



U.S. DOT Connected & Automated Vehicle Research Update

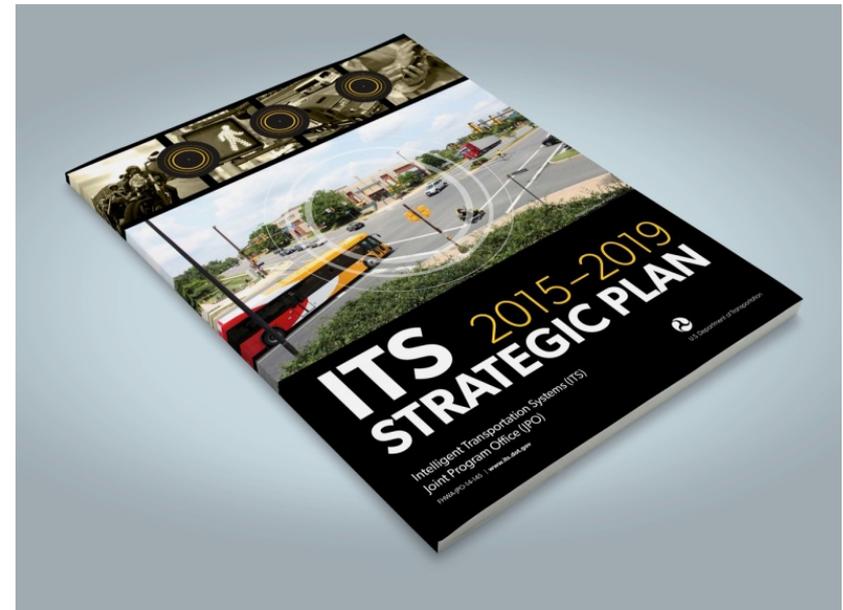
NSF Cyber Physical Systems Principal Investigators

November 17, 2015

Kevin Dopart, U.S. Department of Transportation

ITS Strategic Plan 2015-19 Strategic Priorities

- **Two Strategic Priorities:**
 - **Realizing Connected Vehicle Implementation** – Builds on the substantial progress made in recent years around design, testing, and planning for connected vehicles to be deployed across the nation.
 - **Advancing Automation** – Shapes the ITS Program around research, development, and adoption of automation related technologies as they emerge.





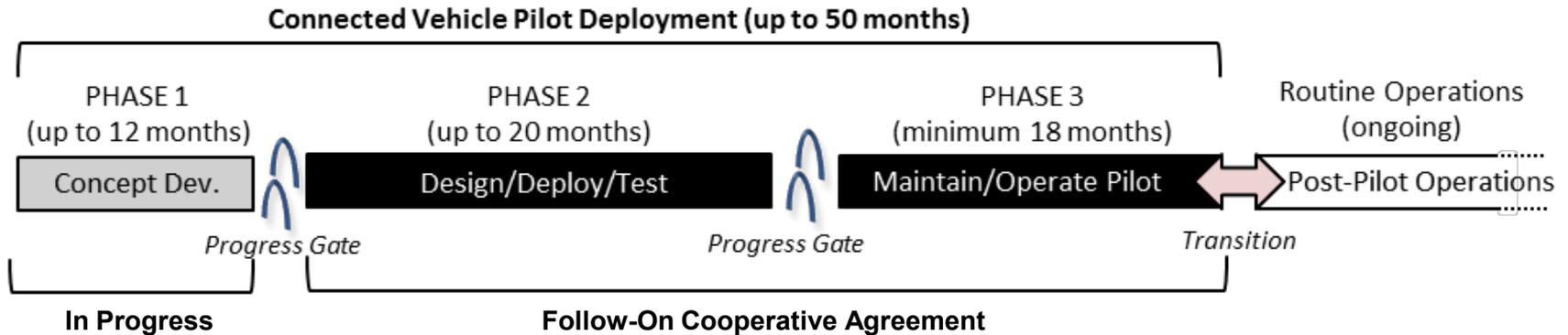
CONNECTED VEHICLES

Connected Vehicle Milestones

- 8/2014: NHTSA ANPRM on vehicle-to-vehicle communications
- 9/2015: First wave of CV Pilots begin
- 12/2015: FHWA V2I guidance document
- 12/2015: V2V NPRM to OMB
- 2016: Publish NPRM



