If These Cars Could Talk: Connected Vehicles & Safety Technology
FACILITATOR:
Major Christopher Grotton,
Maine State Police and
Vice Chair, Law Enforcement Standing Committee
PRESENTERS:
Tim Johnson,
Director, Vehicle Crash Avoidance and Electronic Controls Research, NHTSA

Patrick Son, P.E.,
Senior Technical Programs Specialist, Intelligent Transportation Society of America
Overview and Status of NHTSA’s Vehicle to Vehicle (V2V) Communications Program

Tim Johnson, Director, Office of Crash Avoidance and Electronic Controls Research

AAMVA Spring Workshop and Law Institute Session – Connected Vehicles and Safety Technology
March 18, 2015
Motor vehicle crashes cost nearly $871 billion annually
New Technologies and The Crash Timeline

Prevention

Severity Reduction

Injury Mitigation

Medical Attention

HUMAN / PRE - EVENT

“Driver Assist” Technologies

Safer cars. Safer Drivers. Safer roads.
NHTSA’s strategy to address highway traffic fatalities includes a strong focus on crash avoidance technologies, including DSRC-based Vehicle-to-Vehicle (V2V) Communications

• Light vehicles
  – V2V – ANPRM and readiness report released in August, NPRM to propose requiring V2V in new light vehicles expected 2016
  – Electronic Stability Control - FMVSS 126
  – Rear Visibility Systems - FMVSS 111
  – Forward Crash Warning and Lane Departure Warning - NCAP program
  – Automatic Emergency Braking (AEB) - Research report recently docketed, including latest test procedures. Agency decision upcoming.

• Heavy Vehicles
  – V2V agency decision upcoming
  – Stability control systems - rulemaking underway
  – AEB agency decision upcoming
Vehicle to Vehicle Communications Program

- Partners
- How does it work
- History of Research and Development
- Technical Challenges
- Naturalistic Testing (Safety Pilot)
- Status of Development
- Rulemaking Status
- Remaining Work
- V2V and Automation
Connected Vehicle Safety Program
Partners and Contractors

Vehicle Manufacturers
- BMW
- GM
- Volvo
- Honda
- Daimler
- Toyota
- Nissan
- Chrysler
- Hyundai
- Kia
- Mercedes-Benz
- Ford
- Freightliner
- Volkswagen

Public Agencies
- MDOT (Michigan Department of Transportation)
- VDOT (Virginia Department of Transportation)
- ADOT (Arizona Department of Transportation)
- NYSDOT (New York State Department of Transportation)
- Oak Ridge National Laboratory

Academia
- UGPTI
- UMTRI
- George Mason University
- Montana State University
- PATH
- Texas Transportation Institute

USDOT
- U.S. Department of Transportation Research and Innovative Technology Administration
- NHTSA (National Highway Traffic Safety Administration)

Industry
- Booz Allen Hamilton
- Telcordia
- SiloSmashers
- noblis
- Econolite
- Cambridge Systematics
- Siemens
- Delcan
- Westat
- Autotalks
- Savari
- Visteon
- Denso
- Delphi
- ARAD
- ARINC
- Cohda Wireless
- ATR
- ITC
- IEEE
- MacroSys
- Battelle
- ITRI
- SAE International

Associations/Standards Developers
- ATR
- ITC
- IEEE
- CVSA
- ITS Americas
- SAE International

Safer cars. Safer Drivers. Safer roads.
V2V Technology – 5.9 GHz DSRC

- **What is it?**
  - Wi-Fi radio adapted for vehicle environment

- **How does it work?**
  - A “Basic Safety Message” (BSM) is transmitted from each equipped vehicle 10 times per second.
  - BSM includes information about the vehicles’ location, speed and heading.
  - Each vehicle “listens” for these message from other vehicles, computes trajectories, and identifies potential crash situations.
  - Warnings are issued to the driver if a crash is determined to be “imminent”.

