NHTSA HEAVY VEHICLE CRASH AVOIDANCE RESEARCH OVERVIEW

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NHTSA's Heavy Vehicle Crash Avoidance Research Focus…

- Forward Collision Avoidance & Mitigation (FCAM) systems:
  - Includes Forward Collision Warning (FCW); Adaptive Cruise Control (ACC); and collision imminent braking (CIB)
- Lane Departure Warning (LDW) Systems
- Enhanced Visibility systems (Blind Spot Monitoring)
- Vehicle to Vehicle (V2V) based safety systems.

Rationale for focusing on crash avoidance technologies…

- FCAM and Lane Departure Warning (LDW) alone address approximately 20 to 25 percent of the total heavy vehicle involved crashes[1]
- Enhanced safety through:
  - Driver warnings and active vehicle control
  - Driving performance monitoring, training, and remediation efforts
- Early technical challenges are being addressed by suppliers
  - Newer/better sensor technology and sensor fusion
  - More refined detection algorithms (e.g.; reduced nuisance and false alarms)

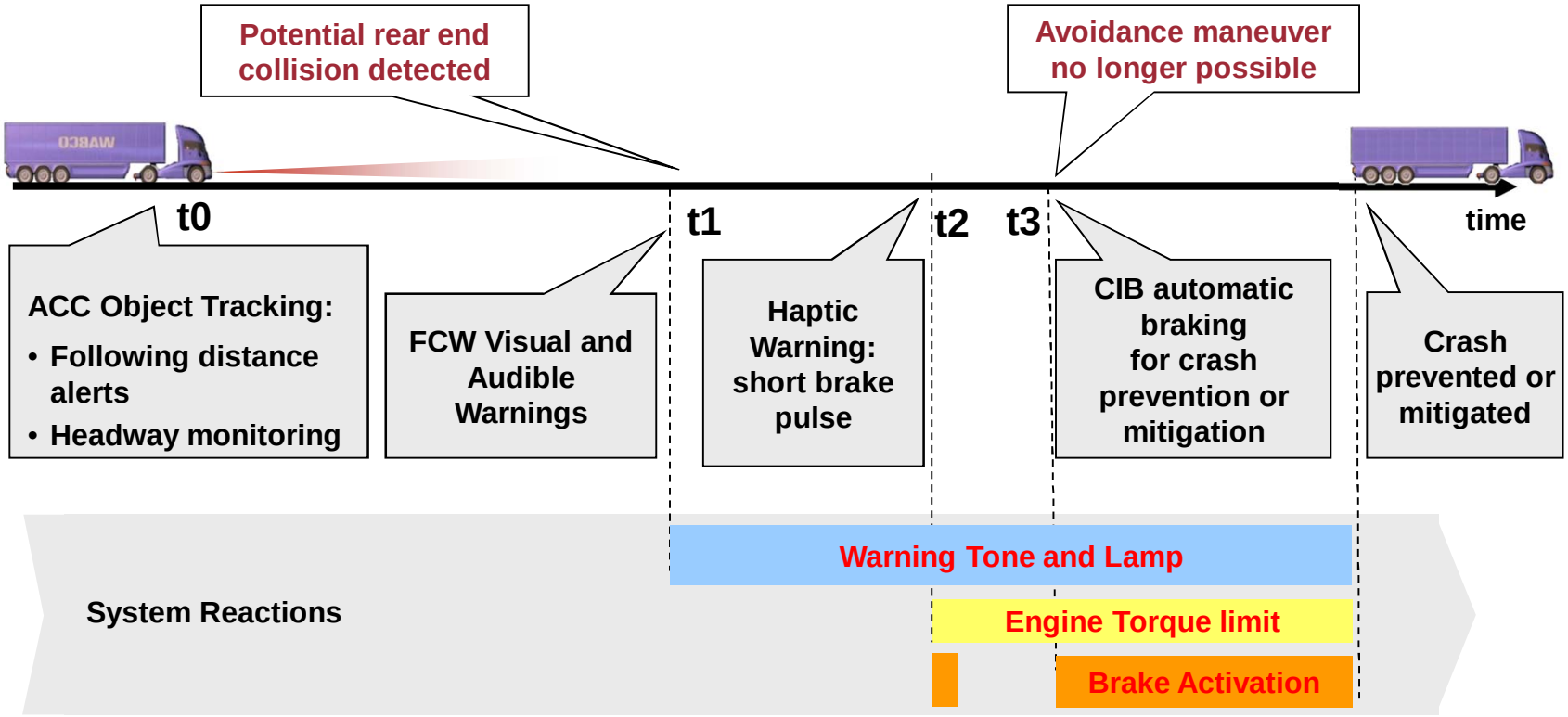
This presentation will focus on NHTSA's FCAM research

