UNITED STATES
DEPARTMENT OF TRANSPORTATION

Connected Vehicles 102: Applications and Implementation

CV 102 Workshop

Participants Workbook

Agenda

Workshop Agenda

1. Connected Vehicles: Introduction and Current Status	**30 minutes**
a. Connected vehicle overview video	
b. Current status	
c. Envision connected everything	
2. Preparing to Implement Connected Vehicle Applications	**30 minutes**
a. Preparing to implement connected vehicle applications	
b. Top regional or local transportation challenges	
c. Setting performance goals	
3. Safety Applications	**30 minutes**
a. V2V safety applications	
b. V2I safety applications	
4. Mobility Applications	**45 minutes**
a. Dynamic mobility applications	
5. Environmental Applications	**30 minutes**
a. AERIS applications	
b. Road weather applications	
6. Implementing Connected Vehicle Applications	**40 minutes**
a. Recommended approach for implementation	
b. Security and privacy considerations	
c. Resources for connected vehicle application deployment	
7. Course Wrap-Up	**15 minutes**

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Connected Vehicles 102

Applications and Planning for Implementation

ITS Professional Capacity Building Program

- Offers FREE training to develop the ITS workforce
- Talking Transportation Technology webinars, with online archive
- ITS Standards (48 modules)
- ITS Transit Standards (14 modules)
- eLearning Courses from Consortium for ITS Education (CITE):
  - Telecommunications and Networking Fundamentals
  - Network Design and Deployment Considerations for ITS Managers
- Workshops at ITS America State chapter meetings

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Additional Connected Vehicle Training Resources

- ITS PCB online course: CV 101 eLearning Course – available Fall 2015
- ITS PCB archived webinars:
  - CV Basics
  - National Connected Vehicle Field Infrastructure Footprint Analysis
- Connected Vehicle Reference Implementation Architecture (CVRIA)
  - http://www.iteris.com/cvria/html/resources/cvriatraining.html
  - http://www.iteris.com/cvria/html/forms/setittrainingform.php
- ITS ePrimer – Connected Vehicle Chapter

Contact: Mac Lister, Program Manager
ITS Professional Capacity Building Program
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708-283-3532 Mac.Lister@dot.gov

www.pcb.its.dot.gov

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Workshop Agenda

Topic	Title	Duration
1	Connected Vehicles: Introduction and Current Status	30 minutes
2	Preparing to Implement Connected Vehicle Applications	30 minutes
3	Safety Applications	30 minutes
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6	Connected Vehicle Considerations and Resources	40 minutes
7	Course Wrap-up	15 minutes

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Why Are You Here Today?

- Shout it out!
  - What is your role related to connected vehicles?
  - What are you most interested in learning more about?
  - What questions do you have that you are hoping to get answered during this session?
  - Do you know what your organization is currently doing related to connected vehicles?
- We want you to leave this workshop with an understanding of the applications available to you, and how you can use these applications to address transportation challenges

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Topic 1: Connected Vehicles: Introduction and Current Status

Topic	Title	Duration
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Connected Vehicle Research
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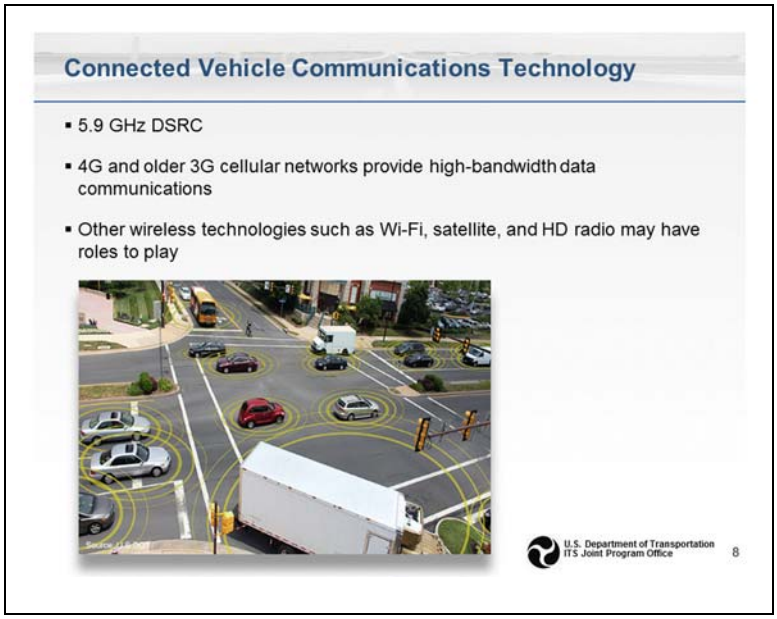
Connected Vehicle Communications Technology
5.9 GHz DSRC
4G and older 3G cellular networks provide high-bandwidth data communications
Other wireless technologies such as Wi-Fi, satellite, and HD radio may have roles to play
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USDOT/NHTSA Advance Notice of Proposed Rule Making on V2V Communications Technology

In May, Secretary of Transportation Anthony Foxx directed the National Highway Traffic Safety Administration (NHTSA) to:

Accelerate the timetable for V2V communications in new vehicles

- Rapid testing of V2V transmissions
- Work on regulatory framework
- Draft rule by end of 2015

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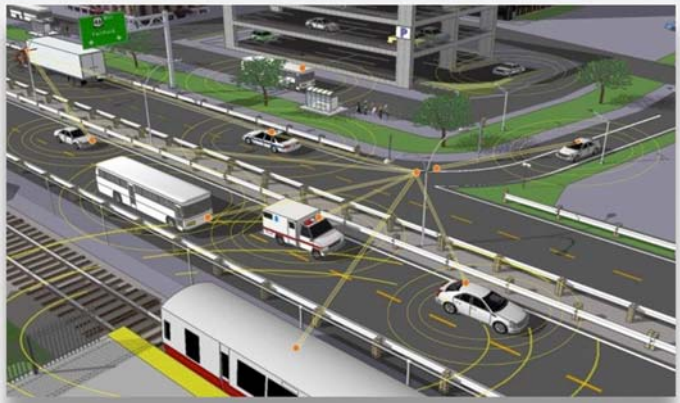
Envision Connected Everything



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Connected Vehicle Pilot Deployment Program
Spur Early CV Tech Deployment
Measure Deployment Benefits
Resolve Deployment Issues
Wirelessly Connected Vehicles
Safety
Technical
Mobile Devices
Mobility
Institutional
Infrastructure
Environment
Financial
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Topic 1 Wrap-up
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Topic 2: Preparing to Implement Connected Vehicle Applications

Topic	Title	Duration
1	Connected Vehicles: Introduction and Current Status	30 minutes
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Topic 2: Preparing to Implement Connected Vehicle Applications

- After this topic, you will be able to:
  - Explain the process for preparing to implement connected vehicle applications
  - Identify your top regional or local transportation challenges
  - Set performance goals

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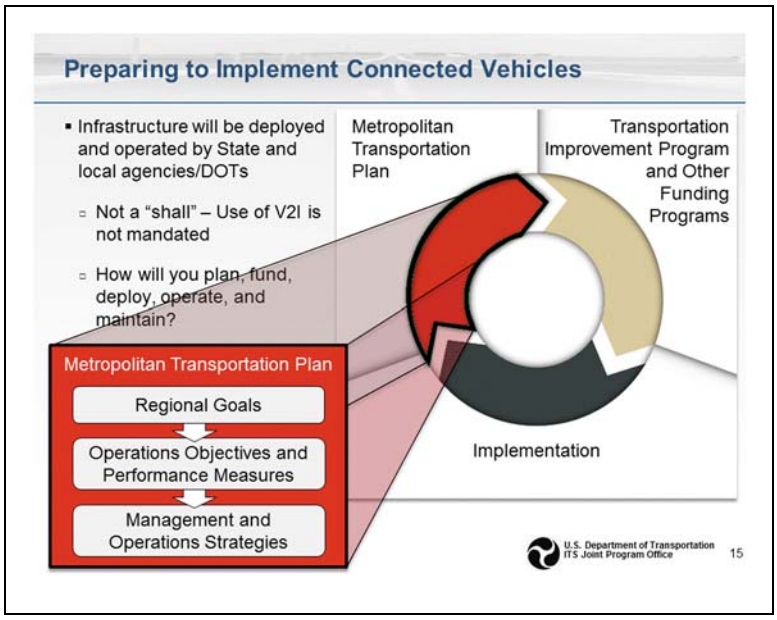
Preparing to Implement Connected Vehicles
Infrastructure will be deployed and operated by State and local agencies/DOTs
Not a "shall" – Use of V2I is not mandated
How will you plan, fund, deploy, operate, and maintain?
Metropolitan Transportation Plan
Transportation Improvement Program and Other Funding Programs
Implementation
Metropolitan Transportation Plan
Regional Goals
Operations Objectives and Performance Measures
Management and Operations Strategies
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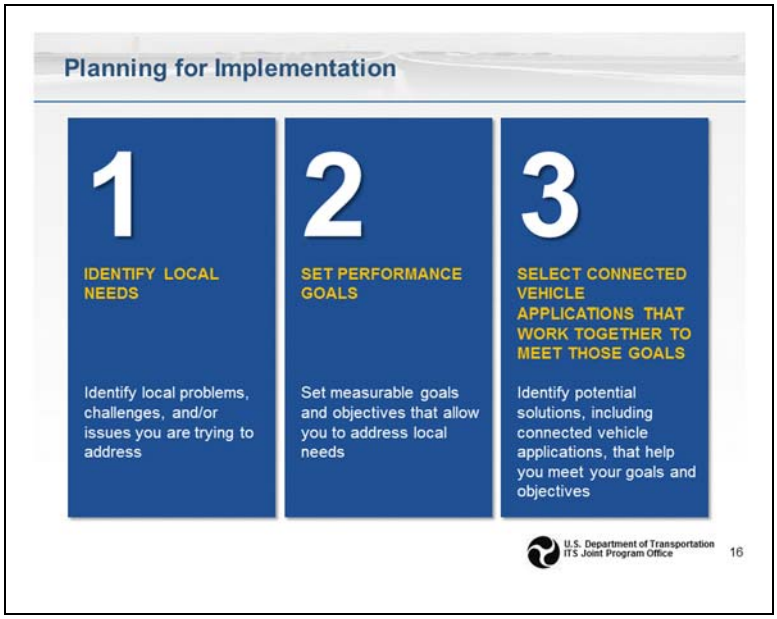
Planning for Implementation
1
IDENTIFY LOCAL NEEDS
Identify local problems, challenges, and/or issues you are trying to address
2
SET PERFORMANCE GOALS
Set measurable goals and objectives that allow you to address local needs
3
SELECT CONNECTED VEHICLE APPLICATIONS THAT WORK TOGETHER TO MEET THOSE GOALS
Identify potential solutions, including connected vehicle applications, that help you meet your goals and objectives
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Identify Needs

1

IDENTIFY LOCAL NEEDS

Identify local problems, challenges, and/or issues you are trying to address

Sample Local Needs

- Safety
  - Reduce crashes and fatalities
  - Decrease conflicts between pedestrians, bicycles, and vehicles
  - Set emergency vehicle preemption
- Mobility
  - Reduce congestion on arterials
  - Improve transit schedule reliability
- Environment
  - Improve air quality in non-attainment areas
  - Reduce wasted fuel along arterials

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Set Performance Goals

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SET PERFORMANCE GOALS

Set measurable goals and objectives that allow you to address local needs

Sample Performance Goals

- Safety
  - Reduce crashes by 10%; injuries by 20%; and fatalities by 30%
  - Reduce pedestrian-vehicle conflicts by 50%
- Mobility
  - Transit vehicles on schedule 90% of the time
  - Increase peak period throughput by 8%
- Environment
  - Reduce emissions by 20%
  - Reduce fuel costs associated with operating a transit fleet by 10%

Performance goals must be measurable!

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Select CV Applications That Work Together To Meet These Goals

3

SELECT CONNECTED VEHICLE APPLICATIONS THAT WORK TOGETHER TO MEET THOSE GOALS

Identify potential solutions, including connected vehicle applications, that help you meet your goals and objectives

Sample CV Applications

- Mobility and safety applications that result in environmental benefits
  - Traffic signal priority applications may improve transit performance, but may also result in fuel consumption and emissions reductions
- Applications that can perform dual roles
  - Speed harmonization may optimize for mobility and at other times may optimize for the environment

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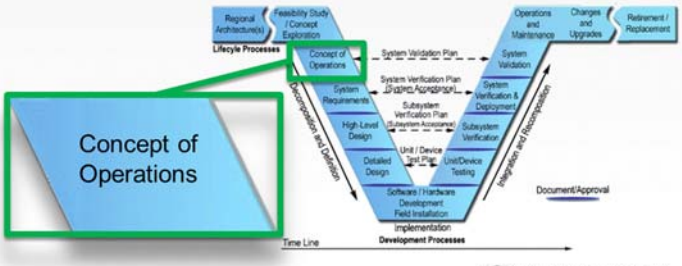
Preparing to Implement Connected Vehicle Applications

- A systems architecture for ITS is part of an overall systems engineering approach
- The CVRIA leverages the National ITS Architecture framework
- CVRIA supports development of the Concept of Operations through the use of the Systems Engineering Tool for Intelligent Transportation (SET-IT)



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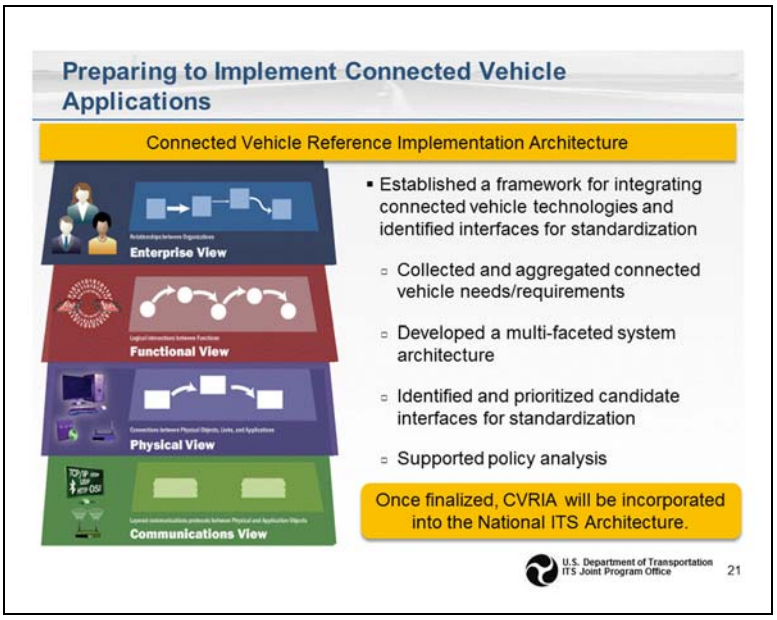
Preparing to Implement Connected Vehicle Applications
Connected Vehicle Reference Implementation Architecture
Enterprise View
Functional View
Physical View
Communications View
Established a framework for integrating connected vehicle technologies and identified interfaces for standardization
Collected and aggregated connected vehicle needs/requirements
Developed a multi-faceted system architecture
Identified and prioritized candidate interfaces for standardization
Supported policy analysis
Once finalized, CVRIA will be incorporated into the National ITS Architecture.
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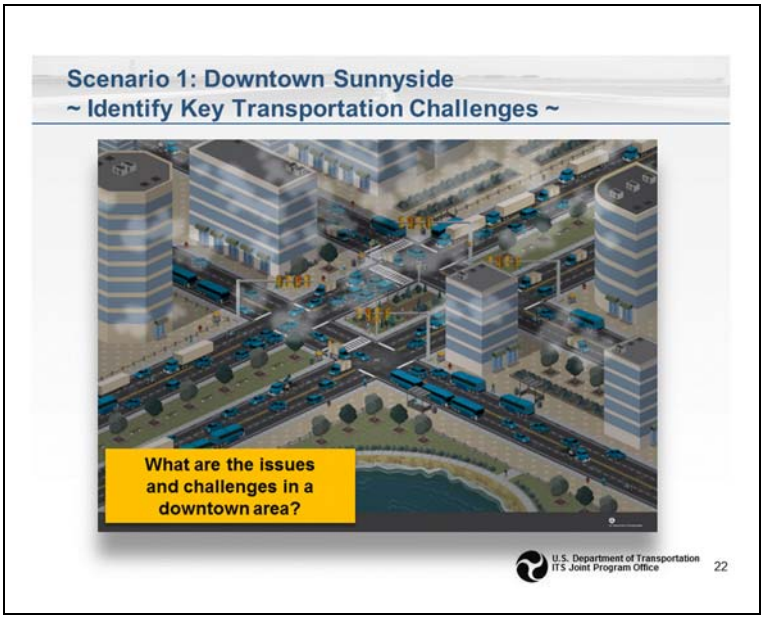
Scenario 1: Downtown Sunnyside
~ Identify Key Transportation Challenges ~
What are the issues and challenges in a downtown area?
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Scenario 1: Downtown Sunnyside
~ Stakeholders Set Three Performance Targets ~

Identify Needs	Performance Measure	Performance Target
Transit vehicles schedule reliability	Increase transit reliability	Transit vehicles on schedule 90% of the time
Pedestrian-vehicle conflicts	Improve pedestrian safety	Reduce pedestrian-vehicle conflicts by 50%
Emissions/air quality hot spots	Improve hot spot air quality	Reduce emissions by 20%

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Scenario 1: Downtown Sunnyside
~ Improving Congestion in an Urban Arterial Network ~

Synergies among applications increase benefits and reduce costs

Improve Transit Reliability
- Application 1
- Application 2

Improve Pedestrian Safety
- Application 3
- Application 4
- Application 5
- Application 6
- Application 7

Improve Air Quality
- Application 8
- Application 9
- Application 10

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Group Exercise

- Begin planning for connected vehicle applications implementation
- Using the Implementing Connected Vehicle Applications worksheet, complete the following tasks:
  - Identify need(s)
  - Set performance goal(s)

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Topic 2 Wrap-up

- Explain the process for planning to implement connected vehicle applications
- Identify your top regional or local transportation challenges
- Set performance goals

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Topic 3: Safety Applications

Topic	Title	Duration
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Topic 3: Safety Applications

- After this topic, you will be able to:
  - Explain the purpose and goals of the safety applications
  - Describe what different safety applications do
  - Evaluate the usefulness of a safety application or applications related to an identified need or performance measure