Safer cars. Safer Drivers. Safer roads.
Vehicle to Vehicle (V2V) Communications

Vehicles “talk” to each other exchanging information such as vehicle size, position, speed, heading, lateral/longitudinal acceleration, yaw rate, throttle position, brake status, steering angle, wiper status, turn signal status, enabling safety and mobility applications.

- High safety benefit potential – many different crash types can be addressed
- Technology: Dedicated Short Range Communications (DSRC) at 5.9GHz
- Range: About 300 Meters
- DSRC augments or replaces onboard sensors (radar, camera, etc)
Sensing Capabilities

V2V System

Conventional System

360 degree coverage and low latency of DSRC enable many safety and mobility applications to augment current technologies.
Key Components of a vehicular DSRC System

For V2V, combination of:
- Hardware
- Software
- Driver-Vehicle Interface
- Data
- V2V Safety Applications
- Security Services

Sources: Crash Avoidance Metrics Partnership and GAO.
NHTSA V2V Research….

<table>
<thead>
<tr>
<th>Track</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Track 1 Crash Scenario Framework</td>
<td>Analyze crash data and define target crash scenarios addressable by V2V. Develop high level performance requirements.</td>
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</tr>
<tr>
<td>Track 2 Interoperability and Security</td>
<td>Standards development for messages, data elements and protocols; Security system design, development and testing.</td>
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</tr>
<tr>
<td>Track 3 Benefits Assessment</td>
<td>Prototype characterization testing; performance measures; prior studies and field tests of crash avoidance systems; simulation and modeling</td>
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</tr>
<tr>
<td>Track 4 Applications Development</td>
<td>Build and test prototype applications; develop objective test procedures.</td>
<td></td>
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</tr>
<tr>
<td>Track 5 Human Factors</td>
<td>Driver-vehicle interface evaluations; Driver workload; Driver acceptance studies.</td>
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<tr>
<td>Track 6 Policy Issues</td>
<td>Privacy impacts and studies; Security system governance; Business models; Retrofit and Aftermarket device considerations;</td>
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</tr>
<tr>
<td>Tracks 7, 8 Commercial &amp; Transit</td>
<td>Specialized technical requirements (articulated vehicles); applications adaptation; participation in Safety Pilot.</td>
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</tbody>
</table>

Foundational research sponsored by USDOT included standards development and proof of concept testing – and began in early 2000’s
## Vehicular Communications - Why DSRC?

<table>
<thead>
<tr>
<th>Requirements</th>
<th>DSRC Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Speed of Transmission</strong></td>
<td></td>
</tr>
<tr>
<td>a) Fast network access times</td>
<td>DSRC has relatively few messaging protocol requirements</td>
</tr>
<tr>
<td>b) Low latency</td>
<td>DSRC offers delays of well under 100 microseconds</td>
</tr>
<tr>
<td>c) Rapid message delivery</td>
<td>DSRC allows for data exchange of over 6 megabytes/second</td>
</tr>
<tr>
<td><strong>Limited Range</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DSRC allows for both broadcast and point-to-point communications over very short distances</td>
</tr>
<tr>
<td></td>
<td>Limited range allows for spectrum reuse and limits interference</td>
</tr>
<tr>
<td><strong>High Reliability and Stability</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DSRC performance immune to extreme weather conditions</td>
</tr>
<tr>
<td></td>
<td>Designed to be tolerant to multi-path transmissions typical within roadway environments</td>
</tr>
<tr>
<td></td>
<td>Works in high vehicle-speed mobility conditions</td>
</tr>
<tr>
<td><strong>Dedication and Availability</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operations are in a licensed frequency band that has a primary allocation for transportation</td>
</tr>
</tbody>
</table>

In its 2004 Report and Order, the FCC concludes: “...it is paramount that such communications be protected from interference given the consequences to the traveling public should any one of the safety applications fail due to unacceptable error rates or delay. In this connection, we also agree...that non-public safety use of the 5.9 GHz band would be inappropriate if such use would degrade the safety/public safety applications.”
## Comparative Analysis of Communications Options

