceleration value in terms that non-technical consumers can better understand.

The example hang tag (Appendix A) features several elements to help educate consumers when making purchasing decisions:

[10] CPSC staff believes that any ROV that does not achieve two-wheel lift in the J-turn test or achieves 1.0g or higher lateral acceleration will have superior rollover resistance as measured by the J-turn test.

1) **ROV Icon.** CPSC staff recommends an ROV icon in a rollover condition to identify the product and hazard. Research studies have found that warning labels with pictorial symbols are more noticeable to consumers (Wogalter, Dejoy, & Laughery, 1999). Although the hang tag is not a warning label, staff believes the ROV icon will help consumers notice and understand the intent of the hang tag.
2) **Graph Label (Better).** Graphical information should be clear and informative with the axes labeled fully complete with the units of measurement (Markel, 2001). CPSC staff recommends the label "Better" at the right end of the scale to indicate that the higher values (as shading increases to the right) correspond to a greater rollover resistance during a turn on a flat surface.
3) **Manufacturer, Model, Model Number, Model Year.** The EnergyGuide label provides information on the manufacturer, model, and size of the product so that consumers can identify exactly what product the label describes.[11] CPSC staff recommends a similar identification of the ROV model on the hang tag for consumers to compare values among different model ROVs.
4) **Textual information.** Text should paraphrase the importance of the graph and how to interpret the information presented. The EnergyGuide label provides textual information in the form of bullets below the graphic of the scale to inform the consumer further on the meaning of the value displayed. CPSC staff recommends similar textual information on the hang tag to provide consumers with more definition of the lateral acceleration value given in the graph.
5) **Graph identifier and label (Minimally acceptable).** CPSC staff recommends a vertical dotted line to show the extreme "worst" end of the lateral acceleration scale, defined by the minimum acceptable lateral acceleration for ROVs, 0.7g. This "minimally acceptable" label allows consumers to judge visually the ROV lateral acceleration value as compared to the minimum value of 0.7 g.
6) **Graph scale beginning lower than the minimally acceptable value (0.65 g).** CPSC staff recommends the scale begin at 0.65 g. The 0.05 g range below 0.7 g provides a visual shaded range for vehicles that only meet, but do not exceed, the minimum 0.7 g lateral acceleration requirement proposed.

[11] Guide to EnergyGuide label. Retrieved at: http://www.consumer.ftc.gov/articles/0072-shopping-home-appliances-use-energyguide-label.

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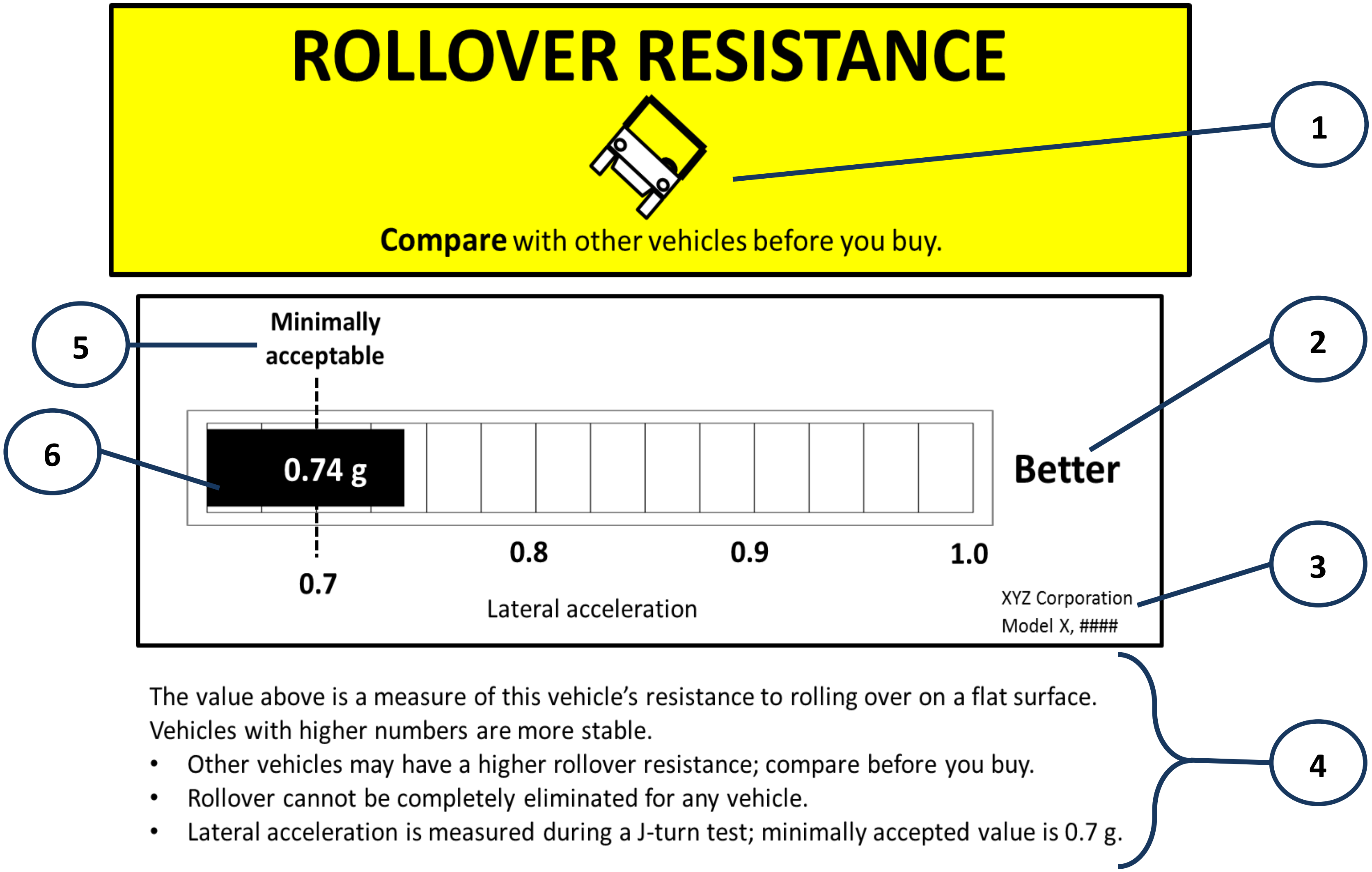
Appendix A: Proposed sample ROV hang tag of a vehicle which has a J-turn lateral acceleration of 0.74 g.