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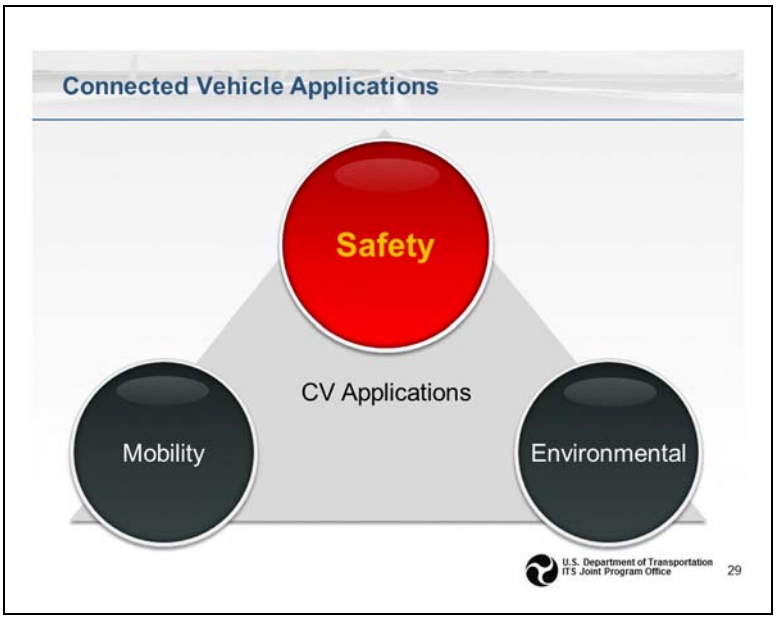
Connected Vehicle Applications
Safety
CV Applications
Mobility
Environmental
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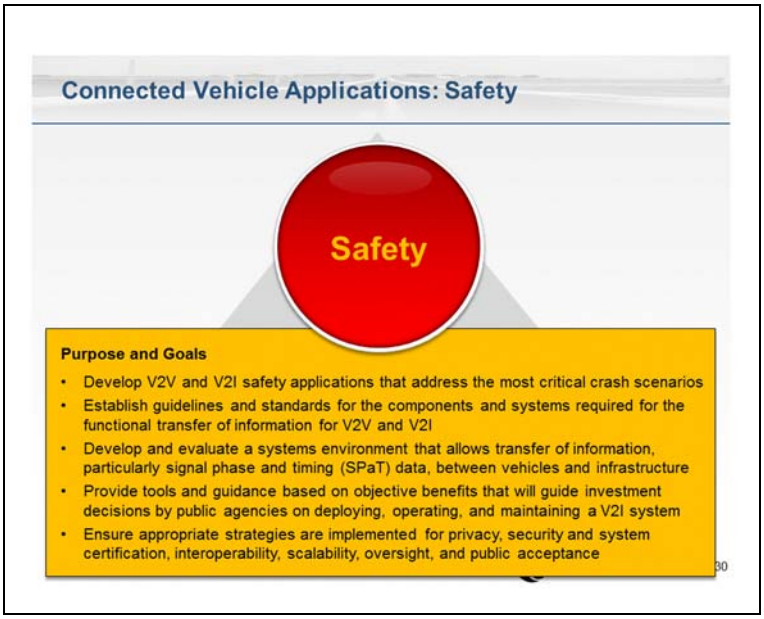
Connected Vehicle Applications: Safety
Safety
Purpose and Goals
• Develop V2V and V2I safety applications that address the most critical crash scenarios
• Establish guidelines and standards for the components and systems required for the functional transfer of information for V2V and V2I
• Develop and evaluate a systems environment that allows transfer of information, particularly signal phase and timing (SPaT) data, between vehicles and infrastructure
• Provide tools and guidance based on objective benefits that will guide investment decisions by public agencies on deploying, operating, and maintaining a V2I system
• Ensure appropriate strategies are implemented for privacy, security and system certification, interoperability, scalability, oversight, and public acceptance
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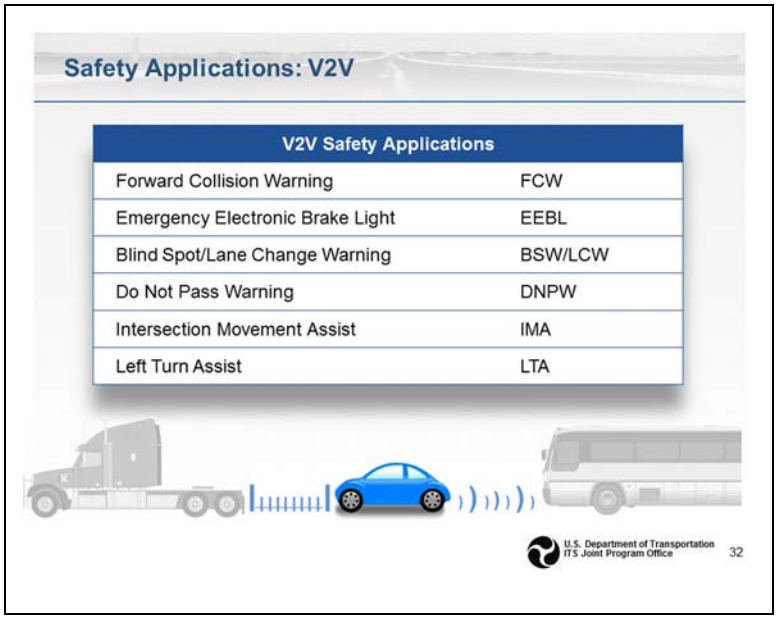
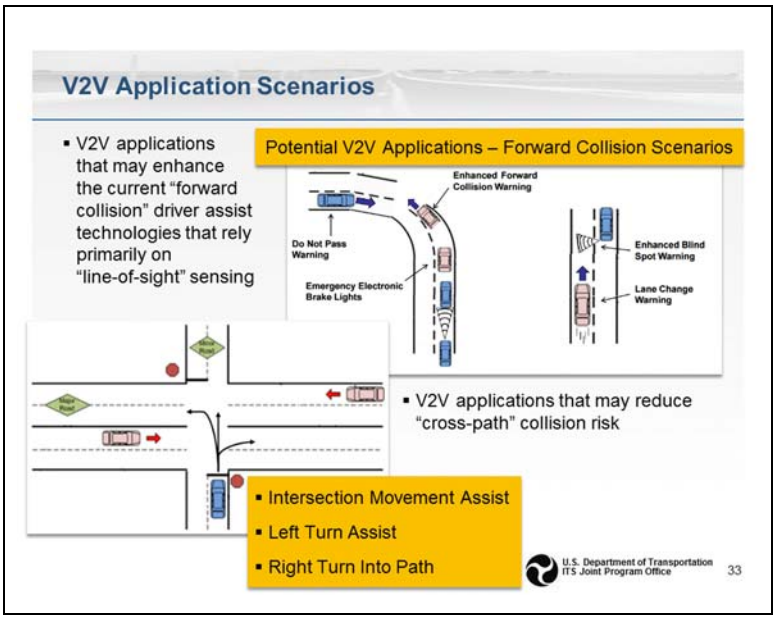


V2V Safety Applications	
Forward Collision Warning	FCW
Emergency Electronic Brake Light	EEBL
Blind Spot/Lane Change Warning	BSW/LCW
Do Not Pass Warning	DNPW
Intersection Movement Assist	IMA
Left Turn Assist	LTA


V2V Application Scenarios
V2V applications that may enhance the current "forward collision" driver assist technologies that rely primarily on "line-of-sight" sensing
Potential V2V Applications – Forward Collision Scenarios
Enhanced Forward Collision Warning
Do Not Pass Warning
Emergency Electronic Brake Lights
Enhanced Blind Spot Warning
Lane Change Warning
V2V applications that may reduce "cross-path" collision risk
Intersection Movement Assist
Left Turn Assist
Right Turn Into Path
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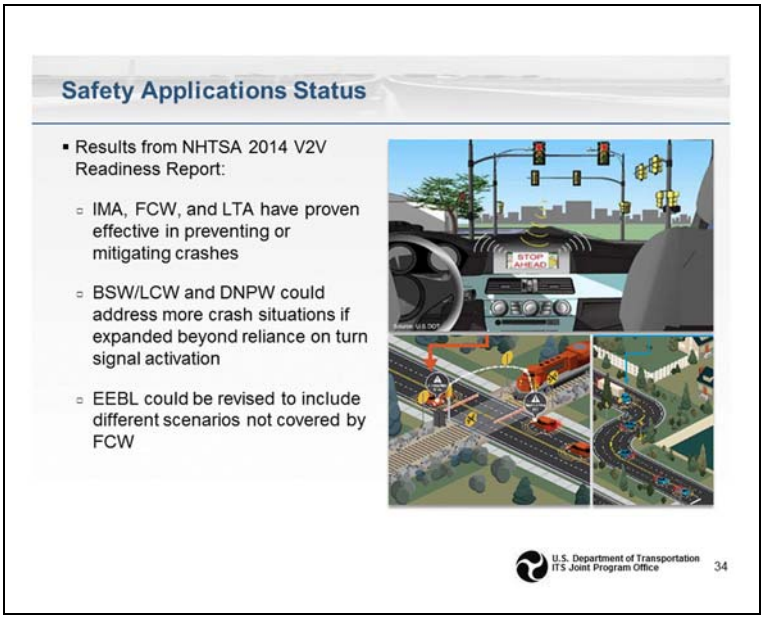
Safety Applications Status
Results from NHTSA 2014 V2V Readiness Report:
IMA, FCW, and LTA have proven effective in preventing or mitigating crashes
BSW/LCW and DNPW could address more crash situations if expanded beyond reliance on turn signal activation
EEBL could be revised to include different scenarios not covered by FCW
STOP AHEAD
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Benefits of V2V Applications

- NHTSA report produced the following potential benefits of IMA and LTA deployment:
  - 41 to 55% of target intersection accidents avoided
  - 36 to 62% of left-turn accidents avoided
  - 413,000 to 592,000 crashes prevented annually
  - 777 to 1,083 lives saved annually
  - Reduction of 191,000 to 270,000 Abbreviated Injury Scale (AIS) injuries annually

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Key Challenges

- Technical
  - Wireless spectrum
  - V2V device certification issues
  - Test procedures, performance requirements, and driver-vehicle interface issues
- Institutional
  - Standing up security and communications systems to support V2V
  - Liability of manufacturers
  - Privacy

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Safety Applications: V2I

V2I Safety Applications	
Curve Speed Warning	CSW
Red Light Violation Warning	RLVW
Spot Weather Information Warning	SWIW
Reduced Speed Zone Warning	RSZW
Stop Sign Gap Assist	SSGA
Smart Roadside	SRI
Transit Pedestrian Warning	

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Curve Speed Warning

V2I

- Target crashes approaching horizontal curves on segments or interchange ramps that are speed-related
- Alert trucks they are entering a curve at too high a speed to negotiate it safely
- Improve:
  - Reduction in truck rollover/run off road crashes

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Red Light Violation Warning
V2I
Red Light Violation Warning
Issues warning to the driver if he/she is about to run a red light
Target crashes that result from signal violations
Wireless exchange of critical safety and operational data between vehicles and the roadway infrastructure
Reduce the frequency and severity of safety-related incidents at signalized intersections
Improves:
Significant reduction in collisions, injuries, and fatalities at intersections
Non-recurring congestion resulting from incidents is reduced
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Stop Sign Gap Assist
V2I
Stop Sign Gap Assistance
Alerts the driver when it is unsafe to enter a STOP-sign controlled intersection.
Target crashes that result from poor gap acceptance at two-way stop-controlled intersection
Poor line of sight at intersections and high speeds on the mainline often result is drivers misjudging gaps when departing from stop signs
Improvement
Reduction in right angle high-speed crashes
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Transit Warnings

V2I

- Transit Pedestrian Warning
  - Alert bus drivers to pedestrians in crosswalk at signalized intersections in their path.
- Curve Speed Warning for Transit
  - Alert buses they are entering a curve at too high a speed to negotiate it safely
- Improves
  - Reduction in pedestrian-bus crashes, injuries, and fatalities
  - Reduction in bus rollover/run off road crashes

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Benefits of V2I Applications

- V2I applications could potentially target approximately 2.3 million crashes costing $202 billion annually, including:
  - Red light running - 234,881 crashes, costing $13.1 billion
  - Driver gap assist at stop-controlled intersections - 278,886 crashes, costing $18.2 billion
  - Curve speed warning - 168,993 crashes, costing $29 billion
  - Infrastructure pedestrian detection - 17,812, costing $3.33 billion

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Key Challenges

- Technical - Changes to the infrastructure needed to support the connected vehicle environment
  - Standardized Traffic signal controller interfaces for applications that require signal phase and timing (SPaT) data.
  - Mapping and positioning services for resolving vehicle locations to high accuracy and precision.
  - Data servers for collecting and processing data provided by vehicles and for distributing information, advisories, and alerts
- Institutional - Changing operational environment
  - Workforce/staffing skills
  - Planning and procuring for interoperability
  - Funding mechanism for public agencies

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Activity

- Continue planning for connected vehicle applications implementation
- Using the Implementing Connected Vehicle Applications worksheet, complete the following tasks:
  - Document safety applications that could help you meet your performance goal(s)
  - Think about the other impacts these applications could have on mobility and the environment

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Topic 3 Wrap-up

- Explain the purpose and goals of the safety applications
- Describe what different safety applications do
- Evaluate the usefulness of a safety application or applications related to an identified need or performance measure

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Topic 4: Mobility Applications

Topic	Title	Duration
1	Connected Vehicles: Introduction and Current Status	30 minutes
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Topic 4: Mobility Applications

- After this topic, you will be able to:
  - Explain the purpose and goals of the mobility applications
  - Describe what different mobility applications do
  - Evaluate the usefulness of a mobility application or applications related to an identified need or performance measure

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Connected Vehicle Applications: Mobility

Purpose and Goals

- Develop open-source applications that use synthesized, multisource ITS data to transform surface transportation management and information
- Develop tools (e.g. an open source portal), metrics, and concepts that support application development
- Develop related applications together in bundles for greater efficiency, less stove-piping, and greater safety and operational awareness

CV Applications

Mobility

Environmental

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Mobility

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Mobility Applications Status

- Prototype development of application bundles.
- Pilot Deployment Solicitation
  - Clear opportunity to successfully deploy collections of complementary connected vehicle applications
  - Have a cost-beneficial impact in the short-term
  - Potentially transformative impacts in the long-term

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Dynamic Mobility Applications

Multi-Modal Intelligent Traffic Signal System	**MMITSS**
Intelligent Traffic Signal System	I-SIG
Transit Signal Priority	TSP
Mobile Accessible Pedestrian Signal System	PED-SIG
Freight Signal Priority	FSP
Emergency Vehicle Preemption	PREEMPT
Intelligent Network Flow Optimization	**INFLO**
Dynamic Speed Harmonization	SPD-HARM
Queue Warning	Q-WARN
Cooperative Adaptive Cruise Control	CACC

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Dynamic Mobility Applications

Response, Emergency Staging and 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
Enable Advanced Traveler Information Systems	**Enable ATIS**

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Dynamic Mobility Applications

Integrated Dynamic Transit Operations	**IDTO**
Connection Protection	T-CONNECT
Dynamic Transit Operations	T-DISP
Dynamic Ridesharing	D-RIDE
Freight Advanced Traveler Information Systems	**FRATIS**
Dynamic Travel Planning and Performance	
Drayage Optimization	

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MMITSS Application Descriptions

Intelligent Traffic Signal System (I-SIG)
An overarching system optimization application accommodating signal priority, preemption, and pedestrian movements.

Emergency Vehicle Preemption (PREEMPT)
An application that provides signal preemption to emergency vehicles, and accommodates multiple emergency requests.

Transit Signal Priority (TSP) and Freight Signal Priority (FSP)
Two applications that provide signal priority to transit at intersections and along arterial corridors as well as signal priority to freight vehicles along an arterial corridor near a freight facility.

Mobile Accessible Pedestrian Signal System (PED-SIG)
An application that allows for an automated call from the smartphone of a visually impaired pedestrian to the traffic signal, as well as audio cues to safely navigate the crosswalk.

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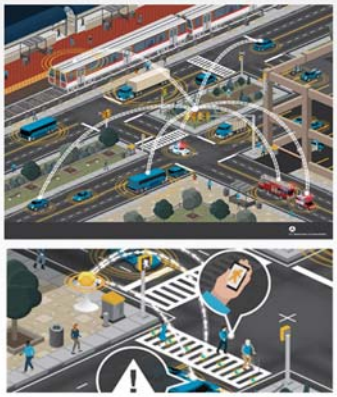
MMITSS Concepts and Performance Measures

- Concepts
  - Preemption
  - Priority
- Performance Measures
  - Decrease Delay
  - Improve Travel Time
  - Through put
  - Decrease Stops
  - Time to service
  - Queue Service Time
  - DSRC Range
  - Packet Drop



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INFLO Application Descriptions

Dynamic Speed Harmonization (SPD-HARM)
An application that aims to recommend target speeds in response to congestion, incidents, and road conditions to maximize throughput and reduce crashes.

Queue Warning (Q-WARN)
An application that provides drivers timely warnings of existing and impending queues.

Cooperative Adaptive Cruise Control (CACC)
An application that aims to dynamically adjust and coordinate cruise control speeds among platooning vehicles to improve traffic flow stability and increase throughput.

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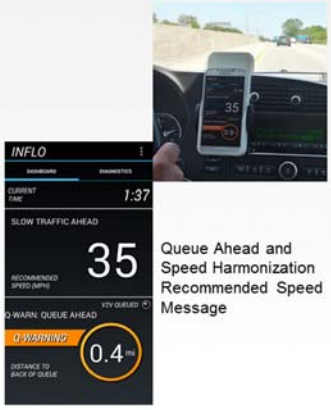
INFLO Concepts and Performance Measures

- Concepts
  - Utilizes V2V and/or V2I communication to coordinate vehicle speeds, share vehicle position/speed/braking information, and implement gap policy
- Performance Measures
  - Reduced speed variability
  - Higher throughput
  - Reduced rear-end collisions
  - Fuel economy savings
  - Emissions reductions



Queue Ahead and Speed Harmonization Recommended Speed Message

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R.E.S.C.U.M.E. Application Descriptions

Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)

An application that provides situational awareness to responders while on route to an incident to assist with routing, staging and secondary dispatch decisions.

Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)

An application that provides in-vehicle messaging to motorists as they approach an incident scene and warnings to on-scene workers.

Emergency Communications and Evacuation (EVAC)

An application that provides dynamic route guidance information, current traffic and road conditions, location and availability of essential services such as hotels. Provides information to identify and locate people who require guidance and assistance, and connect them with service providers and other resources.

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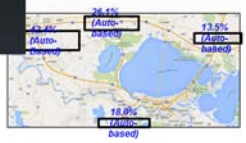
R.E.S.C.U.M.E. Concepts

- RESP-STG and INC-ZONE
  - Based on V2V connected vehicle applications
  - Prototype integrates DSRC, Cellular, and Bluetooth in both oncoming and responder vehicles
  - Lane level mapping and GPS positioning accuracy system critical to success
- EVAC
  - Provide traveler information to improve evacuees' mobility and clearance time



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R.E.S.C.U.M.E. Performance Measures

Direct Performance Measures:

- Network mobility measures
- Average Vehicle Delay
- Average Number of Stops
- Average Travel-Speed of Vehicles
- Throughput of Incident Zones
- Average Fuel Consumption
- Average Emissions

Indirect Performance Measures:

- Surrogate safety measures derived from analysis
- Lane-changes in the vicinity of the incident-zone
- Speed-differential in the vicinity of the incident zone
- Improvement of response vehicle travel-time

EVAC Performance Measures:

- Network mobility measures
- Effectiveness measures: average travel time to lodging; number of fueling failures; average wait time for buses

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Enable ATIS Overview

Foster transformative traveler information applications and strategies that:

- Goal 1: Transform the user experience on the transportation network. Future traveler information systems will intuitively provide users with trip, location, and mode specific information to empower real-time decision making.
- Goal 2: As a result of EnableATIS, the transportation networks will experience measurable gains in performance, including mobility, safety, and efficiency.
- Goal 3: A more robust traveler information suite of capabilities will be enabled through a rich and multisource data environment that leverages public sector system and operations data, transportation network operations, and user data from privately operated systems.

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Enable ATIS Concepts and Performance Measures

- Concepts
  - Federal role to provide framework
  - Demonstration apps record user activity (both mobile and vehicle)
  - Provide users with information for real-time decision making
- Performance Measures
  - Travel time reliability
  - Long-term: impact on network mobility measures

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IDTO Application Descriptions

T-CONNECT (Connection Protection)

Increases the likelihood of making successful transfers by monitoring inbound and outbound vehicles, as well as travelers, determining if/how a connection can be preserved, and initiating the necessary notifications to these parties

T-DISP (Dynamic Transit Operations)

For travelers, T-DISP provides an ability to access real-time information about available travel options in order to best manage their commutes.

For an agency, T-DISP extends demand / response services to support dynamic routing and scheduling

D-RIDE (Dynamic Rideshare)

New, more efficient approach to rideshare concepts including real-time scheduling

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IDTO Overview

- The IDTO bundle provides benefits to travelers and transportation service providers by:
  - Bringing together public and private-sector transportation provider information and operations
  - Leveraging the widespread and growing adoption of smartphones as a travel planning and in-trip notification tool
  - Building on available standards and open-source tools
  - Integrating three travel-related apps that individually offer significant value, and when integrated, provide even greater benefits

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IDTO Concepts and Performance Measures

- Concepts
  - Single user interface
  - Dispatcher interface step towards full CAD/AVL integration
  - Traveler is notified in real time using own mobile device.
- Performance Measures
  - Reduced passenger waiting times
  - Transit trip reliability
  - Fewer missed transit trips
  - Improve transit ridership

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FRATIS Application Descriptions

Freight Specific Dynamic Travel Planning and Performance

Series of applications integrating freight traveler information, dynamic route guidance, and public sector performance monitoring to improve freight travel time and reduce fuel consumption and emissions.

Drayage Optimization

Integrated load matching and freight information exchange, including appointment scheduling and equipment availability at intermodal terminals.