<table>
<thead>
<tr>
<th>V2V Safety Need</th>
<th>100ms</th>
<th>300m</th>
<th>Highway Speed</th>
<th>Y</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Latency</td>
<td>Range</td>
<td>Mobility Design Goal (Relative Speed)</td>
<td>Direct Device-to-Device Mode</td>
<td>Dedicated and Licensed Spectrum</td>
</tr>
<tr>
<td>DSRC</td>
<td>0.2-15ms</td>
<td>&lt;1km</td>
<td>Highway speed</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Wi-Fi</td>
<td>3-5 sec.</td>
<td>&lt;300m</td>
<td>Pedestrian speed</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Wi-Fi Direct</td>
<td>5 sec.</td>
<td>&lt;200m</td>
<td>Pedestrian speed</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Wi-Fi FILS draft standard</td>
<td>&gt;100ms</td>
<td>&lt;300m</td>
<td>Pedestrian speed</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>LTE Cellular</td>
<td>79-100ms</td>
<td>Wide Area</td>
<td>Highway speed</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>LTE-A Cellular</td>
<td>20-70ms</td>
<td>Wide Area</td>
<td>Highway speed</td>
<td>Proposed</td>
<td>Y</td>
</tr>
<tr>
<td>Bluetooth BR/EDR</td>
<td>100ms</td>
<td>&lt;100m</td>
<td>Stationary</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Bluetooth LE</td>
<td>6ms-70 min</td>
<td>&lt;50m</td>
<td>Stationary</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Satellite</td>
<td>&gt; 15-580ms</td>
<td>Wide Area</td>
<td>Varies</td>
<td>N</td>
<td>Y</td>
</tr>
</tbody>
</table>

- **Meets Requirement**
- **Does not meet**
- **Uncertain or unlikely**
Technical Challenges

- Ensuring Interoperability
  - Finalizing communication standards
  - Managing congestion and available spectrum
  - Detecting “bad actors” (misbehavior) and limiting impacts of anomalous messages

- Ensuring security of messaging (authenticity, trust) between vehicles...and between vehicles and infrastructure

- Protecting Privacy

- Efficient data delivery system (to support necessary V2I and I2V communications)
Key Elements:
- 73 miles of instrumented roadway
- 29 roadside units
- Approx. 3000 vehicles
  - Cars, trucks, buses
  - Integrated, aftermarket, and retrofit devices
- 1 year of data collection
- Multiple safety applications, vehicle OEMs, and suppliers

Additional features:
- Exercised security options
- Vetted non-production, basic device certification processes
V2V: Interoperability

- Demonstrated compatibility of radio system from multiple vendors.
- Proven interoperability among vehicles from different vehicle OEMs
- Developed and demonstrated devices that can bring the technology to the existing vehicle fleet (VADs, ASDs, RSDs)
V2V: Practicality

- Demonstrated feasibility for utilizing automotive grade GPS receivers and other components (economic viability)
- Successful initial scalability testing via both simulation and real world tests
- Proven feasibility in a variety of real world environments (Performance testing in multiple urban and rural settings)
V2V: Applications

- Developed and demonstrated key safety applications
- Adapted the technology for multiple vehicle platforms (cars, trucks, buses)
- Modeling based on both simulations and real-world data to derive benefits

- Emergency Electronic Brake Lights
- Blind Spot Warning (BSW)
- Forward Collision Warning (FCW)
- Intersection Movement Assist (IMA)
V2V: Safety Benefits

- **Target population:** A fully mature V2V system could potentially address up to 80% of unimpaired crashes.
- **For just two applications, Intersection Movement Assist (IMA) and Left Turn Assist (LTA),** NHTSA estimates that:
  - IMA could potentially help drivers avoid 41-55 percent of target intersection crashes.
  - LTA could potentially help drivers avoid 36-62 percent of left turn crashes.
  - Together, IMA and LTA could potentially prevent up to 413,000-592,000 crashes and save up to 777-1,083 lives.
What has DOT and its partners accomplished thus far?.....security

- Leveraged a “tried and true” security approach (PKI), and adapted it for a mobile environment.

