



22nd ITS World Congress

Towards Intelligent Mobility – Better Use of Space

GPS 2: Big Data – The Real Value of Your Social Media Accounts

October 7, 2015

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(ITS JPO)

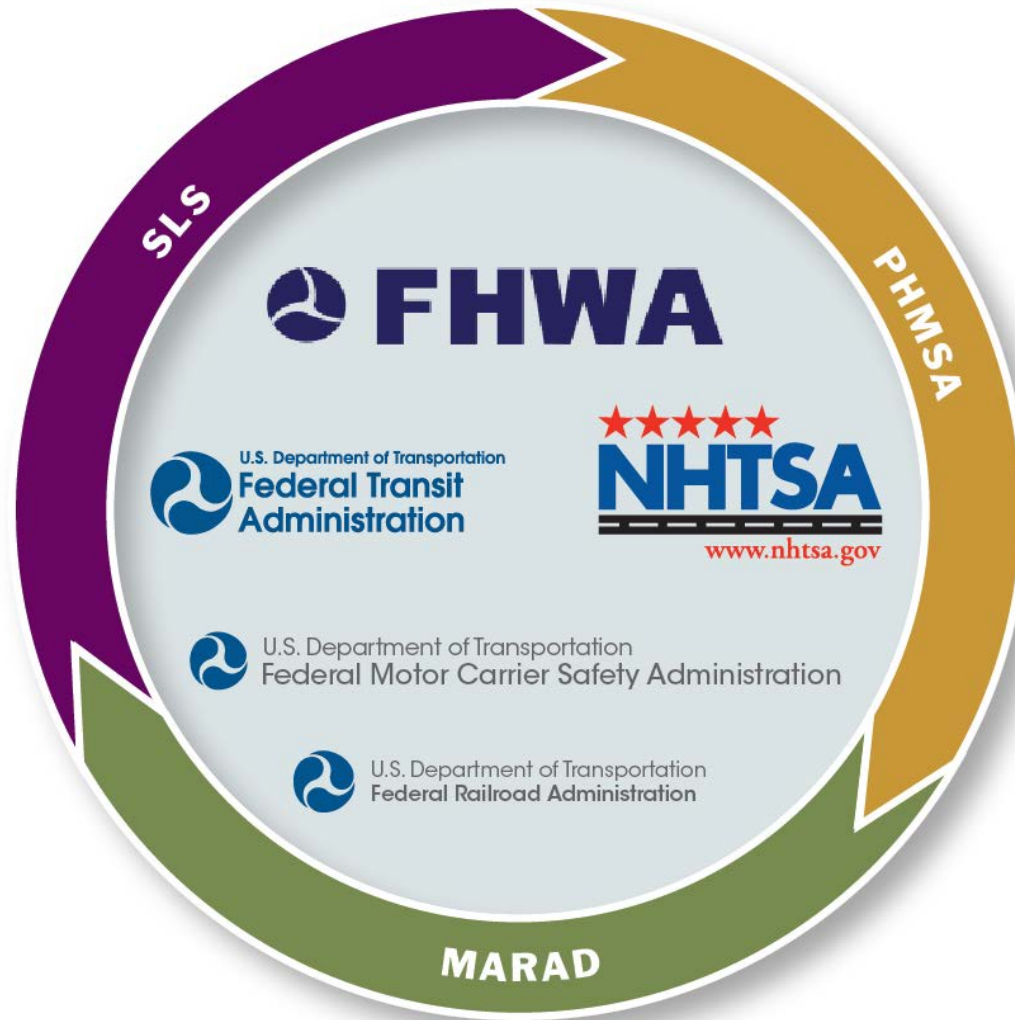
U.S. Department of Transportation (USDOT)

Outline

- USDOT ITS JPO
- USDOT Multimodal Collaboration
- ITS JPO Vision and Mission
- Where We're Headed – the *ITS Strategic Plan*
- Connected Vehicles
 - USDOT Decision on Connected Vehicles
 - Connected Vehicle Timeline
 - Connected Vehicle Pilots
 - Potential Data Explosion
 - Data Capture and Management
 - Big Data and Transition to Connected Data Systems