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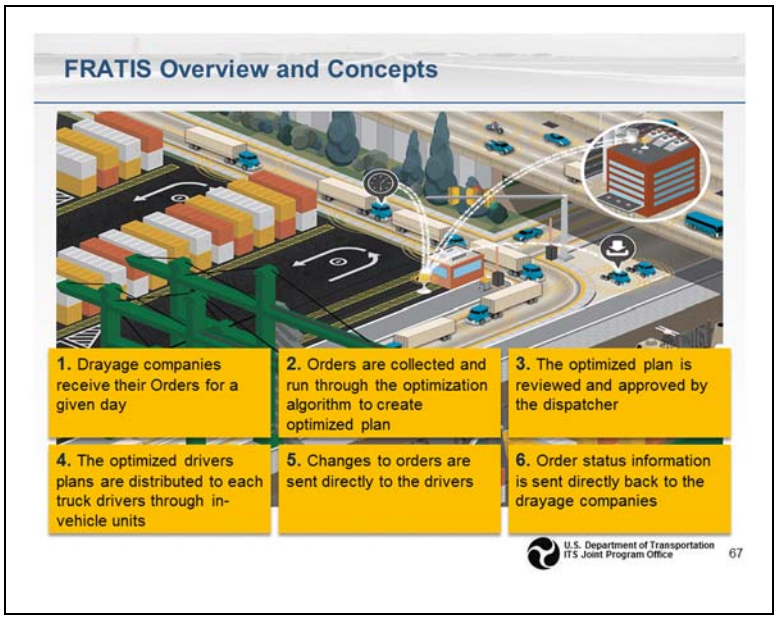
FRATIS Overview and Concepts
1. Drayage companies receive their Orders for a given day
2. Orders are collected and run through the optimization algorithm to create optimized plan
3. The optimized plan is reviewed and approved by the dispatcher
4. The optimized drivers plans are distributed to each truck drivers through in-vehicle units
5. Changes to orders are sent directly to the drivers
6. Order status information is sent directly back to the drayage companies
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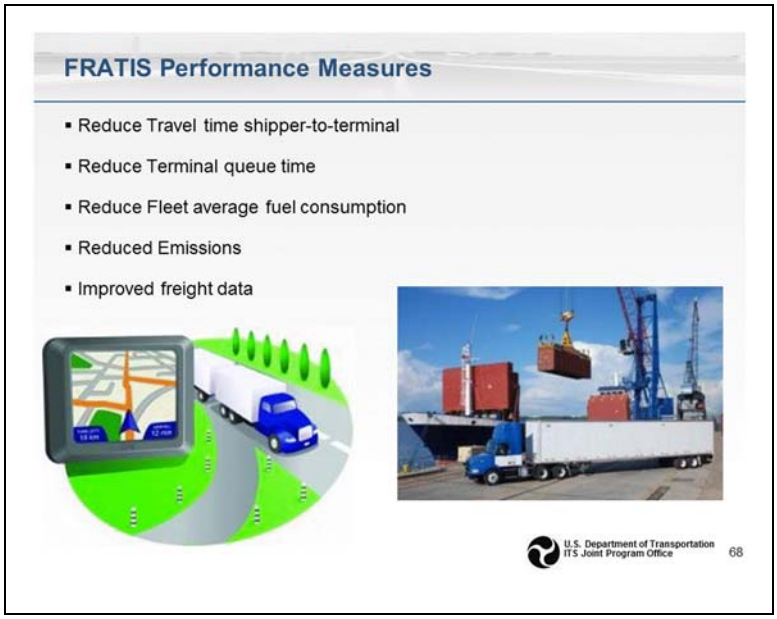
FRATIS Performance Measures
Reduce Travel time shipper-to-terminal
Reduce Terminal queue time
Reduce Fleet average fuel consumption
Reduced Emissions
Improved freight data
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Key Challenges

- Institutional
  - Requires training for engineering and staff to understand technology and system operation
  - Agency/Partner Cooperation
  - Driver/dispatcher acceptance and participation
- Technical
  - Standardization of the information
  - Data exchange interoperability
  - Transferability/scalability

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Activity

- Continue planning for connected vehicle applications implementation
- Using the Implementing Connected Vehicle Applications worksheet, complete the following tasks:
  - Document mobility applications that could help you meet your performance goal(s)
  - Think about the other impacts these applications could have on safety and the environment

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Topic 4 Wrap-up

- Explain the purpose and goals of the mobility applications
- Describe what different mobility applications do
- Evaluate the usefulness of a mobility application or applications related to an identified need or performance measure

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Topic 5: Environmental Applications

Topic	Title	Duration
1	Connected Vehicles: Introduction and Current Status	30 minutes
2	Preparing to Implement Connected Vehicle Applications	30 minutes
3	Safety Applications	30 minutes
4	Mobility Applications	45 minutes
5	Environmental Applications	30 minutes
6	Connected Vehicle Considerations and Resources	40 minutes
7	Course Wrap-up	15 minutes

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Topic 5: Environmental Applications

- After this topic, you will be able to:
  - Explain the purpose and goals of the environmental applications
  - Describe what different environmental applications do
  - Evaluate the usefulness of an environmental application or applications related to an identified need or performance measure

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Connected Vehicle Applications: Environment

AERIS

- Identify connected vehicle applications that could provide environmental impact reduction benefits via reduced fuel use, improved vehicle efficiency, and reduced emissions.
- Facilitate and incentivize "green choices" by transportation service consumers (i.e., system users, system operators, policy decision makers, etc.).
- Identify vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-grid (V2G) data (and other) exchanges via wireless technologies of various types.
- Model and analyze connected vehicle applications to estimate the potential environmental impact reduction benefits.
- Develop a prototype for one of the applications to test its efficacy and usefulness

Road Weather

- Understand the impacts of weather on roadways.
- Conduct applied research to develop strategies and tools to mitigate those impacts.
- Promote the deployment of these strategies and tools.

Environmental

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Environment
ECO-SPEED LIMIT:
50 MPH
ECO-SPEED HARMONIZATION
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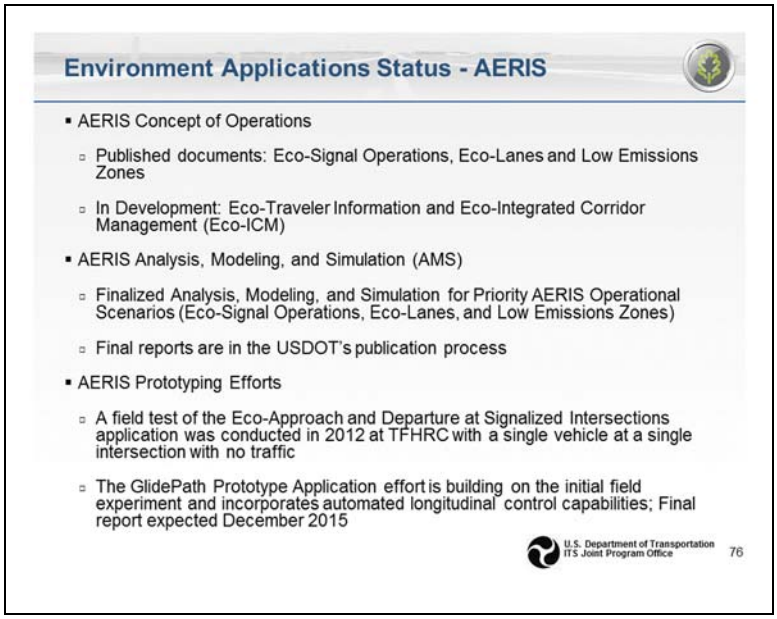
75


Environment Applications Status - AERIS
AERIS Concept of Operations
Published documents: Eco-Signal Operations, Eco-Lanes and Low Emissions Zones
In Development: Eco-Traveler Information and Eco-Integrated Corridor Management (Eco-ICM)
AERIS Analysis, Modeling, and Simulation (AMS)
Finalized Analysis, Modeling, and Simulation for Priority AERIS Operational Scenarios (Eco-Signal Operations, Eco-Lanes, and Low Emissions Zones)
Final reports are in the USDOT's publication process
AERIS Prototyping Efforts
A field test of the Eco-Approach and Departure at Signalized Intersections application was conducted in 2012 at TFHRC with a single vehicle at a single intersection with no traffic
The GlidePath Prototype Application effort is building on the initial field experiment and incorporates automated longitudinal control capabilities; Final report expected December 2015
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Environment Applications: AERIS

AERIS: Cleaner Air Through Smarter Transportation
ECO-SIGNAL OPERATIONS
Eco-Approach and Departure at Signalized Intersections
Eco-Traffic Signal Timing
Eco-Traffic Signal Priority
Connected Eco-Driving
Wireless Inductive/Resonance Charging
ECO-LANES
Eco-Lanes Management
Eco-Speed Harmonization
Eco-Cooperative Adaptive Cruise Control
Eco-Ramp Metering
Connected Eco-Driving
Wireless Inductive/Resonance Charging

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Environment Applications: AERIS

AERIS: Cleaner Air Through Smarter Transportation
LOW EMISSIONS ZONES
Low Emissions Zone Management
Eco-Traveler Information Applications
ECO-TRAVELER INFORMATION
Connected Vehicle-Enabled Environmental Probe Data Collection
Alternative Fuel Vehicle (AFV) Charging/Fueling Information, Reservations, and Payment
Connected Eco-Driving – Gamified/Incentives-Based Apps
Dynamic Eco-Routing
Eco-Smart Parking
Gamified/Incentives-Based Multi-Modal Traveler Information

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Environment Applications: AERIS

AERIS: Cleaner Air Through Smarter Transportation
ECO-INTEGRATED CORRIDOR MANAGEMENT
Eco-ICM Decision Support System
Eco-Signal Operations Applications
Eco-Lanes Applications
Low Emissions Zones Applications
Eco-Traveler Information Applications

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Eco-Signal Operations Overview

- Eco-Approach and Departure
- Eco-Traffic Signal Timing
- Eco-Traffic Signal Priority

Uses connected vehicle technologies to decrease fuel consumption and emissions by reducing idling, the number of stops, unnecessary accelerations/decelerations, and improving traffic flow at signalized intersections

Combined Modeling of Applications:
Resulted in a 9.6% reduction in fuel consumption.

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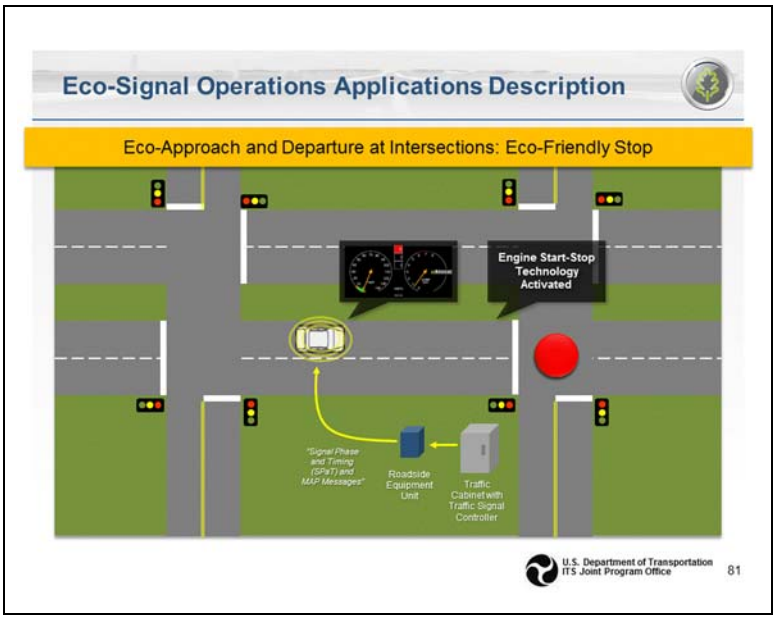
Eco-Signal Operations Applications Description
Eco-Approach and Departure at Intersections: Eco-Friendly Stop
Engine Start-Stop Technology Activated
"Signal Phase and Timing (SPaT) and MAP Messages"
Roadside Equipment Unit
Traffic Cabinet with Traffic Signal Controller
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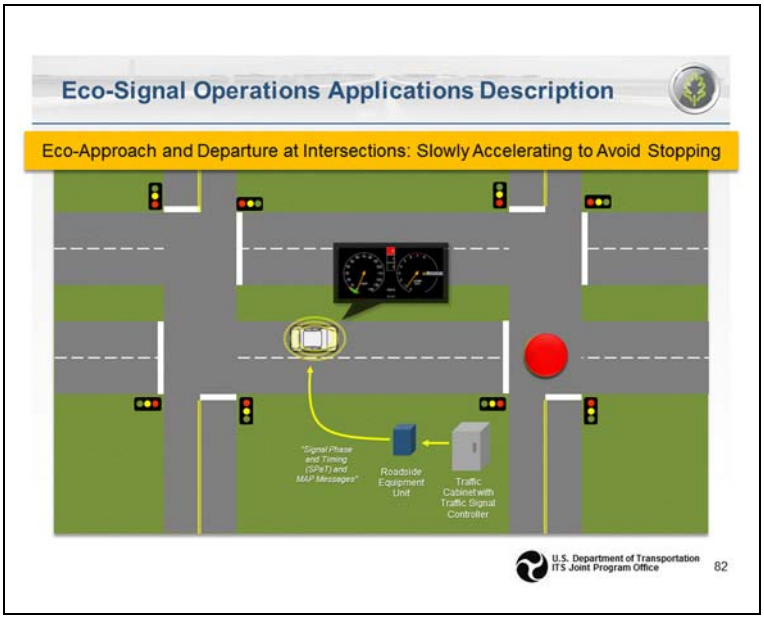
Eco-Signal Operations Applications Description
Eco-Approach and Departure at Intersections: Slowly Accelerating to Avoid Stopping
"Signal Phase and Timing (SPaT) and MAP Messages"
Roadside Equipment Unit
Traffic Cabinet with Traffic Signal Controller
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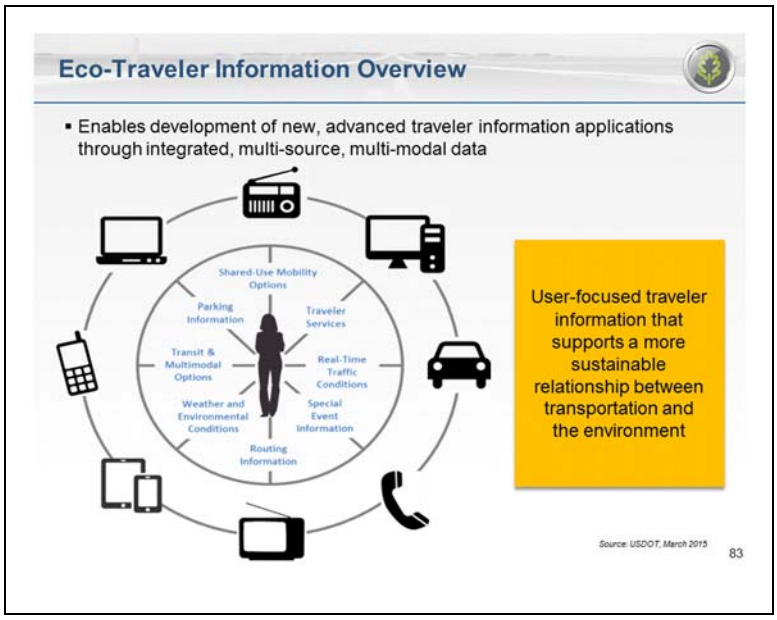
Eco-Traveler Information Overview
▪ Enables development of new, advanced traveler information applications through integrated, multi-source, multi-modal data
Shared-Use Mobility Options
Parking Information
Traveler Services
Transit & Multimodal Options
Real-Time Traffic Conditions
Weather and Environmental Conditions
Special Event Information
Routing Information
User-focused traveler information that supports a more sustainable relationship between transportation and the environment
Source: USDOT, March 2015
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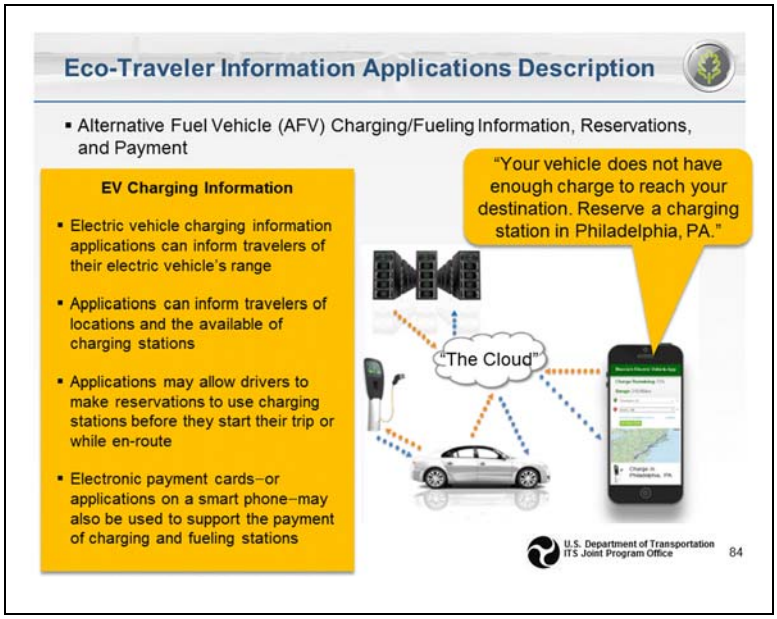
Eco-Traveler Information Applications Description
▪ Alternative Fuel Vehicle (AFV) Charging/Fueling Information, Reservations, and Payment
EV Charging Information
▪ Electric vehicle charging information applications can inform travelers of their electric vehicle's range
▪ Applications can inform travelers of locations and the available of charging stations
▪ Applications may allow drivers to make reservations to use charging stations before they start their trip or while en-route
▪ Electronic payment cards–or applications on a smart phone–may also be used to support the payment of charging and fueling stations
"Your vehicle does not have enough charge to reach your destination. Reserve a charging station in Philadelphia, PA."
"The Cloud"
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AERIS Applications Benefit Drivers, Fleet Operators and Cities

Assuming an Average Corridor

Combined Eco-Signal Operations Modeling Results Indicate:

- Light vehicles: 9.6% reduction in fuel consumption
- Freight: 9.8% reduction in fuel consumption
- Transit: 3.1% reduction in fuel consumption

Gasoline Costs:

- $3.67/gallon (light vehicle and SUV)
- $3.95/gallon for diesel (trucks)
- $3.00/gallon estimated for mix of CNG and diesel fleets (transit)

Average Miles Traveled on Arterials:

- Light duty vehicle and SUVs: 8,250 miles
- City delivery truck: 30,000 miles
- Transit: 44,600 miles

Estimated Benefits

- Light Vehicle, 23 MPG ~ **$126 per year**
- City Delivery Fleet (1,000 vehicles), 7.3 MPG ~ **$1.6M per year**
- Transit Fleet (1,000 vehicles), 4 MPG ~ **$918,000 per year**

AERIS applications help drivers reduce their carbon footprint and reduce their fuel consumption. **Drivers help the environment and save money at the pump.**

Fleet operators also benefit from AERIS applications. **Fuel savings help fleet operators save fuel costs resulting in lower operating costs.**

AERIS applications benefit cities, helping reduce emissions and improving the city's air quality. AERIS applications also help reduce congestion and support sustainable transportation solutions.

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Key Challenges

- Increasing the overall awareness of environmental issues/challenges and the potential for ITS and connected vehicle technologies.
  - Fostering strong partnerships and commitment for environmental deployments.
- Providing eco-information to drivers in a manner that minimizes driver distraction.
  - The AERIS Research Program is investigating how partial and full automation may be used to support environmental applications.
- Ensuring environmental needs and data elements are incorporated into connected vehicle standards (e.g., J2735).
- Conveying environmental benefits to users of all types—including decision makers—that are meaningful (e.g., emissions reductions, fuel savings)

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Road Weather
ICY ROAD AHEAD
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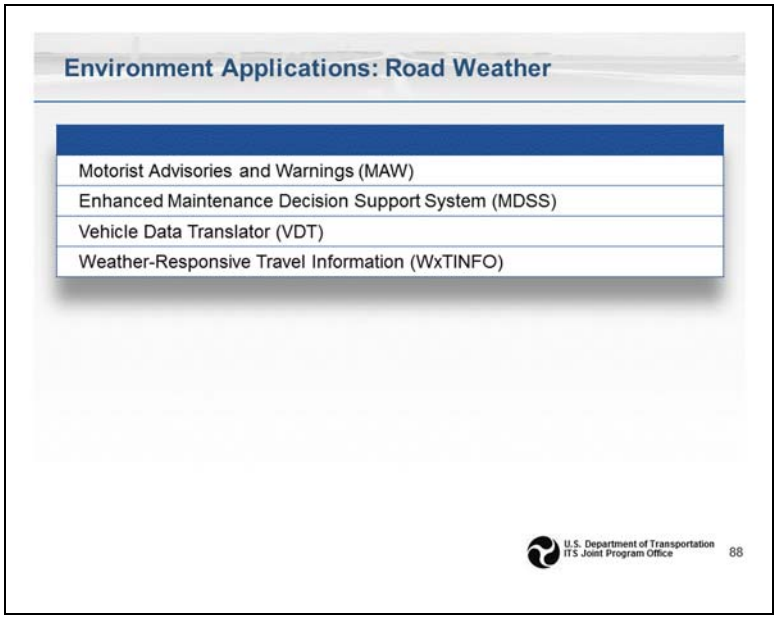
87


Environment Applications: Road Weather
Motorist Advisories and Warnings (MAW)
Enhanced Maintenance Decision Support System (MDSS)
Vehicle Data Translator (VDT)
Weather-Responsive Travel Information (WxTINFO)
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Road Weather Applications Overview

- Motorist Advisories and Warnings (MAW)
- Enhanced Maintenance Decision Support System (MDSS)
- Vehicle Data Translator (VDT)
- Weather-Responsive Travel Information (WxTINFO)

Road Weather Connected Vehicle Applications

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Benefits of Road Weather Applications

- 24 percent of all crashes occur under adverse weather conditions, resulting in more than 673,000 people injured and 7,100 fatalities.
- The estimated cost of weather-related crashes ranges from $22 billion to $51 billion annually.
- Road Weather applications have the potential to lower these costs.
- Current Maintenance Decision Support Systems (MDSS) show benefit cost ratios 1.33 to 8.67, with annual savings ranging from $1.3 million to $11 million.
- Benefit-cost analysis performed in Finland found a benefit cost ratio of 1.1 to 1.9, supporting weather information controlled variable speed limits - one potential benefit of MAW.