Main Operations:
1. Device Initialization
2. Certificate Provisioning
3. Misbehavior Detection and Revocation

Defense Against Attacks
Key Remaining Technical Research

- Finalize on-board device requirements
- Develop certification and testing procedures
- Build larger-scale security system and complete end-to-end testing:
  - Finalize designs including provisions for servicing V2I communications
  - Test “normal” operations and use cases at scale
  - Robustness and vulnerability testing
  - Provide security services to connected vehicle pilots
- Monitor on-going spectrum use issues to ensure non-interference with safety-of-life DSRC communications.
- Support establishment of a security credential management system manager—and the development of appropriate organizational structure, policies and procedures for the SCMS functions.
Continuing Research....

<table>
<thead>
<tr>
<th>Project</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Applications Development</td>
<td>revised prototype applications from vehicle</td>
<td>Detailed procedures; Performance Metrics, and false positive tests</td>
<td></td>
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<tr>
<td>Consumer Acceptance Research</td>
<td>Focus Groups, Surveys</td>
<td></td>
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<tr>
<td>DSRC Market Study</td>
<td>Applications Market Study</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standards Development</td>
<td>IEEE P1609 series of stds</td>
<td>J2735 messages and data element definitions</td>
<td>J2945 DSRC and Safety Communication Performance Reqs</td>
</tr>
<tr>
<td>Interoperability</td>
<td>Congestion, Misbehavior Detection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spectrum</td>
<td>In- and out-of-band interference; support testing of sharing concepts</td>
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</tr>
<tr>
<td>OBU Requirements and Test procedures.</td>
<td>Finalize performance reqts, test, &amp; certification methods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Security System Development &amp; Test</td>
<td>SCMS prototype build &amp; test</td>
<td></td>
<td>Vulnerability Testing</td>
</tr>
<tr>
<td>Vehicle-Based Security Solution</td>
<td>Concept Feasibility and Evaluation</td>
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</table>
V2V: USDOT/NHTSA Decision

• On February 3, 2014 DOT Secretary Anthony Foxx and NHTSA Acting Administrator Friedman announcement.
• Issue a regulatory proposal within this Administration
• Intend to require an onboard DSRC-based V2V communications technology
• Potential to address 80% of crashes involving non-impaired drivers!
V2V: Rulemaking

• Advance Notice of Proposed Rulemaking (ANPRM) published by NHTSA on August 18, 2014
  – Lots of interest - approximately 940 public comments
  – See [www.safercar.gov/v2v](http://www.safercar.gov/v2v) for more information
    • ANPRM and Research Readiness Report Available for review
• Request for Information (RFI) for security system published on October 15, 2014
• NPRM in 2016
Future: Automated Vehicles

- USDOT Automation Program
  - V2V and V2I systems are key building blocks for future automation
- NHTSA Policy Statement
  - Provides guidance to Key Stakeholders (e.g. States)
  - Outlines NHTSA Research Activities
- New and emerging technologies will be part of a continuum of automation
  - In-vehicle crash avoidance systems that provide warnings or limited vehicle control
  - V2V communications that support crash avoidance applications
Conclusion

- DSRC technologies and applications have reached a level of stability that support deployment
- Large-scale testing / Model Deployment have helped evolve the hardware and applications from pre-competitive prototypes into products that are being qualified to support a set of planned Connected Vehicle Pilot sites to be awarded in 2015 (first set) and 2017 (second set)
- Standards have evolved to assure device interoperability
- A security solution has been partially tested under real-world conditions
- A certification program is under development and will result in test procedures that reflect DSRC performance requirements
- Rulemaking is underway
Thank You!

