Connected Commercial Vehicle (CCV) Safety Applications Development

- Overview of the CCV Safety Applications Development Project
  - Dr. Denny Stephens, Battelle

- Integrated Trucks Safety Applications Development
  - Dr. Luca Delgrossi, Mercedes Benz Research and Development North America

- Commercial Vehicle Interoperability & Performance Considerations
  - Dr. David LeBlanc, University of Michigan Transportation Research Institute
Connected Commercial Vehicle (CCV) Safety Applications Development Overview

- Purpose
- Objectives
- Team
- Task Overview
- Technical Approach
- Benefits and Value
- Task Descriptions
CCV Safety Applications Project: Purpose

• Support USDOT Safety Pilot objectives pertaining to commercial vehicles including:
  – Demonstrate V2V and V2I safety-related applications in a real-world environment using multiple vehicle types (at a minimum, light and heavy vehicles and buses).
  – Collect data to project potential safety benefits of V2V safety applications in support of the NHTSA 2013 agency decision for light vehicles and 2014 decision for commercial vehicles.
  – Evaluate the scalability, security, and interoperability of devices using DSRC 5.9 GHz technology.
  – Collect and store data for later use by other researchers, including universities and private industry.

• Commercial vehicle specific requirements and results of this effort will be shared with the commercial vehicle community
CCV Safety Applications Project: Objectives

• Integrate wireless DSRC technology into selected commercial vehicles

• Develop and demonstrate research prototypes of crash avoidance safety applications on commercial vehicles.
  – Forward Collision Warning
  – Lane Change Assist
  – Intersection Movement Assist

• Develop and demonstrate a limited number of vehicle-to-infrastructure (V2I) safety applications,
  – Curve Over-speed Warning
  – Infrastructure-generated in-vehicle signage application
CCV Safety Applications Project: Objectives (cont.)

• Integrate Data Acquisition Systems onboard the vehicles
• Support those vehicles in research and testing activities including
  – Demonstration at the 2011 ITS World Congress
  – Testing Interoperability and Performance of Applications by the USDOT
  – Conducting Driver Clinics by the Project Team
  – Conducting Model Deployment of Safety Applications by the Safety Pilot Contractor
  – Conducting Objective Testing of Applications by USDOT
CCV Safety Applications Project: Team

- Battelle
  - Program Manager and Driver Clinic Conductor
- Mercedes Benz Research and Development North America (MBRDNA)
  - Connected Vehicle Safety Applications Developer
- DENSO INTERNATIONAL North America Research Laboratory (NARL)
  - Wireless Communications Supplier
- Daimler Trucks North America (DTNA) Advanced Engineering NAFTA
  - Heavy Truck OEM and CAN Integration Support
- University of Michigan Transportation Research Institute (UMTRI)
  - Data Acquisition System Provider and Performance Testing Evaluator
- Meritor WABCO
  - Commercial Vehicle Crash Avoidance Systems Supplier
CCV Safety Applications Project: Tasks

- CCV Safety System Development and Integration
  - Tractors and trailers
  - Connected Vehicle Technology Platform (OBE)
  - Safety Applications
  - Data Acquisition System (DAS)

- Testing and Evaluation
  - Support Interoperability and Performance Testing of Applications
  - Design and Conduct Driver Clinics
  - Support Model Deployment
  - Refine On-board Systems and Applications
  - Support Applications Objective Testing

- Outreach and Coordination
  - 2011 ITS World Congress Support in conjunction with CAMP
  - Plan in progress for Connected Vehicle Technology briefings and outreach
CCV Safety Applications Project: Technical Approach

• Leverage the hardware and applications architecture developed by Collision Avoidance Metrics Partnership (CAMP)
  – Enhance and tailor it to support the commercial vehicle dynamics, driver behavior, and operational characteristics
    - Led by CAMP VSC-A Member MBRDNA

• Developments will be guided and supported by
  – Integrated Vehicle Based Safety System performance and field experience of UMTRI and Battelle
  – North American commercial safety systems experience of DTNA, DENSO and Meritor WABCO
CCV Safety Applications Project: Benefits and Value of this Approach

• Maximizes the real world, V2V and V2I safety performance and reliability of CCV safety applications

• Ensures compatibility and interoperability of the passenger and commercial vehicle platforms

• Simplifies and accelerates the delivery of working systems on commercial vehicles for demonstration, testing, and evaluation

• Leverages the extensive prior investment by U.S. DOT and its partners
Tractors and Trailers

• Connected vehicle technology to be implemented on four Class 8 Tractors from Freightliner Cascadia line,
  – Two high-roof sleepers, one mid-roof sleeper, and one day cab
  – Tractors will also have Meritor WABCO OnGuard System, which is turned off during connected vehicle testing
  – Three tractors will be used in Model Deployment, one high roof sleeper will transfer to Smart Roadside Program
Tractors and Trailers

- Seven Trailers will be obtained for use in DSRC and other testing
  - Three 53 ft box trailers
  - One 48 ft box trailer
  - Two 28 ft box trailers
    - Dolly
  - One 40 ft Intermodal Container and Chassis
Connected Vehicle Technology Platform (OBE)

- Tractors will be equipped with Connected Vehicle Onboard Equipment from DENSO
- OBE includes: DSRC radio, DGPS receiver, computer, safety applications, operating system, vehicle data interface, and driver vehicle interface (DVI)