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Road Weather Applications Status and Challenges

- Road Weather Applications development on schedule:
  - **FY15**- Connected vehicle prototype applications developed, tested, evaluated, and potential demonstrated
  - **FY16** – Vehicle Data Translator and Weather Data Environment mature and ready for road weather connected vehicle data capture and management
  - **FY17** – Weather-Responsive Traffic Management strategies implemented, tested, and ready for deployment; Guidance on State DOT/NWS operations completed
  - **FY18** – High-resolution (spatial and temporal) and route/segment-specific road condition prediction capability proven for mainstream implementation
  - **FY19** – Weather-sensitive automation capabilities demonstrated; Guidance for weather-related performance measurement and management ready

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Moving Towards Deployment

1

IDENTIFY LOCAL NEEDS

Identify local problems, challenges, and/or issues you are trying to address

2

SET PERFORMANCE GOALS

Set measurable goals and objectives that allow you to address local needs

3

SELECT CONNECTED VEHICLE APPLICATIONS THAT WORK TOGETHER TO MEET THOSE GOALS

Identify potential solutions, including connected vehicle applications, that help you meet your goals and objectives

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Office of the Assistant Secretary for Research and Technology

Group Exercise

- Complete planning for connected vehicle applications implementation
- Using the Implementing Connected Vehicle Applications worksheet, complete the following tasks:
  - Document environmental applications that could help you meet your performance goal(s)
  - Think about the other impacts these applications could have on safety and mobility
- Choose a transportation challenge and discuss how the safety, mobility, and environmental applications would help you meet your performance goals.

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Topic 5 Wrap-up

- Explain the purpose and goals of the environmental applications
- Describe what different environmental applications do
- Evaluate the usefulness of a environmental application or applications related to an identified need or performance measure

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Topic 6: Connected Vehicle Considerations and Resources

Topic	Title	Duration
1	Connected Vehicles: Introduction and Current Status	30 minutes
2	Preparing to Implement Connected Vehicle Applications	30 minutes
3	Safety Applications	30 minutes
4	Mobility Applications	45 minutes
5	Environmental Applications	30 minutes
6	Connected Vehicle Considerations and Resources	40 minutes
7	Course Wrap-up	15 minutes

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Topic 6: Connected Vehicle Considerations and Resources

- After this topic, you will be able to:
  - Explain the recommend approach for implementing connected vehicle applications
  - Describe security and privacy considerations
  - Identify resources for connected vehicle application deployment
  - Discuss future implementation needs – connected automation

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Moving Towards Deployment

1

IDENTIFY LOCAL NEEDS

Identify local problems, challenges, and/or issues you are trying to address

2

SET PERFORMANCE GOALS

Set measurable goals and objectives that allow you to address local needs

3

SELECT CONNECTED VEHICLE APPLICATIONS THAT WORK TOGETHER TO MEET THOSE GOALS

Identify potential solutions, including connected vehicle applications, that help you meet your goals and objectives

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Consider Communications Security Policy

- How do we know that the sender of a message should be 'trusted'?
  - Need to validate messages exchanged between vehicles (V2V) and between vehicles and infrastructure (V2I)
- Requires Security Credential Management System (SCMS)
  - Organizational entities for operating security management system
  - Communications network for security updates

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Consider Privacy and Data Policy

- A user should not be tracked or identified (e.g., no personally identifiable information)
- Important to ensure that messages cannot be linked to personal information
  - Basic safety messages, certificates, and other information exchange should not link to personal identifiers
- Data management policies

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Infrastructure Deployment Planning and Resources

- FHWA Deployment Guidance
- Standardized Interfaces (CVRIA)
- CO-PILOT
- Research Data Exchange
- SET-IT
- OSADP
- Reference Implementation

Refer to the Connected Vehicle Fact Sheets for more information: http://www.its.dot.gov/landing/cv.htm

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2015 FHWA Vehicle to Infrastructure Deployment Guidance and Products

- FHWA Guidance to State and local agencies for implementing V2I to ensure interoperability and efficient and effective planning, procurement, and operations
- Goal is to provide:
  - Initial advice
  - Best practices
  - Technical support tools
- Draft release September 2014, with planned release in Fall 2015
- Products and Tools:
  - Systems Engineering Process for V2I
  - V2I Benefit Cost Analysis Tool
  - V2I Planning Guide
  - Guide to V2I Cyber-Security
  - Guide to Licensing DSRC Roadside Units
  - Guide to V2I Communication Technology Selection
  - V2I Message Lexicon

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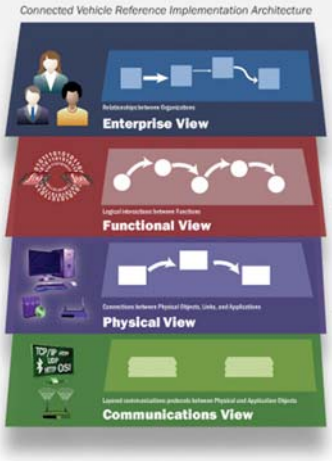
Connected Vehicle Reference Implementation Architecture (CVRIA)



CVRIA: A Framework for integrating technologies and identifying interfaces for standardization

http://www.iteris.com/cvria/

- The Systems Engineering Tool for Intelligent Transportation (SET-IT) is available for download from the CVRIA website
- On-line training for CVRIA and SET-IT are available on the CVRIA website

SET-IT

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CO-PILOT

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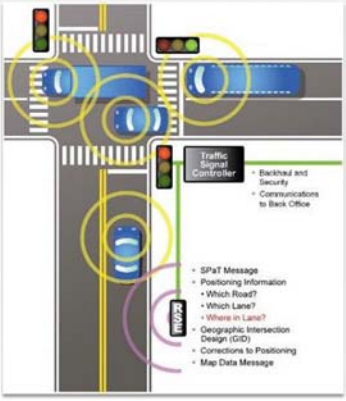
V2I Reference Implementation

- A system of specifications and requirements that allow the various components of V2I hardware, software, and firmware to work together
- An agency will be able to select the capabilities and applications desired at a given installation
- Integrated V2I Prototype
  - Field research testing in 2015
  - Reference Implementation builds upon Integrated V2I Prototype



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Research Data Exchange

- Promotes sharing of archived and real-time connected vehicle data collected in USDOT-sponsored research efforts and field tests
- 2 TB of well-organized and documented data
- Drawn from a dozen geographic locations across the country
- Multi-source data (traditional sensor plus probe and connected vehicle data)
- Search and download functions
- RDE release 2.0 is now available

www.its-rde.net

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Open Source Application Development Portal (OSADP)

- Web-based portal for sharing open source code and software from USDOT-sponsored transportation application to the public
  - 14 open source ITS application packages, with more expected
  - Download software, code, and documentation
  - Free to use, edit, and modify under open source licenses
  - Submit and develop new project ideas (GitHub testing platform)
  - Join and interact with a community of users
  - Download - software, code and documentation

ACCESS, INNOVATE, and COLLABORATE

OPEN SOURCE APPLICATION DEVELOPMENT PORTAL

www.itsforge.net

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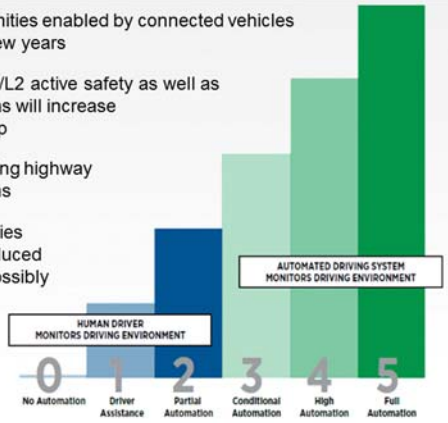
Moving Towards Connected Automation

- The technology opportunities enabled by connected vehicles will grow over the next few years
- Market penetration of L1/L2 active safety as well as driver assistance systems will increase penetration as costs drop
- OEMs will start introducing highway L3 "autopilot" applications
- L1/2 platooning capabilities (via DSRC) will be introduced for motor carriers and possibly for private light vehicles



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What Can You Do To Prepare for CV Implementation?

1. Involve your stakeholders in CV planning
2. Make sure your field devices use current standards, such as NTCIP
3. Get involved with or seek out results from CV Pilots or Test Beds
4. Assess the readiness of your Center to Field network, especially system security
5. Prepare the workforce with training and recruitment in ITS disciplines

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Topic 6 Wrap-up

- Explain the recommend approach for implementing connected vehicle applications
- Describe security and privacy considerations
- Identify resources for connected vehicle application deployment
- Discuss future implementation needs – connected automation

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Topic 7: Course Wrap-up

Topic	Title	Duration
1	Connected Vehicles: Introduction and Current Status	30 minutes
2	Preparing to Implement Connected Vehicle Applications	30 minutes
3	Safety Applications	30 minutes
4	Mobility Applications	45 minutes
5	Environmental Applications	30 minutes
6	Connected Vehicle Considerations and Resources	40 minutes
7	Course Wrap-up	15 minutes

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Course Wrap-up

- Connected Vehicle: Introduction and Current Status
- Preparing to Implement Connected Vehicle Applications
- Safety Applications
- Mobility Applications
- Environmental Applications
- Implementing Connected Vehicle Applications

Please take a moment to give us your feedback by completing the evaluation.

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Additional Examples

Sample Deployment Concept – Halleck Expressway

Synergies Among Applications Increase Benefits and Reduce Costs

Improve Incident Delay
- Incident scene pre-arrival staging guidance for emergency responders
- Incident scene work zone alerts for drivers and workers

Improve Bottleneck Throughput
- Speed harmonization and queue warning
- Emergency electronic brake lights and forward collision warning

Manage Diversions Better
- Enable ATIS
- Intelligent signal control

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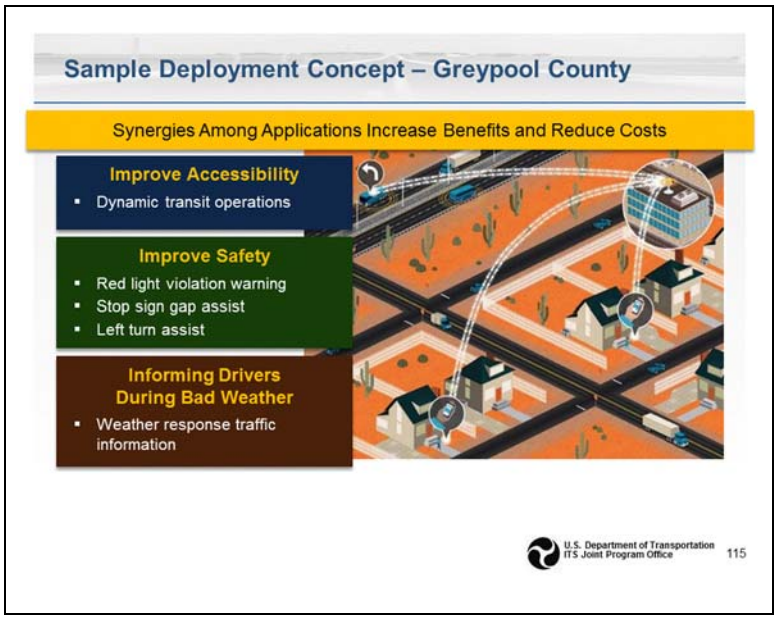
Sample Deployment Concept – Greypool County
Synergies Among Applications Increase Benefits and Reduce Costs
Improve Accessibility
Dynamic transit operations
Improve Safety
Red light violation warning
Stop sign gap assist
Left turn assist
Informing Drivers During Bad Weather
Weather response traffic information
U.S. Department of Transportation
ITS Joint Program Office
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Connected Vehicles 102 Participant Worksheet

1

IDENTIFY LOCAL NEEDS

2

SET PERFORMANCE GOALS

3

SELECT CONNECTED VEHICLE APPLICATIONS THAT WORK TOGETHER TO MEET THOSE GOALS

Local Need 1:	Performance Goals	Connected Vehicle Applications

Local Need 2:	Performance Goals	Connected Vehicle Applications

Local Need 3:	Performance Goals	Connected Vehicle Applications

Vehicle-to-Vehicle Communication (V2V)

Objective

Exchanging vehicle-based data regarding position, speed, and location through V2V communications will enable vehicles to: sense threats and hazards with a 360 degree awareness of the position of other vehicles; calculate risk; issue driver advisories or warnings; and take pre-emptive actions to avoid and mitigate crashes.

Applications

- **Forward Collision Warning (FCW)-** Issues a warning to the driver in case of an impending rear-end collision with a vehicle ahead in traffic in the same lane and direction of travel.
- **Emergency Electronic Brake Lights (EEBL)-** Notifies the driver if there is a sudden-braking vehicle ahead (or several vehicles ahead).
- **Blind Spot/Lane Change Warning (BSW/LCW**)- Will warn the driver when a blind spot zone is or is about to be occupied by another vehicle traveling in the same direction.
- **Do Not Pass Warning (DNPW)**- Warns the driver when a slower moving vehicle cannot be safely passed using a passing zone that is occupied by vehicles traveling the opposite direction.
- **Intersection Movement Assist (IMA)-** Warns a driver when it is not safe to enter an intersection due to high collision probability with other vehicles in cross traffic.
- **Left Turn Assist (LTA)-** Provides information to drivers performing unprotected left turns to judge the gaps in oncoming traffic and to inform them of hazards to completing a safe left turn.

This graphic illustrates the concept of the Emergency Electronic Brake Lights (EEBL) application.

Status

- The Safety Pilot Model Deployment was conducted at the University of Michigan Transportation Research Institute in Ann Arbor, Michigan from August 2012 to February 2014. For the pilot study, approximately 2,800 vehicles – a mix of cars, trucks, and transit vehicles – were equipped with integrated in-vehicle safety systems, aftermarket safety devices, or vehicle awareness devices to estimate the effectiveness of the V2V applications at reducing crashes.
- In August 2014, following the success of the pilot deployment project, NHTSA released an advance notice of proposed rulemaking (ANPRM) that sought to require V2V technology in new light vehicles for a future year. The proposal was originally planned to hit the Office of Management and Budget in 2016, but Department of Transportation Secretary Anthony Foxx has stated that the proposal can be expected to arrive by the end of this year.
- Wanting to get a head start on commercializing the technology, GM is expected to put the first V2V-enabled car on the road with the 2017 Cadillac CTS sedan, set to debut in the second half of 2016.

INTERESTED IN LEARNING MORE?

- ***Visit the Safety- V2V Program website***
  - http://www.its.dot.gov/safety/v2v_comm_safety.htm

For further information: please contact Kevin Dopart, Program Manager- Connected Vehicle Safety & Automation, ITS Joint Program Office at kevin.dopart@dot.gov

Vehicle-to-Infrastructure Communication (V2I)

Objective

V2I Communications seek to avoid or mitigate vehicle crashes particularly for crash scenarios not addressed by V2V communications alone. The V2I applications foster the exchange of data between vehicles and infrastructure elements (e.g. traffic signals) that is then used to perform calculations that recognize anticipated high-risk traffic violations and can issue drivers' the respective pre-emptive alerts.

Applications

- **Curve Speed Warning (CSW)-** advises drivers of upcoming curves and determines appropriate speeds for approaching the curve.
- **Red Light Violation Warning (RLVW)-** Alerts or warns drivers who are approaching a signalized intersection if they are on a trajectory to violate a red signal based on vehicle speeds and distance to intersection.
- **Stop Sign Violation Warning (SSVW)-** Assists drivers in avoiding crashes at intersections by warning the vehicle driver that a stop sign violation is predicted to occur based on vehicle speed and distance to intersection.
- **Spot Weather Impact Warning (SWIW)-** Issues alerts or warning to drivers about real-time weather events and locations based upon information from roadside equipment connections with Transportation Management Centers and other weather data collection sites/services.
- **Reduced Speed Zone Warning (RSZW)-** Issues alerts to driver to reduce speed, change lanes, and/or prepare to stop for upcoming reduced speed/work zones.
- **Stop Sign Gap Assist (SSGA)-** Assists drivers at stop sign controlled intersections via gap detections, alerting motorists when it is unsafe to enter intersections.
- **Transit Pedestrian Warning-** Alerts bus drivers to pedestrians in crosswalk at signalized intersections in their path.

This graphic illustrates the concept of the Stop Sign Gap Assist (SSGA) application.

Status

The V2I application efforts are not in the same state of maturity as the V2V application efforts due to technical and institutional challenges that still need to be resolved. Public agency practitioners have recognized that while the federal research focus will likely shift to implementation of V2I applications over the next several years, an infrastructure lag will exist.

- The Safety Pilot conducted from August 2012 to February 2014 at the University of Michigan Transportation Research Institute featured only limited V2I applications. For the pilot, three locations tested curve speed warning and six intersections along the test corridor were equipped with Signal Phase and Timing (SPaT).
- The Concept of Operations and System Requirements have been completed for the Red Light Violation Warning, Stop Sign Gap Assist, Curve Speed Warning, Reduced Speed Zone Warning, and Spot Weather Information Warning applications. Crash Avoidance Metrics Partnership (CAMP), a cooperative research organization made up of eight of the leading car manufacturers in the U.S, is partnering with the U.S. DOT to develop and evaluate prototypes for three selected applications: Red-Light Violation Warning, Curve Speed Warning, and Reduced Speed Zone Warning.

INTERESTED IN LEARNING MORE?

- ***Visit the Safety-V2I Program website***
  - http://www.its.dot.gov/safety/v2i_comm_safety.htm

For further information: please contact Carl Anderson, Team Leader- Roadway Team, ITS Joint Program Office at kevin.dopart@dot.gov

Multimodal Intelligent Traffic Signal System (MMITSS)

Objective

The MMITSS application bundle seeks to develop a comprehensive traffic signal system that services all modes of transportation (passenger vehicles, transit, emergency vehicles, freight fleets, pedestrians, etc.)

Applications

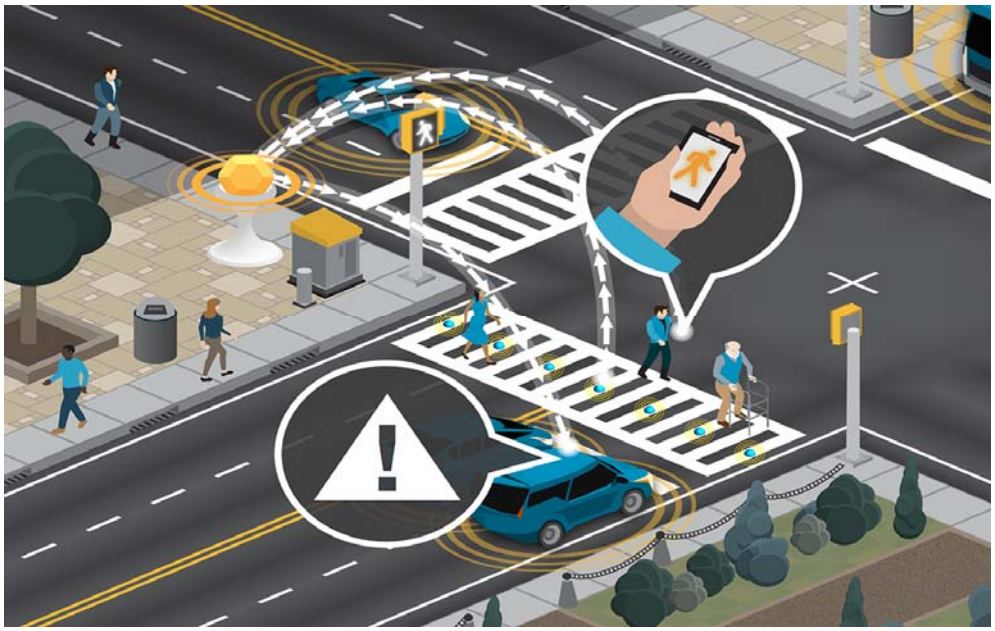
- **Intelligent Traffic Signal System (ISIG)**
  Using high-fidelity data collected from vehicles through vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) wireless communications as well as pedestrian and non-motorized travelers, this proposed application seeks to control signals and maximize flows in real time. The ISIG application also plays the role of an overarching system optimization application, accommodating transit or freight signal priority, preemption, and pedestrian movements to maximize overall network performance.

- **Transit Signal Priority (TSP)**
  This proposed application allows transit agencies to manage bus service by adding the capability to grant buses priority based on local conditions and prioritization factors. The proposed application provides the ability for transit vehicles to communicate passenger count data, service type, scheduled and actual arrival time, and heading information to roadside equipment via an on-board device.

- **Mobile Accessible Pedestrian Signal System (PED-SIG)**
  This application integrates information from roadside or intersection sensors and new forms of data from pedestrian-carried mobile devices. Such systems will be used to inform visually impaired pedestrians when to cross and how to remain aligned with the crosswalk. This application may also support the accommodation of safe and efficient pedestrian movement of a more general nature.

- **Emergency Vehicle Preemption (PREEMPT)**
  This proposed application, while similar to existing technologies, will interface with V2V and V2I communication systems and account for non-linear effects of multiple emergency responses through the same traffic network.

- **Freight Signal Priority (FSP)**
  This application provides signal prioritization near freight facilities based on current and projected freight movements. The objective of this application is to reduce delays and increase travel time reliability for freight traffic, while enhancing safety at key intersections.



This graphic illustrates the concept of the Mobile Accessible Pedestrian Signal System (PED-SIG) application.

Bundle Status

There are two current MMITSS test sites located in Anthem, Arizona and Northern California. The prototypes feature the Intelligent Traffic Signal Control and Priority Control applications. Additionally, a pedestrian smartphone application (Savari SmartCross) was developed that provides pedestrians with auditory and haptic feedback to assist them with navigating crosswalks. Demonstration of the Arizona prototype occurred in March 2015. The Arizona site also recently hosted a 75-person workshop for the Transportation Research Board's Traffic Signal Systems Committee on May 18, with an additional demonstration taking place the following day. Demonstration of the California prototype will occur during early summer 2015. MMITSS source code is expected to be posted to the OSADP by June 2015. A final impacts assessment report is expected to be released in July 2015. Project efforts are expected to be completed by June 2015 (Arizona) and the end of 2015 (California).