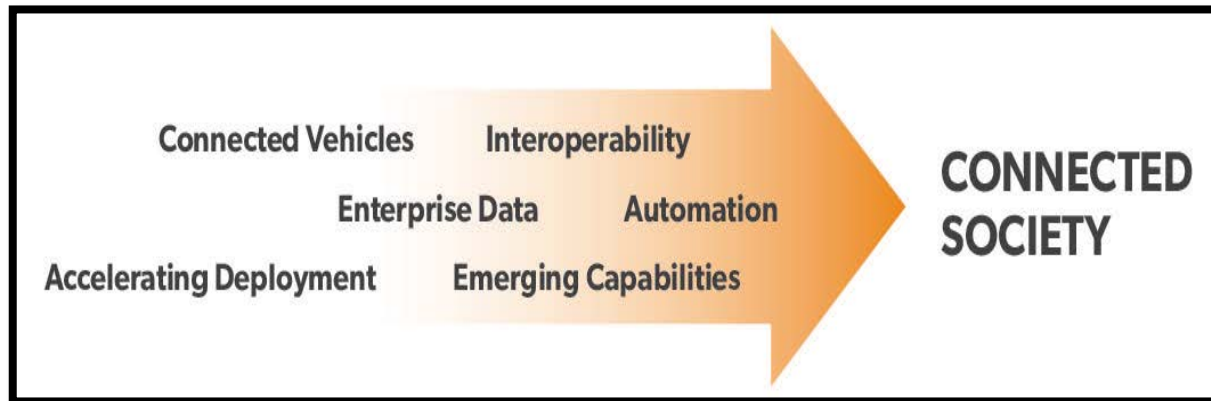
USDOT Modal Collaboration and Partnership



ITS JPO Vision and Mission

VISION

Transform the Way Society Moves



MISSION

Conduct research, development, and education activities to facilitate the adoption of information and communication technology to enable society to move more safely and efficiently.

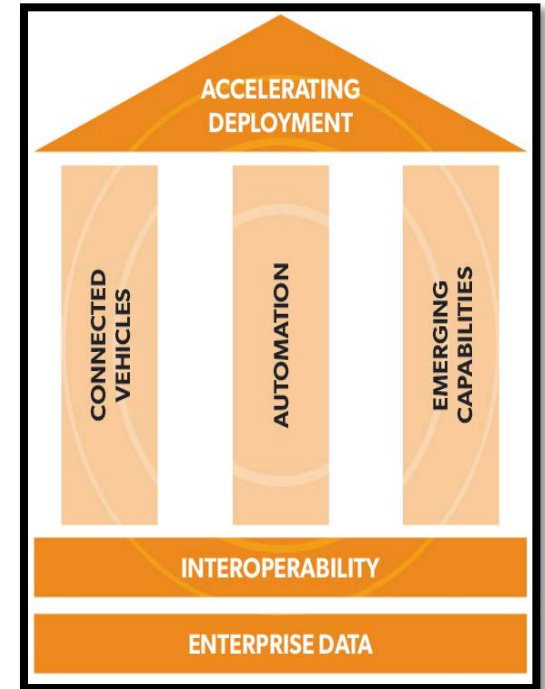


ITS Strategic Plan 2015-2019



Program Categories

- **Connected Vehicles** program category will be primarily focused on adoption and eventual deployment of the system.
- **Automation research** will focus on topics related to automated road-vehicle systems and related technologies that transfer some amount of vehicle control from the driver to the vehicle.
- **Emerging Capabilities** will focus on future generations of transportation systems.
- **Enterprise Data** programs will continue existing efforts in operational data capture from stationary sensors, mobile devices, and connected vehicles, and expand into research activities involving the development of mechanisms for housing, sharing, analyzing, transporting, and applying those data for improved safety and mobility across all modes of travel.
- **Interoperability** focuses on how to ensure effective connectivity among devices and systems.
- **Accelerating Deployment** advances the work from adoption to wider scale deployment in coordination with several other DOT agencies.



