Shiny-side Up:
Advanced Crash Avoidance Technologies That Can Reduce Heavy Truck Crashes

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Acknowledgements

- Sources:
  - Hickman, J., F. Guo, et al. (2013). Onboard Safety Systems Effectiveness Evaluation Final Report. Washington, DC, Federal Motor Carrier Safety Administration: 267.
  - Houser, A., D. Murray, et al. (2009). Analysis of Benefits and Costs of Lane Departure Warning Systems for the Trucking Industry. Washington, DC: 75.
  - Woodrooffe, J., D. Blower, et al. (2009). Safety Benefits of Stability Control Systems for Tractor-Semitrailers. Washington, DC.
  - Woodrooffe, J., D. Blower, et al. (2012). Performance Characterization and Safety Effectiveness of Collision Mitigation Braking and Forward Collision Warning Systems for Commercial Vehicles. Ann Arbor, Michigan, University of Michigan Transportation Research Institute: 138.
- John Woodrooffe, Scott Bogard at UMTRI

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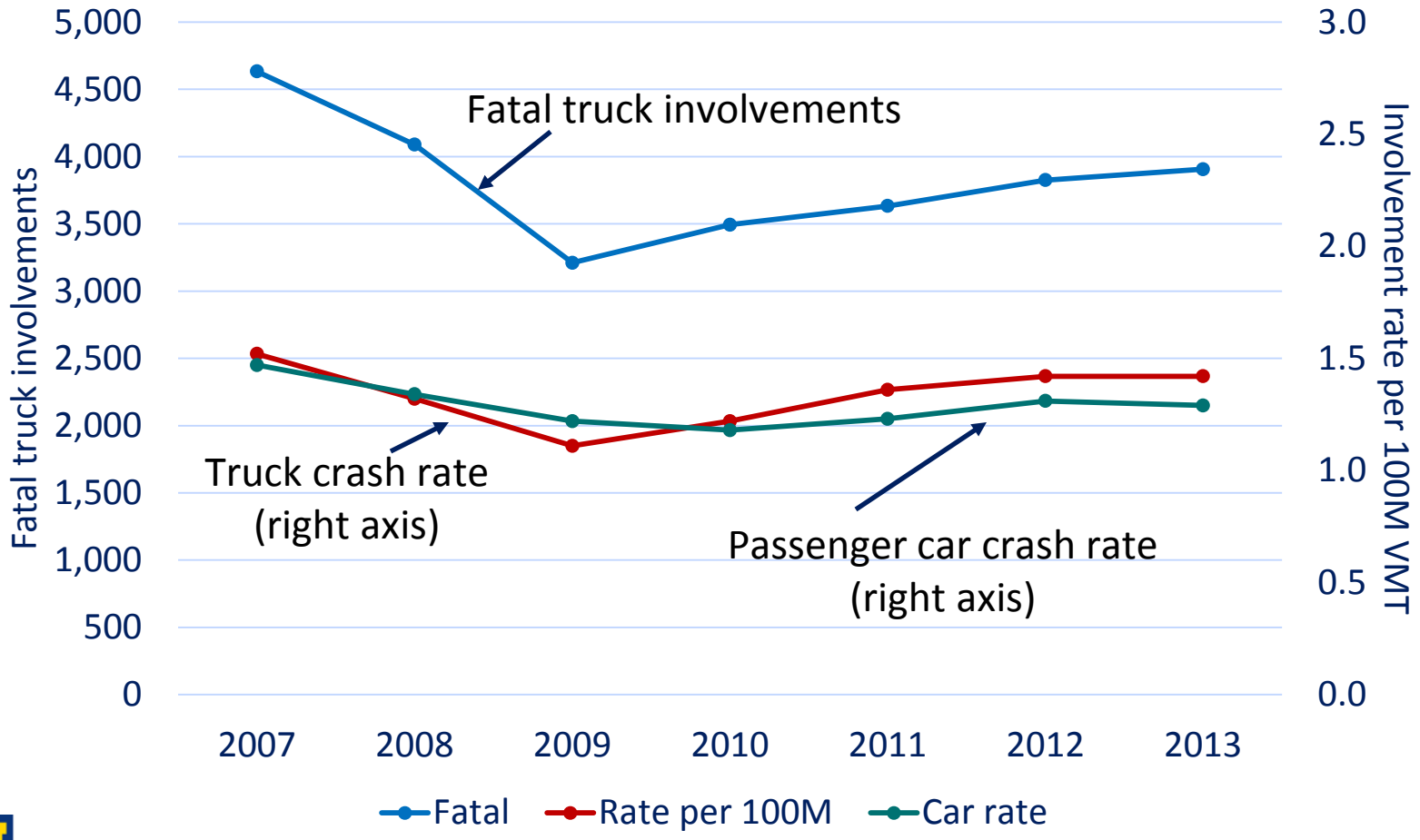
Dimensions of Heavy Truck Crash



