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

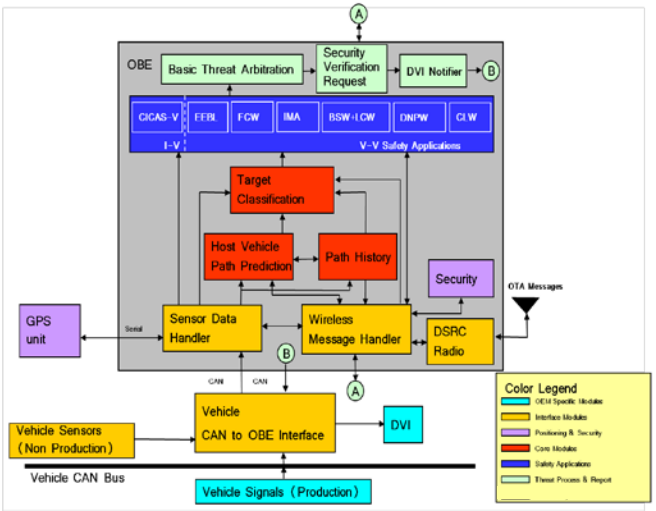
- Battelle
  - Program Manager and Driver Clinic Conductor
- Mercedes Benz Research and Development North America (MBRDNA)
  - Connected Vehicle Safety Applications Developer
- DENSO INTERNATIONAL North America Research Laboratory (NARL)
  - Wireless Communications Supplier
- Daimler Trucks North America (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

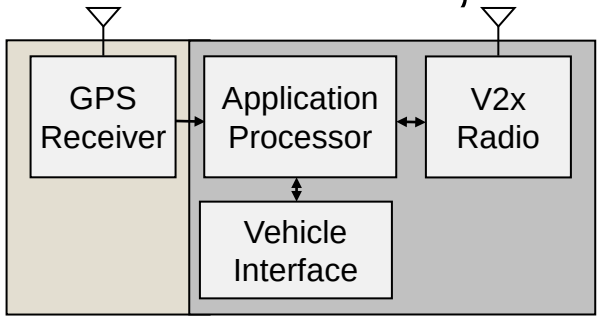
- Connected vehicle technology to be implemented on four Class 8 Tractors from Freightliner Cascadia line,
  - Two high-roof sleepers, one mid-roof sleeper, and one day cab
  - Tractors will also have Meritor WABCO OnGuard System, which is turned off during connected vehicle testing
  - Three tractors 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)

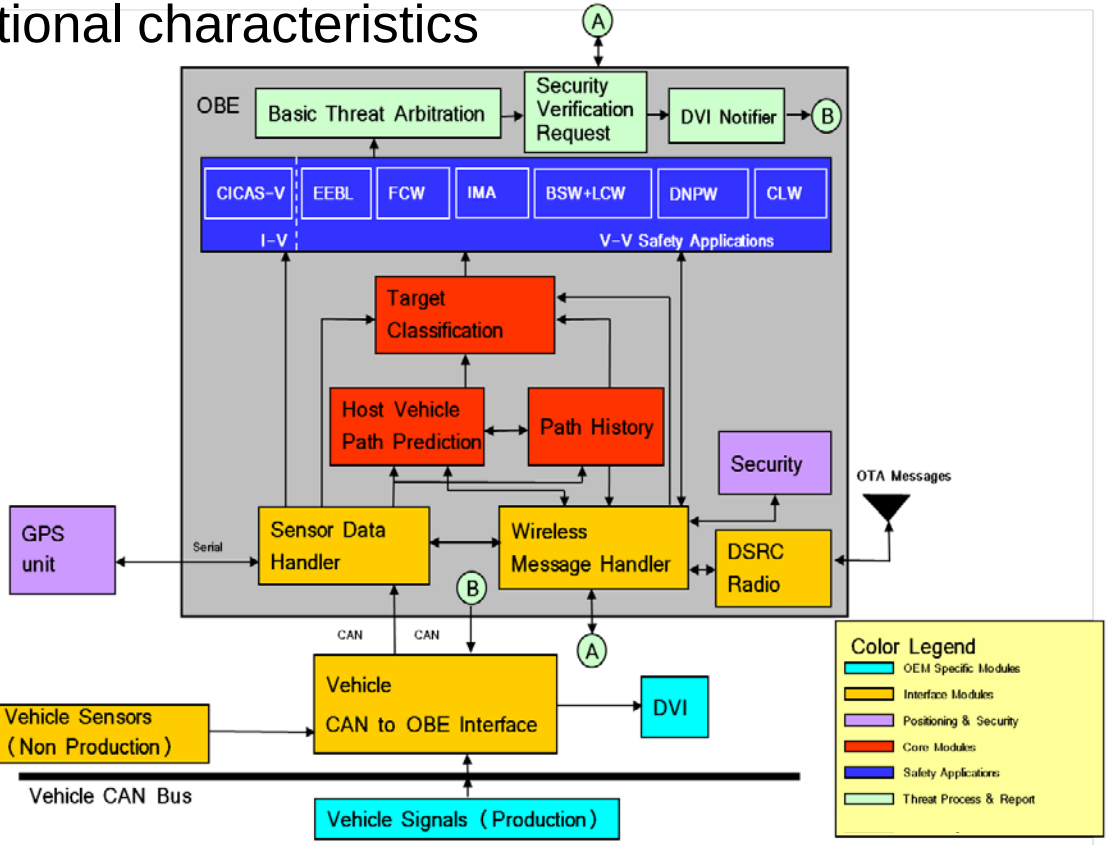
- Tractors will be equipped with Connected Vehicle Onboard Equipment from DENSO
- OBE includes: DSRC radio, DGPS receiver, computer, safety applications, operating system, vehicle data interface, and driver vehicle interface (DVI)