(1) Based on VOLPE analysis from NHTSA's IVBSS FOT

European Regulation Tests

Lead Vehicle Moving				
	EU Phase 1 2013/2015	EU Phase 2 2016/2018	NHTSA Light Veh.	
Subject Vehicle Speed	80 km/h (50 mph)	80 km/h (50 mph)	40 km/h (25 mph)	72 km/h (45 mph)
Lead Vehicle Speed	32 km/h (20 mph)	12 km/h (7.5 mph)	16 km/h (10 mph)	32 km/h (20 mph)
Speed Reduction Requirement	Avoidance	Avoidance	Avoidance	16 km/h (9.8 mph)
Lead Vehicle Stopped				
Subject Vehicle Speed	80 km/h (50 mph)	80 km/h (50 mph)	40 km/h (25 mph)	
Lead Vehicle Speed	0	0	0	
Speed Reduction Requirement	10 km/h (6.2 mph)	20 km/h (12.4 mph)	16 km/h (9.8 mph)	

Generalized FCAM Operation—heavy vehicles



System notes:

- **DBS not offered on FCAM systems for tractor trailers**
- **Driver partial braking does not override CIB control**
- **Trailer brakes are pulsed during CIB events to prevent lock-up of non-ABS trailers**

Heavy Vehicle FCAM Research-Current Projects

- Target Population And Benefits Estimates
- Collision Warning Interface Characterization
- Objective Test Development
- Field Operational Testing

Target Population and Benefits Estimates

- UMTRI-Meritor Wabco Study (completed)
  - *Effectiveness of a Current and Future Commercial Vehicle Forward Collision Avoidance and Mitigation Systems* Docket No. NHTSA-2013-0067
    - *Target Population for straight trucks and truck tractors*
    - *Effectiveness Estimates via simulation/ modeling*
    - *Effectiveness Estimates via real world fleet analysis*
- NHTSA Research (underway)
  - Target Population
    - GES, FARS, LTCCS, Case studies using state data
  - Effectiveness estimates
    - Simulation and modeling

Target population--preliminary estimates[1]

Truck tractors

15,987 target crashes

Fatalities	226
Injuries	7,698
PDO	10,701

For comparison

HV ESC target population:

~300 fatalities

~6,000 injuries

~4,000 PDO

Straight trucks

16,374 target crashes

Fatalities	67
Injuries	7,325
PDO	11,143

Crashes: Rear-end; Tractor-striking;

(annual avg. 2003 to 2008)

Crash type	Fatal	Injury	PDO
Fixed	**33.3%**	**22.7%**	**22.8%**
Stopped	**5.7%**	**23.2%**	**23.0%**
LV slower	**46.9%**	**19.1%**	**19.4%**
LV decelerating	**9.4%**	**30.0%**	**29.7%**
LV cut-in	**4.7%**	**5.1%**	**5.1%**
Total	**100.0%**	**100.0%**	**100.0%**

(1) Data from DOT Report *Effectiveness of a Current and Future Commercial Vehicle Forward Collision Avoidance and Mitigation Systems* Docket No. NHTSA-2013-0067

For the UMTRI Study, three levels of systems performance were defined and evaluated:

- Current Generation:
  - meant to represent performance of systems in market place today.