Connected Vehicles

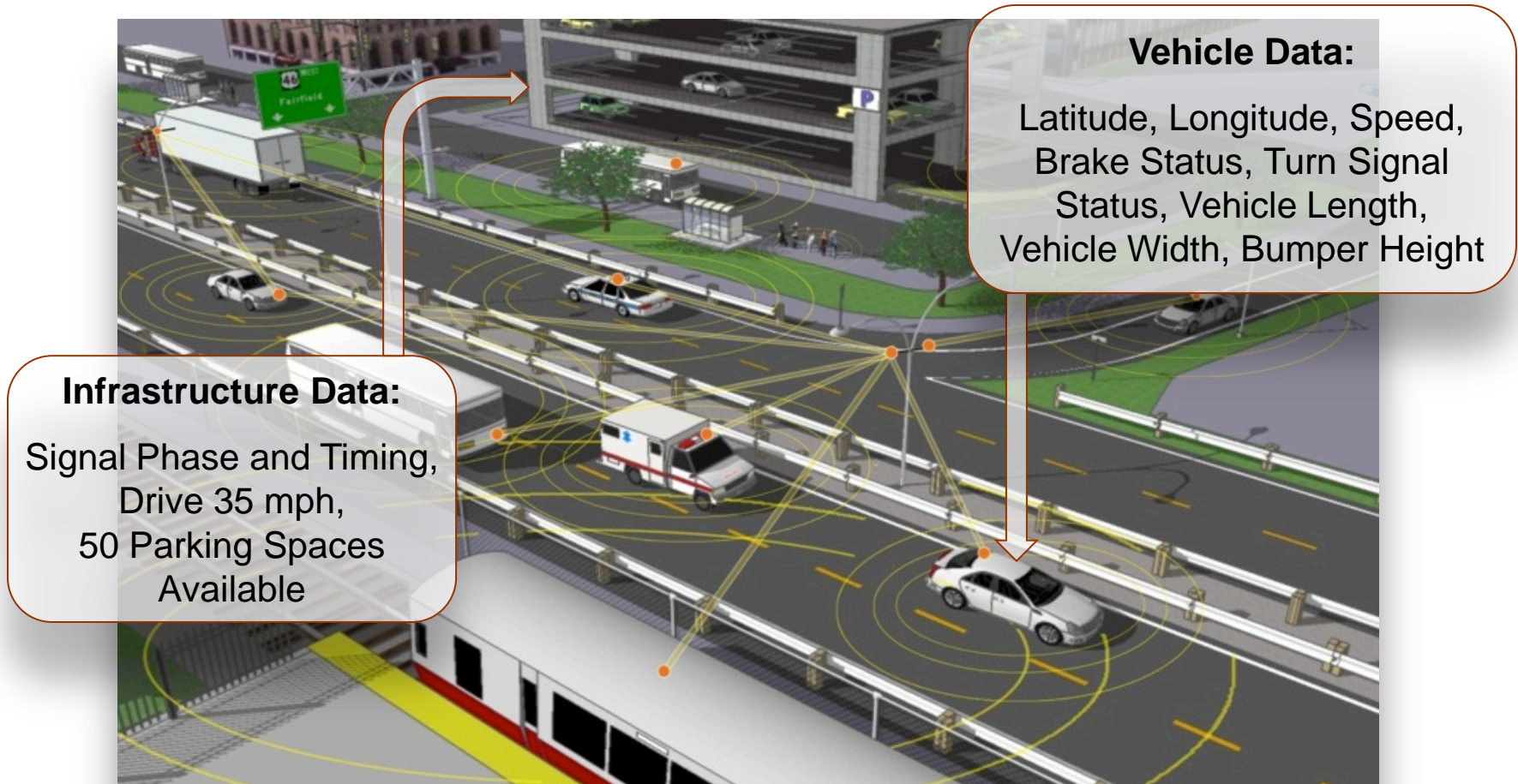
Connected vehicles are the future of transportation:

- Connected vehicles can save lives by significantly reducing traffic accidents
- Connected vehicles can make travel easier, more efficient, and more enjoyable
- Connected vehicles can help curb pollution
- Connected vehicles include all modes of transportation as well as pedestrians
- Connected vehicle research is a partnership between the USDOT, the auto industry, and other public and private researchers
- Connected vehicles are not a threat to your privacy



Connected Vehicle Concept

A connected vehicle system is based on wireless communication among vehicles of all types and the infrastructure.



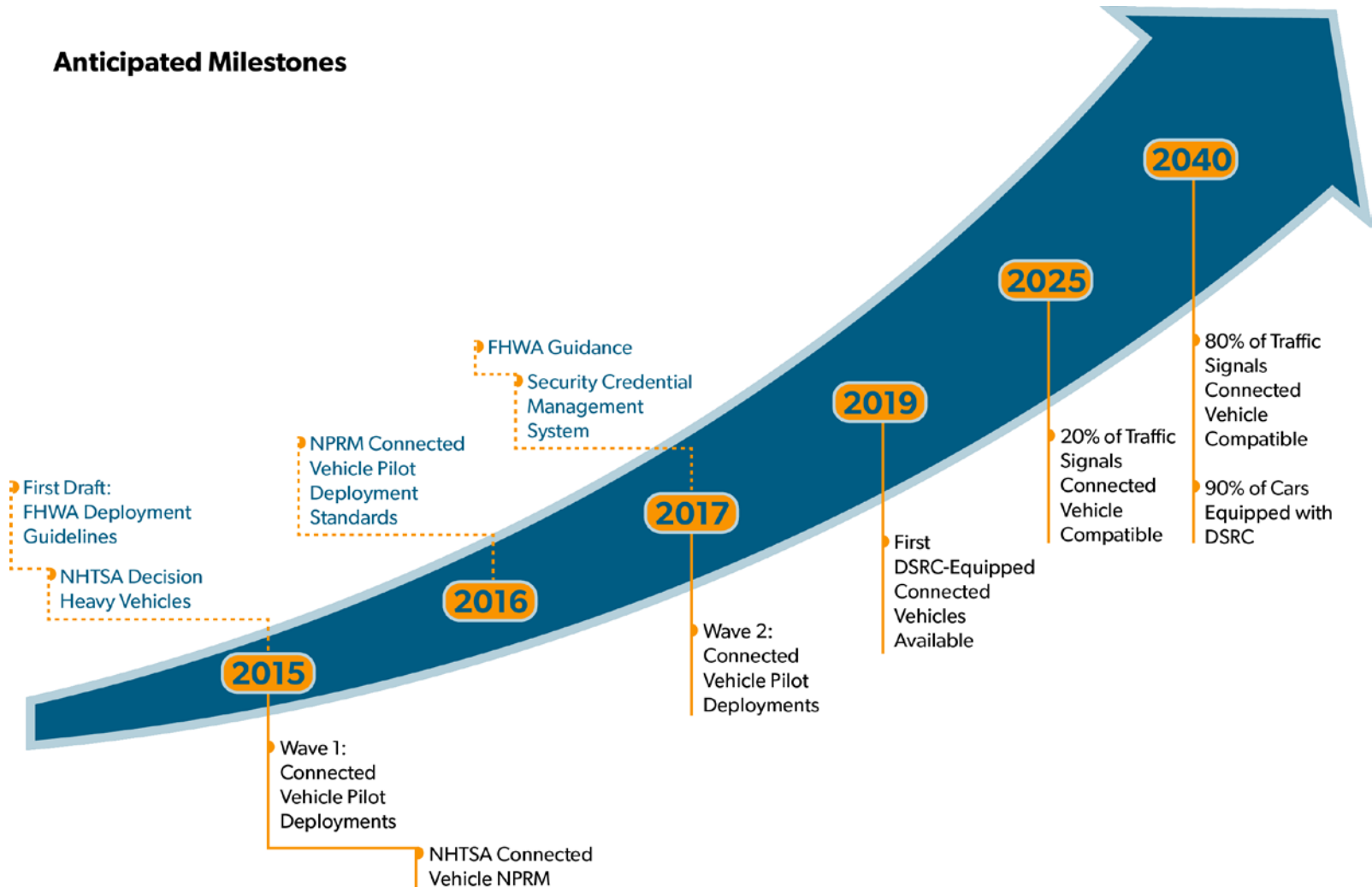
USDOT Decision on Connected Vehicles

- 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 2015, rather than 2016.
- In the fall 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 connected vehicle technology are expected to be available by 2016.



Connected Vehicle Timeline

Anticipated Milestones



Connected Vehicle Pilot Deployment Program

CV Pilot Program Goals



Proposed Program Schedule

- Summer-Fall 2014 - Regional Pre-Deployment Workshops/Webinars
- Early 2015 - Solicitation for Wave 1 Pilot Deployment Concepts
- September 2015 - Wave 1 Pilot Deployments Awards
- Early 2017 - Solicitation for Wave 2 Pilot Deployment Concepts
- September 2017 - Wave 2 Pilot Deployments Award(s)
- September 2020 - Pilot Deployments Complete

Resources

- ITS JPO Website: <http://www.its.dot.gov/>
- CV Pilots Program Website: <http://www.its.dot.gov/pilots>



Wyoming



New York
City



Connected Vehicle

Pilot Deployment Program



Tampa, Florida



Potential Data Explosion With Connected Vehicle Deployment



- Safety Pilot Model Deployment, Ann Arbor, MI
 - 2836 vehicles generating Basic Safety Messages on 73 miles of freeways and arterials (approx. 2% of vehicles)

Data Statistics	October 2012	April 2013
Number of Unique Vehicle IDs	1626	2069
Number of BSMs generated	1.3 Billion	2.7 Billion
BSM Storage Space	96 GB	197 GB

Challenges

- Data explosion imminent as connected vehicle research evolves to deployment phase
 - Significant challenges to data management and data analytics
- Will data communications swamp available channels?