TAB N

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
4330 EAST WEST HIGHWAY
BETHESDA, MD 20814

Memorandum

Date: August 19, 2014

TO	:	Caroleene Paul ROV Project Manager Division of Mechanical Engineering Directorate for Engineering Sciences
THROUGH	:	Joel Recht, Ph.D. Associate Executive Director Directorate for Engineering Sciences Bonnie B. Novak, Director Division of Human Factors Directorate for Engineering Sciences
FROM	:	Sarah B. Newens Human Factors Engineer Division of Human Factors Directorate for Engineering Sciences
SUBJECT	:	Results of Westat focus group study of ROV user acceptance of speed limitation system – Phase 1

Introduction

Consumer Produst Safety Commission (CPSC) staff is not aware of any studies that provide data on the effectiveness of seat belt reminder systems on Recreational Off-Highway Vehicles (ROVs) or user acceptance of such technologies. Therefore, staff contracted with Westat, Inc. (Westat), beginning in April 2012 to conduct focus groups with ROV users to explore their opinions of seat belt speed limitation systems on ROVs. Phase 1 of the effort involved conducting focus groups of ROV users and asking questions about ROV use and user opinions of the Can-Am Commander speed limitation system, which was shown in a video to the participants. Phase 2 of the effort currently involves conducting focus groups of ROV users who provide feedback after driving and interacting with an ROV equipped with a speed limitation system.

Phase 1 Focus Group Results

Westat conducted two 90-minute focus groups with a total of 13 participants who self-reported owning or frequently using ROVS (see report in Appendix A).[1] The objective was to gain a greater understanding of ROV-user behavior and gauge the acceptance of seat belt speed limiters. Participants were asked about these main topics: driving behavior, seat belt use, acceptance of speed limiter, and passenger seat belt use. The two focus groups were conducted; one in South Carolina and one in Maryland, with the participant's average age of 55 and 51, respectively.

Most of the participants reported themselves to be part-time seat belt users, depending on the circumstances. Only one participant reportedly used the seat belt all the time because of traveling at higher speeds on public trails. The reasons given for non-use were using the ROV on familiar territory, frequently getting in and out of the vehicle, and not traveling at unsafe speeds.

Participants of both focus groups indicated their belief that the ease of getting into and out of the ROV outweighed the risk of injury when traveling through their own property. Participants of the South Carolina focus group said they would use restraints for the following four conditions: traveling at an unsafe speed, traveling with child passengers, traveling on rough terrain (steep incline), and traveling on unfamiliar territory. These participants said the only way they would wear a restraint at all times was if wearing a seat belt was required by law and enforced. When asked at what speeds the participants would wear seat belts, two said 25 mph; another said that at the maximum speed of his vehicle, 35 mph, he does not feel the need to wear a seat belt. When asked about helmet use, one participant stated that he felt the roll bars and headrest would provide sufficient protection.