Tim Johnson
tim.johnson@dot.gov
www.NHTSA.gov
ITS America Highlights

• Advancing transportation through technology
• Non-profit, member-driven association
  – Outreach, facilitate and convene
  – Subject matter expert interactions via in-person and online conferences, meetings and surveys
• Ecosystem with hundreds of organizations and thousands of contacts
  – Public, Private, and Academia
  – Auto, Telco, IT, Industrial, Consumer Electronics, Logistics
  – Global, Federal, State, MPO, County, City
  – Universities, tech centers, multi-disciplinary centers
  – Organized into State Chapters and Technical Forums
Membership Diversity is Our Strength

446 Members from…

- Academia 28
- Automotive 8
- Commercial Vehicle 4
- Contractor 3
- Environment 5
- Finance 6
- Homeland Security 7
- Information Technology 26
- Infrastructure 36
- Legal Counsel 4
- Nonprofit 70
- Other 11
- Public Agencies 97
- Public Safety 7
- Public Transit 24
- Research 9
- Supplies 7
- Systems Architecture 5
- Telecommunications 14
- Telematics 14
- Toll Operations 12
- Transportation Planning 32
- Traveler Information 17
State Chapters Program

- Engagement through state chapter meetings
- 40 states participate: 23 state & 4 regional chapters
- Membership includes 32 states

Alaska DOT
Arizona DOT
California DOT
Delaware DOT
Florida DOT
Georgia DOT
Idaho DOT
Illinois DOT
Iowa DOT
Kansas DOT
Louisiana DOT and Development
Maryland DOT
Massachusetts DOT
Michigan DOT
Minnesota DOT
Mississippi DOT
Missouri DOT
Nebraska Department of Roads
Nevada DOT
New Jersey DOT
New York State DOT
New York State Thruway Authority
North Carolina DOT
Ontario Ministry of Transportation
Oregon DOT
Pennsylvania DOT
Tennessee DOT
Texas DOT
Utah DOT
Vermont Agency of Transportation
Virginia DOT
Washington State DOT
West Virginia DOT
Wisconsin DOT
ITS America Market Research

- Market Data Analysis of ITS Revenues and Employment (2011)
- U.S. State Highway Operations survey (2011)
- CLARUS User Survey Findings (2011)
- Smart Parking (2012)
- ITS Market Survey follow-up (2013)
- Infrastructure Navigator (2013)
- State DOT ITS Spending Survey (2013)
Technology Scan and Assessment

• Evaluate technology innovations and inventory new “systems” that may interface with Connected Vehicle core system
  – Sensing Technologies and Machine Perception
  – Wireless Access, Networking and Broadband
  – Service-Oriented Computing, Data Warehousing and Data Mining
  – Predictive Analytics and Adaptive Services

• Engage researchers and technologists in these and other applied engineering fields that are relevant to the Connected Vehicle program
What is Connected Vehicle

- https://www.youtube.com/watch?v=YxmLkqVrg4c
CV is Warning
Not Control
Response, Emergency Staging, Communications, Uniform Management, and Evacuation (R.E.S.C.U.M.E.)

- Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
- Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)
- Emergency Communications and Evacuation (EVAC)
- Information provided by US DOT ITS JPO
INCIDENT SCENE PRE-ARRIVAL STAGING GUIDANCE FOR EMERGENCY RESPONDERS (RESP-STG)

Situational awareness info to responders while en route
Enabled through enhancements in existing public safety communications systems
Input to responder vehicle routing, staging and secondary dispatch decisions
INCIDENT SCENE WORK ZONE ALERTS FOR DRIVERS AND WORKERS (INC–ZONE)

In-vehicle messaging system, provides motorists with:
- Merging and speed guidance as they approach an incident scene
- Warnings if they approach the incident scene at an unsafe speed or trajectory

Provides a warning for on-scene workers.

Source: Ron Moore
November 13, 2014 Demonstration

- 12 scenarios showing functionality of RESP-STG and INC-ZONE applications, viewed from three different perspectives:
  - Oncoming Vehicle Perspective
  - CapWIN Perspective (Position A)
  - Responder Perspective (Position B)

Example message displayed to driver:

```
ALERT!
SPEED LIMIT 25
```

U.S. Department of Transportation
Dramatic Changes in Store for Transportation

The surface transportation system as we know it is preparing for a dramatic organizational redesign

- In 2008, 5.8 million crashes occurred
- 34,017 of which were fatal
- Congestion is spreading, infrastructure assets are deteriorating
- Lack of data/choice between modes
- Lack of coordination between transportation and other national, local and regional goals and operations (energy, environment, security, land use planning)

Increased communication amongst system elements with technology

- Personnel Subsystem – Drivers
- Technological Subsystem – Vehicles
- Environmental Subsystem – Infrastructure, Weather
- Organization Design
  - Top-down: Policy, Laws, Enforcement, Education
  - Bottom-up: Individual Driver Behavior

source: Dr. Greg Fitch, Virginia Tech – ITSA Safety Forum (adapted)
ITS Potential for Infrastructure and the Environment

- Local authorities will not keep up with the demand for transportation infrastructure investment, focusing resources mostly on preservation and maintenance.