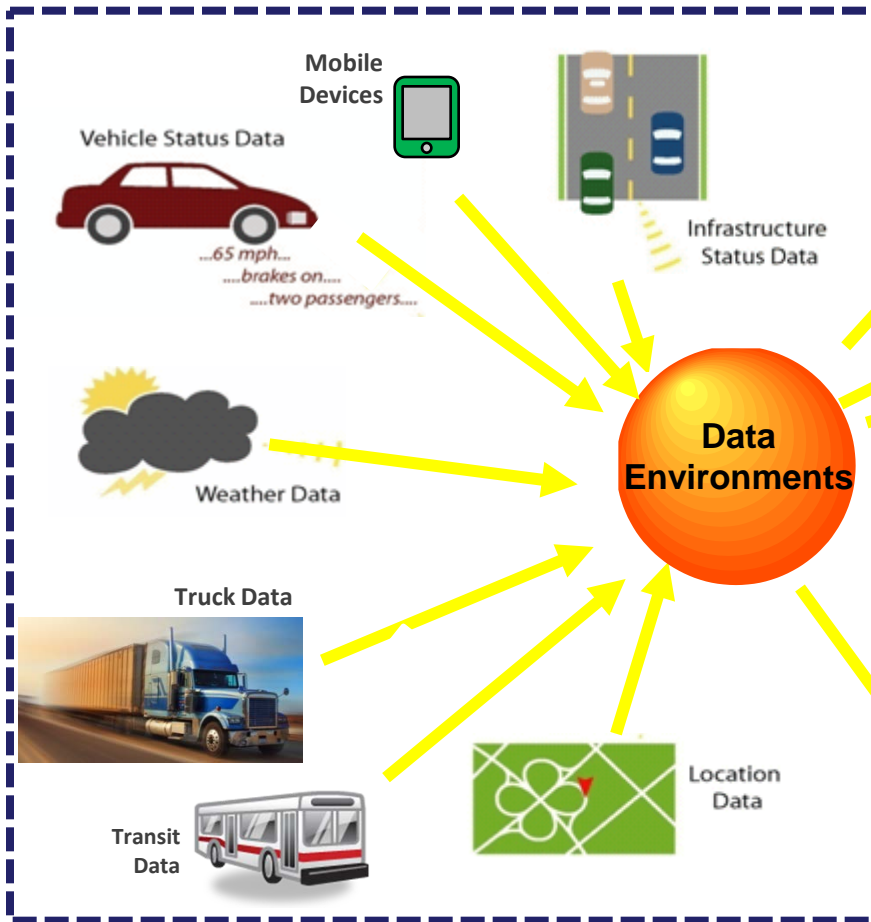
Opportunities

- Use large amount of data collected from connected vehicles for better traffic management through enhanced situational awareness and prediction
 - Improve accuracy and speed of decision-making, thereby facilitating proactive management
 - Affords capability to determine causality of transportation problems, such as crashes, bottlenecks, delays, etc.
 - Provides comprehensive and accurate view of transportation systems



Real-time Data Capture and Management

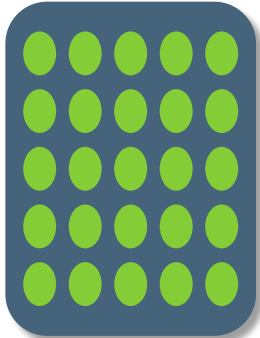
Real-time Data Capture and Management



Connected Vehicle Applications