INTERESTED IN LEARNING MORE?

- ***Visit the DMA Program website***
  - http://www.its.dot.gov/dma/
- ***For further information***: please contact Katherine Hartman, DMA Program Lead, ITS Joint Program Office at kate.hartman@dot.gov or bundle lead Ben McKeever (FHWA) at ben.mckeever@dot.gov

Enabling Advanced Traveler Information Systems (EnableATIS)/ATIS 2.0/Nomadic Devices

EnableATIS is unique among the other Dynamic Mobility Applications as its focus is on providing support to the marketplace for application development—i.e., *enabling* development of Advanced Traveler Information Systems—rather than developing the foundational applications.

Objective

- To enable a more robust traveler information suite of capabilities through a rich and multisource data environment that leverages public sector system and operations data, and transportation network operations and user data from privately operated systems.
- To transform the user experience on the transportation network by having future traveler information systems intuitively provide users with trip, location and mode specific information to empower real-time decision making.
- Create a "two-way street" of data and provide the same information listed above to system managers.

Research Plan

EnableATIS is not developing a specific application or system, but is rather seeking to formalize a framework whereby multiple activities are envisioned to interact to support a diverse traveler information environment. Since a strong federal role was not foreseen in application prototyping for traveler information, the DMA program opted to explore EnableATIS at the broader Operational Concept level rather than develop a Concept of Operations. The Operational Concept describes two operational scenarios that define two different relationships between public sector agencies and the market:

- The laissez-faire operational scenario entails an incremental build out and enhancement of traveler information services over time and with limited influence on the market from the U.S. DOT
- The robust operational scenario represents a desired end-state of a robust, multimodal, multisource traveler information environment that leverages new data sources and generates transformative uses of that information to benefit travelers as well as system operations and management by agencies.

EnableATIS has the potential to transform how traveler information is gathered and shared, how agencies are able to use information to better manage and balance the transportation networks, as

well as transform how users obtain information about every detail of their trip. New forms of data will unlock the potential for a highly personalized, intuitive, and predictive suite of traveler information services well beyond what is experienced today.

Exploratory Research Initiatives

Three EnableATIS exploratory research efforts are currently underway:

- The ATIS 2.0 initiative supports the development of an advanced, transportation traveler information services framework. The research effort is currently focused on the development of Version 2.0 of a precursor system. The project is in the preliminary stages, and the research team recently completed the formulation of goals and objectives and the selection of use cases.

- The University of Minnesota SmarTrac research effort has prototyped an innovative smartphone application that can infer traveler mode and destination from collected data. SmarTrac is able to self-learn by bringing together smartphone-based sensing, data mining, and user communication to detect and classify daily activity and travel behavior. The application is able to recognize trip type, purpose and nature through iterative pattern analysis, and it then records that inferred data. Results from this project will assist in understanding how unobtrusive data capture methods can be included in larger scale, naturalistic studies, specifically attempting to capture and make available disaggregate travel itinerary and purpose data. The initial prototype was debuted in July 2014, and a project demonstration concluded in December 2014.

- Similarly, MIT's CloudCar project consists of a Mobility-as-a-Service element that records user activity and can infer mode of travel through self-learning. The "CloudCar" name comes from its utilization of a low-cost cellular-enabled OBD-II port reader that directs vehicle data directly to a cloud-based archive. The archived data can be accessed in real-time within a data rights-sensitive environment. The goal of the CloudCar effort is to evaluate mobile versus vehicle-based data collection and demonstrate alternative approaches for managing data rights. The initial prototype began testing in June 2014 and the project is slated to conclude in June 2015.

INTERESTED IN LEARNING MORE?

- ***Visit the DMA Program website***
  - http://www.its.dot.gov/dma/
- ***For further information***: please contact Katherine Hartman, DMA Program Lead, ITS Joint Program Office at kate.hartman@dot.gov or bundle lead Bob Rupert (FHWA) at robert.rupert@dot.gov

Intelligent Network Flow Optimization (INFLO)

Objective

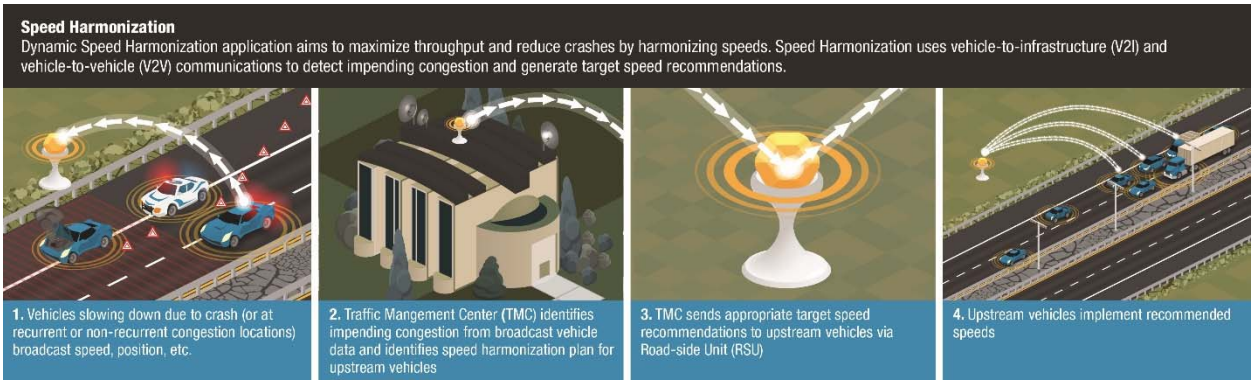
The INFLO application bundle aims to optimize network flow on freeways and arterials by: informing motorists of existing and impending queues and bottlenecks, providing target speeds by location and lane, and allowing the capability to form ad hoc vehicle platoons of uniform speed.

Applications

- **Queue Warning (Q-WARN)**
  The goal of Q-WARN is to provide a vehicle operator with sufficient warning of an impending queue backup in order to brake safely, change lanes, or modify the route such that secondary collisions can be minimized or even eliminated. The INFLO Q-WARN application performs two essential tasks: queue detection or prediction, and queue information dissemination. The decision-making processes may reside within either a central entity (such as a Traffic Management Center or a Cloud-based system) or the connected vehicle.

- **Dynamic Speed Harmonization (SPD-HARM)**
  The goal of SPD-HARM is to dynamically adjust and coordinate appropriate target vehicle speeds in response to downstream congestion, incidents, and weather or road conditions in order to maximize traffic throughput and reduce crashes. The INFLO SPD-HARM system will be successful at managing upstream traffic flow by being able to: reliably detect the location, type, and intensity of downstream congestion (or other relevant) conditions; formulate an appropriate response plan (i.e., target vehicle speed and/or lane recommendations) for approaching vehicles; and disseminate such information to upstream vehicles readily and in a manner which achieves an effective rate of compliance.

- **Cooperative Adaptive Cruise Control (CACC)**
  The goal of CACC is to dynamically and automatically coordinate cruise control speeds among platooning vehicles in order to significantly increase traffic throughput. By tightly coordinating in-platoon vehicle movements, headways among vehicles can be significantly reduced, resulting in a smoothing of traffic flow and an improvement in traffic flow stability. Additionally, by reducing drag, shorter headways can result in improved fuel economy providing the environmental benefits of lowered energy consumption and reduced greenhouse gas emissions. As with SPD-HARM and Q-WARN, CACC-related driver communication will always give priority to crash avoidance/mitigation safety applications when such applications determine that a safety-related warning is necessary.



This graphic illustrates the concept of the Dynamic Speed Harmonization (SPD-HARM) application.

Bundle Status

A prototype of the INFLO SPD-HARM and Q-WARN applications was developed by Battelle and the Texas A&M Transportation Institute (TTI), and a small-scale demonstration was conducted with 20 vehicles on the I-5 corridor in Seattle, WA. Vehicle speed data from the Washington State Department of Transportation (WSDOT) infrastructure-based speed detectors and 20 connected vehicles were collected and processed in real time to deliver Q-WARN and SPD-HARM messages to drivers in advance of congestion. The demonstration revealed that the prototype resulted in fewer panic stops as indicated by longitudinal deceleration. Q-WARN and SPD-HARM messages were sent to the drivers at least a mile in advance of the congestion and within 5 seconds of detection of congestion. An assessment of the impacts of the prototype revealed that SPD-HARM and Q-WARN can be beneficial even in the near term as speed variations between and within freeway segments reduced with only a 10% net response rate (percentage of connected drivers complying precisely with recommendations). The biggest benefit was observed for the first 20% of connected vehicles responding to recommendations.

INFLO CACC was not prototyped as additional research was required. The Crash Avoidance Metrics Partnership (CAMP) has assessed the technical feasibility of prototyping CACC, and developed a plan for prototyping and conducting a small-scale test of CACC. In the next phase of this effort, which will commence later in 2015, CAMP will incorporate both simulations and a prototype deployment effort.

INTERESTED IN LEARNING MORE?

- ***Visit the DMA Program website***
  - http://www.its.dot.gov/dma/
- ***For further information***: please contact Katherine Hartman, DMA Program Lead, ITS Joint Program Office at kate.hartman@dot.gov or bundle lead Govind Vadakpat (FHWA) at g.vadakpat@dot.gov

Response, Emergency Staging and Communications, Uniform Management, and Evacuation (R.E.S.C.U.M.E)

Objective

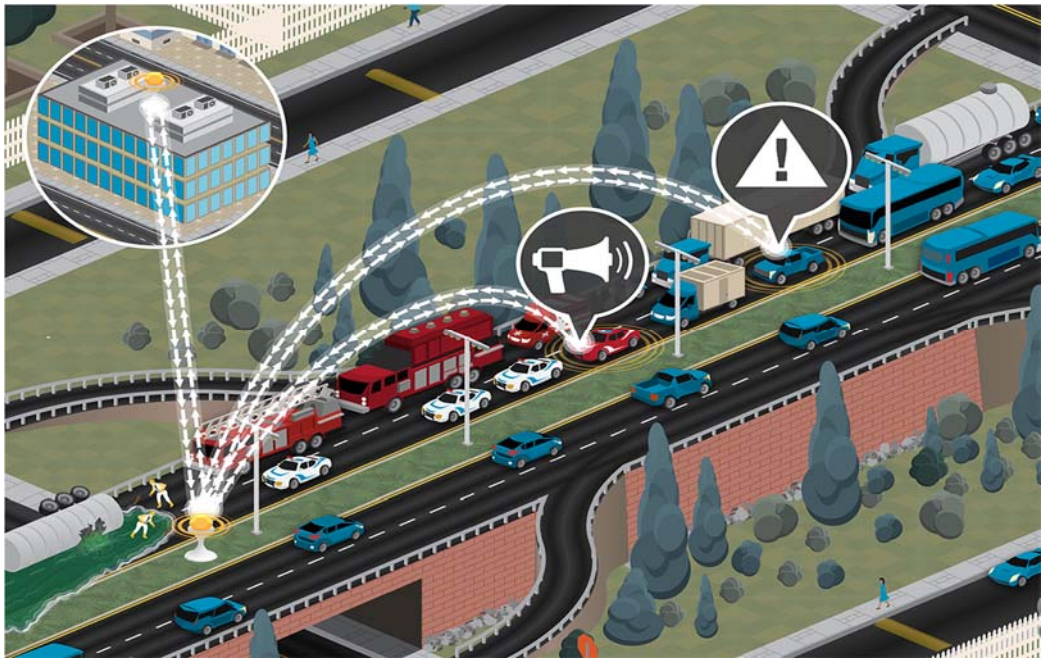
The R.E.S.C.U.M.E application bundle aims to advance vehicle-to-vehicle (V2V) safety messaging over dedicated short-range communications to improve the safety of emergency responders and travelers.

Applications

- **Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)**
  This application provides situational awareness information to public safety responders while enroute to an incident. It can also help establish incident work zones that are safe for responders, travelers, and crash victims by providing input regarding routing, staging, and secondary dispatch decisions; staging plans; satellite imagery; Geographic Information System (GIS) data; current weather data; and real-time modeling outputs. This new information is expected to provide more accurate and detailed information to support decisions and actions made by responders and dispatchers.

- **Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)**
  This application bundle has two components:
  - One warns drivers who are approaching temporary incident work zones at unsafe speeds or in a closed lane
  - The other warns public safety personnel and other officials working in the zone of an unsafe approach through an audible warning system.

- **Emergency Communications and Evacuation (EVAC)**
  This application bundle addresses the needs of two different evacuee groups:
  - For those using their own transportation, EVAC provides dynamic route guidance information, current traffic and road conditions, location of available lodging, and location of fuel, food, water, cash machines, and other necessities.
  - For those requiring transportation assistance, EVAC provides information to identify and locate people who are more likely to require guidance and assistance, and provides them with information about service providers and other available resources.



This graphic illustrates the concept of the Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE) application.

Bundle Status

A R.E.S.C.U.M.E prototype was developed and demonstrated in November 2014 at the Maryland Police and Correctional Training Commission's Driver Training Facility in Sykesville, MD. Twelve scenarios showed functionality of RESP-STG and INC-ZONE applications, which were viewed from the perspectives of the transportation center, the responder and the oncoming Vehicle.

INTERESTED IN LEARNING MORE?

- ***Visit the DMA Program website***
  - http://www.its.dot.gov/dma/
- ***For further information***: please contact Katherine Hartman, DMA Program Lead, ITS Joint Program Office at kate.hartman@dot.gov or bundle lead Linda Dodge (ITS JPO) at linda.dodge@dot.gov

Integrated Dynamic Transit Operations (IDTO)

Objective

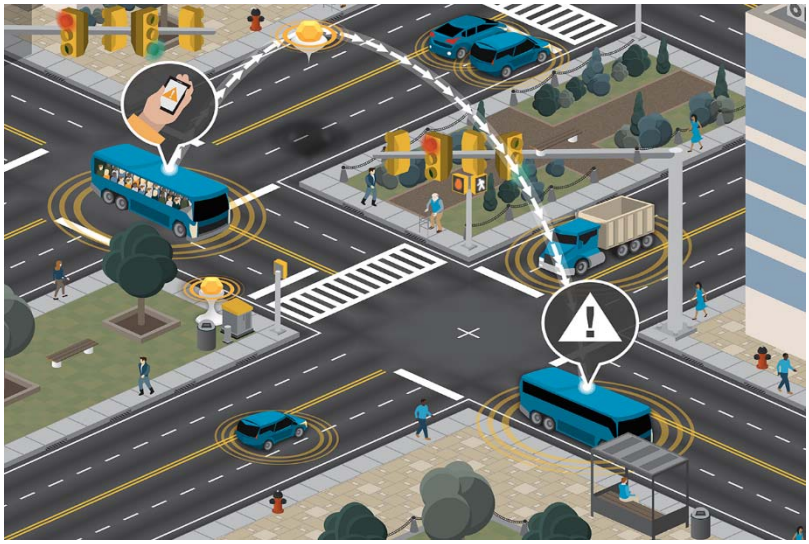
The IDTO application bundle aims to integrate passenger connection protection, dynamic scheduling, dispatching, and routing of transit vehicles, and dynamic ridesharing into a single system that benefits both travelers and operators.

Applications

- **Connection Protection (T-CONNECT)-** T-CONNECT aims to improve rider satisfaction and reduce expected trip time for multimodal travelers by increasing the probability of automatic intermodal or intra-modal connections. T-CONNECT will protect transfers between both transit (e.g., bus, subway, and commuter rail) and non-transit (e.g., shared ride) modes, and will facilitate coordination between multiple agencies to accomplish the tasks. In certain situations, integration with other IDTO bundle applications (T-DISP and D-RIDE) may be required to coordinate connections between transit and non-transit modes.

- **Dynamic Transit Operations (T-DISP) -** T-DISP seeks to expand transportation options by leveraging available services from multiple modes of transportation. Travelers would be able to request a trip via a handheld mobile device (or phone or personal computer) and have itineraries containing multiple transportation services (public transportation modes, private transportation services, shared-ride, walking and biking) sent to them via the same handheld device. T-DISP builds on existing technology systems such as computer-aided dispatch/automatic vehicle location (CAD/AVL) systems and automated scheduling software. A physical or virtual central system, such as a travel management coordination center (TMCC) would dynamically schedule and dispatch trips.

- **Dynamic Ridesharing (D-RIDE)-** The Dynamic Ridesharing (D-RIDE) application is an approach to carpooling in which drivers and riders arrange trips within a relatively short time in advance of departure. Through the D-RIDE application, a person could arrange daily transportation to reach a variety of destinations, including those that are not serviced by transit. D-RIDE serves as a complement subsystem within the IDTO bundle by providing an alternative to transit when it is not a feasible mode of transport or is unavailable within a certain geographic area. The D-RIDE system would usually be used on a one-time, trip-by-trip basis, and would provide drivers and riders with the flexibility of making real-time transportation decisions.



This graphic illustrates the concept of the Connection Protection (T-CONNECT) application.

Bundle Status

The IDTO Phase 1 demonstration site was conducted in Columbus, OH in April 2015. This demonstration was the result of a cooperative arrangement with the Central Ohio Transit Agency (COTA) and the Ohio State University (OSU) Transportation and Traffic Management Department, which operates the Campus Area Bus System (CABS). A second site in Orlando, Florida, in partnership with the Central Florida Regional Transportation Authority (LYNX), which is the primary provider of public transit services in Orlando, was developed in a modular, scalable manner to allow for future use by other agencies. The primary purpose of the second site was to develop the concept for the IDTO demonstration and identify the new and unique system and user requirements for LYNX. A demonstration of this prototyping effort took place in November 2014. Project personnel provided a demonstration of an example D-RIDE application and interfacing capability to U.S. DOT staff in March 2015.

INTERESTED IN LEARNING MORE?

- ***Visit the DMA Program website***
  - http://www.its.dot.gov/dma/
- ***For further information***: please contact Katherine Hartman, DMA Program Lead, ITS Joint Program Office at kate.hartman@dot.gov or bundle lead Ron Boenau (FTA) at ronald.boenau@dot.gov

Freight Advanced Traveler Information Systems (FRATIS)

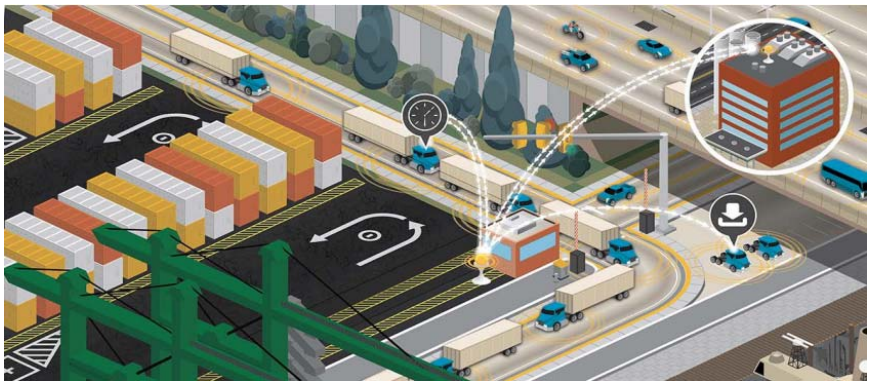
Objective

The FRATIS application bundle seeks to provide freight-specific route guidance and optimize drayage operations so that load movements are coordinated between freight facilities to reduce empty-load trips.

Applications

- **Freight Specific Dynamic Travel Planning and Performance**
  This application seeks to aggregate traveler information, dynamic routing, and performance monitoring elements desired by freight operators. It is expected that this application will leverage existing data in the public domain, as well as emerging private sector applications, to provide benefits to both sectors. Other data includes real-time freeway and key arterial speeds and volumes, incident information, road closure information, route restrictions, bridge heights, truck parking availability, cell phone and/or Bluetooth movement/speed data, weather data, and real-time speed data from fleet management systems.

- **Drayage Optimization**
  This application seeks to combine container load matching and freight information exchange systems to fully optimize drayage operations, thereby minimizing bobtails/dry runs and wasted miles, as well as dispersing truck arrivals at intermodal terminals throughout the day. With this application, the U.S. DOT and freight industry also have an opportunity to address some key industry gaps. To truly optimize a freight carrier's itinerary, extensive communication is required from a wide range of entities (including rail carriers, metropolitan planning organizations, traffic management centers, customers, and the freight carriers themselves) in a manner that assesses all of the variables and produces an optimized itinerary.



Bundle Status

The U.S. DOT selected multiple locations to test the FRATIS prototype under different environments that incorporated innovative, unique features of the FRATIS bundle: Los Angeles Gateway Region, Dallas-Fort Worth, Texas, and South Florida. In addition, an Impacts Assessment activity will evaluate the three FRATIS prototypes.