The participants were also asked questions regarding a seat belt-activated speed limiter. Many thought the system would be a nuisance because the participants were on their own property, driving at what they perceived to be safe speeds, and were also making frequent stops. Participants said they felt a seat belt-activated speed limiter was unnecessary for their purposes, given their reasons for using the ROV. One participant said he would buckle the seat belt behind him to override the system. Other participants thought a seat belt-activated speed limiter would be a good optional feature for younger riders, one based on a key system, whereby, different keys would allow different functionality. When asked about the speed at which the seat belt limiter should be activated, South Carolina participants indicated 10 mph would be appropriate; in contrast, participants in Maryland said 15−20 mph would be an appropriate speed to activate the speed limiter. Participants in both focus groups said they felt that a 6 mph limited speed was too slow; they said they would be more likely to override a system limited to 6 mph because it would impede their tasks. Some Maryland participants agreed that they would not try to override a limited speed of 15 mph.

[1] To participate, users reported to own or use for work an ROV with a seat belt system. During the focus group, participants reported owning ROVs, Utility Vehicles, and All-Terrain Vehicles when discussing which vehicles they owned. Participants may have used different work vehicles than those that they owned.

USER ACCEPTANCE AND EFFECTIVENESS OF SEAT BELT SPEED LIMITERS ON RECREATIONAL OFF-HIGHWAY VEHICLES
Contract Number: CPSC-D-12-0002
Westat Project Number: 6000.01

Focus Group: Summary (South Carolina/Maryland)

1. Focus Group

CPSC's interest in obtaining data to support agency decision making regarding speed limiters makes the interest in knowing about user acceptance of great importance. The focus groups allow for a richness of discussion, and exchange of multiple ideas regarding usability, problems in acceptance, potential for system defeat, motivations underlying seat belt nonuse, riding experiences, etc. They are intended to provide information that is critical for providing information regarding overall user acceptance of this feature, but also important for planning the details of the qualitative focus group study (Task 2).

Upon completion, Westat will integrate these findings so that results and insights gained from the focus groups can inform CPSC decisions and direct adjustments to the methodology for the qualitative focus group study (Task 2). The proceedings, findings, and conclusions of the focus groups, including a description of user characteristics and user acceptance issues with restraint system technologies among ROV users or part-time users, will be summarized below. The following sections outline these topics for the two focus groups. One was conducted in Myrtle Beach, South Carolina, and a second in Reisterstown, Maryland.

1.1 Participant Sample

Recruitment strategies differed for each of the two locations. Eight participants were recruited through advertisement in local newspapers or through referrals in the Myrtle Beach area of South Carolina. All advertising materials referred to a discussion "of Recreational Off-Highway Vehicles including ROVs and Side-by-Sides for a 90 minute focus group", and required that participant to own or frequently use an ROV equipped with a steering wheel & pedals, bucket or bench seats, and capable of carrying 2 to 4 people.

The second recruitment strategy involved approaching and developing a cooperative agreement with Maryland's Motor Vehicle Administration (MVA) to provide a mechanism for identifying a pool of qualified riders. Participants recruited in Carroll County, Maryland were individuals over the age of 21 years, who had registered an ATV with the MVA. Based on information received from the CPSC, it was assumed that registered owners of an ATV were also likely to own or use an ROV.

Once a working relationship was established, a four-step structured sampling and enrollment strategy was implemented:

- Sampling frame - a well define sampling frame of registered ATV owners who lived in the state of Maryland was provided to the MVA.
- Owner sample - The MVA generated a random owner sample from the frame for recruitment.
- Initial contact - The MVA contacted the owner sample and requested that they contact the research team to discuss participation in a research study. This method preserved the anonymity of the riders until they elected to participate in the survey.
- Intake survey and recruitment – Once interested drivers contacted the research team, callers were screened to recruit qualified study participants.

When potential participants called in response to the advertisements or the MVA letter (see attached), they were administered a brief screener that collected information on age, gender, whether or not they possessed a valid driver's license, their driving practices, and whether or not they frequently use a seat belt when driving the ROV.

All participants were over 21 years old in both focus groups (average age was 55 in South Carolina and 51 in Maryland), in possession of a valid driver's license, and owned or regularly used an ROV vehicle with a seat belt system on a regular basis. Seven participants reported driving their ROV almost every day, two reporting driving it 2-3 times a week, and three reported driving at least once a month. Eleven participants indicated that their ROV did have a seat belt system. Five of the seven reported that they never wore a seat belt, 2 indicated that they did on occasion, and six indicated that they always wore a seat belt. Note, some of the participants responded differently during the focus group. One participant indicated that he had never used the seatbelt system in his vehicle; and in fact, he was unsure as to whether his vehicle had a restraint system for the driver.

