Electronically Controlled Braking Systems
Field Operational Test
(ECBS FOT)

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Office of Applied Vehicle Safety Research
Driver-Vehicle Interaction & Heavy Truck Research Division
Agenda

• FOT Introduction
• Test Approach & Templates
• The Technologies
• Vehicle Fleet
• Data Collection & Project Schedule
Introduction

DOT Initiatives

- Accelerate deployment of new safety technologies to reduce accidents & fatalities
- Demonstrate benefits, measure reliability and advance state of the art of heavy truck ECBS & ABS technology
  - Laboratory and track testing (SAE/RAI)
  - Field testing in real-life commercial operations
- August 2002: RFA for ECBS Field Operational Tests
  - Template 1: Severe Duty Truck
  - Template 2: “Mixed” Tractor-Trailer
  - Template 3: “Optimized” Tractor-Trailer

- May 1, 2003: Award made to the Freightliner Team for a combination of Templates 2 and 3
FOT Team Structure

Booz Allen Hamilton

Freightliner LLC

Battelle

Walmart

Bendix

Meritor Wabco

SAE
Goals and Objectives

Overall Goal

Evaluate the safety, performance, reliability, maintainability and durability of ECBS, ABS and enabled safety technologies

Template 2 Objective: “Mixed” Tractor-Trailers
Evaluate the compatibility and performance of unmatched combinations of tractors and trailers equipped with ABS or ECBS from multiple suppliers

Template 3 Objective: “Matched” Tractor-Trailers
Evaluate ECBS and ECBS-enabled safety technologies on matched tractor-trailers with brake control systems from the same suppliers
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Test Approach

- Install ECBS and ABS with enabled safety technologies on Freightliner tractors and Great Dane trailers purchased by WAL*MART
- Operate vehicles in WAL*MART real-life commercial operations for 12 months
  - Collect vehicle onboard system data, maintenance data, fleet operator and driver experience, and safety-related data
- Provide information to DOT and the Independent Evaluator for analysis and evaluation throughout the FOT
**Template 2: Quantity of Tractor & Trailers**

### “Mixed” Tractor-Trailer

<table>
<thead>
<tr>
<th>Group</th>
<th>Tractors</th>
<th>Trailers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tractors: 10 Meritor Wabco ABS w/ Arvin Meritor drum</td>
<td>Trailers: 15 Meritor Wabco ABS w/ Arvin Meritor drum</td>
</tr>
<tr>
<td>$T2$-</td>
<td>10 Meritor Wabco ABS w/ Bendix Knorr disc</td>
<td>15 Meritor Wabco ABS w/ Bendix Knorr disc</td>
</tr>
<tr>
<td>Config.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T2$-</td>
<td>10 Meritor Wabco ECBS w/ Bendix Knorr disc</td>
<td>15 Meritor Wabco ECBS w/ Bendix Knorr disc</td>
</tr>
<tr>
<td>Config.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T2$-</td>
<td>10 Bendix ABS6 w/ Bendix Knorr disc</td>
<td>15 Bendix EBS w/ Bendix Knorr disc</td>
</tr>
<tr>
<td>Config.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total 40</strong></td>
<td><strong>Total 60</strong></td>
</tr>
</tbody>
</table>
Template 2
Experimental Plan

- **Phase 1:**
  - 6 Months Duration
  - Enabled Technologies “OFF”
    - Data recorded, but does not affect operations

- **Phase 2:**
  - 6 Months Duration
  - Enabled Technologies “ON”
    - Data recorded and fully functional interactive systems
### “Optimized” Tractor-Trailers

<table>
<thead>
<tr>
<th>Group</th>
<th>Tractors</th>
<th>Trailers</th>
</tr>
</thead>
<tbody>
<tr>
<td>T3</td>
<td>8 Meritor Wabco ECBS w/ Bendix Knorr disc</td>
<td>40 Meritor Wabco ECBS w/ Bendix Knorr disc</td>
</tr>
<tr>
<td></td>
<td>Total 8</td>
<td>Total 40</td>
</tr>
</tbody>
</table>
Template 3
Experimental Plan

• Phase 0:
  – Profile drivers in ABS tractors prior to operation of ECBS tractors

• Phase 1:
  – 6 Months Duration
  – ECBS with Enabled Technologies “OFF”
    • Data recorded, but does not affect operations

• Phase 2:
  – 6 Months Duration
  – ECBS with Enabled Technologies “ON”
    • Data recorded and fully functional interactive systems
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Meritor WABCO Technologies

Tractor:

- **Electronically Controlled Braking System (ECBS)**
  - Pneumatic control lines and logic replaced with electronics
  - Platform for future advanced technologies
  - Full pneumatic redundancy in the event of a major electrical malfunction

- **Electronic Stability Control (ESC)**
  - Attempts to correct instabilities caused by roll and yaw inducing maneuvers
  - Assists driver to follow intended course

- **Adaptive Cruise Control (ACC)**
  - Extension of Cruise Control
  - Automatic control of engine, engine brake & foundation brakes to maintain a safe following distance
  - Collision warning capability
Meritor WABCO Technologies

Tractor:

- Baseline ABS Systems
- ABS with Brake Performance Monitoring
  - Detects degraded brake performance
- ABS with Roll Stability Control
  - Attempts to correct instabilities caused by roll inducing maneuvers
Meritor WABCO Technologies

Trailer:

• Standard ABS

• Electronically Controlled Braking System (ECBS)
  – Pneumatic control lines and logic replaced with electronics
  – Electronically controlled by ECBS tractor or pneumatically controlled by ABS tractor
  – Platform for future advanced technologies
  – Full pneumatic redundancy in the event of a major electrical failure

• Roll Stability Support (RSS)
  – Attempts to correct instabilities caused by roll inducing maneuvers
Bendix Technologies

Tractor:

- Premium ABS6 Features
  - Anti-lock braking
  - Automatic traction control
  - Brake system monitoring and diagnostics

- Air Disc Brakes
  - Increased braking torque
  - Resistance to brake fade
  - Reduced hysteresis & improved side-to-side brake balance
  - Improved brake diagnostics
  - Lining wear sensing
  - Reduced maintenance downtime & parts count
Bendix Technologies

**Trailer:**

- **ECBS (TEBS4) Features**
  - Closed-loop service brake pressure control
  - Lining wear monitoring for air disc brakes
  - Brake system monitoring and diagnostics

- **ECBS Enabled Technologies**
  - Trailer roll stability program (TRSP)

- **Air Disc Brakes**
  - Increased braking torque
  - Resistance to brake fade
  - Reduced hysteresis & improved side-to-side brake balance
  - Improved brake diagnostics
  - Lining wear sensing
  - Reduced maintenance downtime & parts count
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WAL*MART
Fleet Operations

• Distribution of perishables and dry goods
• 24 / 7 Operations
• Hub-and-Spoke operations
  – Deliveries from hubs to distribution centers (DC), and from DC to WAL*MART stores, SuperCenters or Sam’s club stores
• National operations
  – 38 Distribution Centers (Terminals)
  – > 4,700 stores, SuperCenters and Sam’s club stores
WAL*MART
Loveland Fleet Statistics

• Operations
  – Approx. 217 Tractors & 1000 Trailers
  – Freightliner 58” Columbia RR Sleeper Cab
  – Single Trailers
  – Average of 125,000 miles / year / tractor
  – Average trip: ~ 250 miles (one way), one or more deliveries
  – Variety of routes and weather (highways, urban and/or country roads, mountains, plains)

• Drivers
  – Assigned to their own tractor
  – ~ 14 years experience with WAL*MART
  – < 1% driver turn-over rate
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Data Sources

- Onboard Driving & Equipment Data
- Fleet Operations and Maintenance Data
- Surveys and Interviews
- Safety Benefits Data
- Relevant Fleet Historical Information
Data Transfer
On-Board Vehicle Data

Step 1
Onboard data collection & storage

Step 2
Data download to local PC

Step 3
Local data validity checks

Step 4
Data upload to Battelle

Step 5
Data validation and storage

Step 6
Data delivery to IE

On board Data Acquisition Systems

Wireless LAN (ftp)

Harvesting Computer

Wireless LAN (ftp)

Battelle Central Computer

Physical media

IE Computer
Program Schedule & Work Plan Highlights

MAY ’03 – Dec. ’03
Develop & Finalize FOT Test Plan

NOV. ’03 – MAY ’04
Vehicle build and checkout

AUG. ’04 – JULY ’05
Data Collection

MAY ’04
Field Training

AUG. ’05 – JAN ’06
Data Analysis w/IE

APR. ’06
Final Report

Task 1. Develop Field Operational Test Plan

Task 2/3: ECBS FOT Vehicle and Instrumentation Development, Assembly and Shakedown

Task 4. Conduct Field Operational Test
- Task 4a Field Training and Preparation
- Task 4b Field Operations, Data Collection
- Task 4c Data Compilation, Assessment and Reporting

Task 5. Briefings and Reporting
- Project Review Briefings
- Interim report
- Final report

Year 1

Year 2

Year 3
Thank you!

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