In Los Angeles, a prototype demonstration was implemented in early 2014 around marine terminals to help move cargo out of the port more efficiently. A Bluetooth (Wi-Fi) - based terminal queue management system was used to provide travel information, including:

- Daily optimized schedules per driver based on average stop times, predicted travel times, expected terminal wait times, and other constraints.
- Real time terminal queue info, driver messaging, and traffic; dynamic routing for trucks through in-cab navigation TomTom devices

Also in early 2014, the Dallas-Fort Worth prototype demonstration was implemented with drayage operations coordinated among rail and local truck drayage companies. The DFW project has four major stakeholder participants: a container yard (IMCG), a rail company (BNSF), and two drayage companies (Associated Carriers and Southwest Freight International). The unique feature of the Dallas-Fort Worth FRATIS prototype was calculating terminal queue time using DSRC 9.5 GHz technology. Partners were the U.S. DOT ITS JPO and the container yard. Stationary DSRC roadside units (RSUs) and DSRC radios on trucks were deployment for a 30-day pilot test. Code was developed to calculate relevant metrics (e.g., wait time, time in yard (active vs. idle)). Data collection is complete and will be compared with the Bluetooth technology that was also used for terminal queue time measurement. Data analysis is underway; results are not yet available.

The South Florida FRATIS demonstration was implemented after the other two demonstrations with focus on a web-based drayage optimization tool that provided integrated load matching and freight information exchange to maximize the efficiency of daily load assignments. The primary partner for the demonstration was the Florida East Coast (FEC) Highway Services – the drayage arm of FEC Railway. The South Florida FRATIS demonstration had a similar focus as the other two sites, but included emergency response capability.

Findings from the impacts assessment will be presented to the FRATIS prototype development teams for validation in mid-June 2015 and to the Freight community at the TRB summer freight meeting in Washington, DC at the end of June. The final impacts Assessment report is expected mid-July 2015.

INTERESTED IN LEARNING MORE?

- ***Visit the DMA Program website***
  - http://www.its.dot.gov/dma/
- ***For further information***: please contact Katherine Hartman, DMA Program Lead, ITS Joint Program Office at kate.hartman@dot.gov or bundle lead Carl Andersen (FHWA) at carl.andersen@dot.gov

Eco-Signal Operations

Objective

The Eco-Signal Operations applications use connected vehicle technologies to decrease fuel consumption and emissions on arterials by reducing idling, reducing unnecessary stops, and improving traffic flow at signalized intersections.

Applications

- **Eco-Approach and Departure at Signalized Intersections**
  The Eco-Approach and Departure at Signalized Intersection application uses wireless data communications sent from a roadside equipment unit to connected vehicles to encourage "green" approaches to signalized intersections. The application, located in a vehicle, collects signal phase and timing (SPaT) and MAP messages using vehicle-to-infrastructure (V2I) communications and data from nearby vehicles using vehicle-to-vehicle (V2V) communications. Upon receiving these messages, the application performs calculations to determine the vehicle's optimal speed to pass the next traffic signal on a green light or to decelerate to a stop in the most eco-friendly manner. Speed recommendations may be provided to the driver using a driver-vehicle interface (DVI) or provided to the vehicle systems that support automated longitudinal control capabilities.

- **Eco-Traffic Signal Timing**
  The Eco-Traffic Signal Timing application's objective is to optimize the performance of traffic signals for the environment. The application collects data from vehicles, such as vehicle location, speed, and emissions data using connected vehicle technologies. It then processes these data to develop signal timing strategies focused on reducing fuel consumption and overall emissions at the intersection, along a corridor, or for a region. The application evaluates traffic and environmental parameters at each intersection in real-time and adapts so the traffic network is optimized using available green time to serve the actual traffic demands while minimizing the environmental impact.

- **Eco-Traffic Signal Priority**
  The Eco-Traffic Signal Priority application allows either transit or freight vehicles approaching a signalized intersection to request signal priority. The application considers the vehicle's location, speed, vehicle type, and associated emissions to determine whether priority should be granted. Information collected from vehicles approaching the intersection, such as a transit vehicle's adherence to its schedule, the number of passengers on the transit vehicle, or weight of a truck may also be considered in granting priority. If priority is granted, the traffic signal would hold the green on the approach until the transit or freight vehicle clears the intersection.

- **Connected Eco-Driving**
  The Connected Eco-Driving application provides customized real-time driving advice to drivers so that they can adjust their driving behavior to save fuel and reduce emissions. Eco-driving advice includes recommended driving speeds, optimal acceleration, and optimal deceleration profiles based on prevailing traffic conditions, interactions with nearby vehicles, and upcoming road grades. The application provides feedback to drivers on their driving behavior to encourage drivers to drive in a more environmentally efficient manner. The application may also include vehicle-assisted strategies where the vehicle automatically implements the eco-driving strategy (e.g., changes gears, switches power sources, or reduces its speed in an eco-friendly manner).

- **Wireless Inductive/Resonance Charging**
  Wireless inductive/resonance charging includes infrastructure deployed along the roadway that uses magnetic fields to wirelessly transmit large electric currents between metal coils placed several feet apart. This infrastructure enables wireless charging of electric vehicle batteries including cars, trucks, and buses. Roadside charging infrastructure supports static charging capable of transferring electric power to a vehicle parked in a garage or on the street and vehicles stopped at a traffic signal or a stop sign. It also supports dynamic charging of electric vehicle batteries when the vehicle is in motion.

Bundle Status

- **Concept of Operations**
  A Concept of Operations (ConOps) was developed for the Eco-Signal Operations bundle. The ConOps describes the Eco-Signal Operations applications; communicates user needs and desired capabilities for and expectations of the applications; provides operational scenarios describing how the applications may operate; and identifies goals, objectives, and potential performance measures for the bundle. The ConOps is available in the National Transportation Library: http://ntl.bts.gov/lib/51000/51400/51429/FINAL_Eco-Signal_Operations_ConOps_01-2014.pdf

- **Analysis, Modeling, and Simulation (AMS)**
  The AERIS Program completed detailed analysis, modeling, and simulation (AMS) of the Eco-Signal Operations applications. Modeling of the applications was conducted using a microscopic traffic simulation model (VISSIM) and the Environmental Protection Agency's (EPA) Motor Vehicle Emission Simulator (MOVES) emissions model. A twenty-seven intersection, 6.5 mile segment of El Camino Real in Northern California was modeled. Modeling was conducted under different traffic conditions, network conditions, connected vehicle penetration rates, and other variables. Modeling was conducted for individual applications to understand the potential benefits of each application. Additionally, combined modeling was performed to understand potential synergies of the applications. Assuming average traffic congestion, combined modeling results indicated 9.6 percent reduction in fuel consumption for light vehicles, 9.8 percent for freight vehicles, and 3.1 percent for transit vehicles. The Eco-Signal Operations Modeling report is currently in the USDOT publication process.

- **Application Prototyping**
  An initial field test of the Eco-Approach and departure at Signalized Intersections application was conducted at Turner Fairbank Highway Research Center (TFHRC) with a single vehicle at a single intersection with no traffic. Drivers were provided with speed recommendations using a DVI incorporated into the speedometer (driver advisory feedback). The field experiment resulted in up to 18% reductions in fuel consumption. Researchers also learned that it was difficult for drivers to follow the recommended speed on the "speed advice speedometer" and this created driver distraction.

  Currently in development, the GlidePath Prototype Application sets out to test the efficacy and usefulness of automated longitudinal control capabilities with the Eco-Approach and Departure at Signalized Intersections application. The project will evaluate the performance of the eco-approach and departure algorithm and automated prototype (specifically, the energy savings and environmental benefits). Testing and demonstrations of the application will be conducted at TFHRC in the summer of 2015 with a final report expected to be released in early 2016.

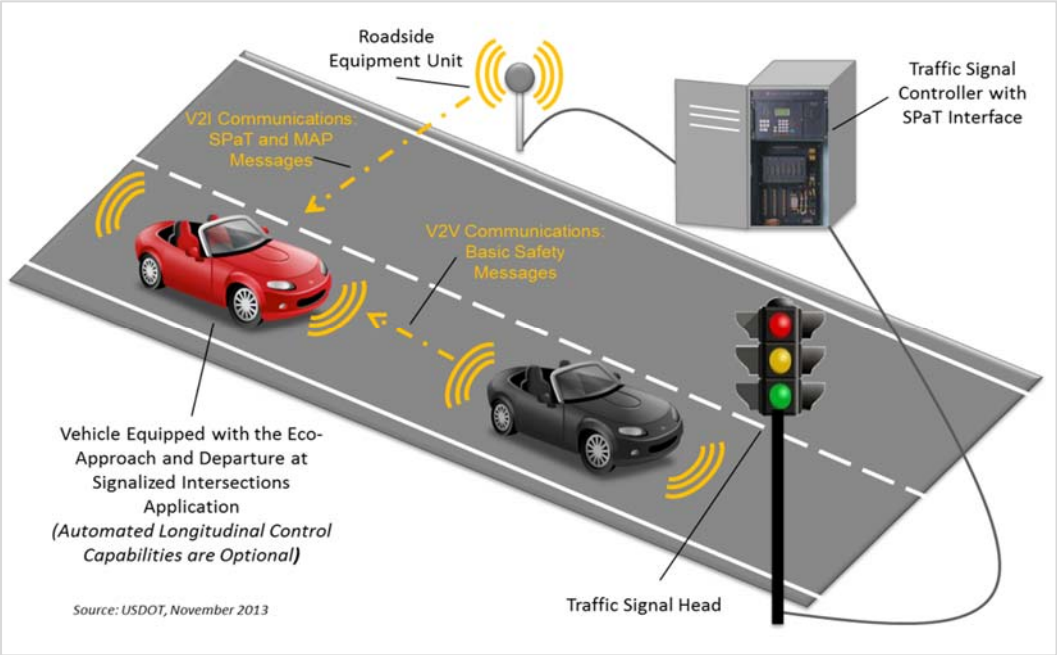


Figure 1. Illustration of the Eco-Approach and Departure at Signalized Intersections application

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Eco-Lanes

Objective

This Operational Scenario includes dedicated lanes optimized for the environment, referred to as Eco-Lanes. Eco-Lanes are similar to managed lanes; however these lanes are optimized for the environment using connected vehicle data and can be responsive to real-time traffic and environmental conditions. These lanes would be targeted toward low emission, high occupancy, transit, and alternative fuel vehicles. Drivers would be able to opt-in to these dedicated eco-lanes to take advantage of eco-friendly applications such as eco-cooperative adaptive cruise control, connected eco-driving, and wireless inductive/resonance charging applications.

Applications

- **Eco-Lanes Management**
  The Eco-Lanes Management application is used to manage the eco-lanes. The application establishes parameters and defines or geo-fences the eco-lanes boundaries. Eco-lanes parameters may include the types of vehicles allowed in the eco-lanes, emissions parameters for entering the eco-lanes, the number of lanes, and the start and end of the eco-lanes. The application also conveys pre-trip and en-route traveler information about eco-lanes to travelers, including information about parameters for vehicles to enter the eco-lanes, current and predicted traffic conditions in the eco-lanes, and geographic boundaries of the eco-lanes.

- **Eco-Speed Harmonization**
  The Eco-Speed Harmonization application determines eco-speed limits based on traffic conditions, weather information, and emissions information. The purpose of speed harmonization is to change speed limits on links that approach areas of traffic congestion, bottlenecks, incidents, special events, and other conditions that affect flow. Speed harmonization assists in maintaining flow, reducing unnecessary stops and starts, and maintaining consistent speeds, thus reducing fuel consumption, and emissions on the roadway. Eco-speed limits may be broadcast by roadside equipment units and received by on-board equipment units and/or posted on variable speed limit signs.

- **Eco-Cooperative Adaptive Cruise Control (ECACC)**
  The Eco-Cooperative Adaptive Cruise Control application includes automated longitudinal vehicle control while considering eco-driving strategies. Expanding on existing ACC systems, which use radar and LIDAR measurements to identify the location of the preceding vehicle, connected vehicle technologies can be used to collect the preceding vehicle's speed, acceleration, and location and feed these data into the vehicle's ACC. These data are transmitted from the lead vehicle to the following vehicle. This application allows following vehicles to use CACC aimed at relieving a driver from manually adjusting his or her speed to maintain a constant speed and a safe time gap from the lead vehicle. The Eco-Cooperative

Adaptive Cruise Control application also incorporates other information, such as road grade, roadway geometry, and road weather information.

- **Eco-Ramp Metering**
  The Eco-Ramp Metering application determines the most environmentally efficient operation of traffic signals at freeway on-ramps to manage the rate of entering vehicles. This application collects traffic and environmental data to allow on-ramp merge operations that minimize overall emissions, including traffic and environmental conditions on the ramp and on the freeway upstream and downstream of the ramp. Using this information, the application determines a timing plan for the ramp meter based on current and predicted traffic and environmental conditions. The objective for this application is to produce timing plans that reduce overall emissions.

- **Connected Eco-Driving**
  The Connected Eco-Driving application provides customized real-time driving advice to drivers so that they can adjust their driving behavior to save fuel and reduce emissions. Eco-driving advice includes recommended driving speeds, optimal acceleration, and optimal deceleration profiles based on prevailing traffic conditions, interactions with nearby vehicles, and upcoming road grades. The application provides feedback to drivers on their driving behavior to encourage drivers to drive in a more environmentally efficient manner. The application may also include vehicle-assisted strategies where the vehicle automatically implements the eco-driving strategy (e.g., changes gears, switches power sources, or reduces its speed in an eco-friendly manner).

- **Wireless Inductive/Resonance Charging**
  Wireless inductive/resonance charging includes infrastructure deployed along the roadway that uses magnetic fields to wirelessly transmit large electric currents between metal coils placed several feet apart. This infrastructure enables wireless charging of electric vehicle batteries including cars, trucks, and buses. Roadside charging infrastructure supports static charging capable of transferring electric power to a vehicle parked in a garage or on the street and vehicles stopped at a traffic signal or a stop sign. It also supports dynamic charging of electric vehicle batteries when the vehicle is in motion.

Bundle Status

- **Concept of Operations**
  A Concept of Operations (ConOps) was developed for the Eco-Lanes Operational Scenario. The ConOps describes the Eco-Signal Operations applications; communicates user needs and desired capabilities for and expectations of the applications; provides operational scenarios describing how the applications may operate; and identifies goals, objectives, and potential performance measures for the bundle. The ConOps is available in the National Transportation Library: http://ntl.bts.gov/lib/51000/51700/51774/114.pdf

- **Analysis, Modeling, and Simulation (AMS)**
  Analysis, modeling, and simulation of Eco-Lanes Operational Scenario was conducted using a microscopic traffic simulation model (VISSIM) and the Environmental Protection Agency's (EPA's) Motor Vehicle Emission Simulator (MOVES) emissions model. The Eco-Speed Harmonization and Eco-Cooperative Adaptive Cruise Control applications were modeled for a segment of roadway on State Route 91 Eastbound (SR-91 E) in Southern California. An ECACC-reserved "Eco-Lane" was developed from an existing HOV lane on the corridor, while the remaining lanes were used for Eco-Speed Harmonization. The results showed that Eco-Speed Harmonization has the potential to yield up to 4.4 percent in energy savings; ECACC has potential to provide up to 19 percent in energy savings; and combined, Eco-Speed Harmonization may yield up to a 22 percent energy savings for the corridor.

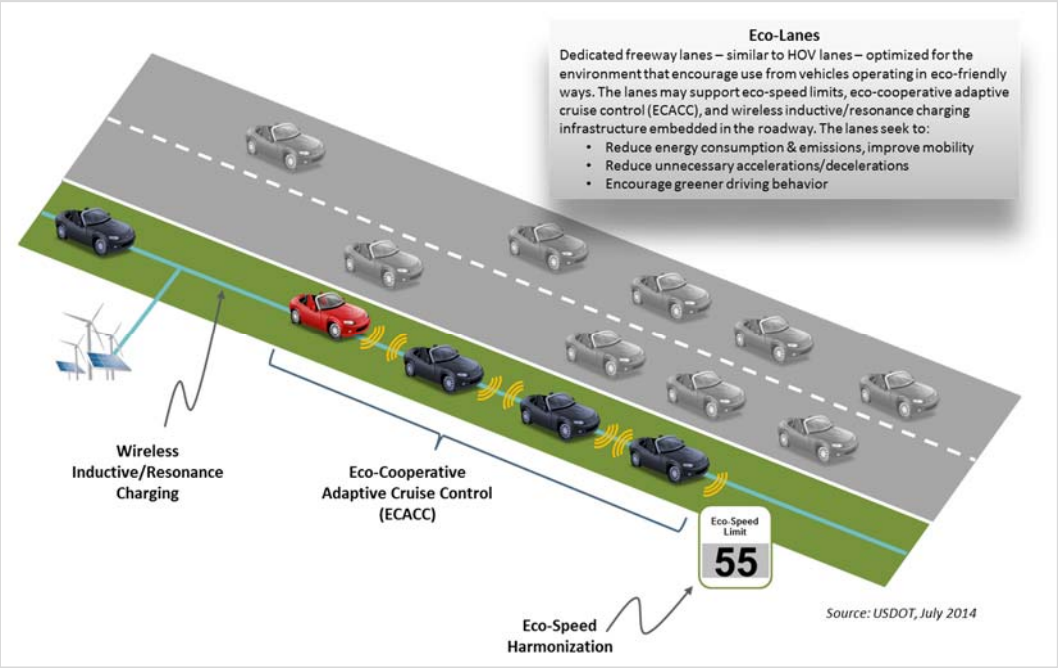

Figure 2. Illustration of the Eco-Lanes Concept and associated applications

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For further information: please contact Marcia Pincus, AERIS Program Manager, ITS Joint Program Office at Marcia.Pincus@dot.gov

Low Emissions Zones

Objective

Low Emissions Zones would be used to encourage decisions by travelers that help reduce transportation's negative impact on the environment. The Low Emissions Zones Operational Scenario envisions entities responsible for the operations of the transportation network to have the ability to define geographic areas that seeks to restrict or deter access by specific categories of high-polluting vehicles into the area for the purpose of improving the air quality within the geographic area. Alternatively, the Operational Scenario may incentivize traveler decisions that are determined to be environmentally friendly such as the use of alternative fuel vehicles or transit. Low Emissions Zones in a connected vehicle environment would be similar to existing low emissions zones; however they would leverage connected vehicle technologies allowing the systems to be more responsive to real-time traffic and environmental conditions.

Applications

- **Low Emissions Zone Management**
  This application supports the operation of a Low Emissions Zone that is responsive to real-time traffic and environmental conditions. The application uses data collected from vehicles using connected vehicle technologies and from roadside equipment as input to the system. The Low Emissions Zone Management application supports the geo-fencing of a cordon that may be scalable and moveable (e.g., created for a day, removable, flexible in its boundaries) and would be less dependent on conventional ITS infrastructure. The application would establish parameters including the types of vehicles permitted to enter the zone, exemptions for transit vehicles, emissions criteria for entering the zone, fees or incentives for vehicles based on emissions data collected from the vehicle, and geographic boundaries for the low emissions zones. The application would also include electronic toll collection functions that support payments of fees or collection of incentives for registered vehicles.

- **Eco-Traveler Information Applications**
  Eco-Traveler Information Applications provide pre-trip and en-route traveler information about the Low Emissions Zones. This includes information about the geographic boundaries of the low emissions zones, criteria for vehicles to enter the Low Emissions Zones, expected fees and incentives for their trip, and current and predicted traffic and environmental conditions within and adjacent to the zones. Traveler information messages may be provided to various personal devices and in-vehicle systems and used by travelers to adjust their departure time or select an alternate route. Another key component of these applications is providing travelers with transit and shared use mobility options to encourage mode shift. Parking information in the Low Emissions Zones or at parking lots outside of the zones may also be provided.

Bundle Status

- **Concept of Operations**
  A Concept of Operations (ConOps) was developed for the Low Emissions Zones Operational Scenario. The ConOps describes the Eco-Signal Operations applications; communicates user needs and desired capabilities for and expectations of the applications; provides operational scenarios describing how the applications may operate; and identifies goals, objectives, and potential performance measures for the bundle. The ConOps is available in the National Transportation Library:
  http://ntl.bts.gov/lib/52000/52700/52755/FINAL_Low_Emissions_Zones_ConOps_01-2014.pdf

- **Analysis, Modeling, and Simulation (AMS)**
  Analysis, modeling, and simulation was conducted for a low emissions zone in the Phoenix, AZ metropolitan area using the SimTRAVEL (Simulator of Transport, Routes, Activities, Vehicles, Emissions, and Land) integrated model system. The simulation results suggested that energy and emissions benefits of 3 percent to 5 percent may be achieved with even very modest penetration of eco-vehicles in the market. Coupled with enhanced transit services that incentivize mode-shift, benefits in the range of 15 percent to 20 percent may be achieved, indicating the presence of a strong synergistic effect when enhanced transit services are coupled with Low Emissions Zone strategies.