1.2 Procedures

The focus group followed a structured question path led by a moderator. The focus group was approximately 1½ hour in duration and was audio taped for review and analysis. The introduction indicated federal government sponsorship and described the intent of the focus group to explore the feasibility of using restraint system requirements related to seat belt speed limiter technology in all recreational off-road vehicles. The overall objective of the focus group was to explore the system's potential effectiveness, as well as user acceptance issues, and factors that would increase the likelihood of drivers accepting this type of device in their vehicles. The moderator emphasized the need to discuss, in a non-judgmental way, their honest opinions regarding factors that would increase the likelihood of drivers accepting this type of device in their vehicle, rather than what they consider ideal or socially acceptable behavior.

The discussion began with an "ice breaker" question. The ice breaker gave everyone in the room the opportunity to introduce themselves and directed the attention of the group to the topic at hand. Participants were asked to introduce themselves and indicate what types of ROV they own or regularly use, and for what purpose (e.g.; recreation, work, other). The moderator then proceeded to guide participants through a range of topics related to driving behavior and the acceptance of an in-vehicle speed limiter. At the end of the focus group participants were reimbursed for their time.

1.2.1 Topics

The focus group topics included various issues related to driving behavior and acceptability of a speed limiter system. Each topic was introduced as a series of questions by the moderator. Major focus group topics included:

- Driving behavior
  - Driving frequency;
  - Types of terrain;
  - Specific tasks and activities;
  - Maneuvers;
  - Typical speed;
  - Accidents or close calls;
- Seatbelt Use
  - Is current vehicle equipped with a seat belt system;
  - Frequency of use and under what conditions;
  - Reasons for not using a seatbelt;
  - Seatbelt use and its influence on driving behavior;
  - Likelihood of being involved in a crash;
  - Opinion regarding the effectiveness of seat belt providing protection in a crash;
- Acceptance of a speed limiter
  - Overall feelings about having this system in an ROV;
  - Likelihood that the device would increase seat belt use;
  - Concerns about the limiter impeding ability to perform tasks;
  - Likelihood of defeating or disabling the system;
  - Opinions regarding the maximum speed (6 mph) the limiter is set when the driver is unbelted;
  - Suggested changes to the system that would increase likelihood of user acceptance;
- Passenger Seat belt Use
  - Frequency of passengers in vehicles;
  - Frequency of passenger restraint use;
  - Speed limiters influence on passenger restraint use.

2 Key Findings

Several major themes emerged during the focus group discussion. The major themes were specific broad concerns that stood out based on commonality among the focus group participants, the intensity of the discussion, the diversity of the described behavior, or significance of the issue.

Participants had mixed responses to the “ice breaker” regarding the types of ROV’s they owned. When asked to identify the type of ROV, participants named the following:

- 3 Polaris Ranger
- 3 John Deere Gator
- 1 Yamaha Rhino 450
- 2 Suzuki 450
- 1 Honda 300 4-Wheeler
- 1 Honda Big Red
- 1 Subaru Bulldog
- 2 Kawasaki Mule
- 1 Cushman Truck (Note: we recognize that this is not an ROV)

It is important to note that some participants were familiar with more than one type of ROV. Several used one vehicle for work and another recreationally.

Participants in both focus groups drove frequently, and used their ROV for a variety of reasons on both public and private properties. In South Carolina, several participants use their ROV's for working on their own property, driving to the front of their property daily to collect mail, giving grandchildren "joy" rides, and transporting materials on their property for various reasons. Others used their ROV for hunting, driving along their local roads, or as part of their job. For example, one participant was a realtor and used his ROV to show potential clients properties, one was a golf ball retriever, and two owned a Christmas tree farm.

Participants in the Maryland focus group also used their ROV for occupational and recreational purposes. One participant only used his vehicle recreationally riding along public trails in West Virginia. Another participant's job required him to ride through creeks and along nature trails that were up to one mile. A third participant was a military officer who used ROVs professionally and personally. Professionally, ROV's were used for pulling things, combat exercises and snow removal. He also used his own ROV to off-road on his farm. Others used the ROV for hunting, giving children and grandchildren "joy" rides around ponds or through the woods, and transporting materials on their property for various reasons.

Participants in Maryland also admitted to modifying their vehicles. The participant who used his vehicle for trail riding made numerous changes to his vehicle which included: changing tires, installing rear window and windshields, installing lights, installing a radio system. Other participants installed mud flaps, lights, and horns. They also enclosed the vehicle and installed a heating system. Two participants swapped the standard restraint for a 5-point harness system in both seating positions. A third agreed that modifying the seatbelt system to a harness system would be a good for keeping children safe.

"Children can slip out from under the shoulder strap."

"Weakest system in the ROV is the seatbelt system."

