

Safety Benefits of Stability Control Systems for Tractor-Semitrailers

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Presentation Agenda

Stability Control Effectiveness Report

- Project Goals
- Stability Control Systems
- Design and approach
- Results and conclusions

Safety Benefits of Stability Control for Tractor-Semitrailers

- Study conducted by University of Michigan Transportation Research Institute (UMTRI)
- Cooperative agreement between NHTSA and Meritor WABCO
- Study took place between September 2006 and September 2008
- Final report (DOT HS 811 205) issued October 2009

Introduction

- Tractor-semitrailer combination vehicles account for 75% of large truck fatal crashes while accounting for 65% of vehicle miles traveled
- 178,000 annual tractor-semitrailer accidents resulting in 3329 fatalities and 58,714 injuries (5 year annual average GES, TIFA, 2000 – 2004)
- Rollovers occur in about 13% of heavy truck fatal crashes but account for 50% of truck occupant fatalities
- Loss of control (LOC) and rollover crashes major cause of fatalities/injuries/equipment damage/ infrastructure issues
- Stability enhancing technologies capable of sensing when rollover or loss of control is imminent
 - Able to take corrective action without any input from driver

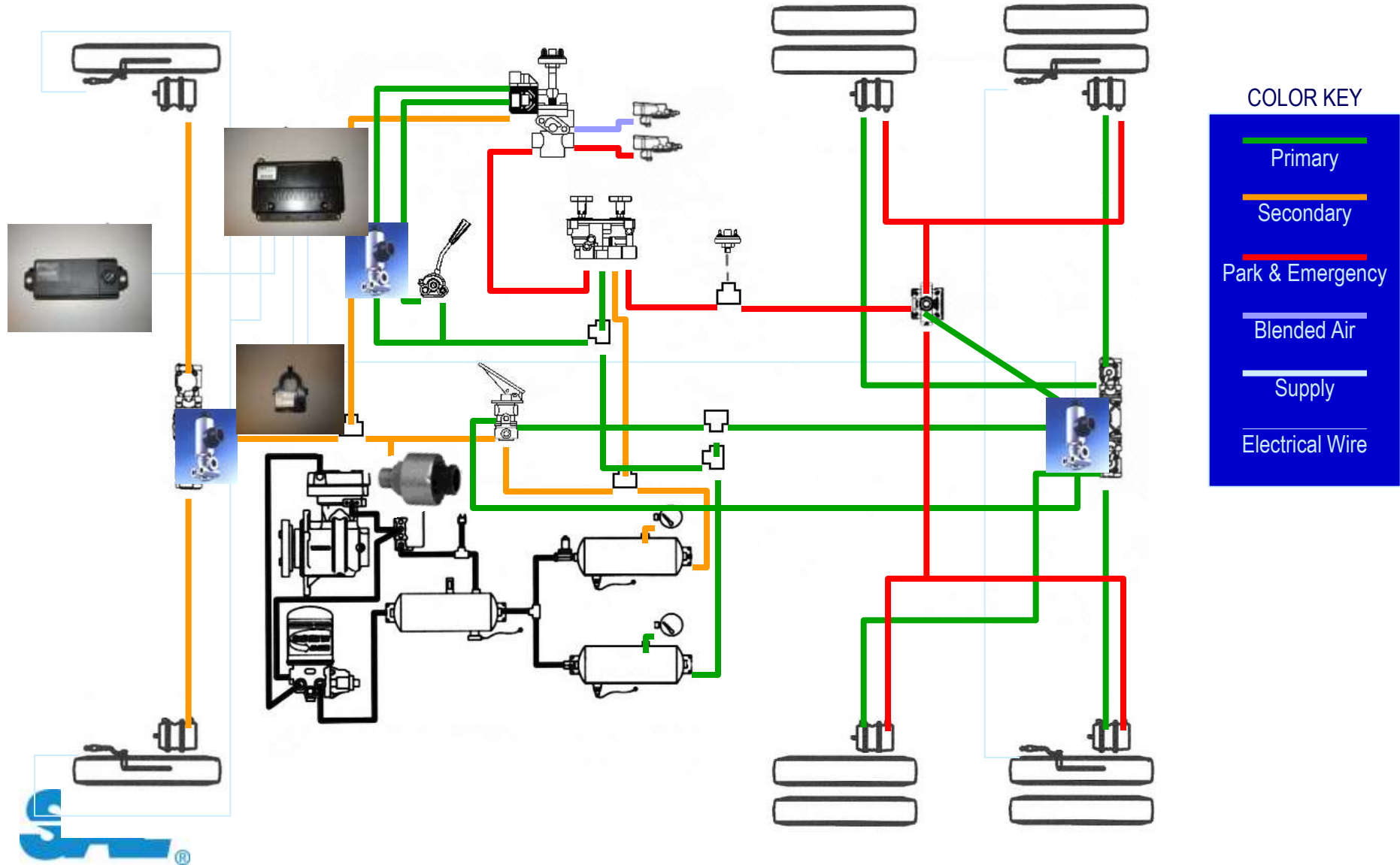
Project Goals

- Define pre-crash scenarios and identify factors associated with loss of control and rollover for 5 axle tractor-semitrailers
- Review applicability of tractor stability enhancing technologies to address scenarios
- Develop independent measure of relative safety effectiveness of stability control approaches
- Determine potential crashes, fatalities and injuries prevented by use of these stability enhancing technologies

Stability Systems Considered

- Two types of tractor stability systems evaluated
 - Roll Stability Control (RSC): ABS based, measures lateral acceleration, able to automatically decelerate the vehicle if potential rollover imminent
 - Electronic Stability Control (ESC): ABS based, same capability as RSC plus ability to sense and control vehicle understeer and oversteer directly related to LOC
 - Uses a selective braking strategy on individual wheels to generate a counteractive force in an attempt to regain directional control
 - Additional sensors required

Electronic Stability Control (ESC)



Study Design and Approach

- Conventional study approach for analyzing safety benefits of technology
 - Compare crash datasets of vehicles equipped and not equipped with the technology