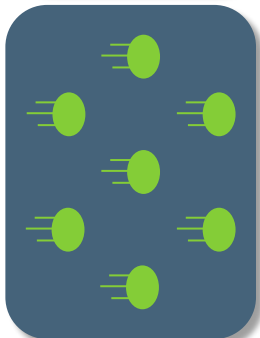


What is Big Data?



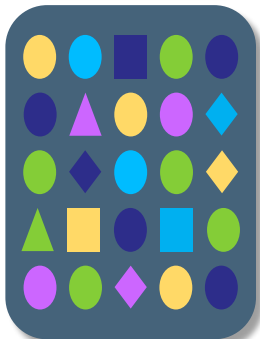
Volume

Use greater amounts of data



Velocity

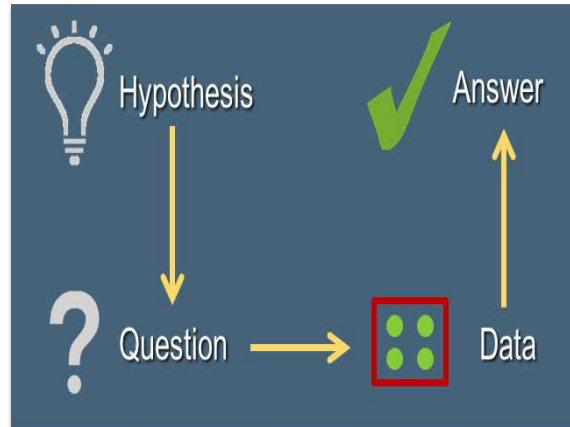
Use data more quickly



Variety

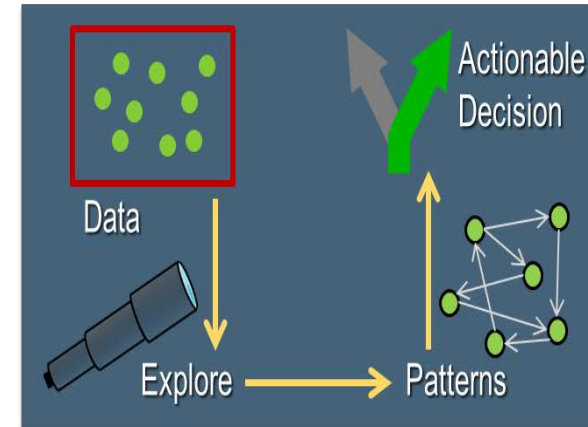
Use more types of data

Traditional Approach



Hypothesize – test against subset of data that has been cleansed

Big Data Approach: Data Leads the Way



Explore all data as is – identify patterns – take action

- Exceeds capabilities of conventional tools
- Requires alternative or new solutions
- Requires high performance computing and advanced analytics