Three Pilots Awarded Phase 1 Contracts



- Tampa, Florida
- New York City, New York
- State of Wyoming

<http://www.its.dot.gov/pilots/>

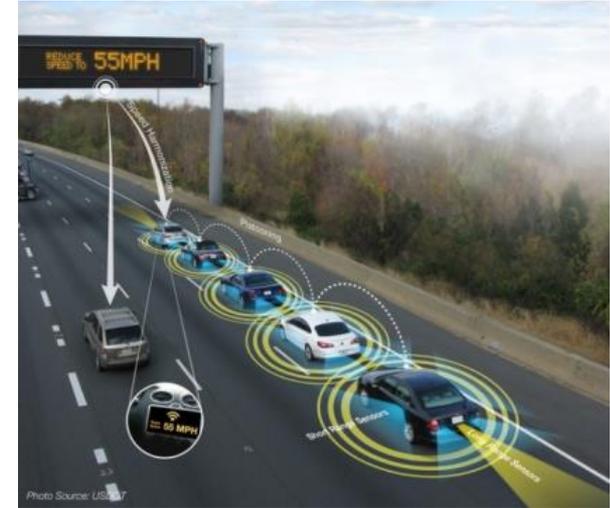




CONNECTED AUTOMATION

Automation Can Be a Tool for Solving Transportation Problems

- **Improving safety**
 - Reduce and mitigate crashes
- **Increasing mobility and accessibility**
 - Expand capacity of roadway infrastructure
 - Enhance traffic flow dynamics
 - More personal mobility options for disabled and aging population
- **Reducing energy use and emissions**
 - Aerodynamic “drafting”
 - Improve traffic flow dynamics



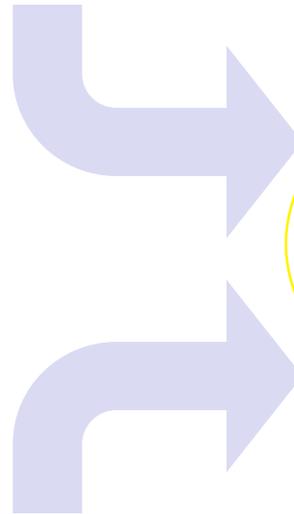
...but connectivity is critical to achieving the greatest benefits



Connected Automation for Greatest Benefits

Autonomous Vehicle

Operates in isolation from other vehicles using internal sensors



Connected Automated Vehicle

Leverages autonomous and connected vehicle capabilities

Connected Vehicle

Communicates with nearby vehicles and infrastructure



Automation Program Research Tracks

Enabling Technologies			
Digital Infrastructure	Communications	Technology Research	

Safety Assurance			
Electronic Control Systems	Functional Safety and Electronics Reliability	Cybersecurity	Human Factors

Transportation System Performance		
CACC, Speed Harmonization, and Platooning	Lateral Control	First/Last Mile and Transit Operations

Testing and Evaluation		
Interoperability	Testing Methods	Benefits Assessment

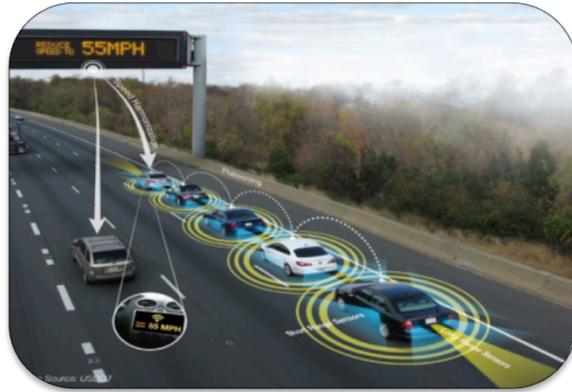
Policy and Planning			
Standards	Federal Policy Analysis	Stakeholder Engagement	Transportation Planning