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Heavy truck crashes

- 3,800 fatal crashes annually.
- 3,900 deaths annually; 100,000 injuries.
- Truck crashes account for 13% of all traffic fatalities.
- Fatal crash involvement rate by VMT has converged with passenger cars.
- Crash avoidance technologies can drive the numbers down more.

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Key Crash Avoidance Technologies

- Electronic stability control (ESC)
- Roll stability control (RSC)
- Forward Collision Avoidance and Mitigation Systems (F-CAM)
- Lane departure warning (LDW)

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Electronic Stability Control
&
Roll Stability Control

Woodrooffe, J., D. Blower, et al. (2009). Safety Benefits of Stability Control Systems for Tractor-Semitrailers. Washington, DC.

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Electronic Stability Control (ESC)
Roll Stability Control (RSC)

Description of the technologies

- Both ESC and RSC respond to lateral acceleration
- ESC senses divergent yaw rate & lateral acceleration
- ESC & RSC have mass-related intervention strategies
- Assess vehicle mass using engine torque and acceleration
- Braking strategies:
  - De-throttle engine
  - Engage engine retarder
  - Apply foundation brakes
  - ESC-selective wheel braking

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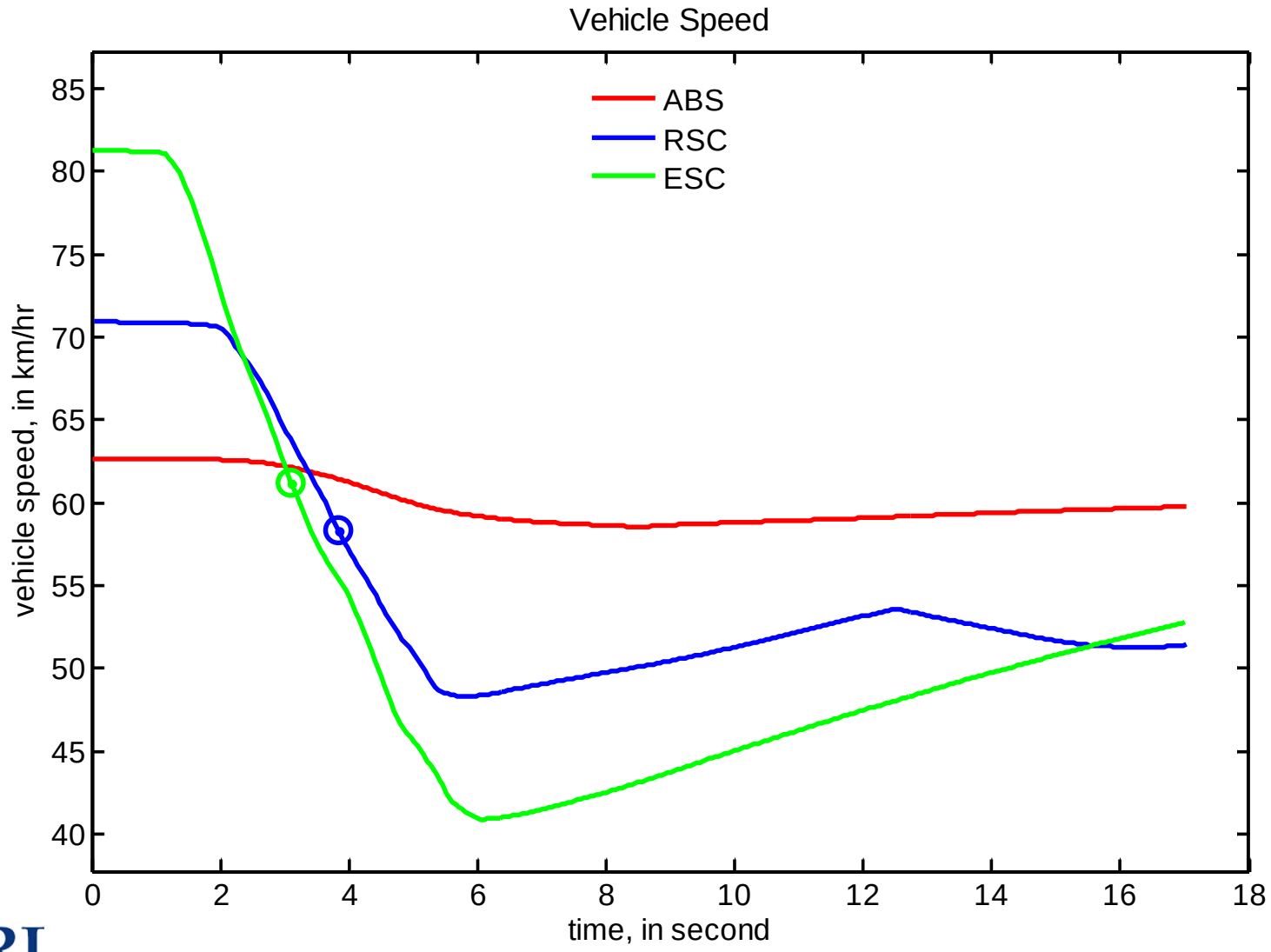
ESC engages earlier to control speed



