

Ejection of a Rear Facing, Golf Cart Passenger

Kyle Schau and Dr. Oren Masory

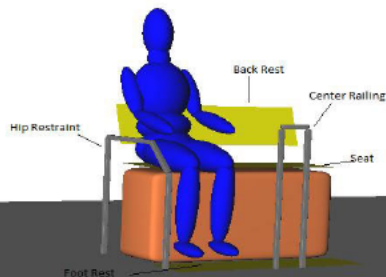
College of Engineering and Computer Science

How safe are shuttle style golf carts? How likely is ejection of a rear facing passenger?

Problem

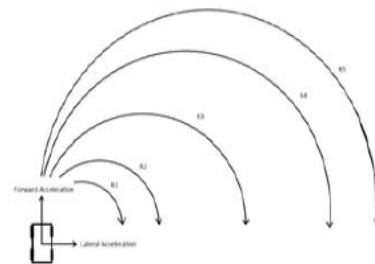
- Due to several environmental, social, and economic factors, the use of golf carts has become increasingly prevalent in recent years (Insurance Institute for Highway Safety)
- In a nation wide study published in *The Journal of Trauma Injury, Infection, and Critical Care*, there were an estimated 48,255 golf car related injuries during the years 2002-2005 (McGwin et. al)
- The populations at greatest risk are observed to be teenagers and the elderly (McGwin et. al)
- Rear facing passengers (RFP) are particularly associated with golf car ejection due to their lack of passive restraints in the direction of ejection during typical acceleration (Watson et. al)
- Seat belts on golf carts are not required by any governing authority, society, or manufacturer
- **THE CURRENT RESTRAINTS AVAILABLE TO PREVENT EJECTION OF A REAR FACING PASSENGER DURING RAPID ACCELERATIONS ARE NOT ADEQUATE**

Current Restraints

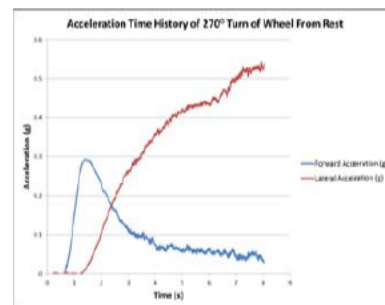


Experiment

Data was collected from a commercially available golf cart using a 3 axis accelerometer during maximum acceleration from rest with the steering wheel turned to several positions



The forward and lateral accelerations were measured and filtered. This data was used to determine if the forces acting on the rear facing passenger were great enough to overcome friction between the seat and passenger, causing them to slide.



This data was then input into the Articulated Total Body (ATB) software to simulate each maneuver and determine if the ejection of the RFP. Between the experimental and simulated results, the level of risk for each maneuver was determined. A golf cart with dimensions of the cart tested was modeled and a 50th percentile male was placed in the rear seat.

Results

The results of the accelerometer data showed that three of the 5 maneuvers tested generated forces capable of causing the RFP to slide along the back seat.

Label	Steering Wheel Rotation	Maximum Lateral Acceleration (G)	Maximum Forward Acceleration (G)	Occurrence of Sliding
R5	90°	0.268	0.293	NO
R4	180°	0.447	0.315	NO
R3	270°	0.542	0.292	YES
R2	360°	0.644	0.315	YES
R1	540°	0.691	0.318	YES

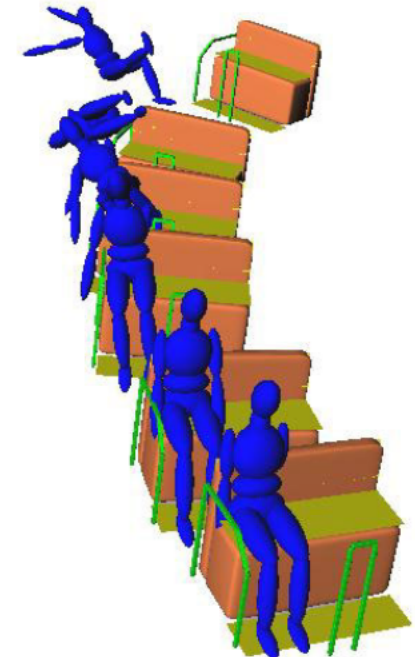
When the accelerometer data was input into the ATB software, simulations were run with the following results.

Maneuver	Results	Time to Ejection (ms)
R1	Ejected	950
R2	Ejected	1200
R3	Ejected	1450
R4	Ejected	1500
R5	Not Ejected	N/A

Discussion

- As shown above, 3 of the 5 maneuvers tested were capable of causing the passenger to slide. This could result in ejection from the rear seat.
- The ATB simulations show that all but the most mild maneuvers were capable of causing the RFP to tip over the hip restraint, AND sliding out of the back of the vehicle is very likely
- The more severe the turn, the faster a RFP is ejected
- With nothing in front of the RFP to prevent ejection, tipping over the hip restraint, AND sliding out of the back of the vehicle is very likely
- THE HIP RESTRAINT WAS RAISED IN THE SIMULATED TRIALS UNTIL EJECTION WAS PREVENTED. THE NECESSARY HEIGHT IS TWICE AS HIGH AS THE CURRENT RESTRAINTS!**

Example simulation resulting in ejection



References

- Insurance Institute for Highway Safety, "Status Report: Improve Fuel Economy Without Negative Safety Consequences," Insurance Institute for Highway Safety, Vol. 37, no. 4, April 6, 2002.
- G. McGwin, J. Zoghby, R. Griffin, L. W. Rue III "Incidence of Golf Car Related Injury in the United States," *The Journal of TRAUMA Injury, Infection, and Critical Care*, Vol. 64, no. 6, June 2008.
- D. Watson, T. Mehan, G. Smith, "Golf Car Related Injuries in the U.S.," *American Journal of Preventive Medicine*, Vol. 35, no. 1, 55-59, July 2008.