Enabling Technologies Example

Enabling Technologies			
Big Data Analytics	Connectivity	Cloud Computing	Technology Research
Safety Assurance			
Autonomous Control	Autonomous Safety and Security	Autonomous Navigation	Autonomous Decision Making
Transportation System Performance			
CO ₂ Emissions Reduction and Air Quality	Energy Efficiency	Infrastructure Modernization	System Resilience
Testing and Evaluation			
Interoperability	Testing Methods	Benefits Assessment	
Policy and Planning			
Standards	Federal Policy Research	Stakeholder Engagement	Transportation Planning

POSITION, NAV & TIMING



MAPPING



SENSORS



COMMUNICATIONS



HUMAN FACTORS



Safety Assurance Example: Human Factors Research

Enabling Technologies			
Signal Infrastructure	Communications	Technology Research	
Safety Processes			
Business Cases	Business Safety and Performance Objectives	Liability	Market Factors
Human Factors Research Performance			
Task, Speed, Attention, and Behavior	Load Control	Workload and Error	
Training and Evaluation			
Responsibility	Training Methods	Benefits Assessment	
Operational Considerations			
Hardware	Policy/Procedures	Operator/Equipment	Operator Training

- Transition between automated and non-automated modes
- Level 2 (2010 Cadillac SRX) and Level 3 (Google-modified 2012 Lexus RX450h)
- Results published; also producing Driver-Vehicle Interface Design Principles
 - [http://www.nhtsa.gov/DOT/NHTSA/NVS/Crash Avoidance/Technical Publications/2015/812182_HumanFactorsEval-L2L3-AutomDrivingConcepts.pdf](http://www.nhtsa.gov/DOT/NHTSA/NVS/Crash%20Avoidance/Technical%20Publications/2015/812182_HumanFactorsEval-L2L3-AutomDrivingConcepts.pdf)