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RSC helps maintain stability in curves

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ESC adds control
on slick roads as well

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Fitting the technologies to all tractor semitrailers

Crash reduction from RSC

- 3,489 crashes
- 106 fatalities
- 4,384 injuries

Crash reduction from ESC

- 4,659 crashes
- 126 fatalities
- 5,909 injuries

Fleet data show reduction in probability of roll by 25%.

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Forward Collision Avoidance and Mitigation Systems (F-CAM)

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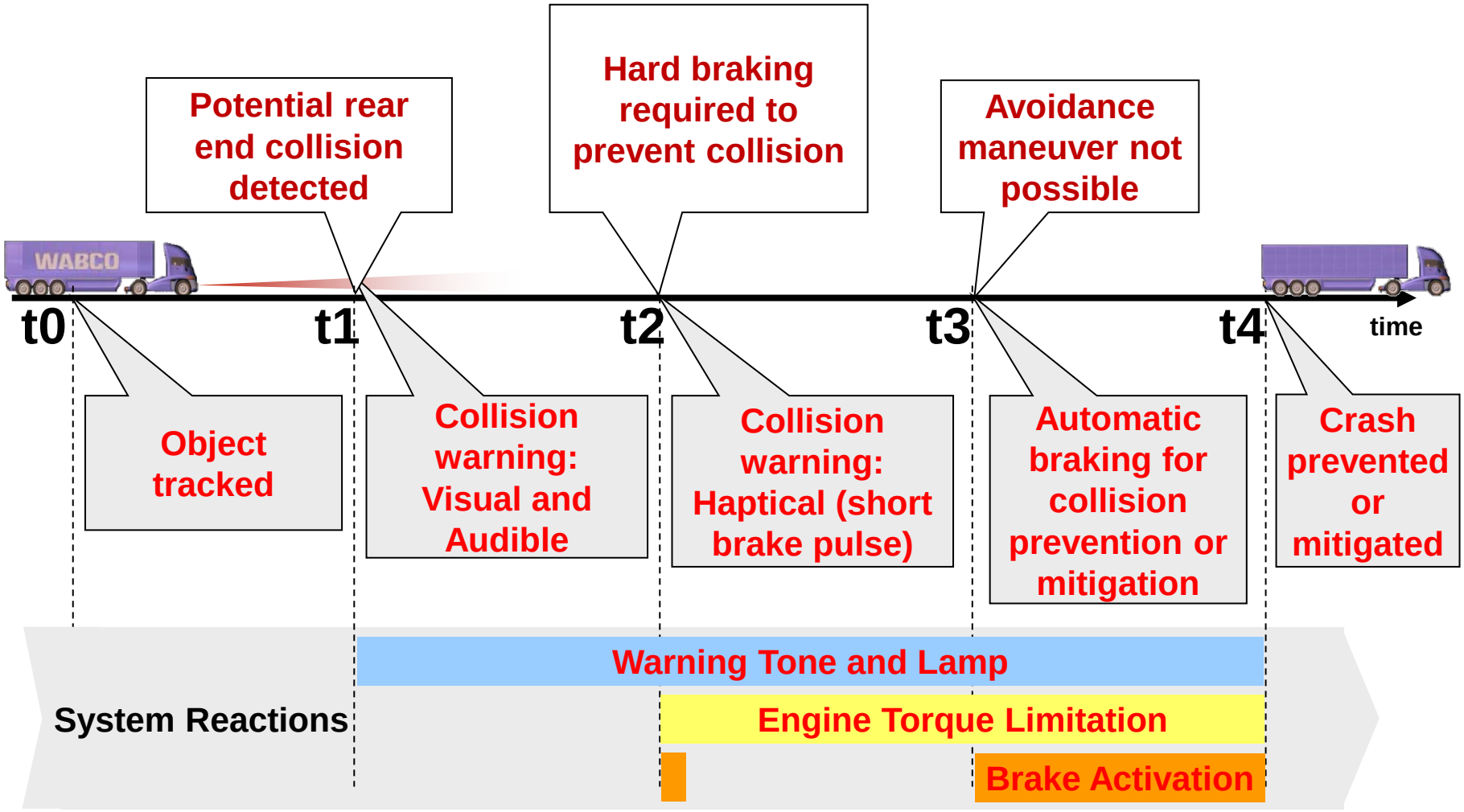
F-CAM Intervention Sequence