2.1 Driving Behavior

All participants indicated that their ROV's do have restraint systems. Overall, participants admitted to being part-time seat belt users, and restraint use was often related to the circumstances under which they were using the ROV. Only one participant used his seat belt all the time because he often rode on public trails at higher speeds. The group agreed that when driving around their own property, there was no need for using a seat belt. Their yard was familiar territory, they frequently would get in and out of the vehicle (carrying wood, gardening tools, moving fruit and vegetables to a produce stand), and they never would travel at an unsafe speed so there was no need for additional protection. Under these conditions, the seat belt was perceived as more of an annoyance than a safety feature. Conversely, some participants did mention that they would use a seat belt if they were traveling along local roads, or drove the vehicle at a faster speed such as 30-35 mph, "run the vehicle to its limit".

> "Bulldog only goes 16 mph …..I never wear a seat belt….I know it has it in there. I have been out on the road a couple of times, but since it goes so slow, I just use it in the neighborhood."

Interestingly, all participants with grandchildren required the children to use a restraint system at all times, regardless of vehicle speed, location or child's age. One gentleman also required the children to hold on to the "hand-hold" whenever in the vehicle.

Two participants indicated that their vehicles had speed governors that were unrelated to the use of the restraint system (Polaris Ranger; Cushman Truck). According to the participants the Polaris is limited to speeds up to 25 mph, and the Cushman is limited to 50 mph. Each recognized that speed is a safety issue, and felt that the governor prevented the driver from driving too fast.

Terrain

In South Carolina, none of the participants used public trails, most rode on trails within their property lines, open roads, or wooded areas. All participants recognize that different terrains pose different types of threats. They often travel on areas that are bumpy, have varying degrees of inclines, or trees. One gentleman travels on some pretty steep inclines at a golf course. However, all felt that the areas they frequent were familiar to them; and therefore, they can adjust their driving behavior depending on the perceived danger. That is, they will adjust their speed and be more vigilant of their surroundings. One gentleman often travels on steep inclines as a golf ball retriever, and rather than use the seatbelt, he will simply lower his speed to enhance safety under these conditions. Participants agree that if someone was unfamiliar with these surroundings there might be more of a safety issue.

> "It might be 5 acres of property, but I know where the ditches and trees are….If you are unfamiliar with where you are at, then you need to be buckled up….you need that safety."

One woman often travels unbelted over a bridge on her property. While she expressed a fear of crashing while driving over the bridge, she does not think to use the belt but is grateful to have a roll-bar in the event of a crash.

In Maryland, participants used public trails, trails within their property lines, open roads, wooded areas, or on military bases within the US as well as overseas. The terrain varied from dirt trails to rocks and sand. Drivers also had experience along slopes, steep hills, and rocky terrain. One participant frequented the Outlaw trails which covered everything from "balls to the walls" flat trails, and steep rocky terrain developed by the locals in West Virginia.

Speed

In South Carolina, participants reported various average speeds, but most could not (or would not) identify their maximum speed. Most travel about 5 mph when moving around their home property. When on a paved or open road, one woman reported travelling at speeds close to 15 mph. Another gentleman traveled about 12-15 mph on open roads when hunting, but reported slower speeds (not even 5 mph) in the woods because area is somewhat unfamiliar to him. Others mentioned speeds of 15-30 mph. One participant would travel at 30 mph at least once a day.

In Maryland, most participants agreed that commonsense typically dictates their elected speed. If participants were driving along smooth flat terrain, where there were no perceived threats, they would "open up the vehicle". That is, drive close to the vehicle's maximum speed. Conversely, along steep hills, where the risk of rolling over at higher speeds is increased, all of the participants would elect to drive at a slower speed. Steep inclines and slopes require the driver to have more control over the vehicle, and this requires a slower speed. In some cases, participants indicated that when they drive along local paved roads they will typically drive up to 60 mph (or whatever the maximum speed of the vehicle may be). However, these same participants will decrease their speed when on trails (some down to 25 mph). For personal use one participant indicated that they would only drive up to 8-10 mph. However, when on the job, this participant would drive up to 50 mph because it might be required under some conditions. Some Maryland participants also indicated that they often elect to drive at slower speeds on their own vehicles because any damages incurred by a crash would cost them money.

When asked how often they drive with passengers in the vehicle, Maryland participant's responses were mixed. While all participants drive with passengers in the vehicle, the percentage of time varies. One gentleman only has passengers in the vehicle 10 percent of the time. Another reported having passengers approximately 50 percent of the time. Others reported driving children, grandchildren, and neighborhood children from several times a months to several times a year. In addition, the elected speed was often contingent upon the type of passenger. Most participants would slow down when children were passengers. However, if a coworker or peer were in the vehicle, their speed would increase. Most participants required children under 18 were to use a seat belt. One participant does not know whether her teen drivers use a seat belt because the key stay with the vehicle (unsupervised).

Accidents or Close Calls

No one within either group had been involved in a crash. However, in South Carolina several knew individuals who had been involved in crashes. A neighbor had been drinking and rolled over the vehicle causing leg injuries that required a hospital stay. Another mentioned a friend's nephew died as a result of running into a tree on a trail. The group tended to agree that both of these crashes were either the result of alcohol impaired driving or the inexperience of youth. All agreed that with youth comes inexperience, and poor decisions. Often, younger teens and adults are irresponsible and test the limits of safety. No one was aware if these two individuals were belted at the time of the crash.