Transportation System Performance

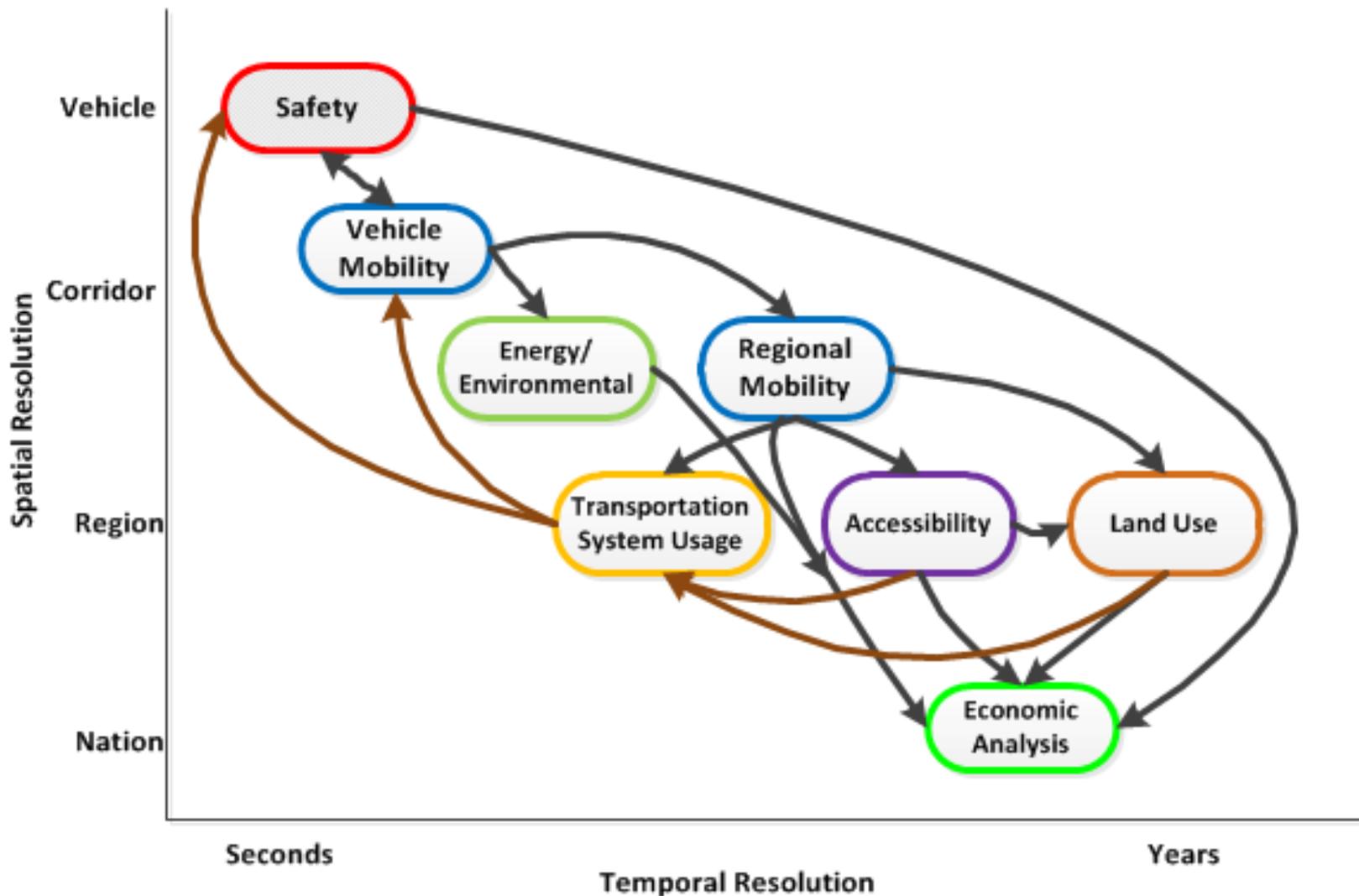
Building Block Diagram			
Signal Information	Control Information	Communication	Performance Metrics
Safety Features			
Advanced Driver Assistance Systems (ADAS)	Autonomous Safety and Control (ASC)	Collision Avoidance	Autonomous Braking
Transportation System Performance			
ACC, Speed Adaptation, and Lane Control	Lateral Control	Brake/Steer/Shift and Control	Brake/Steer/Shift
Testing and Evaluation			
Interoperability	Testing Methods	Benefits Assessment	
Performance Metrics			
Throughput	Control Policy Metrics	Statistical Performance	Transportation Planning

- Application and prototype development
- Primarily human-in-the-loop level 1 connected automation
- (More details later in presentation)



Evaluation and Testing Example: Benefits Evaluation Framework

Evaluation Framework			
System Performance	System Reliability	System Safety	System Security
System Cost	System Efficiency	System Effectiveness	System Resilience
System Sustainability	System Scalability	System Flexibility	System Adaptability
System Interoperability	System Compatibility	System Integration	System Collaboration
System Innovation	System Creativity	System Innovation	System Innovation
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Policy and Planning Example: Review of Federal Motor Vehicle Safety Standards

Building Bridges			
Digital Infrastructure	Communications	Outillage Support	
Quality Resources			
Customer Center	Customer Safety and	Customer Care	Product Safety
Quality	Customer Support	Customer Care	Product Safety
Transportation System Performance			
AVL, Speed Measurement, and	Label Control	Vehicle Weigh and	Vehicle
Performance	Label Control	Vehicle Weigh and	Vehicle
Safety and Compliance			
Interoperability	Testing Methods	Benefits Assessment	
Interoperability	Testing Methods	Benefits Assessment	
Standards	Control Policy Review	Stakeholder Engagement	Transportation Planning

How could highly automated vehicles impact or change the nature of existing Federal Motor Vehicle Safety Standards (FMVSS)?