Device	Characteristics	Primary Usage	Photo
WSU1.0	flexible I/O (PC based), robust, dual WAVE radio	proof of concept feasibility study, DOT R&D, small scale road tests	
WSU1.5	compact size, automotive interconnect, lower cost	production-like vehicle integration, large field tests	
miniWSU	smallest size, simplest installation, lowest cost, self contained	aftermarket - retrofit feasibility study, larger field tests	

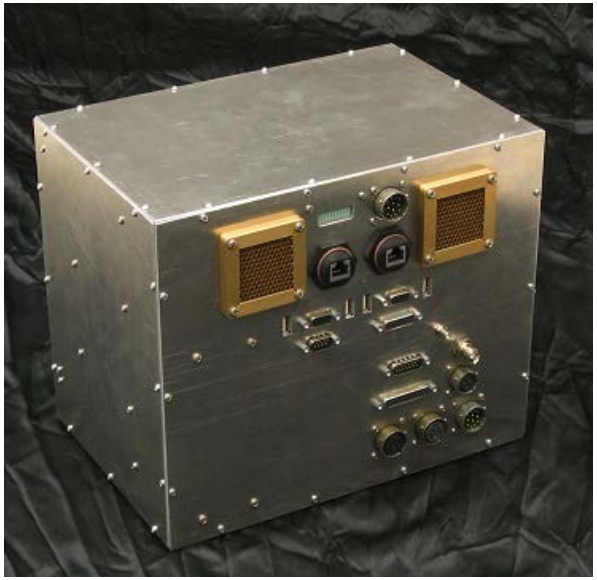
Safety Applications Development

- 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



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

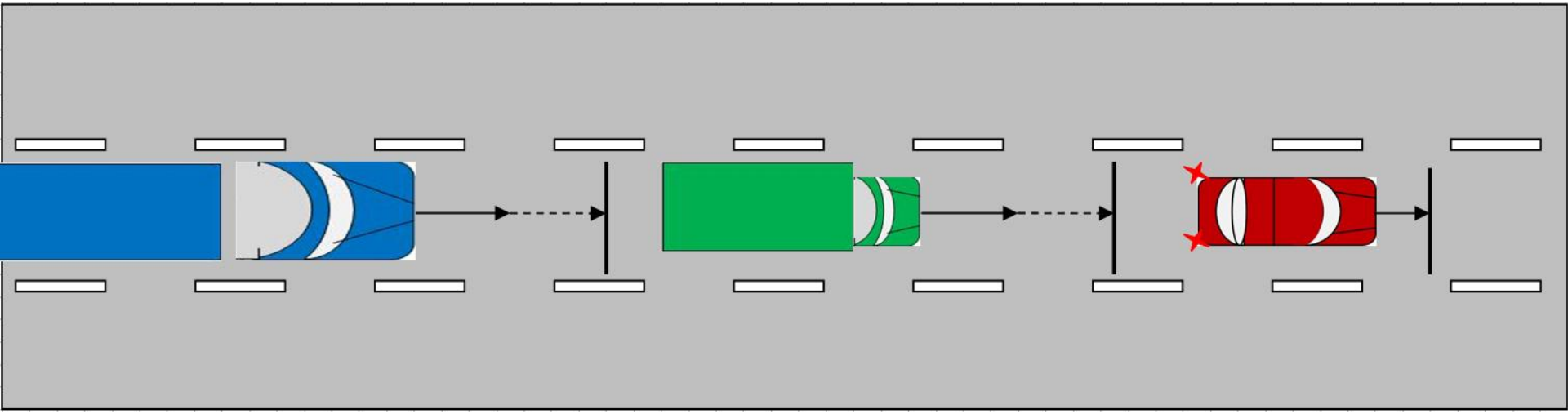
Data Acquisition System (DAS) Example Output

