



NHTSA's Research on Seat Belt Interlocks

SAE Government Industry Meeting
January 24-26, 2018

Background

- In 2016, unrestrained passenger vehicle occupant fatalities increased by 4.6 percent, from 9,968 to 10,428 (+460).
- Among passenger vehicle occupants killed in 2016, almost half (48%) were unrestrained
- Seat belt use in 2017 dropped to 89.7 percent, down from 90.1 percent in 2016
- MAP-21 modified US Code to permit seat belt interlocks as a compliance option





Research Objectives and Approach

- Objective: Collect and interpret data related to seatbelt assurance systems:
 - System effectiveness
 - User acceptance
 - Unintended consequences
- Approach
 - Field operational test
 - Part-time seat belt users
 - Collection of objective driving data through naturalistic driving data
 - Collection of subjective data through a survey questionnaire

Experimental Design

- Mixed Design
 - Two seat belt assurance systems
 - Vehicles with transmission interlock (General Motors)
 - Vehicles with speed limiter (BMW)
 - 48 subjects
 - System condition (one week of baseline, two weeks of treatment)
 - Belt user group (Frequent seat belt users, Infrequent seat belt users)
 - Gender (Male, Female)
 - Age (Younger, Middle-aged)

Week	BMW System (A)	GM System (B)
1	Baseline_SystemA	Baseline_SystemB
2	SystemA	SystemB
3	SystemA	SystemB
# of participants	n=24	n=24

Test Vehicles with Speed Limiter Assurance (BMW)

- 2014 BMW X5
- Prevent vehicle with unbelted driver/passenger from driving faster than 15 mph;
- The system will issue continuous aggressive seatbelt reminder, acoustic and optical warning in central display;
- When the assurance system is activated and drivers remain unbelted, speed will be reduced automatically to 15 mph at a certain deceleration level after a certain period of warning time;
- Both visual and auditory signals will be issued to drivers by the seatbelt assurance system.



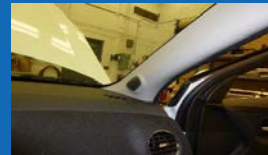
Test Vehicles with Transmission Assurance (General Motors)



- 2014 Chevrolet Cruze
- Prevent drivers from shifting into gear if driver/front passenger is unbelted;
- Sensors used for driver side are buckle, brake, and transmission status. Sensors used for passenger side include buckle and seat occupant;
- The basic or enhanced seat belt reminder in these vehicles (baseline condition for this vehicle) have both visual and audio warnings;
- Both visual and auditory signals will be issued to drivers by the seatbelt assurance system.

Vehicle Instrumentation

- Each vehicle was equipped with an UMTRI data acquisition system (DAS):
 - Embedded microcontroller board for recording objective data
 - Video module for recording the forward scene
 - Video module for recording the vehicle cabin (with audio)
 - Infrared cabin illumination
 - GPS receiver
 - CAN bus interface
 - Custom power/interface/controller board





Recruitment and Eligibility

- Recruitment
 - Posted flyers (e.g., local community colleges, bars)
 - Ads online (e.g., UM's clinical research study site)
 - Subject pool from previous UMTRI field studies
 - Initial screening over the phone
- Eligibility criteria
 - Valid Michigan driver's license
 - Self-report being part-time or non-seatbelt user
 - Driven for at least 2 years and currently driving at least 5 days per week
 - Check their first week of driving data to validate if they are qualified for continuing with the treatment week



Results: Data Collection

- Data collection
 - Screened 2,900 drivers
 - 84 drivers enrolled and 48 qualified drivers completed three-weeks of participation
 - Ages between 19 and 60 years old with a mean age of 33 years old
 - 27 drivers from the speed limiter group (12 males, 15 females)
 - 21 drivers from the transmission interlock group (10 males, 11 females)



Results: Data Reduction

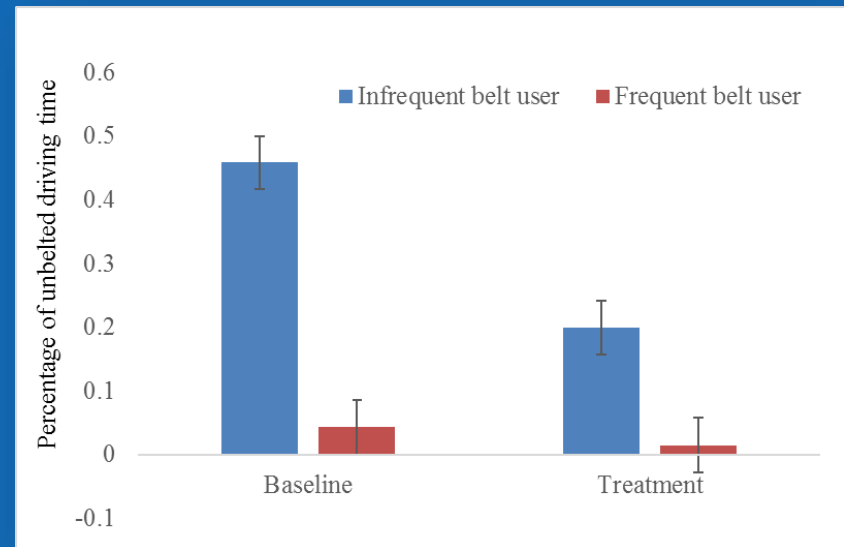
- A total of 6,254 valid trips were identified, representing 1,785.6 hours
- 48 drivers were divided into two groups with half of the participants classified as “Frequent Seat Belt Users” while the other half classified as “Infrequent Seat Belt Users” (though all were part-time users)