- Identifying where current FMVSS pose challenges to introduction of AVs
- Ensure NHTSA regulations do not stifle innovation
- NHTSA and ITS JPO coordinated research





L1 CONNECTED AUTOMATION

Example Systems at Each Automation Level

SAEL level	Example Systems	Driver Roles
1	Adaptive Cruise Control OR Lane Keeping Assistance	Must drive <u>other</u> functions and monitor driving environment
2	Adaptive Cruise Control AND Lane Keeping Assistance Traffic Jam Assist	Must monitor driving environment (system nags driver to try to ensure it)
3	Traffic Jam Pilot Automated parking Highway Autopilot	May read a book, text, or web surf, but be prepared to intervene when needed
4	Closed campus driverless shuttle Valet parking in garage 'Fully automated' in certain conditions	May sleep, and system can revert to minimum risk condition if needed
5	Automated taxi Car-share repositioning system	No driver needed

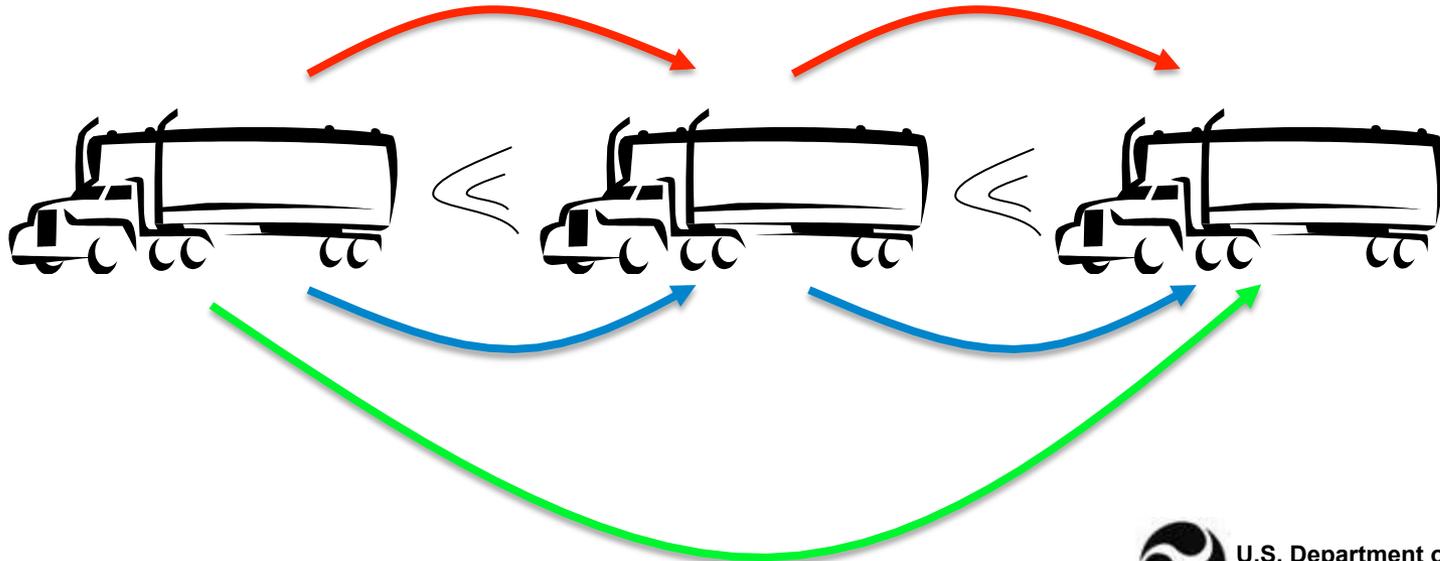
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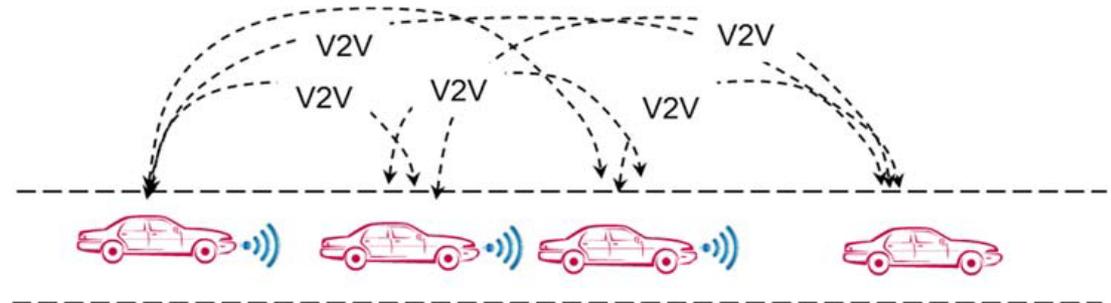
L1 Connected Automation R&D at USDOT