Maryland participants admitted to a number of risky maneuvers, but not were involved in a crash. Several complete "donuts" in the snow, get caught up on something in the center of the road (wheels in the air), finding themselves in precarious situations when driving head first up a very steep incline, and intentionally rolling over the vehicle in military drills.

2.2 Seat belt Use

In South Carolina, most ROV's had a 3 point lap shoulder belt, but two vehicles had only lap belts. As mentioned previously, all participants indicated that they were part-time users. However, while they did use the restraint system occasionally, it was never used when driving on their own property. The group agreed that the ease of getting on/off of the vehicle outweighed risk of injury when traveling through their yard or farm. One gentleman agreed that this would be particularly annoying for him as a golf ball retriever. Having to buckle/unbuckle the seat belt repeatedly getting on and off the ROV would become annoying and slowdown his progress. This participant felt that if you respect the vehicle, you will be safe. Participants really did not mention discomfort as a reason for not using the restraint system. However, one did suggest that with the frequency with which he gets into and out of his vehicle, he might "strangle" himself if he wore the seatbelt.

Again, it is important to note that all participants with grandchildren require them to use the restraint system regardless of age, even when children repeatedly complain about the shoulder strap scratching their neck.

Participants all agreed that they would use the restraint system under the following 4 conditions:

- Traveling at an unsafe speed
- Traveling with child passengers
- Traveling on rough terrain (steep incline)
- Travelling on unfamiliar territory

If they had to indicate a speed at which they would always wear a seat belt, one person said 10 mph, but other felt it was depended on the terrain.

Overall, most participants felt that the only way they would use the restraint system all the time would be if it were required by law, or automatically came on when you turned on the vehicle. The group made several comparisons to systems (alerts) that currently exist in passenger vehicles as well as laws that address drivers of passenger vehicles. A strongly enforced seat belt law was effective for passenger vehicles. The penalty of a monetary fine for not using a restraint while in a passenger vehicle was enough incentive for some participants to start using a restraint when driving a passenger vehicle.

In Maryland, most ROV's had a 3-point lap shoulder belt. Two owners modified their vehicles by installing a 5-point harness in both the driver and passenger seats. However, 4 out of 5 participants indicated that they were part-time users. Only one participant used his 5-point harness all the time, and he indicated that this was due to the kinds of terrain he travels along. The group agreed that the ease of getting on/off of the vehicle often outweighed risk of injury when traveling. When working, most participants felt that the terrain and speed were not dangerous. Also, if you were to get into a predicament at that speed along that roadway, it would not result in a vehicle occupant being thrown from the vehicle.

However, if you were travelling along a trail (example: Gorge in Westat Virginia) even at the slowest speed, a driver may be thrown from the vehicle.

Two participants with John Deere Gators indicated that the vehicle had a seat belt indicator light, and both found ways to override the system. One simply placed a piece of tape over the indicator light, and the other buckled both the driver and passenger belt in behind the occupants back. Two participants are required, while working, to use the seat belt system. However, both do not unless a supervisor is present.

Overall passengers felt that the terrain also dictated whether or not the occupant should use a safety restraint. The participant who frequents trails, uses the seat belt when travelling along long narrow trails at speeds close to 25 mph. He also mentioned that he slides in the seat when making turns or going up a huge rock hill, and the seatbelt helps to hold him in place. In addition, some terrains are pretty rough and will cause the vehicle's occupants to bounce around. Although one participant will use the seat belt when retrieving the morning mail from the mailbox which is approximately 160-170 yards from house, most felt that seat belts were only needed for "extreme driving". Again, it is important to note that all participants with young grandchildren require them to use the restraint system regardless of the conditions.

In addition, only one of the five Maryland drivers used a helmet. In fact, one participant required helmet use by individuals driving their ATV, but never thought of using a helmet for the ROV. This participant felt the roll bars and headrest would provide sufficient protection in the event of a crash. Some participants, however, require any rider under the age of 17 to use helmets when in the vehicle.

When pressed to identify a speed at which they would wear a seat belt, two participants felt 25 mph would be the point. However, one participant indicated that his vehicle only goes up to 35 mph, and even at it's maximum speed he does not feel the need to use a seat belt.

Protection in a Crash

Participants in both groups did not believe that there was a strong chance of their being involved in a rollover/crash while driving. While most participants seemed to feel that a seat belt would protect them during a crash, some felt that only the 3-point system would provide the proper protection. Note, two participants in Maryland modified their vehicle system and now have 5-point harness. In addition, several felt that if you were belted in during a roll over you would be trapped, or that a belt would not prevent your legs or arms from moving outside of the vehicle. Note, none of the participant's vehicles in South Carolina were equipped with a door or netting (except for the Cushman) that would protect their legs and arms in the event of a rollover. South Carolina participants also felt that if they were involved in a crash/rollover, it would be beneficial to be unrestraint so that you can jump free of the crash.