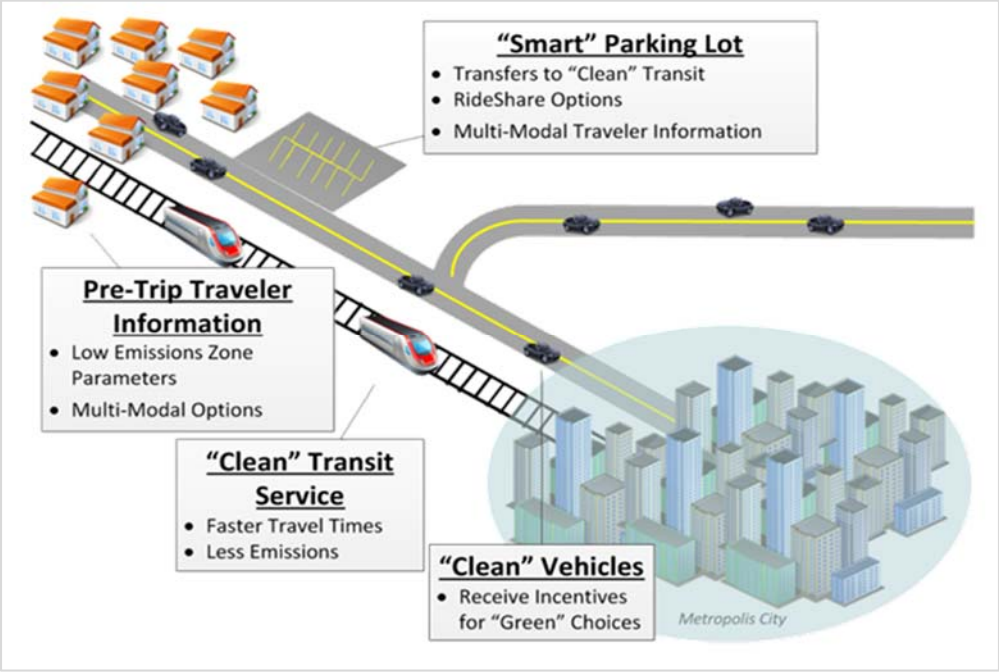

Figure 3. Illustration of the Low Emissions Zones Operational Scenario

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For further information: please contact Marcia Pincus, AERIS Program Manager, ITS Joint Program Office at Marcia.Pincus@dot.gov

Eco-Traveler Information

Objective

The Eco-Traveler Information Operational Scenario is focused on providing traveler information that assists travelers in making decisions that reduce fuel consumption and vehicular emissions. The objective of traveler information is to provide the traveling public with information regarding available modes, optimal routes, and departure times in real-time either pre-trip or en-route. Research has shown that successful traveler information services can impact fuel consumption and vehicular emissions in various forms. For example, applications that assist drivers in determining their route selection, departure times to avoid traffic, and eco-driving guidance can reduce non-optimal driving and reduce emissions. Significant environmental benefits also exist from mode shifts (e.g., from a single occupancy vehicle to transit, bicycle, carpool, etc.).

Applications

- **Connected Vehicle-Enabled Environmental Probe Data Collection**
  The Connected Vehicle-enabled Environmental Probe Data Collection Application supports the collection of fuel consumption and emissions data from vehicles. Connected vehicle technologies allow fuel consumption and emissions data to be collected from vehicle systems or sensors located on the vehicle and wirelessly transmitted back to centers. Using these data, real-time air quality maps may be created for roadway segments, corridors, and urban areas. By developing these maps, operating entities would be able to identify segments of the transportation network where fuel is being wasted or segments of the network prone to poor air quality.

- **Multimodal Traveler Information**
  Multimodal Traveler Information Applications provides pre-trip and en-route traveler information to travelers encouraging a more sustainable relationship between transportation and the environment. The application collects multimodal data from connected vehicles, crowdsourced data from smartphone apps, and data from other sources. Trip planning tools provide travelers with information about multimodal travel options including transit service, bike share options, and car share options. Various tools including location aware, wirelessly enabled mobile devices enable travelers to find information and make reservations for these multimodal and shared-use services. Additionally, applications provide travelers with real-time traffic conditions so that they can either plan to or dynamically adjust departure time and mode choices (e.g., use transit) or select an alternate route to avoid congestion or incidents.

- **Eco-Smart Parking**
  Eco-Smart Parking Applications provide users with real-time location, availability, type (e.g., street, garage), and price of parking. These applications reduce time required for drivers to search for a parking space, thereby reducing vehicular emissions. Eco-Smart Parking applications also supports dynamic pricing or incentives for parking based on vehicle type. Pricing and incentives may serve a traffic demand management strategy helping to reduce vehicle miles traveled in an area, or incentivize travel by eco-vehicles. These applications also allow travelers to reserve parking spaces in advance, as well as pay for parking, using mobile devices and connected vehicle technologies. Eco-Smart Parking applications may be combined with other

Eco-Traveler Information applications and services such as trip planning services and eco-routing applications to provide more complete traveler information services to travelers.

- **AFV Charging/Fueling Information, Reservations, and Payment**
  Alternative Fuel Vehicle (AFV) Charging/Fueling Information, Reservations, and Payment Applications inform travelers of the range of their AFV and provide locations and the availability of AFV charging and fueling stations. The application allows drivers to make reservations to use charging/fueling stations before they start their trip or while en-route. Additionally, the application supports electronic payment for fuel/energy using connected vehicle technologies. In a connected environment, the results from the application would be dependent upon real-time traffic data sent to the car from infrastructure as well as an assessment of a driver's past behavior impact on range—e.g., lead-foot, light-foot, etc. Real-time data collected from vehicles (collected using connected vehicle technologies) would be used to provide better estimates of traffic delays and arrival times at the destination. Additionally, the vehicle would also learn from the driver's behavior providing accurate estimates of the vehicle's range in real-time, thus reducing the driver's fear of being stranded.

- **Dynamic Eco-Routing**
  The Dynamic Eco-Routing application determines the most eco-friendly route, in terms of minimum fuel consumption or emissions, for individual travelers. The application is similar to current navigation systems which determine routes based on the shortest path or minimum time. The application leverages connected vehicle data to determine the eco-routes based on historical, real-time, predicted traffic and environmental data as well as road type (e.g., arterial or freeway) and road grade. The Dynamic Eco-Routing application takes into account a variety of different data, including: real-time traffic information, road type, road grade, and others. The application not only provides the eco-route, but may also provide information on the recommended departure time to avoid congestion based on current and historical traffic conditions. Trip departure times can impact the fuel consumption due to heavy traffic that causes congestions and therefore results in inefficient driving and increased fuel consumptions.

- **Connected Eco-Driving – Gamified / Incentives-Based Applications**
  Connected Eco-Driving – Gamified / Incentives-based Applications use advanced sensors, software, and telematics allowing vehicular systems to communicate information about the vehicle's performance directly to the driver—via the dashboard or wirelessly to a smartphone. Drivers receive eco-driving recommendations and post-trip feedback on their behavior adapted to them and to their vehicle's characteristics. Eco-driving information applications provide training programs or recommendations via an onboard unit (OBU) to promote energy efficient driving techniques. These applications would leverage a social media component, where people can compete on leaderboards on how much fuel and emissions they save from practicing eco-driving strategies. Drivers would compete with other drivers, earn points, get a better "status", and/or receive incentives for eco-driving behavior. For consumers of more fuel efficient vehicles, people would be able to post their results back to social media, helping to create a more visible culture of electric (or other AFVs) enthusiasts who want to share with the world how much money they save on gas and how much fewer emissions they are emitting compared to their counterparts driving gasoline vehicles.

- **Gamified / Incentives-Based Multimodal Traveler Information Applications**
  This application allows travelers to opt-in to smartphone apps to earn points based on their travel choices. Travelers would earn points for green transportation choices including travel during off-peak hours, transit usage, bike usage, etc. These applications would allow system operators to collect data from travelers on their traveling behavior, would allow app users to receive customized traveler information, and would leverage a social media component where people would compete on leaderboards on how much fuel and emissions they save from making green transportation choices. Travelers would compete with other travelers, earn points, get a better "status", and/or receive incentives. Demand management strategies are a key component of these applications as they aim to reduce travel demand. In general, the benefits of access management include improved movement of traffic, reduced crashes, and fewer vehicle conflicts. Demand management applications can offer cost-effective strategies that help to increase freeway capacities without investing in a new, or expanding upon the existing, infrastructure.

Bundle Status

- **Concept of Operations**
  The AERIS Program is currently developing a Concept of Operations for the Eco-Traveler Information Operational Scenario. The ConOps is expected to be finalized in fall 2015.

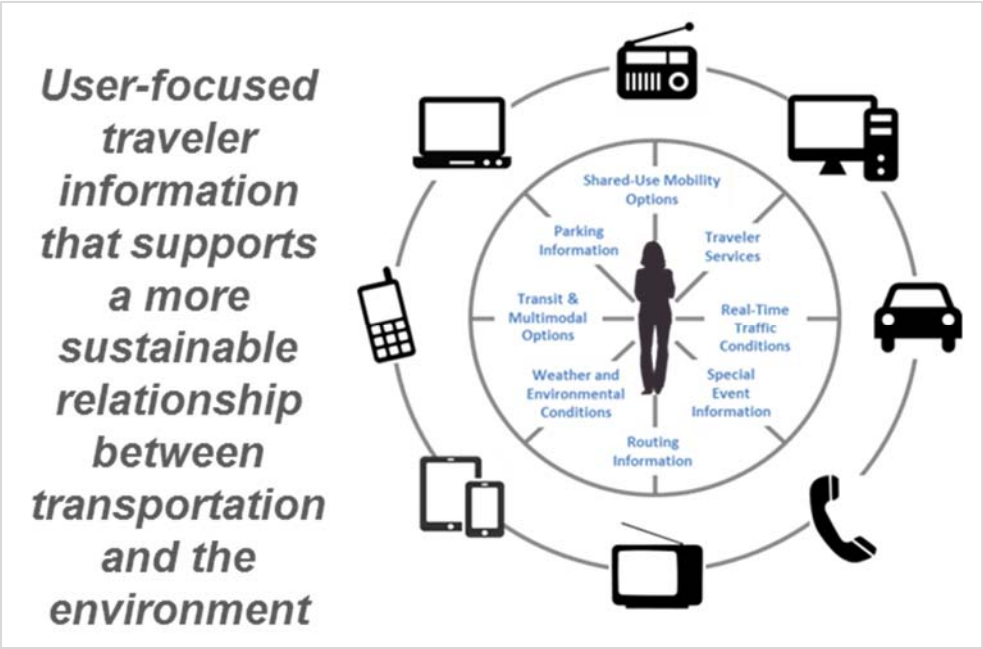

Figure 4. Illustration of the Eco-Traveler Information Operational Scenario

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For further information: please contact Marcia Pincus, AERIS Program Manager, ITS Joint Program Office at Marcia.Pincus@dot.gov

Eco-Integrated Corridor Management

Objectives

The objective of Eco-Integrated Corridor Management (Eco-ICM) is to realize significant environmental improvements in the efficient movement of people and goods through the integrated and proactive management of major multimodal transportation corridors. The Eco-ICM Operational Scenario seeks to build on the successes of previous ICM initiatives by considering how connected vehicle and other future technologies may support the integrated operation of a major travel corridor to reduce transportation-related emissions on arterials and freeways. Eco-ICM should be thought of as an extension to the existing ICM concept – with the difference being that Eco-ICM seeks to ensure that environmental data and performance measures are considered in making operational decisions including the implementation of environmentally-oriented operational strategies such as eco-traffic signal timing, eco-speed harmonization, eco-traveler information, and other strategies defined by the AERIS Research Program.

Applications

- **Eco-Integrated Corridor Management Decision Support System**.
  The Eco-Integrated Corridor Management Decision Support System (DSS) seeks to assist managers in the process of collaboratively managing a multimodal transportation network. The ICM DSS would support eco-capabilities to ensure that environmental objectives are considered when managing the transportation network for the purpose of reducing transportation's negative impact on the environment. In general, the ICM DSS and associated eco-capabilities support multimodal, transportation operational decision-making in real-time including reducing delay as well as reducing emissions and fuel consumption. The DSS would integrate multiple real-time data sources from a variety of systems – including arterial, freeway, transit, and other management systems. Expanding on existing ICM DSSs, the Eco-ICM DSS would also collect environmental, connected vehicle, and shared use mobility data. These data would be processed, modeled, and analyzed to support decisions for specific actions, strategies, and recommendations. Those strategies would support environmental (and other) objectives such as reducing emissions, reducing fuel consumption, and improving air quality.

Bundle Status

- **Concept of Operations**
  The AERIS Program is currently developing a Concept of Operations for the Eco-Traveler Information Operational Scenario. The ConOps is expected to be finalized in fall 2015.

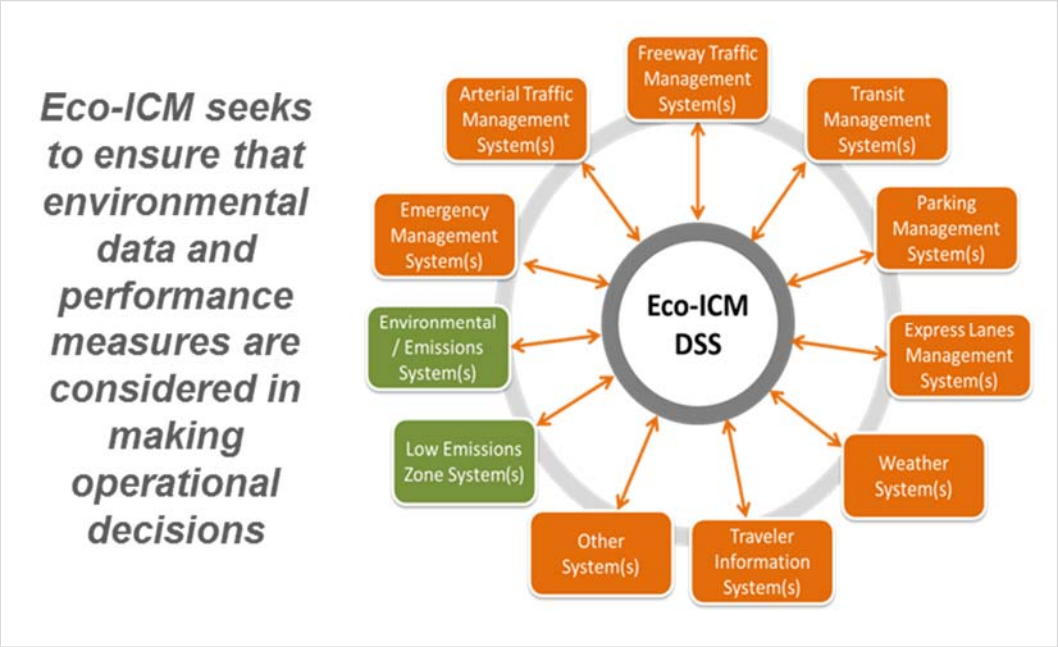

Figure 5. Illustration of the Eco-Integrated Corridor Management Decision Support System (DSS)

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Road Weather

Objective

Road Weather applications seek to increase awareness among agencies and users of the real-time conditions of roads during inclement weather to help to reduce the risk experienced by motorists and to mitigate the impact of weather-related delays. Road Weather connected vehicle applications assess, forecast, and address the impacts that weather has on roads, vehicles, and travelers. Road Weather applications broaden the foundation of road weather data to include mobile sources and to focus the analysis on improving the ability to detect and forecast road weather and pavement conditions by specific roadway links.

Applications

- **Motorist Advisories and Warnings (MAW)**
  Information on segment-specific weather and road conditions is not broadly available, even though surveys suggest that this information is considered of significant importance to travelers. The ability to gather road weather information from connected vehicles will dramatically change this situation. This application will utilize mobile alerts and advisories to push to travelers, information on deteriorating road and weather conditions on specific roadway segments. This application will also be able to provide travelers with “nowcasts” and forecasts out to 24-hours.

- **Enhanced Maintenance Decision Support System (EMDSS)**
  The Enhanced Maintenance Decision Support System application incorporates the additional information that can come from collecting road weather data from connected vehicles into the existing Maintenance Decision Support System capabilities. The information may come from either vehicles operated by the general public and commercial entities (including passenger cars and trucks) or specialty vehicles and public fleet vehicles (such as snowplows, maintenance trucks, and other agency pool vehicles). The raw data will be processed, either at the field or in a controlling center, to generate road segment-based data outputs. The processed data is then used by the EMDSS to generate improved plans and recommendations to maintenance personnel.

- **Weather Data Environment (WxDE)**
  The Weather Data Environment (WxDE) is an application that collects and shares transportation-related weather data with a particular focus on weather data related to connected vehicle applications. The WxDE collects data in real time from both fixed environmental sensor stations and mobile sources and computes value-added enhancements to this data, such as by computing quality-check values for observed data and computing inferred weather parameters from vehicle data. The WxDE builds on the *Clarus* system and incorporates the Vehicle Data Translator (VDT). The WxDE will operate in coordination with other systems developed under the Connected Vehicle Program.

- **Weather-Responsive Travel Information (WxTINFO)**
  The purpose of the WxTINFO application is to design a system that brings together near-time environmental/weather-related data collected from both fixed and mobile data sources. Data will be leveraged from multiple fixed and mobile sources to provide a broader picture of

weather conditions, analyzed into weather condition decision trees and along with other relevant fields are information will be automatically generated into a file that will be picked up by the advanced transportation management system (ATMS), message is verified and posted to the appropriate traffic information source.

This graphic illustrates the concept of the Enhanced Maintenance Decision Support System (EMDSS) application.

Status

With FHWA funding, the National Center for Atmospheric Research (NCAR) is currently partnering with the State Departments of Transportation of Minnesota, Michigan, and Nevada to pilot the MAW and EMDSS applications under the Pikalert™ prototype. These three states have placed readers and external road weather sensors on over 600 of their maintenance fleet vehicles to collect vehicular and meteorological data. Once collected, data from all three states is sent to a VDT processing house that checks data quality and uses the data to infer current and forecasted weather conditions. This data is then used by the road weather connected vehicle applications to provide advisory warnings to motorists and maintenance recommendations to the operations crew.

In addition to the deployment of the various data-collection systems, other initiatives are being undertaken to improve how the data is managed. The *Clarus* surface transportation weather data management system is currently being transitioned to the National Oceanic and Atmospheric Administration's Meteorological Assimilation Data Ingest System (MADIS). The objective of the *Clarus* Transition effort is to incorporate *Clarus* system functionality into the MADIS system so that Clarus transportation users and operators do not lose the *Clarus* capabilities they have grown to rely on to help with transportation decision support issues.

INTERESTED IN LEARNING MORE?

- ***Visit the Road Weather Program website***
  - http://www.its.dot.gov/road_weather/

For further information: please contact Paul Pisano, Road Weather Program Lead, ITS Joint Program Office at Paul.Pisano@dot.gov

OPEN SOURCE APPLICATION DEVELOPMENT PORTAL

www.itsforge.net

The Open Source Application Development Portal (OSADP) is an open source Web portal where users can collaborate on the development of open source transportation applications. Created in support of the DMA program, the OSADP aims to provide complete and deployment-ready application packages, containing all necessary components such as source code, documentation, and test data sets. *Please see the reverse side for a roster of current and future OSADP application offerings.*

OSADP Objectives

- **Collaborative Development** – one of the primary goals of the OSADP to create an environment that cultivates friendly dialog between users and developers in an effort to create and enhance existing transportation applications.
- **Transparency** –By having everything available and open to the users and developers, including full access to the source code, the community as a whole can create better applications. This type of access allows users to understand exactly how an application will work and then make changes as needed to improve its use under different environments, security measures, and many other facets of the application.
- **Reusability** – Application information including the source code, documentation, and lessons learned can be captured and have the potential to be used again in future projects.
- **Provide Complete Application Packages** – To make this all work the OSADP has to provide applications that include all of their required information. This includes the source code, licensing information, user guides, test data sets where possible and system documents for the application

OSADP Features

- **Application Download Page**
- **Information on New Applications**
- **Discussion Forums**
- **Developer Guide and FAQs**
- **GitHub Testing Platform**
- **Application Submittal Capability**

Sample Screenshot: Download an Application

Acronym and Abbreviation List

AACN	Advanced Automatic Crash Notification
AASHTO	American Association of State Highway and Transportation Officials
AERIS	Applications for the Environment: Real-Time Information Synthesis
AFV	Alternative Fuel Vehicle
AIS	Abbreviated Injury Scale
ANPRM	Advance Notice of Proposed Rulemaking
APTS	Advanced Public Transportation System
ATIS	Advanced Traveler Information System
ATMS	Advanced Transportation Management System
BSM	Basic Safety Message
BSW	Blind Spot Warning
CACC	Cooperative Adaptive Cruise Control
CAD/AVL	Computer Aided Dispatch/Automatic Vehicle Location
CAMP	Crash Avoidance Metrics Partnership
CCTV	Closed Circuit Television
CICAS-SSA	Cooperative Intersection Collision Avoidance System—Stop Sign Assist
CITE	Consortium for ITS Education
CO2	Carbon Dioxide
ConOps	Concept of Operation
CO-PILOT	Cost Overview for Planning Ideas and Logical Organization Tool
CSW	Curve Speed Warning
CV	Connected Vehicle
CVII	Commercial Vehicle Infrastructure Integration
CVO	Commercial Vehicle Operations
CVRIA	Connected Vehicle Reference Implementation Architecture
C-TIP	Cross-Town Improvement Project

DCM	Data Capture and Management
DII	Driver Infrastructure Interface
DMA	Dynamic Mobility Applications
DNPW	Do Not Pass Warning
DOT	Department of Transportation
DRG	Dynamic Route Guidance
DSRC	Dedicated Short Range Communications
DVI	Driver Vehicle Interface
D-RIDE	Dynamic Ridesharing
Eco-ICM	Eco-Integrated Corridor Management
EEBL	Emergency Electronic Brake Light
EnableATIS	Enable Advanced Traveler Information Systems
EV	Emergency Vehicle
EVAC	Emergency Communications and Evacuation
FCC	Federal Communications Commission
FCW	Forward Collision Warning
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FMVSS	Federal Motor Vehicle Safety Standards
FRATIS	Freight Advanced Traveler Information Systems
FSP	Freight Signal Priority
GHz	Gigihertz
GID	Geometric Intersection Description
GIS	Geographical Information Systems
GPS	Global Positioning System
GUI	Graphic User Interface
HOT	High-Occupancy Toll
HOV	High-Occupancy Vehicle