- Cooperative Adaptive Cruise Control (CACC) development
- Freeway Operations Applications
- Eco-Approach and Departure from Signals
- Truck Platooning



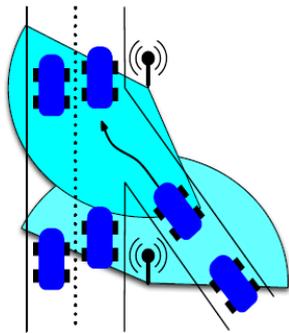
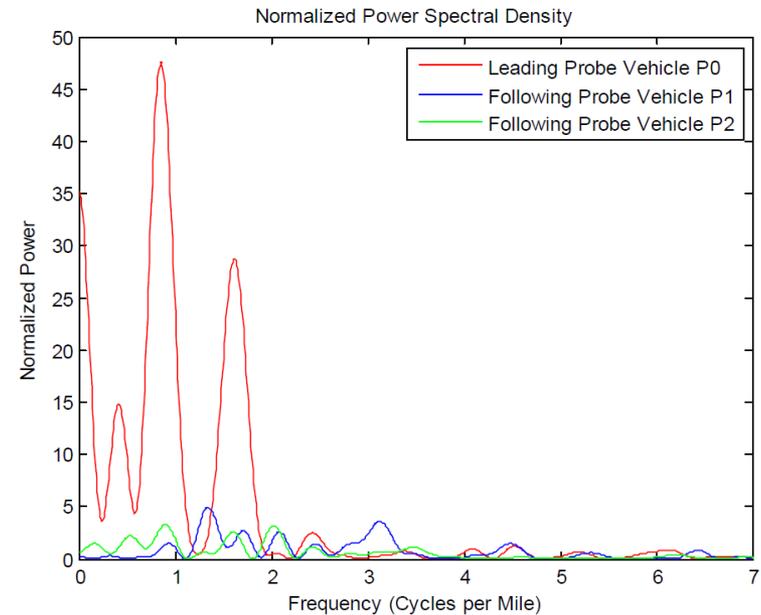
CACC Development Projects

- Enabling CACC High Performance Vehicle Streams
- CACC Field Tests
- OEM Assessment of CACC Concepts and Prototype
- Driver Acceptance of L1 Applications

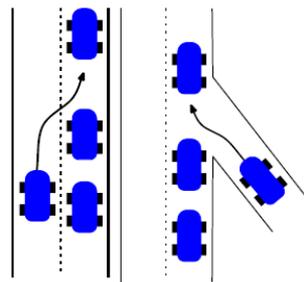


Freeway Traffic Operations Applications

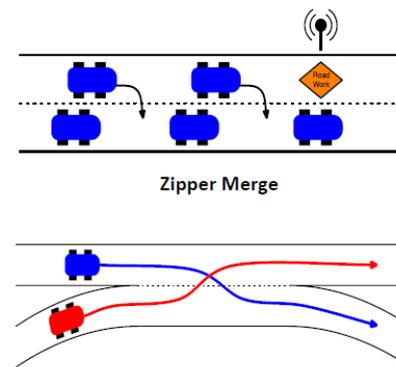
- Freeway Speed Harmonization
- Lane Change/Merge Operations