USDOT Big Data Research is Addressing Specific Questions and Challenges

Example Big Data Research (by Category)

Example Questions Addressed

Big Data Capture and Management

Research Data Exchange (RDE)

How can very large connected vehicle data sets be stored and made accessible to many researchers and developers?

Operational Data Environment (ODE)

How can connected vehicle data be integrated and aggregated in a real-world, operational connected vehicle environment and be provided to all applications and users?

Dynamic Interrogative Data Capture (DIDC)

How can the volume of connected vehicle data be reduced to more manageable levels without comprising functionality?

Crowdsourcing Research

How can travelers and citizens serve as potential data and information sources?

Big Data Analytics

Graph Analytics for Connected Vehicles – Bottleneck Prediction

How can big data analytics, such as graphic network techniques, be applied to predict traffic congestion?

Using Big Data for Transportation Operations

Big Data for Next Generation Integrated Corridor Management (ICM)

How can big data tools and techniques be applied within a real-world transportation system management strategy?

Agency Readiness for Big Data – Transitioning to a Data Culture

How must transportation agencies change in order to effectively incorporate big data strategies?

Connected Cities Research

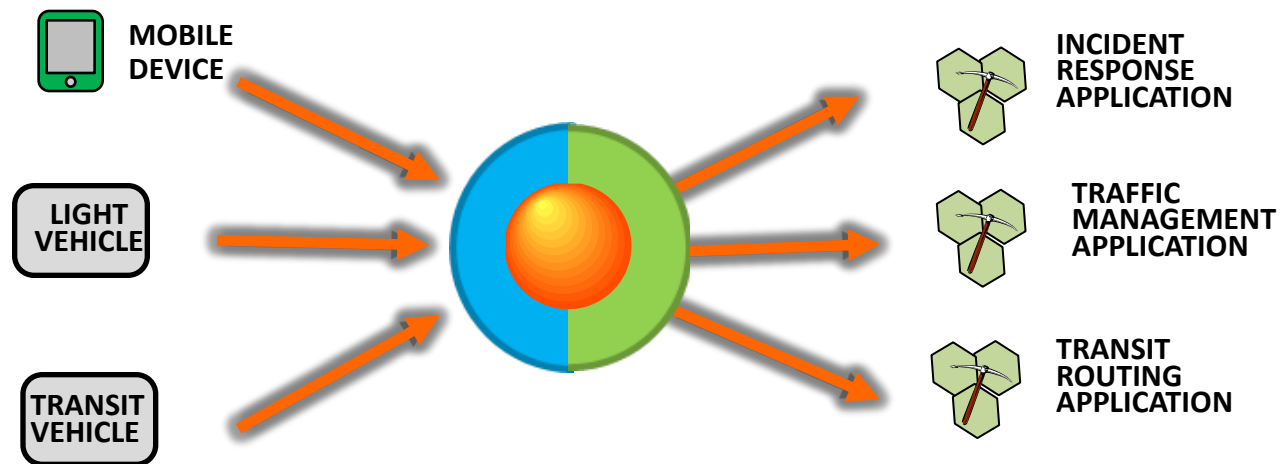
How will connected and automated vehicles and other aspects of a dynamic, multi-modal and integrated transportation system link with the other elements of a Connected City?