ICM	Integrated Corridor Management
IDTO	Integrated Dynamic Transit Operations
IMA	Intersection Movement Assist
INC-ZONE	Incident Scene Work Zone Alerts for Drivers and Workers
INFLO	Intelligent Network Flow Optimization
ITS	Intelligent Transportation Systems
IVP	Integrated Vehicle Prototype
I-SIG	Intelligent Traffic Signal System
JPO	Joint Program Office
LAN/WAN	Local Area Network/Wide Area Network
LCW	Lane Change Warning
LTA	Left Turn Assist
MAP-21	Moving Ahead for Progress in the 21st Century
MAW	Motorist Advisories and Warnings
MDSS	Enhanced Maintenance Decision Support System
MMITSS	Multimodal Intelligent Traffic Signal System
MOU	Memorandum of Understanding
NASS GES	National Automotive Sampling System General Estimates System
NCHRP	National Cooperative Highway Research Program
NCHRP 03-101	"Costs and Benefits of Public Sector Connected Vehicle Deployment"
NHTSA	National Highway Traffic Safety Administration
NTCIP	National Transportation Communications for ITS Protocol
O&M	Operations and Maintenance
OBE	Onboard Equipment
OEM	Original Equipment Manufacturer
OSADP	Open Source Application Development Portal
PCB	Professional Capacity Building Program
PED-SIG	Mobile Accessible Pedestrian Signal System

PKI	Public Key Infrastructure
PREEMPT	Emergency Vehicle Preemption
Q-WARN	Queue Warning
RDE	Research Data Exchange
RESP-STG	Incident Scene Pre-Arrival Staging Guidance for Emergency Respond
R.E.S.C.U.M.E.	Response, Emergency Staging and Communications, Uniform Management, and Evacuation
RLVW	Red Light Violation Warning
RQPL	Research Qualified Products List
RSU	Roadside Unit
RSZW	Reduced Speed Zone Warning
RTTM	Real-Time Traffic Monitoring
RWIS	Road Weather Information System
SCMS	Security Credential Management System
SET-IT	Systems Engineering Tool for Intelligent Transportation
SPaT	Signal Phase and Timing
SPD-HARM	Dynamic Speed Harmonization
SRI	Smart Roadside
SSGA	Stop Sign Gap Assist
SWIW	Spot Weather Information Warning
TFHRC	Turner-Fairbank Highway Research Center
TSP	Transit Signal Priority
T-CONNECT	Connection Protection
T-DISP	Dynamic Transit Operations
UMTRI	University of Michigan Transportation Research Institute
U-NII	Unlicensed National Information Infrastructure
U.S. DOT	United States Department of Transportation
V2G	Vehicle-to-Grid
V2I	Vehicle-to-Infrastructure

V2V	Vehicle-to-Vehicle
VDT	Vehicle Data Translator
VISSIM	Visual Simulation
VMS	Variable Message Sign
VMT	Vehicle Miles Traveled
VSC3	Vehicle Safety Communications 3
VSL	Variable Speed Limit
WRTM	Weather-Responsive Transportation Management
WxTINFO	Weather-Responsive Traffic Information

CV 102 Workshop

Additional Resources

ITS Professional Capacity Building - www.pcb.its.dot.gov
Connected Vehicle Reference Implementation Architecture (CVRIA) Training – http://www.iteris.com/cvria/html/resources/cvriatraining.html http://www.iteris.com/cvria/html/forms/setittrainingform.php
NHTSA's Advance Notice of Proposed Rulemaking on Vehicle-to-Vehicle Communications Technology - http://www.safercar.gov/v2v/index.html
DSRC Video (slide 7) – http://www.its.dot.gov/library/media/16dsrc.htm
Safety Video (Slide 31) – http://www.its.dot.gov/library/media/14safety.htm
Crash Data Analyses for Vehicle-to-Infrastructure Communications for Safety Applications, FHWA, November 2012 - http://www.fhwa.dot.gov/publications/research/connectedvehicles/11040/11040.pdf
Mobility Video (Slide 49) – http://www.its.dot.gov/library/media/12mobility.htm
Environment Video (Slide 75) – http://www.its.dot.gov/library/media/11environment.htm
Road Weather Video (Slide 87) – http://www.its.dot.gov/library/media/13roadweather.htm

ITS Professional Capacity Building - www.pcb.its.dot.gov
FHWA V2I Deployment Guidance for Connected Vehicles – http://www.its.dot.gov/meetings/pdf/V2I_DeploymentGuidanceDraftv9.pdf
CVRIA – CV Reference Implementation Architecture – http://www.iteris.com/cvria/ http://www.standards.its.dot.gov/DevelopmentActivities/CVReference
Set-it Tool – http://www.iteris.com/cvria/html/resources/tools.html
CO-PILOT Tool – https://co-pilot.noblis.org/CVP_CET/
Research Data Exchange – www.its-rde.net
Open Source Application Development Portal (OSADP) – www.itsforge.net
Connected Vehicle Fact Sheets – http://www.its.dot.gov/landing/cv.htm
Recommendations for States Considering Law and Policies for Self-Driving Vehicles – http://www.nhtsa.gov/About+NHTSA/Press+Releases/U.S.+Department+of+Transportation+Releases+Policy+on+Automated+Vehicle+Development

Vehicle To Infrastructure (V2I) Deployment What should States do now?

Here are six (6) basic steps for State DOTs and Owners/Operators if they are considering Vehicle-to-Infrastructure deployments for Connected/Automated Vehicle Technology.

1. **Planning Process** – Start to consider how vehicle to infrastructure communications and applications could be used to solve your problems. What applications have the potential to address critical safety, mobility, and environmental problems? Would the technology be helpful in collecting data on the operations of your system? Where would I need to implement equipment? FHWA is developing a product that will be available later this year to help with these planning questions. In the meantime, the AASHTO National Connected Vehicle Field Infrastructure Footprint Analysis, available at http://ntl.bts.gov/lib/52000/52600/52602/FHWA-JPO-14-125_v2.pdf, provides some information. The Connected Vehicle Pilots webpage (http://www.its.dot.gov/pilots/index.htm) also has information on various applications that were developed over the last several years.

2. **Regional ITS Architecture** – Regions should start to update their Regional ITS Architecture with connected vehicles in mind. The first step is to create a connected vehicle architecture component. The SET-IT tool (http://www.iteris.com/cvria/html/resources/tools.html) was developed to help with this process. USDOT is currently working in the Southeast Michigan area to develop a comprehensive example of a reference architecture. Details are available at http://standards.its.dot.gov/DevelopmentActivities/CVReference.

3. **Connected Vehicle Pooled Fund** – Virginia DOT leads the connected vehicle pooled fund study (CV PFS). Many States find that this group provides a great opportunity for them to gain hands-on experience dealing with V2I deployment and research issues. A State, regional, or local agency can become an official member for $50,000. Some agencies have observer status at no cost. The CV PFS website is: http://www.cts.virginia.edu/cvpfs/. Melissa Lance (Melissa.Lance@vdot.virginia.gov) is the lead for the pooled fund study. Her phone number is (804) 371-4360.

4. **Vehicle to Infrastructure Deployment Coalition** – AASHTO, in collaboration with ITE and ITSA, have formed a Vehicle-to-Infrastructure Deployment Coalition (V2I-DC) to provide a more centralized framework for achieving a comprehensive stakeholder input and participation from owner/operators and accelerate V2I deployment activities. The V2I-DC has become an interface for peer interaction, webinars, research, conferences, and technical working groups. The V2I DC is open to the public. The first meeting is on June 4 and 5 in Pittsburgh, PA.

   Currently, the V2I DC consists of five Technical Working Groups (TWG) and they focus on separate aspects of V2I deployment activities. Each TWG will exchange information, discuss issues, and recommend actions towards a work plan and next steps. The initial TWGs are as follows:

TWG 1: Deployment Initiatives	TWG 2: Deployment Research
TWG 3: Infrastructure Operator, OEM and Supplier Partnerships	
TWG 4: Deployment Guidance	TWG 5: Deployment Standards

Vehicle To Infrastructure (V2I) Deployment
What should States do now?

To become involved with the V2I-DC, please contact Mr. Gummada Murthy, Ph.D., P.E. of AASHTO at 202-624-8913.

5. **Affiliated Testbed**. The OST-R, ITS Joint Program Office is partnering with industry to provide technology transfer on detailed technical issues with respect to connected vehicle technologies. The OST-R has entered into 72 Memorandums of Agreement (MOA) with public, private, and academic organizations involved in the Affiliation of Test Beds. The purpose of the agreements and similar memoranda is to create a non-binding, precompetitive affiliation among those using devices and installations related to V2I communications. The affiliation will facilitate information exchanges, share USDOT tools and resources, and encourage the consistent development and deployment of infrastructure components. States should consider joining the testbed, and/or monitoring the work. Go to http://www.its.dot.gov/testbed/testbed_affiliated.htm for more information.

6. **Purchase Certified Equipment.** Three independent testing entities are developing certification processes for key information flows in the connected vehicle system architecture that will be used to ensure basic interoperability in connected vehicle installations. Certification processes will be available for self-application, and testing services will be available in 2016 from the three testing entities on a fee-for-service basis. Contact Walt Fehr for further information. Walton.Fehr@dot.gov.

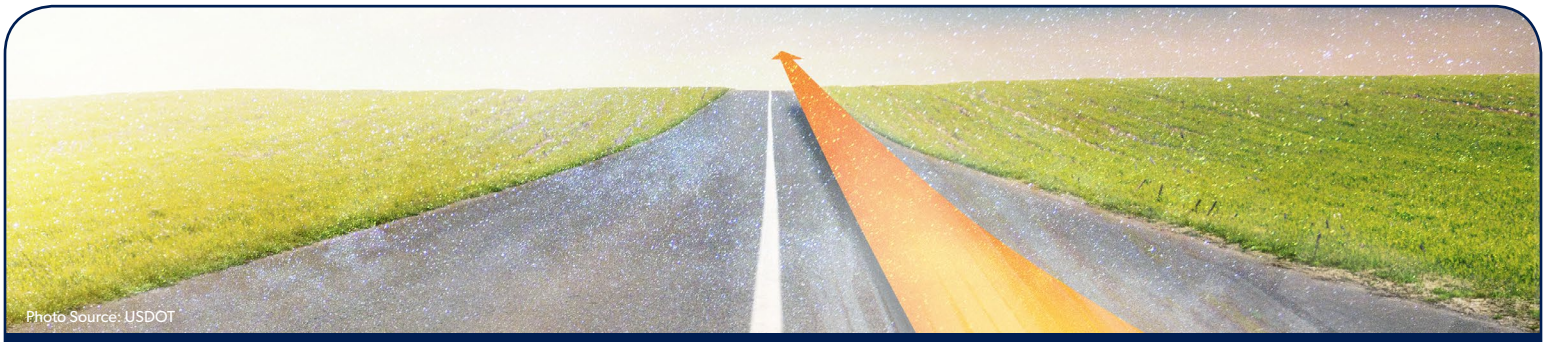
Photo Source: USDOT

PLANNING FOR THE FUTURE OF TRANSPORTATION: CONNECTED VEHICLES AND ITS

LIMIT 35 SAFETY MOBILITY ENVIRONMENT

For the past decade, the U.S. Department of Transportation (USDOT) has been researching and testing a system of vehicles that can sense the environment around them and communicate with other vehicles and with infrastructure. This vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications will enable safety, mobility, and environmental advancements that current technologies are unable to provide. The technology is expected to reduce unimpaired vehicle crashes by 80 percent, while also reducing the 4.8 billion hours that Americans spend in traffic annually.

In August of 2014, the National Highway Traffic Safety Administration (NHTSA) gave V2V communications technology the green light and is working on a regulatory rulemaking that will require the technology to be installed in all new light vehicles in the coming years.

In May 2015, Secretary Foxx announced the USDOT would accelerate the deployment of connected vehicles. NHTSA will move ahead of its timetable for the proposed V2V rule. The proposal is expected in 2016.

In the summer of 2015, the Federal Highway Administration (FHWA) will release a V2I guidance document to assist transportation managers and operators interested in adapting their traffic signals and other roadside devices so they are compatible with the new connected vehicles.

New Cars with USDOT-mandated connected vehicle technology should be available by 2019.

Planning for the Future of Transportation

Now is the time to start planning for the inevitability of this life-saving innovation. Planning agencies should begin to consider how their local transportation systems will function in a connected vehicle environment.

The biggest trend in transportation right now is connectivity. Wirelessly connecting our vehicles, roads, and mobile devices will provide tremendous benefits in the improved safety, mobility, and environmental sustainability of our transportation system. When defining the goals and objectives that will drive decision making, planners should be aware of and consider the impact of connected vehicles.

Connected Vehicles and the Planning Process

Transportation agencies have increasingly embraced Performance-based Planning and Programming (PBPP). PBPP attempts to ensure that transportation investment decisions are made—both in long-term planning and short-term programming of projects—based on their ability to meet established goals. The following key elements of PBPP present opportunities for addressing this connected vehicle environment.

www.fhwa.dot.gov/planning/performance_based_planning/

Maturing Transportation Technology through Connected Vehicle Research Planning

Safety Pilot Model Deployment:
The USDOT has been conducting connected vehicle research and implementation planning since the 1990s, culminating in the 1999 decision by the Federal Communications Commission to reserve dedicated short-range communications spectrum for safety-critical applications. The USDOT explored alternative technologies in the 2000s, ultimately deciding to pursue a V2V regulatory decision. In August 2012, the USDOT tested the ability of connected vehicle technology to address transportation's toughest safety challenges. The Safety Pilot Model Deployment was the largest real-world test of connected vehicle technology to date, with over 2,700 participating vehicles using wireless safety technology to help everyday drivers avoid crashes as they traveled along their normal routines. Safety applications warned drivers of alerts such as braking vehicles ahead, vehicles in their blind spots, or impending red light violations. Our efforts proved that connected vehicle technology indeed works in the real world and in a variety of vehicle types including cars, trucks, transit vehicles, motorcycles, and even bicycles. In 2014, NHTSA announced its intent to make a regulatory rulemaking.

Connected Vehicle Pilot Deployment Program:
To further advance the deployment of connected vehicles, the USDOT is funding regional connected vehicle pilots around the country. FHWA is helping public agencies plan for deployment by providing connected vehicle deployment guidance in the summer of 2015.

The pilots will demonstrate connected vehicle solutions in real-world environments. The program seeks to spur innovation among early adopters of connected vehicle application concepts, using best available and emerging technologies. The pilot deployments are expected to integrate connected vehicle research concepts into practical and effective elements, enhancing existing operational capabilities. The intent of these pilot deployments is to encourage partnerships of multiple stakeholders (e.g., private companies, states, transit agencies, commercial vehicle operators, and freight shippers) to deploy applications using data captured from multiple sources (e.g., vehicles, mobile devices, and infrastructure) across all elements of the surface transportation system (i.e., transit, freeway, arterial, parking facilities, and tollways) to support improved system performance and enhanced performance-based management.

For more information on the connected vehicle pilots, visit: www.its.dot.gov/pilots.

U.S. Department of Transportation

Strategic Direction (Where do we want to go?)

The Intelligent Transportation Systems Joint Program Office (ITS JPO) has developed the new ITS Strategic Plan 2015-2019, which focuses on six priority areas—Connected Vehicles, Automation, Enterprise Data, Emerging Capabilities, Interoperability, and Accelerating Deployment. In the transportation planning process, strategic direction is based on a vision for the future, as articulated by the public and stakeholders. This includes:

Goals and Objectives – Stemming from a state or region's vision, goals address key desired outcomes; supporting objectives play a key role in shaping planning priorities.

Performance Measures – Performance measures support objectives and serve as a basis for comparing alternative improvement strategies (investment and policy approaches) and for tracking results over time.

The objectives and goals related to safety, congestion, reliability, environment, freight movement, economic vitality, and other regionally important considerations (e.g., multi-modal travel options, real-time traveler information) need to be framed with consideration of how connected vehicles will impact possible outcomes.

Planning Analysis (How are we going to get there?)

Driven by data on performance, along with public involvement and policy considerations, agencies conduct analysis to develop investment and policy priorities:

Identify Trends and Targets: Connected vehicle technology will impact data, public involvement, and policy considerations.

Identify Strategies and Analyze Alternatives: The analysis an agency conducts should consider the technology's implications to identify their long- and short-term targets and develop and analyze alternatives that impact their investment and policy decisions (e.g., the impact on significant roadway capacity, travel demand models, roadway design width, and safety).

Develop Investment Priorities: Agencies should choose strategies as part of their Long Range Transportation Plan (LRTP) that will help achieve targets and consider tradeoffs between different goal areas, as well as policy priorities. Investments should consider the long-term possibilities of a connected vehicle environment.

Programming (What will it take?)

Programming involves selecting specific investments to include in an agency capital plan and/or a transportation improvement program (TIP) or statewide TIP. Programming decisions are made based on their ability to support the achievement of performance targets or contribute to desired trends, and account for a range of factors.

Implementation and Evaluation (How did we do?)

These activities occur throughout implementation on an ongoing basis, and include:

Monitoring – Gathering information on actual conditions

Evaluation – Conducting analysis to understand to what extent implemented strategies have been effective

Reporting – Communicating information about system performance and the effectiveness of plans and programs to policymakers, stakeholders, and the public.

Monitoring, evaluation, and reporting are key elements to ensure that there is proof of concept to add to the case for connected vehicle deployment.

Connected vehicle technology will help address many of the transportation challenges facing communities today:

- Reduce traffic congestion
- Make intersections safer
- Curb vehicle pollution
- Make truck corridors move more efficiently
- Make crosswalks safer for pedestrians and the disabled
- Make public bus transfers move more smoothly
- Make work zones safer for roadside personnel
- Make high-incident management safer for first responders.

ITS and Strategic Planning

The USDOT's ITS JPO fosters the development and future deployment of connected vehicle planning and technology deployment. To achieve this goal, the ITS JPO coordinates connected vehicle research with agencies within the USDOT, including NHTSA, the Federal Highway Administration, FHWA, the Federal Transit Administration, and the Federal Railroad Administration.

Visit the ITS JPO web site to access planning tools and learn more about connected vehicles and ITS.

Planning Tools

- Read the ITS JPO's ITS Strategic Plan 2015-2019
- Use the Asset Viewer and Peer-to-Peer exchange
- View technical publications
- Access economic data and evaluation results
- Read the V2I Deployment Guidance (coming in the summer of 2015)

ITS News

- View an award-winning animation showing how connected vehicles work
- Sign up for email alerts
- Download connected vehicle fact sheets, infographics, presentations, and more.

For more information about this initiative, please contact:
Mike Pina, Program Manager, Communications and Outreach
ITS Joint Program Office | (202) 366-3700 | mike.pina@dot.gov | www.its.dot.gov

FHWA-JPO-15-214

Connected Vehicles are coming…

Photo Source: USDOT

…and your community can be part of the evolution of this exciting new technology. Consider becoming part of the U.S. Department of Transportation's Connected Vehicle Pilots Program.

USDOT has begun taking steps to enable wireless vehicle-to-vehicle (V2V) communication technology for light vehicles. This technology would improve safety by allowing vehicles to "talk" to each other and ultimately avoid many crashes altogether.

The Connected Vehicle pilots program is helping to make connected vehicles a reality by testing this technology in several U.S. communities. The pilots are expected to showcase a myriad of exciting new transportation applications for cars, pedestrians, trucks, transit and personal devices. These pilots will also showcase Vehicle-to-Infrastructure applications for safety, mobility and the environment. Your community can help USDOT show the rest of the world how connected vehicles can revolutionize transportation; consider submitting a bid to be part of this transformative research project.

Learn more about the pilots and upcoming information sessions at

www.its.dot.gov/pilots

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www.itskr.its.dot.gov

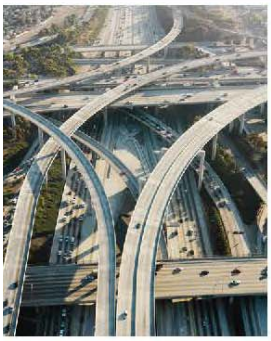

Photo courtesy Jeffrey Katz and Thinkstock

The new ITS Knowledge Resources database features data on:

- **The benefits of ITS technology for transportation operations**
- **Cost estimates for ITS deployment**
- **Lessons learned from today's ITS practitioners**
- **ITS deployment statistics from 108 metro areas in all 50 States**
- **Interactive maps to help locate deployment leaders in your State**

If you are looking for a proven set of strategies for advancing transportation safety, mobility, and environmental sustainability in your community, visit the U.S. Department of Transportation's ITS Knowledge Resources database. Categories include:

- Freeway Management
- Arterial Management
- Transit Management
- Transportation Management Centers
- Electronic Toll Collection
- Public Safety: Law Enforcement

U.S. Department of Transportation
Research and Innovative Technology Administration

Your search is over. Find the free data you need at: **www.itskr.its.dot.gov**