Freeway Entrance with Infrastructure Support



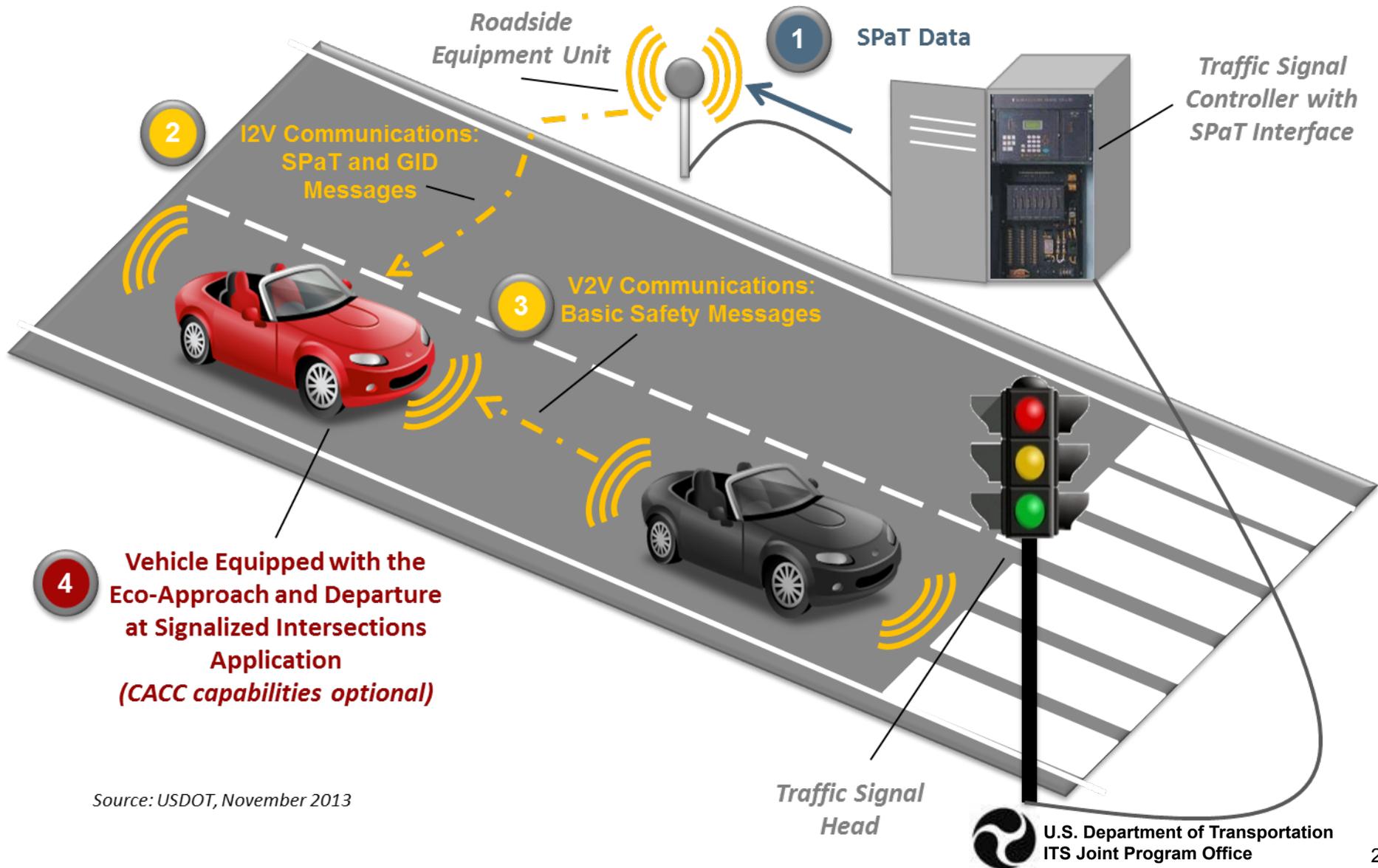
Joining into Car Convoy - Lane Change/Merge