SBAS	Treatment	Belt-user group	# of valid trips	Driving hours	# of participants
Speed Limiter System	Baseline	Frequent-belt user	757	234.82	15 (6 male, 9 female)
Speed Limiter System	Baseline	Infrequent-belt user	554	178.00	12 (6 male, 6 female)
Speed Limiter System	Treatment	Frequent-belt user	1323	382.85	
Speed Limiter System	Treatment	Infrequent-belt user	858	283.83	
Transmission Interlock System	Baseline	Frequent-belt user	497	124.71	9 (5 male, 4 female)
Transmission Interlock System	Baseline	Infrequent-belt user	573	159.05	12 (5 male, 7 female)
Transmission Interlock System	Treatment	Frequent-belt user	676	136.36	
Transmission Interlock System	Treatment	Infrequent-belt user	1015	285.98	

Results: Percentage of unbelted moving time

$$\% \text{ of unbelted motion time} = \frac{\text{Total unbelted time when the car was in motion}}{\text{Total time when the car was in motion}}$$

- Significant interaction effect between treatment and belt-user group $F(1,44)=19.9$, $p<0.01$)
- Significant treatment period effect ($F(1,44)=30.94$, $p<0.01$).
 - 24.1 percent during baseline
 - 10.7 percent during treatment
- No main effect of SBAS type was observed ($p>0.05$).
 - 16.5 percent for speed limiter group
 - 19.4 percent for transmission interlock group`

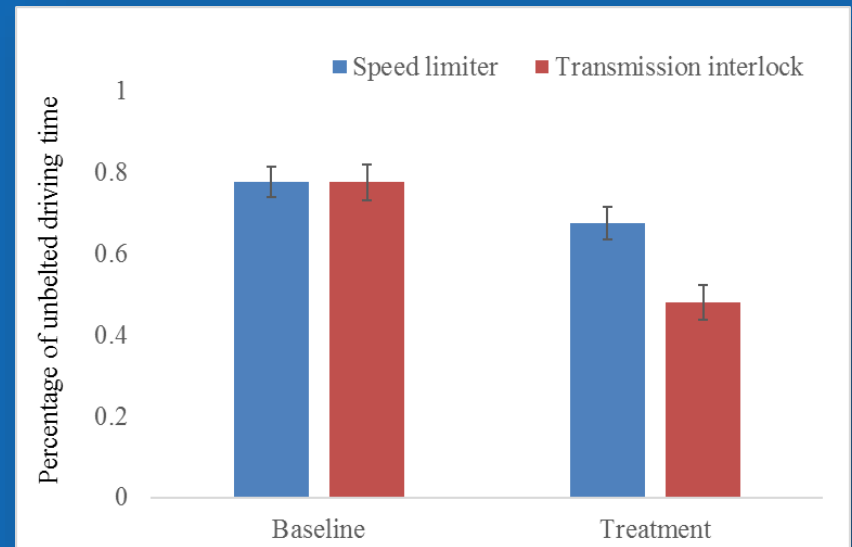




Results: Percentage of unbelted trips

$$\% \text{ of unbelted trip with motion} = \frac{\text{Total number of trips with unbelted behavior when the car in motion}}{\text{Total number of trips with motion}}$$

- Significant interaction effect between treatment and SBAS type ($F(1,44) = 7.1, p < 0.05$)
- Significant treatment period effect ($F(1,54) = 25.2, p < 0.05$)
 - 77.6 percent during baseline
 - 57.8 percent during treatment
- Significant SBAS ($F(1,41) = 4.8, p < 0.05$)
 - 72.6 percent for speed limiter group
 - 77.1 percent for transmission interlock group
- Significant belt-user group ($F(1,41) = 18.2, p < 0.05$)
 - 77.1 percent for infrequent belt users
 - 58.4 percent for Frequent belt users



Results: System Cheating Strategy

- Two main defeating methods were observed:
 - Buckling the belt before entering the vehicle and then sitting on it;
 - Waiting out the transmission interlock timer
- Three drivers tricked the SBRS during baseline period driving
- Eight drivers tricked the SBAS by not using the seat belts appropriately:
 - Five were from the transmission interlock system group
 - Three were from the speed limiter group
 - All infrequent-belt users
- Drivers from the transmission interlock group are about 2.5 times more likely to cheat than the drivers from the speed limiter group
- Drivers were 3 times more likely to cheat during treatment condition than during baseline condition





Conclusions and Discussions

- Significant system effects observed for both SBAS with an average of 14.4% increase in seat belt use while the vehicle was moving, or about 19.8% increase of belted trips from baseline to treatment condition
- This effectiveness was more pronounced for infrequent belt users than for frequent belt users
- Comparative differences between the two SBAS systems were observed with different measures:
 - The decrease in the percentage of unbelted trips (between treatment and baseline driving) for the speed limiter group was much less than for the transmission interlock group
 - Similar reductions in the percentage of unbelted driving time were observed for both SBAS groups



Conclusions and Discussions

- Two main system-defeating or “cheating” strategies were observed, pre-buckling then sitting on the seat belt and waiting out the transmission interlock timer
- All eight drivers who showed any SBAS cheating behavior were infrequent belt users
- Drivers from the transmission interlock group tended to be more likely to “cheat” the SBAS than drivers from the speed limiter group
- The SBAS may induce more cheating behavior
- Generally high levels of user-acceptance were observed
- Countermeasures for system defeating behavior are not available in either vehicle platform

NHTSA

THANK YOU

chris.monk@dot.gov