Auto braking deceleration levels

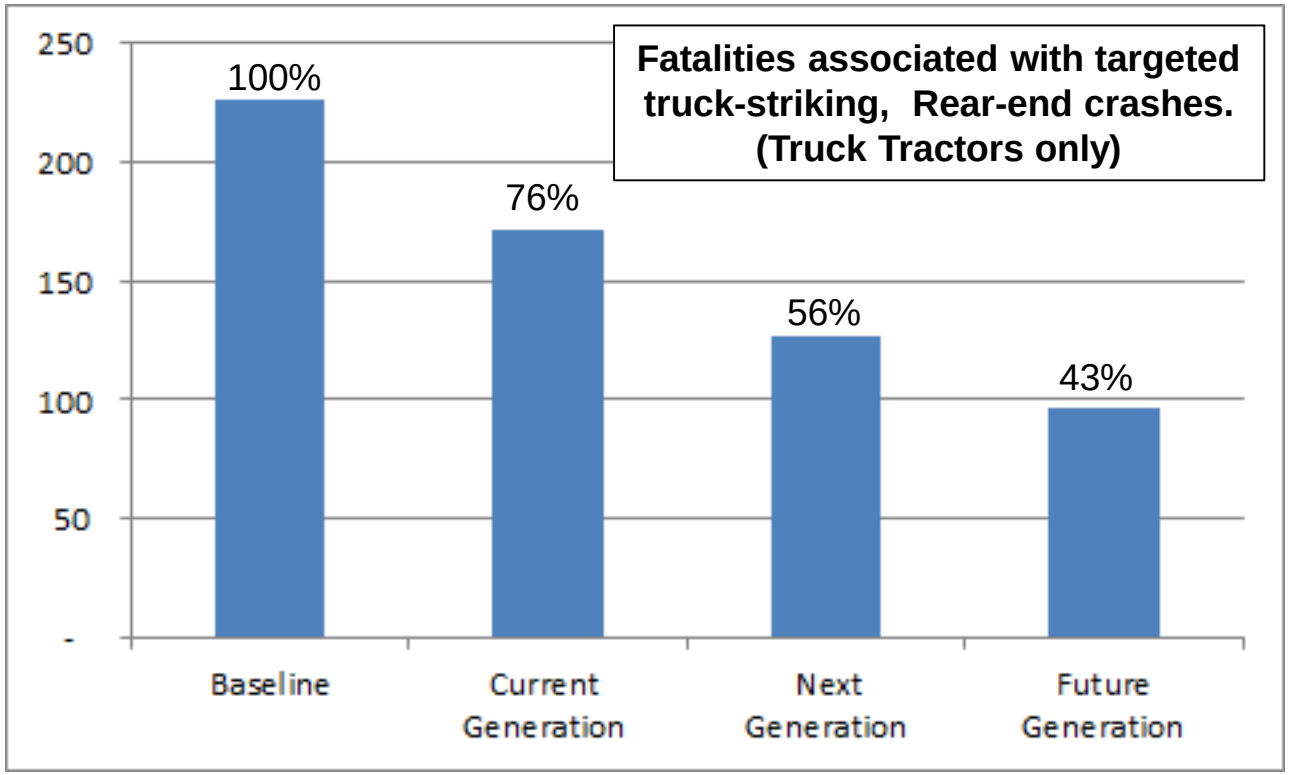
Technology generation	slower, decelerating or "stopped" Lead Vehicles	fixed lead vehicle
Current Generation	~ 0.35g	0
Next Generation (2014)?	~ 0.45g	~ 0.3g
Future Generation	~ 0.5g	~ 0.5g

- Next Generation
  - Meant to represent systems anticipated to be in the marketplace within the next year; or, performance estimated to meet near term ECE regulations
- Future Generation
  - Meant to represent a “stretch” technological level—or, performance estimated to meet longer term (2018) ECE regulations

UMTRI Project Results – Estimated Safety Benefits

Estimated reductions in injury severity

System	Fatalities		Injuries		No injury	
Baseline	226	100%	7,698	100%	35,553	100%
Complete System Contribution						
Current Generation	55	24%	1,895	25%	3,234	9%
Next Generation	99	44%	3,590	47%	7,194	20%
Future Generation	129	57%	4,191	54%	10,182	29%



CWI RESEARCH

NHTSA heavy vehicle CWI research

- Focus is on establishing minimum requirements for audio and visual modalities:
  - Sound pressure level?
  - Need for suppression of other in-cab sound sources (radio)?
  - Visual alert functional/performance features
- VTTI along with Battelle completing the effort:
  - Simulator studies
  - Test Track research
- Meaningful results available in Q2, 2014

Research Questions

Focus: Imminent Auditory and Visual Forward Collision Warnings for Heavy T

Auditory Alerts

1. Is there a performance improvement in terms of driver response (braking reaction time) to muting secondary audio sources during an imminent collision warning (FCW)?