Weaving (Cloverleaf Enter/Exit Lane)

Lane change, merge, and weave maneuvers

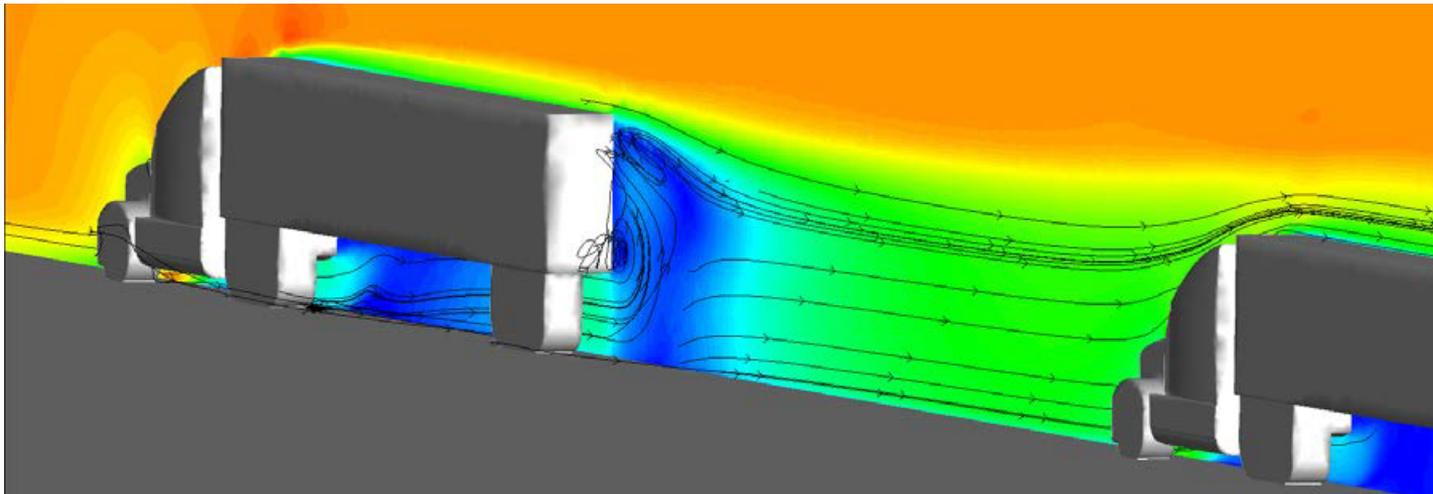
Eco GlidePath at Signalized Intersections



Source: USDOT, November 2013

Truck Platooning

- Two projects underway
 - Auburn U/Peterbilt (2-truck platoons)
 - Caltrans/UC Berkeley/Volvo (3-truck platoons)
- Concept: longitudinal control only; all drivers steer



Conclusion – Technical and Policy Challenges

- Public expectations and understanding
- Human factors
- Data ownership, privacy, and cybersecurity
- Testing and certification complexity
- Harmonizing state and local regulations



For More Information

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AMERICANS WITH DISABILITIES ACT

Current Research

- + Strategic Plan 2015-2019
- + Safety
- + Mobility
- + Environment
- + Road Weather
- + Policy
- + Connected Vehicle Technology
- + Intermodal Research
- + Exploratory
- + ITS Cross-Cutting Support
- + Success Stories

All Research >>

Spotlight

September 8, 2015
USDOT Releases Dedicated Short Range Communications (DSRC) Spectrum Sharing Test Plan ... [Read more](#)

August 18, 2015
Report from the 2015 Automated Vehicles Symposium (AVS 2015) in Ann Arbor, Michigan ... [Read more](#)

July 14, 2015
Release 2.2 of the Research Data Exchange and New Connected Vehicle Data Sets Are Now Available. ... [Read more](#)

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Public Meetings & Webinars

Connected Vehicle Basics

CV Pilots Deployment Project

Planning for the Future of ITS

ITS 2015-2019 STRATEGIC PLAN

f t e r +

<http://www.dot.gov/>

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