Participants in Maryland also mentioned features such as a kill switch or netting that might provide additional protection in the event of a crash.

2.3 Seat belt Speed Limiter

Overall, the reactions from participants were mixed in both South Carolina and Maryland. Some participants in South Carolina felt that this was a good safety feature, others that it was a "pain in the butt", and still others felt that the limiter would not influence their restraint use at all. Two or three participants felt that it would be a nuisance to have this type of system. These drivers often use their ROV's on their own property, at what is perceived to be safe speeds (5-10 mph), and make frequent stops to accomplish chores. Requiring the driver to constantly latch and unlatch the restraint system is unnecessary under these conditions. According to the participant, the driver is traveling at a "safe" speed on familiar territory with frequent stops. The gentleman who is a golf ball retriever expressed similar thoughts. One participant went so far as to indicate that he would find a way to disconnect or override the system.

Alternatively, others felt that this might be a good safety feature. While one driver felt it might not be appropriate for all drivers, he recognized the benefits of having this as a safety feature. He cited several instances where this feature would be useful for some types of drivers. For example, he has a neighbor with young grandchildren that frequently ride his ROV at high speeds. The limiter would require the driver (grandchild) to buckle up prior to speeding off. If he/she was not restrained, it would limit the speed of the vehicle, and decrease the likelihood of their being involved in a serious crash/rollover. All agreed that this feature would increase safety for teen drivers of ROV's. However, most felt it was not necessary for the types of conditions they drive.

When asked how they would feel if the limiter was a required feature, most were agreeable. However, two indicated that they would "customize" the vehicle by disconnecting the system, or simply latching the buckle behind their back. The group seemed to think that they do not need to use a seat belt as adults, but they want their children or grandchildren to be protected.

In Maryland, most participants had a negative reaction towards the Speed Limiter. As participants viewed an illustrative video, the immediate and overwhelming reaction was negative. Most immediately began to identify ways to override the mechanism. One participant indicated that he would simple insert the buckle behind his back.

After some time, one participant said that the limiter might be a good idea for approximately 50-60 percent of the population. He felt that the limiter should be used for teen drivers and riders, and possibly sold as an optional feature as opposed to standard. However, he was quick to point out that many teens today would be able to quickly figure out how to override the mechanism. Another participant felt that the mechanism should be linked to a key switch. That is, a specific key would activate the system when novice drivers, or youths were occupants or drivers.

Alternatively, the vehicle could have multiple keys, and one or more ignition keys would activate the limiter feature when inserted into the ignition (Participants felt this should be called the "teenager key"). Several participants seemed to agree with the idea of having one ignition key that will activate the system (not that they themselves would use the key). One felt for this mechanism to be effective it cannot be mechanical, it will have to be a software driven feature or people will find a way around it.

In addition, on participant suggested that the feature be standard on child-size ROV's models as a safety mechanism.

Adjusting the Limit

In South Carolina, when asked their opinion on the maximum speed for unbelted drivers, most participants felt that 10 mph would be appropriate. However, this is not because 6 mph is any safer than 10 mph. In most cases participants felt that they typically did not drive as fast as 10 mph, and by adjusting the maximum speed up to 10 mph it would allow them to continue driving unbelted.

A participant inquired as to whether this was standard or an option. Most preferred that the feature be an option, and that the owner also have the ability to adjust the limiter to 6 mph or 10 mph.

In order to identify the best speed to activate the limiter, one participant suggested conducting a study on speed vs. injuries. That is, at what speed is there a significant increase in the risk of involvement in fatal and injury crashes. Once the number is identified, it should be well publicized.

In Maryland, most participants agreed that the maximum speed for an unbelted driver should be between 15-20 mph. If the limiter was set to 6 mph, all of the participants would disable the feature and may not purchase the vehicle. Some agreed that they would not try to override a system set at 15 mph.

Increase Appeal of the Limiter

One participant recommended, and other participants agreed to an override switch for the system, so that the owner could activate the limiter system with a key. The key would give the owner some control and also prevent children from accidentally deactivated the system by flipping switch.

In Maryland, most participants felt that raising the limit to 15 mph, a key switch, or a programmed ignition key would increase the likelihood that their accepting the feature. Also, one participant felt that states could implement a seat belt law for public trails, and required drivers (and passengers) to use the seat belt.