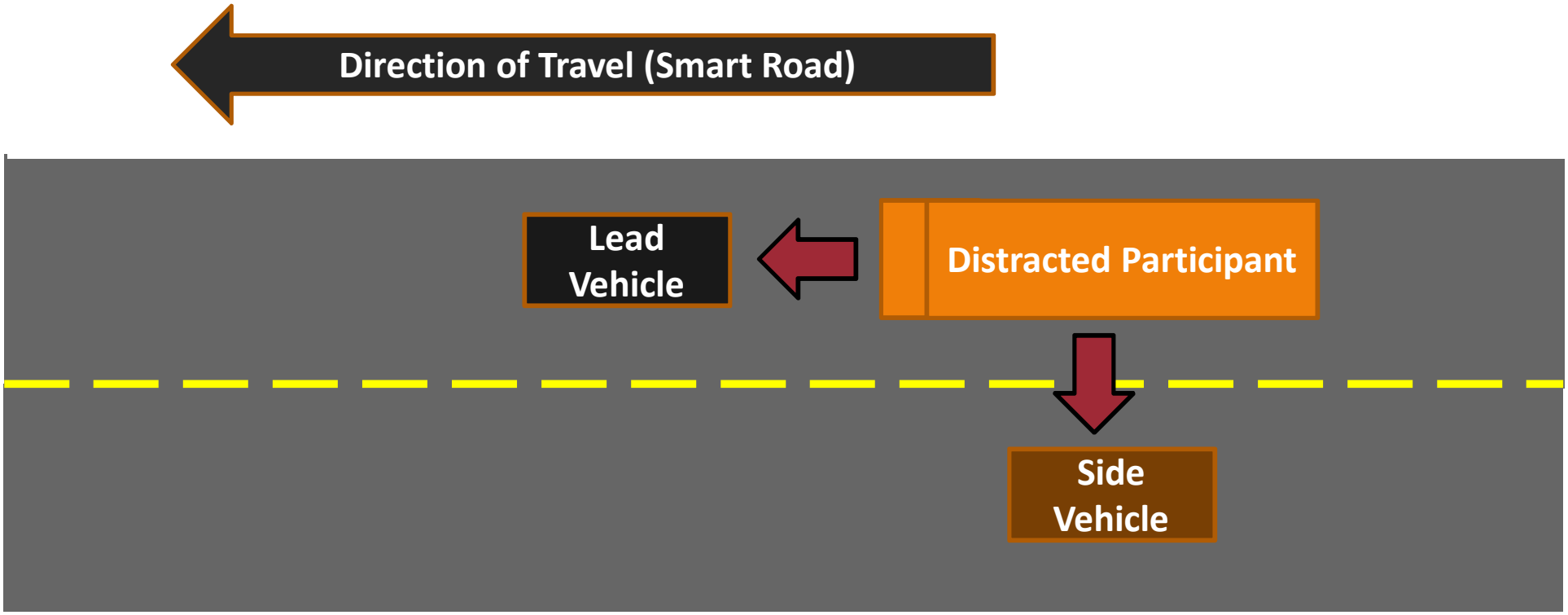
Visual Alerts

2. What is the impact on driver response (braking reaction time) to providing drivers with : (1) no visual display with imminent audio alert: (2) very simple display; (3) a more complex FCW display that provides more information than an FCW?

Audio and Visual Combination

3. Based on the findings of Research Questions 1 & 2, quantify any improvement in braking reaction time to the optimized system over a baseline condition

Surprise Event



Find the "red" pen
Reality: Red pen doesn't exist

Eliciting "true" driver responses from the true surprise event in this project poses some challenges as participants may not fully look away from the road

50-60% success rate for obtaining "true" driver responses

OBJECTIVE TEST DEVELOPMENT

Heavy Vehicle FCAM Objective Test procedure development

- Currently adapting light vehicle FCAM procedures:
  - FCW: generally following NCAP procedures
  - CIB: procedures generally follow those as outlined in NHTSA's *Forward-Looking Advanced Braking Technologies Research Report (need citation)*
- NHTSA has tested current generation systems from both main suppliers (Bendix and Meritor Wabco)
  - 2 production tractors,
  - 1 prototype motorcoach system
- Testing to-date has been with foam car
- Testing has been limited to lead vehicle moving and lead vehicle stopped scenarios (no lead vehicle decel testing)

Early test results …

Testing at LLVW (SV/POV)	Proposed Speed Reduction (mph)	Speed Reduction (mph)		
		Volvo (Gen 2)	Freightliner	MCI Coach
LVS (25/0)	9.8	N/A	N/A	N/A
LVM (25/10)	Avoidance	Avoided	Avoided	Avoided
LVM (45/20)	9.8	22.2	14.8	20.3

LLVW

Testing at GVWR	Proposed Speed Reduction (mph)	Speed Reduction (mph)		
		Volvo (Gen 3)	Freightliner	MCI Coach
LVS (25/0)	9.8	N/A	N/A	N/A
LVM (25/10)	Avoidance	Avoided	Avoided	Avoided
LVM (45/20)	9.8	Avoided*	18.5	22.5**