- US land use will still be suburban, requiring travel by greater distances feeding congestion, which is spreading to smaller cities and more of the road system.

- US Road networks fit traffic patterns of the 1950's, not the 2010's.

- Technology can improve the Infrastructure/Environmental Subsystem:
  - Public decisions to invest in new infrastructure are driven by benefit cost analyses based upon data generated by ITS sensor networks.
  - The transportation system will transmit quality-of-service information and pricing signals to all users. Traffic is intelligently re-routed around disturbances and peaks.
  - Security and credentialing is automated; freight flows more predictably.
  - ITS travel demand management help push some transportation related environmental emissions back to safe levels.
V2I Components of a CV Environment

• Applications: Safety, Mobility, Environment
• Roadside Units (RSUs)
• Signal Phasing and Timing (SPaT) enabled traffic signal controllers
• Data links between V2I components and a traffic management center (TMC) or other back office
• Any sensors or relays that link to or serve those components
Curve Speed Warning

Driver Vehicle Interface (DVI) Example

Smart Roadside

Stop Sign Gap Assist

Pedestrian Warning Application for Transit Vehicles

Driver Infrastructure Interface (DII) Example

Driver Infrastructure Interface (DII) Example

Option 1 – This option includes sending an alert when the crosswalk signal has been activated.
Option 2 – This option includes the use of a pedestrian detection system to detect the presence of a pedestrian in the crosswalk.

NOTE:

Image Source: USDOT
Open Source Portal
Associated Applications

OS Portal Manager:
The entity or community that manages the OS Portal

<table>
<thead>
<tr>
<th>Program</th>
<th>Description</th>
<th>Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMITSS</td>
<td>Multimodal Intelligent Traffic Signal System</td>
<td>Ben McKeever</td>
</tr>
<tr>
<td>INFLO</td>
<td>Intelligent Network Flow Optimization</td>
<td>Mohammed Yousuf</td>
</tr>
<tr>
<td>Enable ATIS</td>
<td>Enable Advanced Traveler Information Systems</td>
<td>Bob Rupert</td>
</tr>
<tr>
<td>IDTO</td>
<td>Intelligent Dynamic Transit Operations</td>
<td>Ron Boenau</td>
</tr>
<tr>
<td>FRATIS</td>
<td>Freight Advanced Traveler Information Systems</td>
<td>Randy Butler</td>
</tr>
</tbody>
</table>

Other Programs: ICM ATDM Weather
DSRC Roadside Unit

• Specification 3.0 (prototype unit) is available
  – Used for Safety Pilot

• Specification 4.0 underway (pre-production unit) based on lessons learned – due in Summer 2014
  – Purpose of Update: to improve performance reliability, strengthen security protocols and promote common configurations and user interfaces across different vendors
  – Key changes
Signal Phase and Timing

• SPaT tested in Safety Pilot:
  – 6 intersections
  – Transit application
  – SPaT data

• Deploying in Affiliated Test Beds to support testing of Multi-Modal Intelligent Traffic Signal System (MMITSS) applications

• ConOps, Interface Control documents, and System Requirements available now – ask Deborah.Curtis@dot.gov
Other V2I Deployment Considerations

- V2I deployment sites can serve more than one application, strategy, or impact area.

- V2I deployments and CV technology should consider pedestrians, bicycles, and other possible non-motorized users that may be within highways rights-of-way.

- Autonomous vehicles are not addressed in this guidance at this time.
Questions

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If These Cars Could Talk: Connected Vehicles & Safety Technology