2.3 Passenger Seatbelt Use

In both Maryland and South Carolina, participants often take their grandchildren and other children out as passengers in the ROV. Some go out as often as once a week while others will go out once a month. All child passengers are required to be restrained while in the vehicle. However, the children do not offer must resistance to this rule because they were raised with the requirement of using a seat belt in passenger vehicle. Most agreed that their grandchildren often remind them to wear their seatbelt, and when reminded the adults comply.

In South Carolina, no participant discussed identified adult passengers.

In Maryland, participants do not currently require adult passengers to use seat belts, but would require the passengers to use the seatbelt if the limiter was activated.

2.4 Netting/Door

In Maryland, all participants indicated that the netting was inconvenient and they never used the netting on their vehicles. However, all felt that the netting on the Commander was the "slickest" because the netting was easily latched with the seat belt buckle design. Having said that, the participants pointed out that the driver in the illustrative video was "large", and people would get tired of rubbing against the netting while trying to maneuver the ROV.

Based on their view of the videos, Maryland participants felt that the Commander netting was superior to that found on the Polaris RZR. All participants noticed that there were gaps in the Polaris RZR netting which would increase the likelihood of something or someone falling out. The Commander had no such gaps in the netting.

Type of attachment ***(single-handed vs. both handed operation)***

In both focus groups, most participants would not want any netting. However, if they were required to have netting, they would prefer to have the single handed attachment. They prefer something simple and quick. Participants agreed that the single handed was easy to secure and remove. If it gets complicated you would prefer to walk.

Design of attachment and Force Required to Snap (Snap buckle vs. seat belt buckle)

The participants in the South Carolina focus group were older in age and expressed concerns about arthritis and problems with dexterity and mobility. Having said this, they unanimously agreed that the seat belt buckle was preferable to a snap buckle. Some felt that the snap buckle would require two hands which would become annoying, and in addition others mentioned that they have found snaps difficult or impossible to work. Snaps often get rusted when exposed to the elements, making it even more of a challenge to secure. The seat belt buckle was perceived as familiar and a simple one step motion.

The Maryland participants tended to agree with the South Carolina participants. Again, participants overwhelming preferred to have a seat belt buckle design. One participant with a Polaris RZR referred to his netting system as "terrible". The participants felt that the netting system with the snap on the Polaris RZR would not hold you in if the vehicle rolled, and that is was too much effort to secure the netting. Many indicated that the plastic snap buckle is sensitive to weather and often breaks due to cold inclement weather. One thought the snap would be last longer if it were made of metal.

Number of attachments (Single vs. multiple)

As with the other features, ease of use was a priority for both South Carolina and Maryland participants. All preferred the single attachment site. All referred to the video of the Commander indicating that the simple attachment close to the knee seemed reasonable. Multiple attachments would decrease the likelihood of use.

Location of attachments

Most participants requested that the attachment be located toward the front end of the vehicle with the attachment no lower than the knee. In fact some suggested that the latch be slightly above the knee in order to increase ease of use. Anything lower or behind the driver would decrease the likelihood of use.

Ease of ingress and egress (based on permanent attachment points of net)

Based on the video for the Commander, many felt that the netting should retract to make it easier to get into and out of the vehicle. Others were concerned that they would end up sitting on the netting if it did not fall properly, block their vision, or get caught up on the brush when travelling through the woods or on trails.

In Maryland, the participants did not have concerns or issues with ingress and egress. However, one participant pointed out the he has used ROV's with netting that is weighted in the center. The weighted center pulls the netting toward the back of the vehicle (out of the way) when it is unlatched allowing the occupant to get into and out of the vehicle without interference.

Letter Sent to Maryland Residents from MVA

May XX, 2013

«Name»
«Street»
«City», «State» «ZIP»

Dear «Name»,

The Maryland Motor Vehicle Administration (MVA) is committed to improving driver safety. As a part of that effort, the MVA regularly supports research with that goal. Westat, a Rockville, Maryland research organization, has asked the MVA to support them with a research project conducted for the Federal Government. Westat is studying the use of seatbelt systems in side-by-side ATV's, also referred to as off-road vehicles (ROVs) and has asked the MVA to assist in soliciting participants for the study.

Study participants must own and regularly use an ROV. The ROV should be equipped with a steering wheel and pedals, bucket or bench seats, and carry 2 to 4 people. **Participation in this study is voluntary and would involve participating in a 90 minute focus group.** Participants will receive $75 from Westat.

All information regarding participation in this study will be **confidential**. Only Westat will know who is participating and opinions and information provided during the focus group will be kept confidential. This information will not be shared with anyone including the MVA, law enforcement, insurance companies or any other government or private organizations.

If you are interested in volunteering for this study, please contact Diane Snow at Westat by calling **(888)-902-0873**. On behalf of the MVA, and Westat, we thank you for considering participation in this study to help improve driver safety.

Sincerely,

Andrew Krajewski
Driver Safety Division
Motor Vehicle Administration