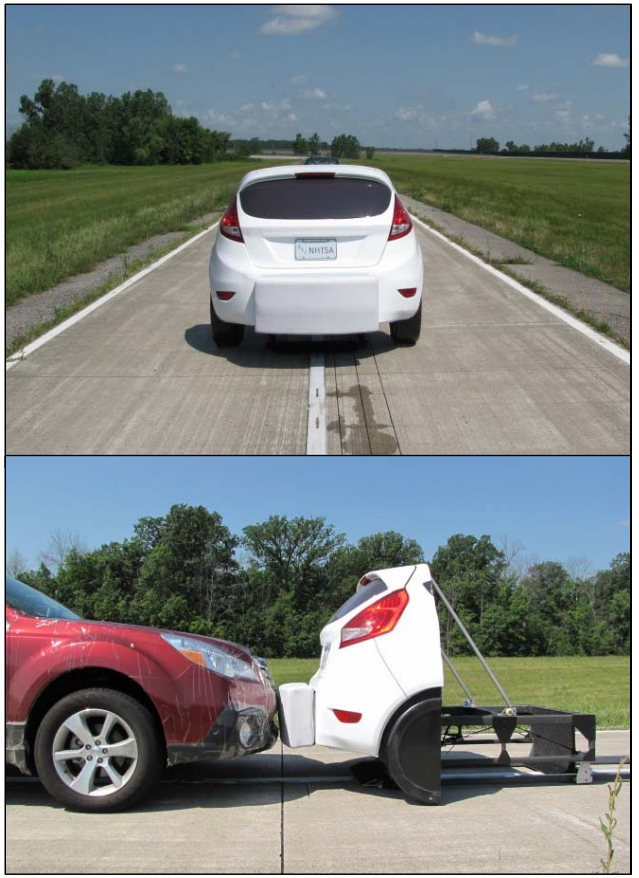
GVWR

* Testing **Gen 3: 8 of 10 avoided**. 2 bad tests from driver engaging clutch.

** 4 of 10 trials avoided collision.

Next Steps for Objective Test Procedure Development

- Refine Test Procedures
  - Scenarios; speeds; tolerances
- Refine Test Target
  - Harmonize with light vehicle if possible (Strikeable Surrogate Vehicle (SSV)
  - Evaluate sensitivity of system performance to target design
- False Positive Tests
  - Develop false positive tests that challenge the system's ability to discriminate real from non-real crash threats



REAL WORLD TESTING (FIELD DATA)

Early Adopter Analysis—UMTRI Study

- Crash records from three fleets were examined after having operated a portion of their fleet equipped with FCAM systems for a year or more.
  - Results from 2 of the fleets were statistically valid.
  - Insufficient data was available from the third fleet.

- Results from both fleets were consistent. The FCAM system had a protective effect against rear-end crashes:
  - **In the case of Fleet A, trucks *without* the FCAM system were 2.2 times more likely to be the striking vehicle in a rear-end crash than trucks with the system.**
  - **The result for Fleet B was very similar, with an odds ratio 1.96.**

NHTSA has initiated an FOT focused on Crash Avoidance systems for heavy vehicles

- Seek broad cross section of fleet types and drivers
- Minimum of 150 vehicles; one year of operation…and includes both leading FCAM suppliers
- Interviews with fleet managers (subjective evaluations).
- Key outputs:
  - Characterize frequency, circumstances associated with warnings and brake activations. (nuisance alarms, false alarms)
  - Changes in "normal" driving behavior (adaptation, reliance, etc……in both the positive and negative direction)
  - Driver reactions to warnings (delay times, braking response)
  - Other unintended consequences.
- Data collection just starting now (Q1, 14). First useable results in Q3, 14.

Heavy Vehicle FCAM Research Timeline

Resaerch Activities	2014				2015			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Objective Test Procedures								
Refine test procedures & equipment								
Develop Performance Metrics								
HV CWI Research:								
Auditory Alert Performance Evaluations								
Develop CWI Objective test procedures								
Finalize guidelines & minimum reqt's.								
Field Operational Testing of HV FCAM								
Driver acceptance, real world performance								
Safety Benefits Estimates								
Target Population Analysis								
Benefits Methodology Synthesis Study								