Connected Vehicle Testing: Design and Conduct Driver Clinics

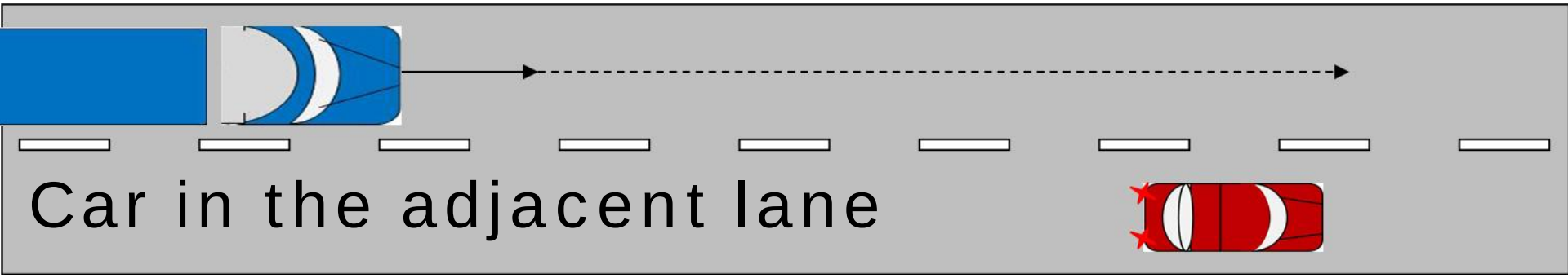
- Objective
  - Evaluate Driver Acceptance of V2V applications
    - Surveys and direct observation of driver responses to warnings
    - Drivers with valid CDL in good health
  - System Performance Tests
  - Coordinated with the Small Vehicle Clinics and Volpe Independent Evaluator
- Approach
  - Plan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

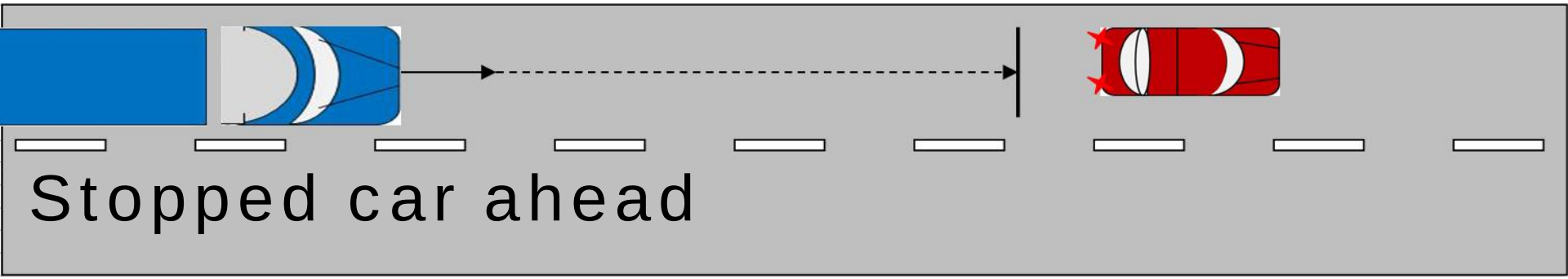
Candidate Driver Clinic Demonstration Scenarios:

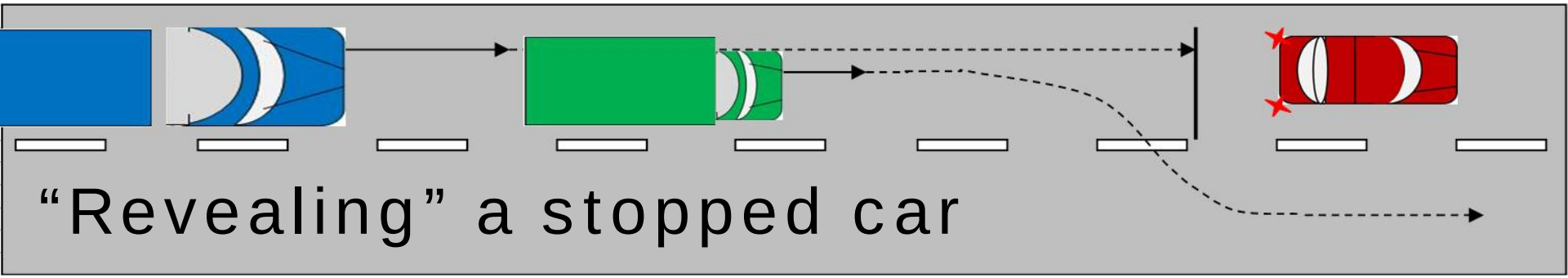
Emergency Electronic Brake Light : Hidden car suddenly brakes



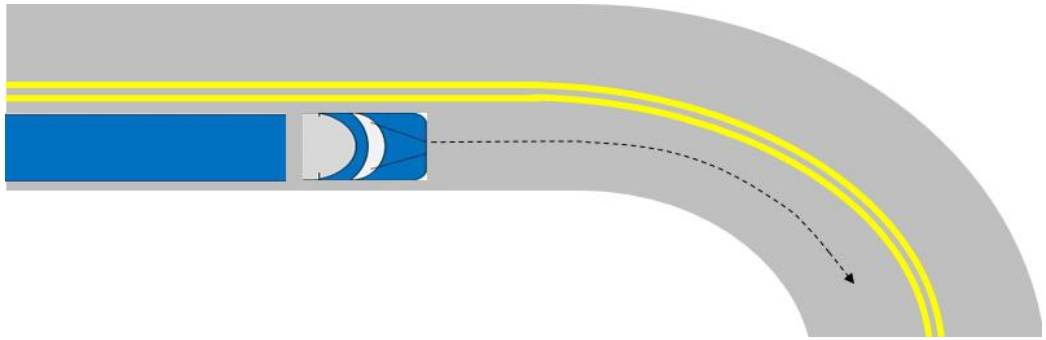
Forward Collision Warning:



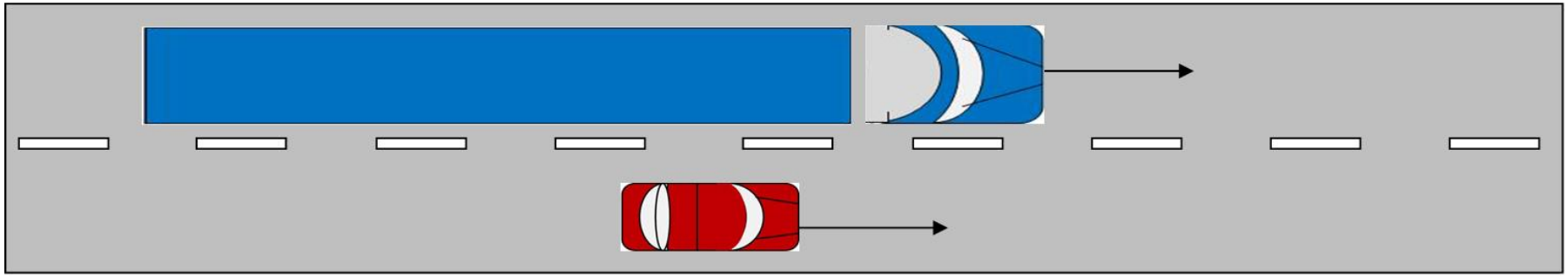




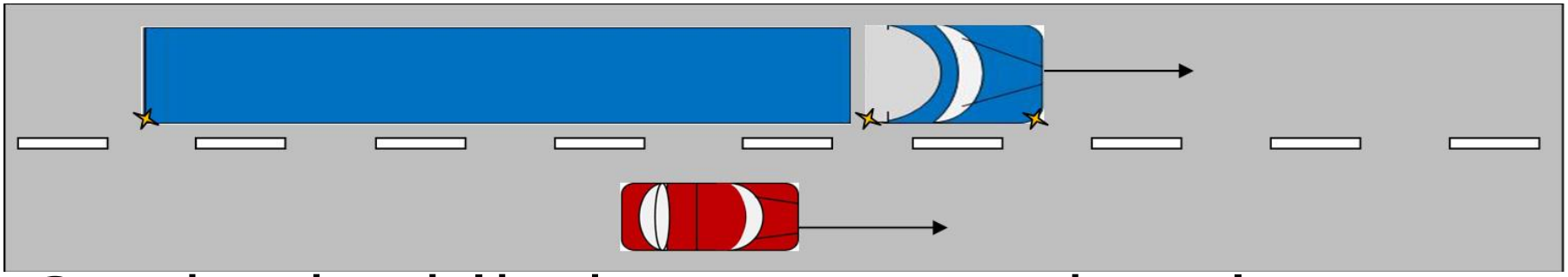
Curve Overspeed Warning



Blind Spot Warning/Lane Change Warning

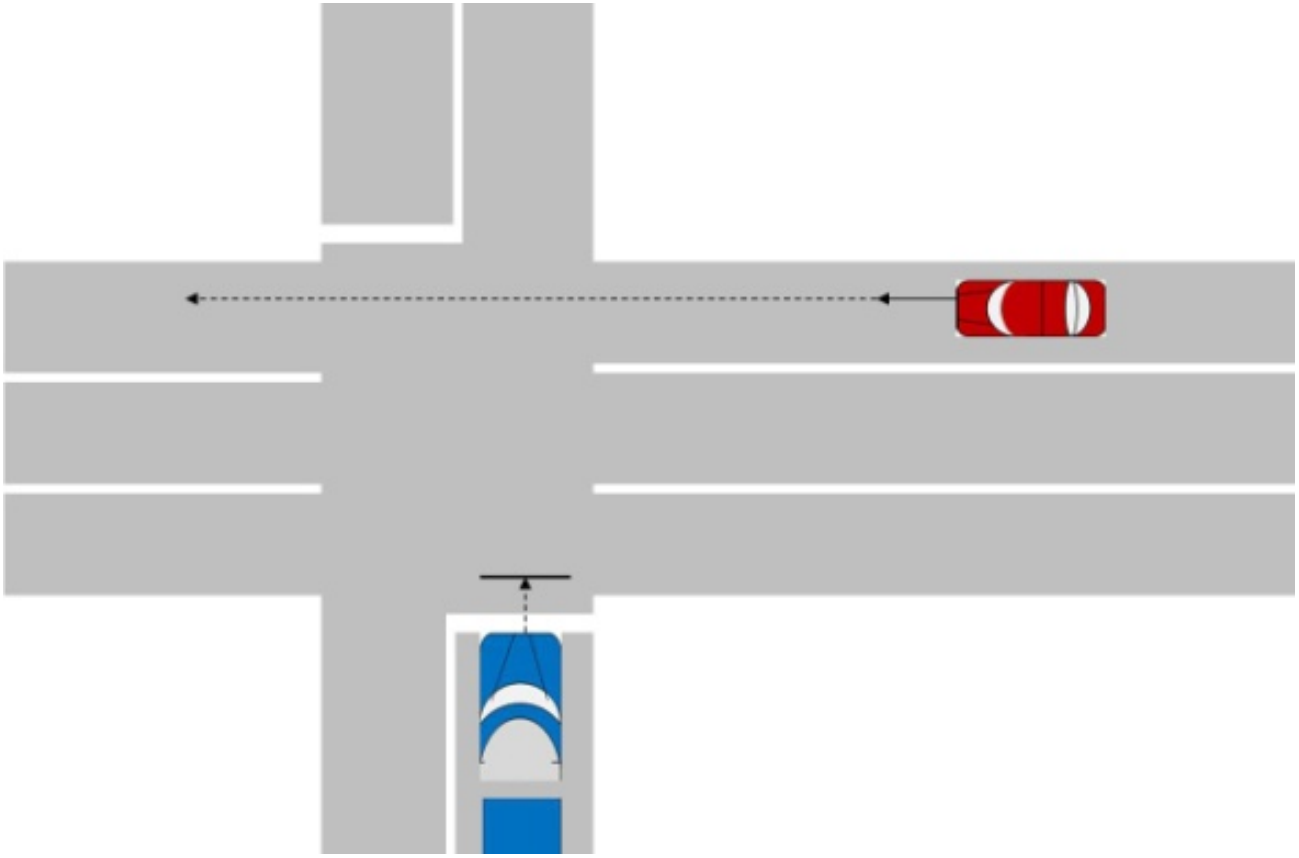


Car in the blind spot



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