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System characteristics

- Forward Collision Warning + Autonomous Braking
- Sensor range up to 100m
- FCW: audible, haptic warning
- Braking authority:

Generation	Vehicle detected moving	Vehicle never detected moving
Current	0.35 *g*	No response.
Next	0.6 *g*	0.3 *g*
Future	0.6 *g*	0.6 *g*

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Target Crash Types

Rear-end, truck striking

- Current generation:
  - Lead vehicle stopped at impact, but seen moving.
  - Lead vehicle slower, steady speed.
  - Lead vehicle decelerating.
  - Lead vehicle cut-in.
- Next, future generation:
  - Lead vehicle stopped at impact, regardless whether ever detected as moving.

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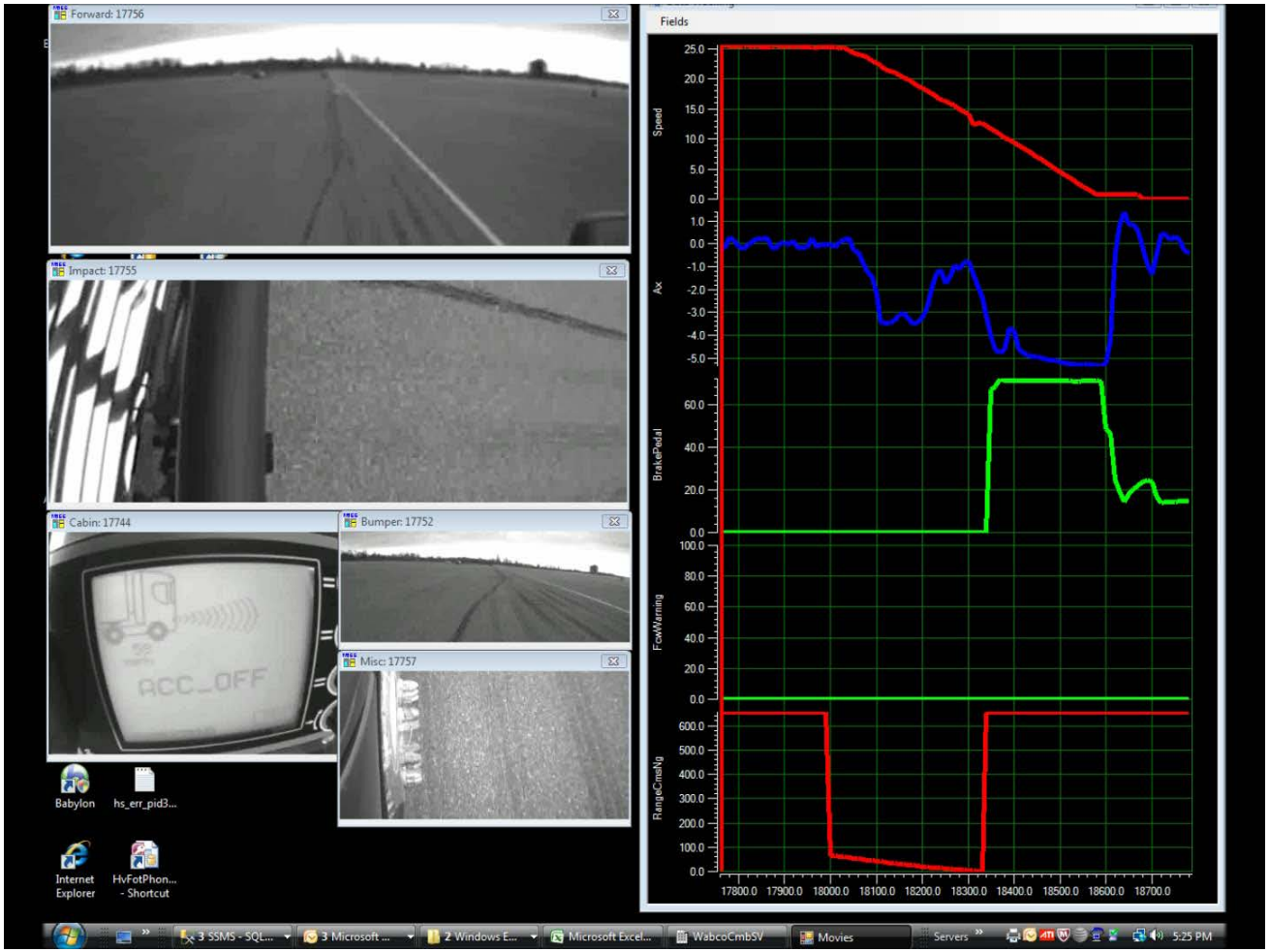
F-CAM system test