 - Above option not possible with heavy truck stability control as technology is new and national crash databases do not have necessary factual information
- Above limitation required an indirect method be developed for predicting the safety benefit of heavy truck stability control

Study Design and Approach

Study organized into distinct modules:

- National Crash Databases
 - Used to determine frequency of selected crash scenarios and severity of selected crashes
- Naturalistic Driving Databases
 - Develop likely pre-crash scenarios
- Hardware-in-the-Loop (HIL)
 - Quantify performance of the technologies using various representative crash maneuvers
- Fleet Case Study
 - Quantify performance of technology in normal fleet usage

National Crash Databases

- General Estimates System (GES)
 - Nationally representative sample of estimated annual 6.4 million police reported crashes, includes all vehicle types
 - Has variables that allow tractor trailers as well LOC and rollover crashes to be identified
- Trucks Involved in Fatal Accidents (TIFA)
 - Survey of all medium and heavy trucks involved in fatal crashes
 - More detailed than GES
- Large Truck Crash Causation Study (LTCCS)
 - Jointly undertaken by FMCSA & NHTSA, provides in-depth analysis of 963 injury or fatal crashes between April 2001 and Dec 2003
 - Detailed accident descriptions to help determine crash root cause
- GES and TIFA jointly used to identify and select types of crashes that potentially can benefit from stability control
 - UMTRI developed algorithm used for crash selection process
- LTCCS used to test the logic / validate selection algorithms & help determine system effectiveness

Definitions Used for Selection Algorithm

- Study definition for rollover used in selection algorithm
 - Untripped rollover
 - Rollover from first harmful event
- Study definition for loss of control used in selection algorithm
 - Control / traction loss or a maneuver to avoid a collision
 - Loss of control from critical event
 - Due to poor road conditions or other causes
 - Loss of control from first event jackknife

Potentially Addressable Annual Rollover Crashes

Using the selection algorithm applied to GES and TIFA, the following rollover crashes potentially addressable

Roadway Alignment	Surface Condition	Crashes	Fatal	Injuries
Straight	Dry	2480	54	1643
Straight	Not Dry	207	6	64
Curve	Dry	3783	124	2972
Curve	Not Dry	403	12	196
Total		6874 (3.9%)	197	4875

Source: 5 year annual average GES, TIFA, 2000-2004

Based on 178,000 annual tractor-semitrailer accidents

Potentially Addressable Annual LOC Crashes

Using the selection algorithm applied to GES and TIFA, the following LOC crashes potentially addressable