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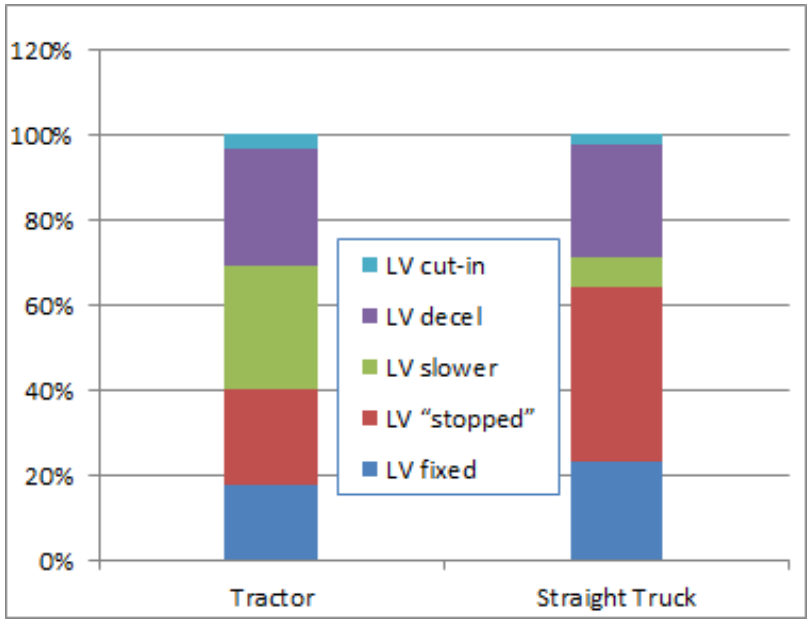
BACKUP

Target population:

by crash type,

Percent of truck striking rear-end crashes by crash scenario

	Tractor Trailer	Straight Truck
LV fixed	18%	23%
LV "stopped"	22%	41%
LV slower	29%	7%
LV decel	27%	26%
LV cut-in	3%	2%
Total	100%	100%

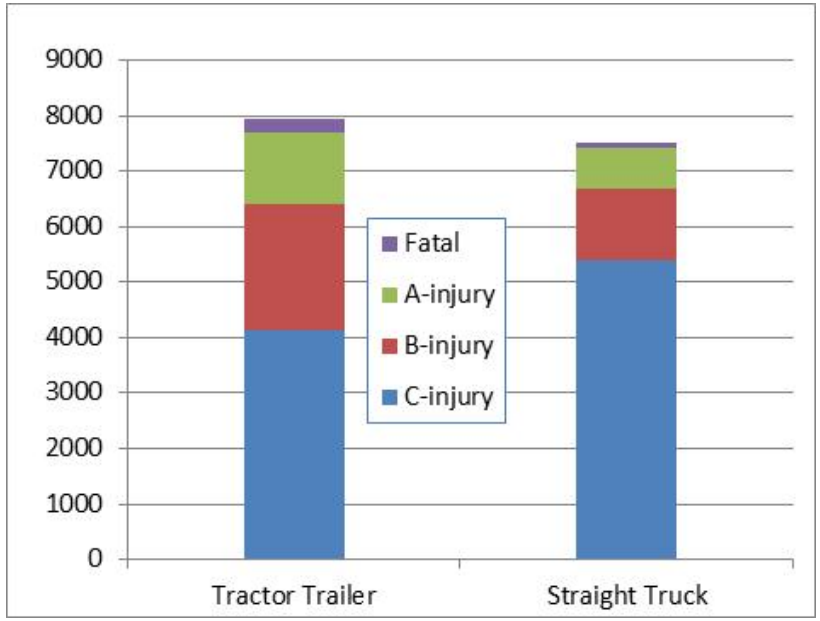


LV stopped together with LV decelerating to a stop represents about half of all rear-end crashes.