- Run to measure system characteristics.
- No FCW issued.
- Sensor detects at about 80m.
- Automatic braking at 0.35 *g*.
- Driver brakes after impact.



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F-CAM test of next generation

- Test of next generation.
- Triggers on stopped objects.
- Brakes up to 0.6*g*.
- First run is at 40 mph.
- Second run is at 50 mph.

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Estimated reduction in rear-end truck-striking crashes by severity

Generation	Fatal	Injury	No injury
Current	24%	25%	9%
Next	44%	47%	20%
Future	57%	54%	29%

- Analysis of fleet data showed F-CAM systems reduced truck-striking rear-end crashes by about one-third.

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Lane departure warning

Hickman, J., F. Guo, et al. (2013). Onboard Safety Systems Effectiveness Evaluation Final Report. Washington, DC, Federal Motor Carrier Safety Administration: 267.

Houser, A., D. Murray, et al. (2009). Analysis of Benefits and Costs of Lane Departure Warning Systems for the Trucking Industry. Washington, DC: 75.

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System characteristics

- Detect lane markings using windshield mounted camera.
  - Challenges: worn, missing lane lines; glare at night, especially on wet roads.
- Monitor truck position in lane.
  - Lateral position.
  - Speed.
  - Heading.
  - Compute time-to-lane crossing
- Detect lane crossing.
- Issue audible/haptic warning, if turn signal not activated.
- Active above set speeds (25-35 mph).

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Target crash types

- Single-vehicle road departure, followed by untripped rollover.
- Single-vehicle road departure, collision with fixed object.
- Lane departure, same-direction sideswipes.
- Lane departure, opposite direction sideswipes and head-on.

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Lane change crash example only (Crash would not have been affected by LDW)

- Truck signals, so lane change warning would have been suppressed.
- Injuries in crash were moderate.

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Estimated crash reductions

- About 48% for relevant crash types.
- Target crash types are about 10% of all tractor-semitrailer crashes.
- Net crash reduction is about 4.6% of all tractor-semitrailer crashes.

- Estimates are from deployments in 14 fleets.

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Conclusions

- Advanced crash avoidance technologies can significant reduce heavy truck crash involvement.
  - ESC: 31% of relevant rollover & loss of control.
  - F-CAM: 37% of relevant forward collisions.
  - LDW: 48% of relevant lane/road departures.
- Need more validation in actual deployment.
- Current rulemaking by NHTSA on ESC.
- Other technologies voluntarily adopted by safety-oriented carriers.

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Thank you!

Questions?

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