Roadway Alignment	Surface Condition	Crashes	Fatal	Injuries
Straight	Dry	1208	16	462
Straight	Not dry	1802	22	533
Curve	Dry	572	7	189
Curve	Not dry	767	13	489
Total		4350 (2.4%)	58	1673

Source: 5 year annual average GES, TIFA, 2000-2004

Based on 178,000 annual tractor-semitrailer accidents

LTCCS Algorithm Results & Technology Benefits Determination

- Algorithm identified 159 crashes that might potentially benefit from stability control
 - 113 Roll / 46 LOC
- Expert Panel and HIL results used to determine potential stability control effectiveness of RSC and ESC at preventing above identified crashes
 - HIL mainly used to evaluate roll crashes
 - Expert panel utilized a systematic approach consisting of scoring 15 factors from the crash
- Once established, effectiveness ratings applied to relevant crashes identified in GES and TIFA databases to determine overall stability control effectiveness in preventing crashes

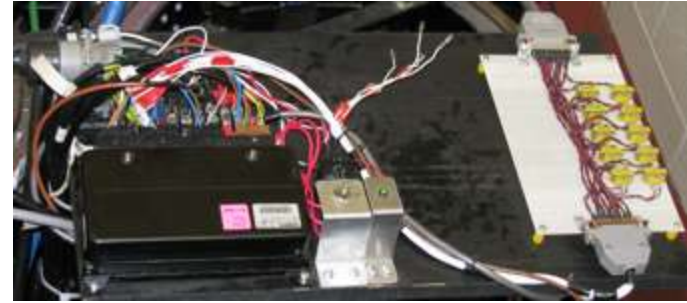
ESC/RSC Effectiveness for Relevant LTCCS Roll Crashes

Road Alignment	Surface Condition	LTCCS Cases	ESC	RSC
Straight	Dry	22	21.1%	16.4%
Straight	Not Dry	3	0%	0%
Curve	Dry	79	75.1%	71.2%
Curve	Not Dry	9	55.6%	45.6%
Total		113		

ESC/RSC Effectiveness for Relevant LTCCS LOC Crashes

Road Alignment	Surface Condition	LTCCS Cases	ESC	RSC
Straight	Dry	9	17.8%	0.6%
Straight	Not Dry	17	20.6%	1.8%
Curve	Dry	7	31.6%	14.0%
Curve	Not Dry	13	39.6%	11.5%
Total		46		

Hardware-in-the-Loop (HIL)



Potential RSC Benefit From Reduction of Relevant Crashes

Instability	Roadway Alignment	Surface Condition	Crashes	Fatal	Injuries
Roll	Straight	Dry	405	9	269
Roll	Straight	Not Dry	0	0	0
Roll	Curve	Dry	2,692	88	2114
Roll	Curve	Not Dry	184	6	89
Roll	Total		3,282 (48%)	103	2472
LOC	Straight	Dry	7	0	3
LOC	Straight	Not Dry	32	0	9
LOC	Curve	Dry	80	1	26
LOC	Curve	Not Dry	89	2	57
LOC	Total		208 (5%)	3	71

Potential ESC Benefit From Reduction of Relevant Crashes

Instability	Roadway Alignment	Surface Condition	Crashes	Fatal	Injuries
Roll	Straight	Dry	524	11	347
Roll	Straight	Not Dry	0	0	0
Roll	Curve	Dry	2840	93	2230
Roll	Curve	Not Dry	224	7	109
Roll	Total		3,588 (52%)	111	2686
LOC	Straight	Dry	215	3	82
LOC	Straight	Not Dry	371	5	110
LOC	Curve	Dry	181	2	60
LOC	Curve	Not Dry	304	5	194
LOC	Total		1071 (25%)	15	446

Study Conclusions

- Electronic stability control systems found to provide substantial safety benefits to tractor-semitrailers
 - Reduction in number of rollover and LOC crashes
- ESC provided more overall safety benefit than RSC
 - More braking capability during roll event
 - Ability to more effectively address LOC accidents
- Rollover crashes more frequent and severe than LOC
- Study could not account for secondary benefits such as improved driver awareness from interventions
- Analysis of data from one fleet produced similar results

Total Potential Benefit of RSC and ESC

	Annual Total Study Population	Prevented by RSC	Prevented by ESC
Crashes	11,224	3,489	4,659
Fatalities	255	106	126
Injuries	6,548	2,543	3132