and by injury level

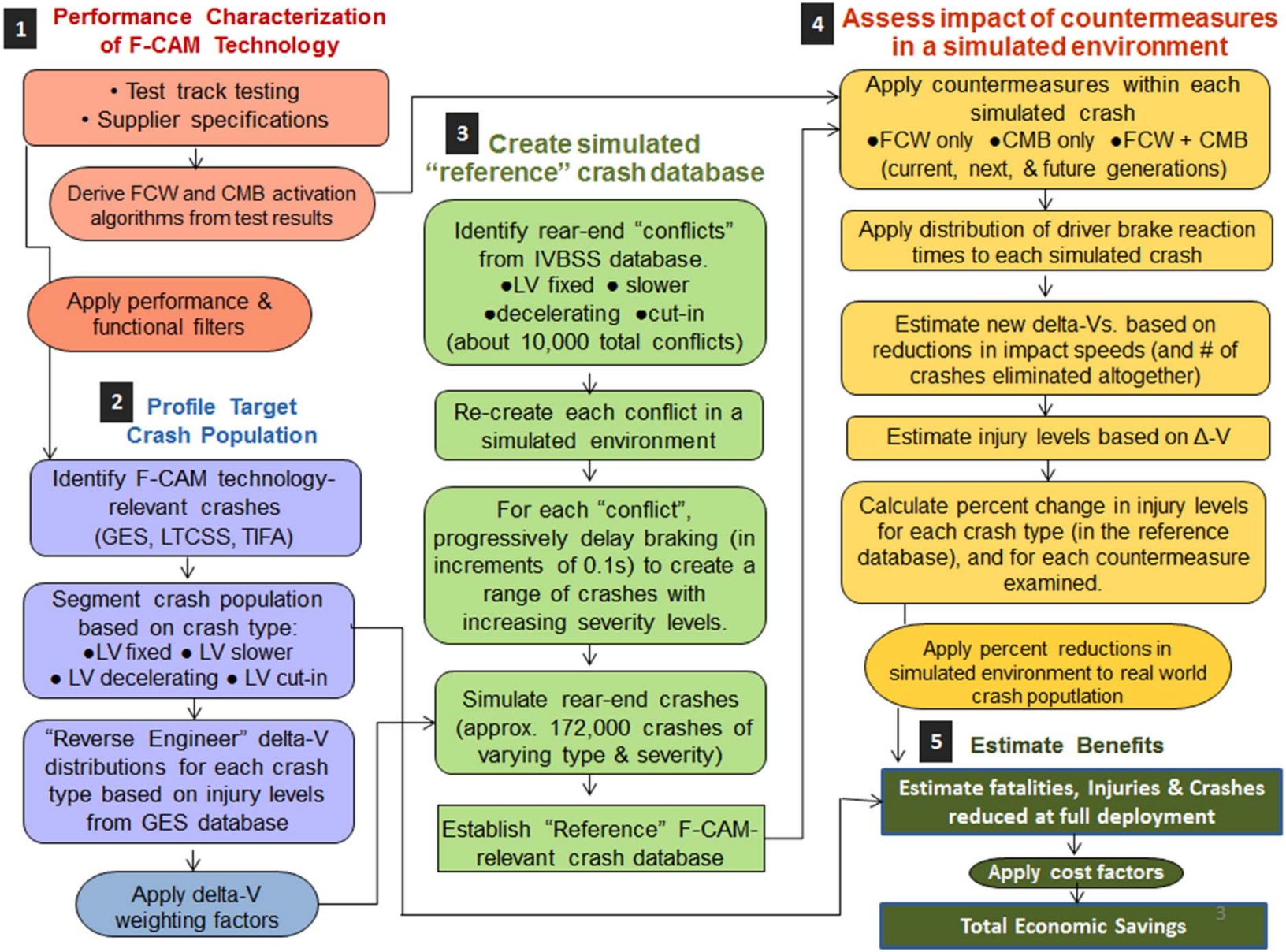
Injury Severity in truck striking rear-end crashes

	C-injury	B-injury	A-injury	Fatal
Tractor Trailer	4,132	2,284	1,287	231
Straight Truck	5,386	1,298	740	72



Severe injury crashes (A injury + fatals) represents about 25% of all tractor trailer target crashes.

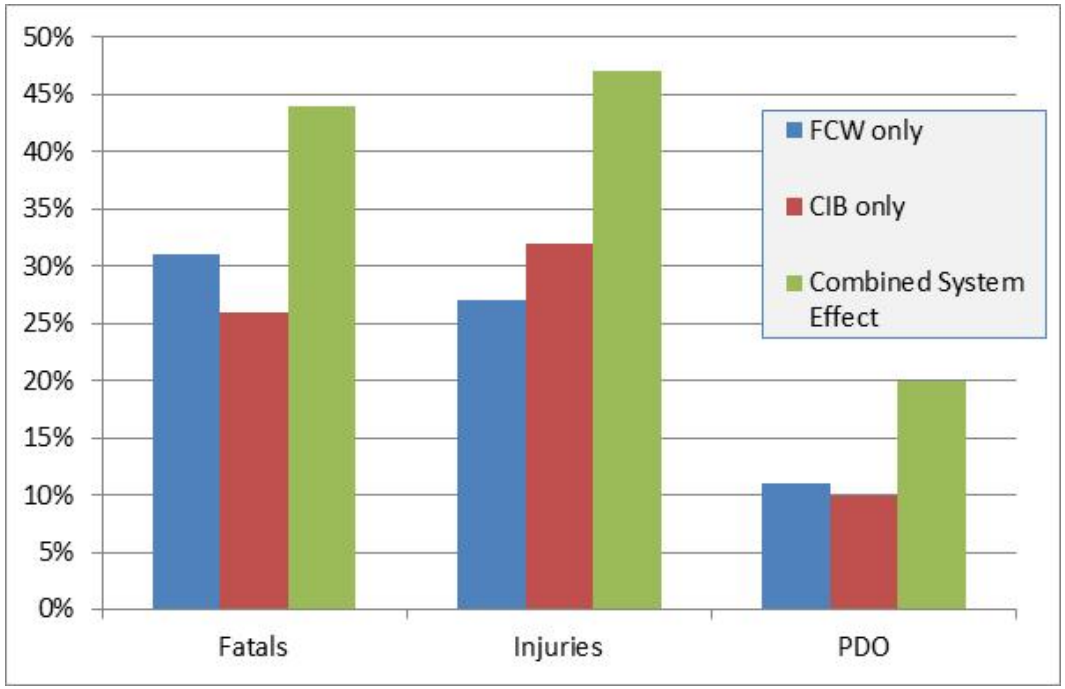
UMTRI methodology for calculating safety benefits



