Basic Safety Message
Emulator / Software

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March 7, 2014
USDOT Mobility Program

Real-time Data Capture and Management

- Vehicle Status Data
- Infrastructure Status Data
- Weather Data

Dynamic Mobility Applications

- Reduce Speed 35 MPH
- Weather Application
- Transit Signal Priority
- Real-Time Travel Info
- Fleet Management/Dynamic Route Guidance
- Signal Phase & Timing Adjusts
- Safety Alerts and Warnings
- Dynamic Mobility Applications
Data

- **Basic Safety Message Part 1**
  - Core data elements communicated 10x per second
  - DSRC

- **Basic Safety Message Part 2**
  - Additional data elements communicated when an “event” happens
  - DSRC - Cellular, other?

- **Other data elements** needed for additional safety or mobility applications
**Key Elements of BSM Part 2 Needed for Mobility Applications**

- BSM Parts 1 and 2 via DSRC provides the vehicle data needed to support some localized mobility applications

<table>
<thead>
<tr>
<th>MOBILITY APPLICATIONS (where roadside units deployed)</th>
<th>KEY PART 2 DATA ELEMENTS TO SUPPLEMENT PART 1 DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Cooperative Adaptive Cruise Control</td>
<td>- Weather Data (with examples)</td>
</tr>
<tr>
<td>- Speed Harmonization</td>
<td>- Ambient Temperature</td>
</tr>
<tr>
<td>- Queue Warning</td>
<td>- Ambient Air Pressure</td>
</tr>
<tr>
<td>- Transit Signal Priority</td>
<td>- Traction Control Status</td>
</tr>
<tr>
<td>- Incident Scene Work Alerts</td>
<td>- Wiper Status</td>
</tr>
<tr>
<td>- Emergency Road-Weather Conditions (Diagnosis/Prediction)</td>
<td>- Vehicle Data (with examples)</td>
</tr>
<tr>
<td></td>
<td>- Exterior Lights Status</td>
</tr>
<tr>
<td></td>
<td>- Type</td>
</tr>
<tr>
<td></td>
<td>- Antilock Brake System Status</td>
</tr>
</tbody>
</table>

- HOWEVER: DSRC link burdened by redundant Part 2 elements
Key Research Questions for the Mobility Program

- What are the benefits of applications enabled by connected vehicle and connected traveler data?

- What are the cross-cutting data and communication needs among connected vehicle applications?

- What is the role of Basic Safety Message (BSM)?

- What other messages are needed to support connected vehicle applications, if any?
## Key Project Deliverables and Products

- **Trajectory Conversion Algorithm (TCA) Software Version 2**
  - TCA 2.X Offline Analysis Software
  - TCA-V 2.X VISSIM API
  - TCA-P 2.X PARAMICS API

- **Simulate Basic Safety Message (BSM) and other messaging variants**
  - DSRC, cellular and dual-mode variants
  - Domestic and international variants

- **Performance Measure Calculation Algorithms**
  - E.g., shockwave and queue length estimation

- All products available under open source license to the research community
TCA Version 2 Software Focus

- Represent and model V>I messaging variants
- Model messaging variants that utilize DSRC, cellular (or both)
- Simulate latency and data loss by messaging variant & communications media for system manager use in an operational data environment
TCA Version 2 Software: **Offline** Mode of Operation

**ConOps Figure 5-1, pg. 26**

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TCA Version 2 Software: **Real-Time** Mode of Operation

**TCA Version 2 Software Products**
- Software Plus User Guide
- Documented Code

**TCA Control Files**
- RSE Locations, Message Control Settings

**Traffic Simulation Software**
- Vehicle Trajectory Files
- Vehicle Location and Speed

**Traffic Simulation Analyst**
- Traffic Sim. Inputs
- Trans. Sys. Network, Travel Demand

**CV App Emulator Inputs**
- Modified traveler/driver behavior
- Adapted trans. sys. control strategies

**CV Application Emulation Software**
- CV Application Developer

**CV Analyst**
- Vehicle trajectory files
- Vehicle location and speed

**ConOps Figure 5-2, pg. 27**

**TCA-V or TCA-P 2.X**

**Estimation**
- Estimated Measures

**Measurement Analysis**
- Estimated Trans. Sys. Performance
- Ground Truth Measures

**Ground Truth Analysis**
- Received messages by comm media
- Messages transmitted

**Comm Analytics**
- Messages received
- Performance measurement analyst

**Comm Systems Analyst**
- Messages logs

**Communications Systems Analyst**
- Simple comm

**Real-Time Analytic Loop**
- Archived vehicle location and speed

**Mode of Operations Legend**
- Real-Time and Off-Line
- Real-Time Only
- Off-Line Only

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# TCA-V 2.1 Demo

<table>
<thead>
<tr>
<th>Color</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>PDM Start Snapshot</td>
</tr>
<tr>
<td>Orange</td>
<td>PDM Stop Snapshot</td>
</tr>
<tr>
<td>Purple</td>
<td>PDM Periodic Snapshot</td>
</tr>
<tr>
<td>Black</td>
<td>PDM DSRC Transmission</td>
</tr>
<tr>
<td>Light Blue</td>
<td>PDM Cellular Transmission</td>
</tr>
<tr>
<td>Dark Blue</td>
<td>BSM equipped vehicle (BSM vehicles are constantly blue since they are constantly generating and transmitting BSMs)</td>
</tr>
<tr>
<td>Teal</td>
<td>Default color for PDM equipped only vehicles</td>
</tr>
<tr>
<td>Yellow</td>
<td>Default color for Dual PDM-BSM equipped vehicles</td>
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# TCA Version 2 Software Planned Features

<table>
<thead>
<tr>
<th>Build</th>
<th>Features</th>
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<tbody>
<tr>
<td><strong>Build 1 (TCA 2.1)</strong></td>
<td></td>
<td></td>
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<tr>
<td>November 2013</td>
<td></td>
<td>- Emulate wide-area (e.g., cellular) and short-range (DSRC) communications</td>
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<tr>
<td></td>
<td></td>
<td>- Model variants of the Basic Safety Message (BSM)</td>
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<tr>
<td><strong>Build 2 (TCA 2.2)</strong></td>
<td></td>
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<tr>
<td>March 2014</td>
<td></td>
<td>- Update DSRC communications model</td>
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<td></td>
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<td>- Support dual-mode V2I messaging</td>
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<td></td>
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<td>- Model vehicle status data beyond speed, position</td>
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<tr>
<td><strong>Build 3 (TCA 2.3)</strong></td>
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<tr>
<td>July 2014</td>
<td></td>
<td>- User-configurable variants of Japanese and EU message protocols</td>
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<tr>
<td><strong>Build 4 (TCA 2.4)</strong></td>
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<tr>
<td>July 2015</td>
<td></td>
<td>- Support large network analyses</td>
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<td>- Model dynamic rules for regulating and tailoring message transmission</td>
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Downloading the TCA Version 2 Software

- Available at the Open Source Application Development Portal (OSADP)
  - [http://www.itsforge.net](http://www.itsforge.net)

- What’s there: *TCA 1.0 and TCA-V 2.1, TCA-P 2.1, TCA-V 2.2*
  - Documented Source Code and Executables
  - Algorithms
  - Users Guides

- Available under the Apache 2.0 open source license
  - Download is free, you may edit or improve source code with proper attribution
  - You are encouraged, but not required, to return any modified code back to the development community