<table>
<thead>
<tr>
<th>Device</th>
<th>Characteristics</th>
<th>Primary Usage</th>
<th>Photo</th>
</tr>
</thead>
<tbody>
<tr>
<td>WSU1.0</td>
<td>flexible I/O (PC based), robust, dual WAVE radio</td>
<td>proof of concept feasibility study, DOT R&amp;D, small scale road tests</td>
<td><img src="image1.png" alt="Photo" /></td>
</tr>
<tr>
<td>WSU1.5</td>
<td>compact size, automotive interconnect, lower cost</td>
<td>production-like vehicle integration, large field tests</td>
<td><img src="image2.png" alt="Photo" /></td>
</tr>
<tr>
<td>miniWSU</td>
<td>smallest size, simplest installation, lowest cost, self contained</td>
<td>aftermarket - retrofit feasibility study, larger field tests</td>
<td><img src="image3.png" alt="Photo" /></td>
</tr>
</tbody>
</table>
Safety Applications Development

• System Software Architecture and Design will leverage that developed by CAMP
  – Enhanced and tailored to support the commercial vehicles dynamics, driver behavior, and operational characteristics

• Applications
  – Forward Collision Warning
  – Lane Change Assist
  – Intersection Movement Assist
  – Curve Over-speed Warning
  – Infrastructure-generated in-vehicle signage application

Diagram of safety applications and system components.
Data Acquisition System (DAS)

- Tractors will be instrumented with an On-board Data Acquisition System (DAS) developed by UMTRI
  - Will leverage existing UMTRI DAS units from IVBSS FOT, with minor modifications.
  - IVBSS heavy truck platform DAS:
    - 600,000 miles over 10 months (98% data capture)
    - Unattended 3 weeks (truck) to 6 weeks (light vehicle).
    - Used in objective testing at VRTC, Dana Proving Grounds

- CPU 1.4 GHz
- A/D 16 bit
- CAN card PC-104+
- Frame Grabber 4-input, MPEG-4
- Disk drives Automotive 80GB
- GPS time synching
- Sensors IMU
- Processing rate 100 Hz
- Up to 6 video images
- Audio
Data Acquisition System (DAS) Example Output
Connected Vehicle Testing: Design and Conduct Driver Clinics

- **Objective**
  - Evaluate Driver Acceptance of V2V applications
    - Surveys and direct observation of driver responses to warnings
    - Drivers with valid CDL in good health
  - System Performance Tests
  - Coordinated with the Small Vehicle Clinics and Volpe Independent Evaluator

- **Approach**
  - Plan the clinics with input from all stakeholders
  - Conduct two clinics—one in the Eastern US and one in the West.
  - Gather data from drivers five times
    - Screening for recruitment
    - Pre-drive questionnaire
    - During the drive
    - Post-drive questionnaire
    - Focus group
Candidate Driver Clinic
Demonstration Scenarios:

Emergency Electronic Brake Light :
Hidden car suddenly brakes

![Diagram showing emergency electronic brake light scenario](image-url)
Forward Collision Warning:

Car in the adjacent lane

Stopped car ahead

“Revealing” a stopped car
Curve Overspeed Warning
Blind Spot Warning/Lane Change Warning

Car in the blind spot

Car in the blind spot, turn signal on
Intersection Movement Assist: Truck pulls away from a stop sign
Examples of Questions to be Asked during the drive

• What is your immediate impression of this application?
• Was the warning easy to understand?
• How effective was this application at alerting you to the threat?
• Which elements drew your attention to the potential conflict?
• If a visual warning was present, was the location was acceptable?
• To what extent did the warning startle you?
• Would you like to have this application in your vehicle?
• How useful do you think this application would be in terms of improving driving safety in the real world?
• Concerns, suggestions, other comments?
  – Most responses measured on a 7-point scale
CCV Safety Applications Testing Support: Interoperability and Performance Testing

• Support baseline interoperability and functional testing of Applications by NHTSA at Vehicle Research Test Center, East Liberty, Ohio
  – Verify that the system meets performance requirements developed in the program and other CV interoperability studies, including:
    - Compatibility with other vehicle platforms and other V2V hardware suppliers.
    - Functionality in congested environments, and reliability of DSRC communication (and safety application performance) in obstructed situations without clear line-of-sight communications

• Est start: April 2012
CCV Safety Applications Testing Support: Support Safety Pilot Model Deployment

• Provide three fully integrated tractors and technical support throughout the V2V Safety Pilot

• Verify that a large-scale deployment of V2V enabled vehicles meet performance requirements including:
  – Interaction and communication with other cooperative V2V enabled vehicles and V2I nodes.
  – A naturalistic demonstration of the capabilities of V2V and V2I applications, primarily related to safety and user acceptance over an extended time period.
  – Investigation of large-scale aspects of V2V technology and how they manifest themselves in a real world environment on different platforms.

• Est start: July 2012
CCV Safety Applications Testing Support: Support USDOT Applications Objective Testing

- Update applications based upon experience and lessons learned in Driver Clinics and Model Deployment
- Support objective performance testing of V2V and V2I applications by NHTSA at Vehicle Research Test Center, East Liberty, Ohio
- Est start April 2013
Outreach and Coordination

• Support USDOT connected vehicle technology outreach activities that deliver the compelling information and messages to articulate the value of connected vehicle investment and deployment.

• Approach
  – Use a combination of communication tools and methods to support needs for outreach and communication including
    - Presentations on project progress and results
    - Authoring technical papers for presentation at conferences
    - Developing and leading webinars and on-line meetings
    - Providing quarterly summary level project status for publication on the USDOT website.
    - Final Report for the project