Based on UMRTI simulation, FCW and CIB contribute roughly equally to overall benefits

Percent reductions in rear end crashes due to FCAM Technology

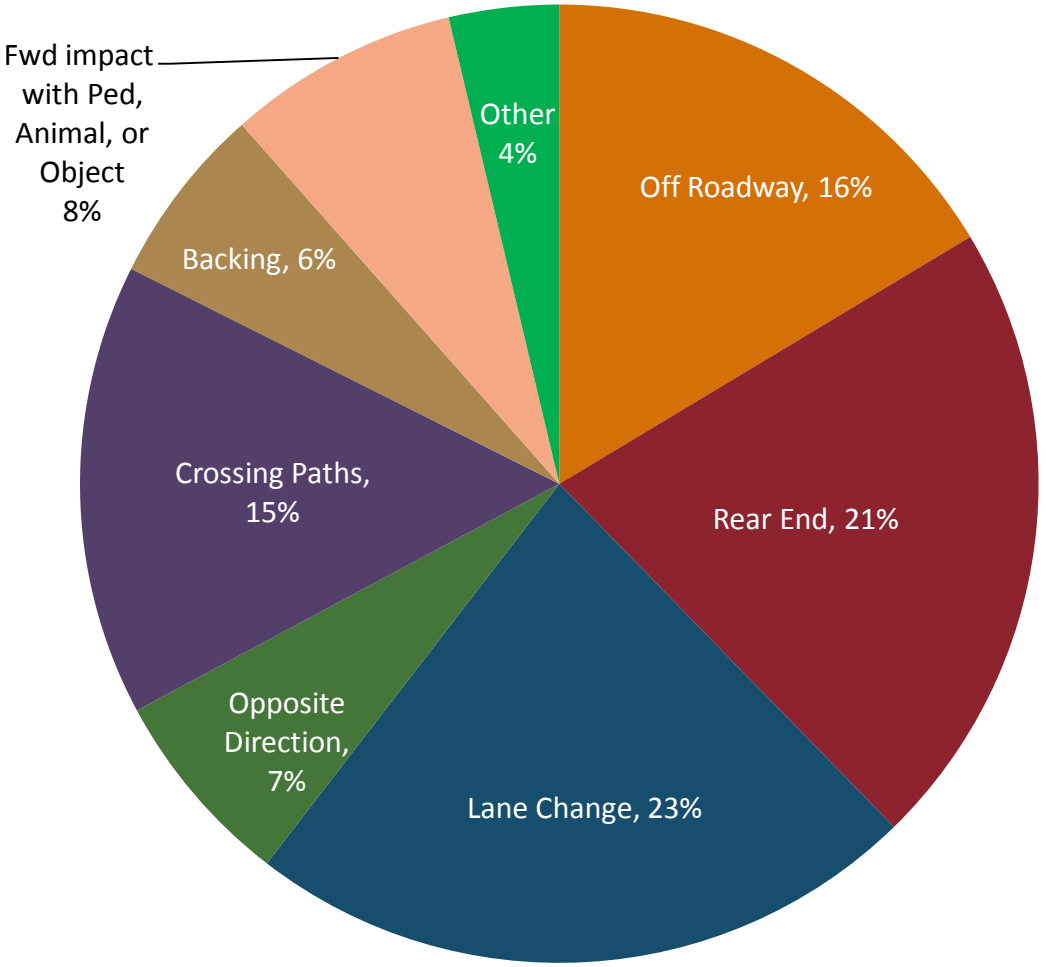
(assumes next generation FCAM system)



Reductions in Rear-end crashes due to FCAM (heavy vehicles)

	Fatals	Injuries	PDO
FCW only	31%	27%	11%
CIB only	26%	32%	10%
Combined System Effect	**44%**	**47%**	**20%**

Heavy vehicle crashes by crash type



- Data for truck tractors only, and, truck was striking vehicle (or otherwise "at fault")
- Based on data from Volpe Report *Heavy Vehicle Pre-Crash Scenario Typology for Crash Avoidance Res*earch

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