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

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Acknowledgements

Sources:


John Woodrooffe, Scott Bogard at UMTRI
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.
Key Crash Avoidance Technologies

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

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
ESC engages earlier to control speed

Vehicle Speed

- **ABS**
- **RSC**
- **ESC**

Vehicle speed, in km/hr

Time, in second

Umtri
RSC helps maintain stability in curves
ESC adds control on slick roads as well
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%.
Forward Collision Avoidance and Mitigation Systems (F-CAM)

F-CAM Intervention Sequence

- **t0**: Object tracked
  - Potential rear end collision detected

- **t1**: Collision warning: Visual and Audible
  - Crash prevented or mitigated

- **t2**: Collision warning: Haptic (short brake pulse)
  - Avoidance maneuver not possible

- **t3**: Automatic braking for collision prevention or mitigation

- **t4**: Engine Torque Limitation
  - Brake Activation
System characteristics

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

<table>
<thead>
<tr>
<th>Generation</th>
<th>Vehicle detected moving</th>
<th>Vehicle never detected moving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>0.35 g</td>
<td>No response.</td>
</tr>
<tr>
<td>Next</td>
<td>0.6 g</td>
<td>0.3 g</td>
</tr>
<tr>
<td>Future</td>
<td>0.6 g</td>
<td>0.6 g</td>
</tr>
</tbody>
</table>
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.
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.
F-CAM test of next generation

- Test of next generation.
- Triggers on stopped objects.
- Brakes up to 0.6g.
- First run is at 40 mph.
- Second run is at 50 mph.
### Estimated reduction in rear-end truck-striking crashes by severity

<table>
<thead>
<tr>
<th>Generation</th>
<th>Fatal</th>
<th>Injury</th>
<th>No injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>24%</td>
<td>25%</td>
<td>9%</td>
</tr>
<tr>
<td>Next</td>
<td>44%</td>
<td>47%</td>
<td>20%</td>
</tr>
<tr>
<td>Future</td>
<td>57%</td>
<td>54%</td>
<td>29%</td>
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</tbody>
</table>

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


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).
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.
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.
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.
Conclusions

- Advanced crash avoidance technologies can significantly 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.
Thank you!

Questions?

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