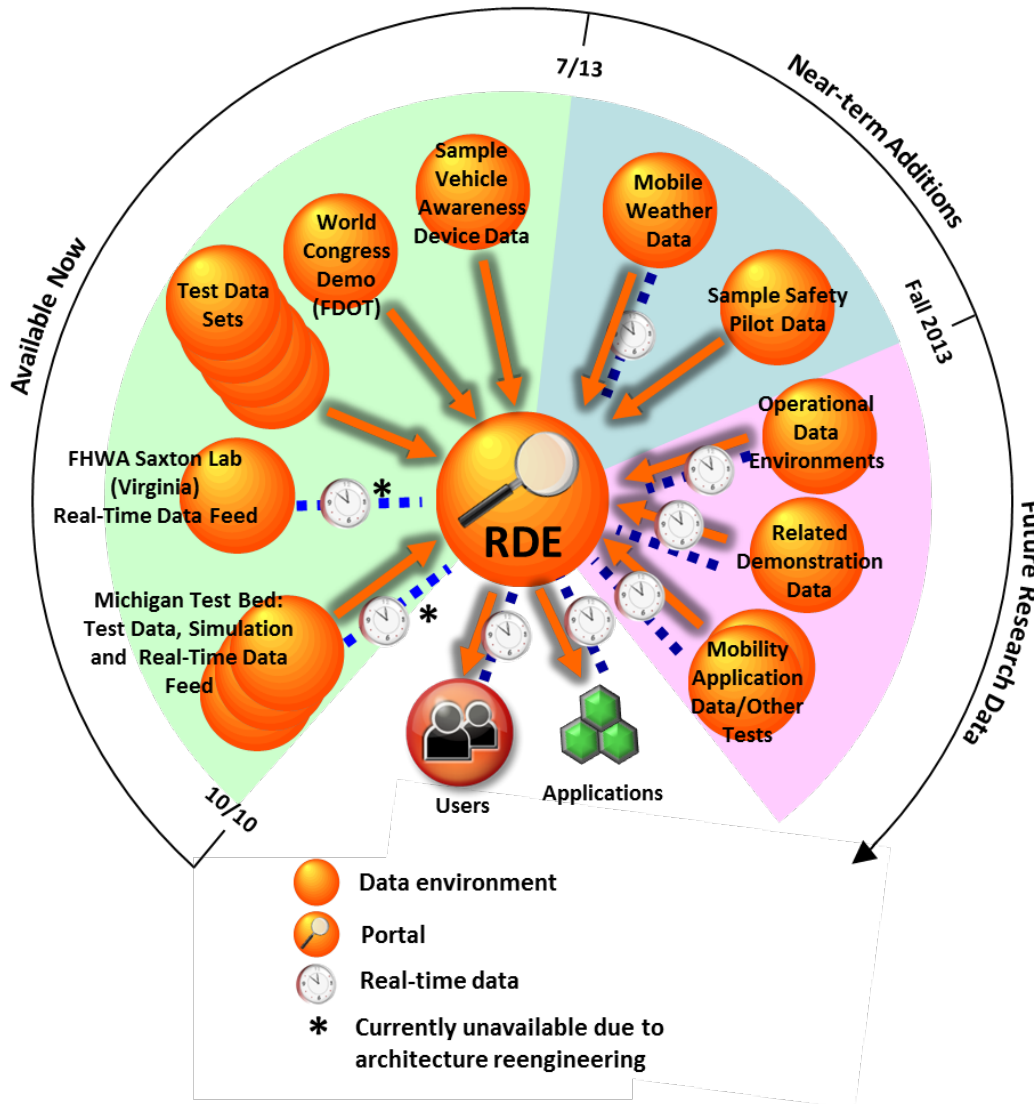
Operational Data Environment (ODE)

Establish a prototype ODE to demonstrate the feasibility of real-time data integration and aggregation for implementing connected vehicle applications

- Emulate a connected vehicle application in an operational setting.
- Assess the technical difficulties and risks associated with ODEs
- Develop and test procedures for collecting, validating, and distributing connected vehicle data using anticipated messages.
- Step towards cloud computing



Research Data Exchange (RDE)



What is the RDE?

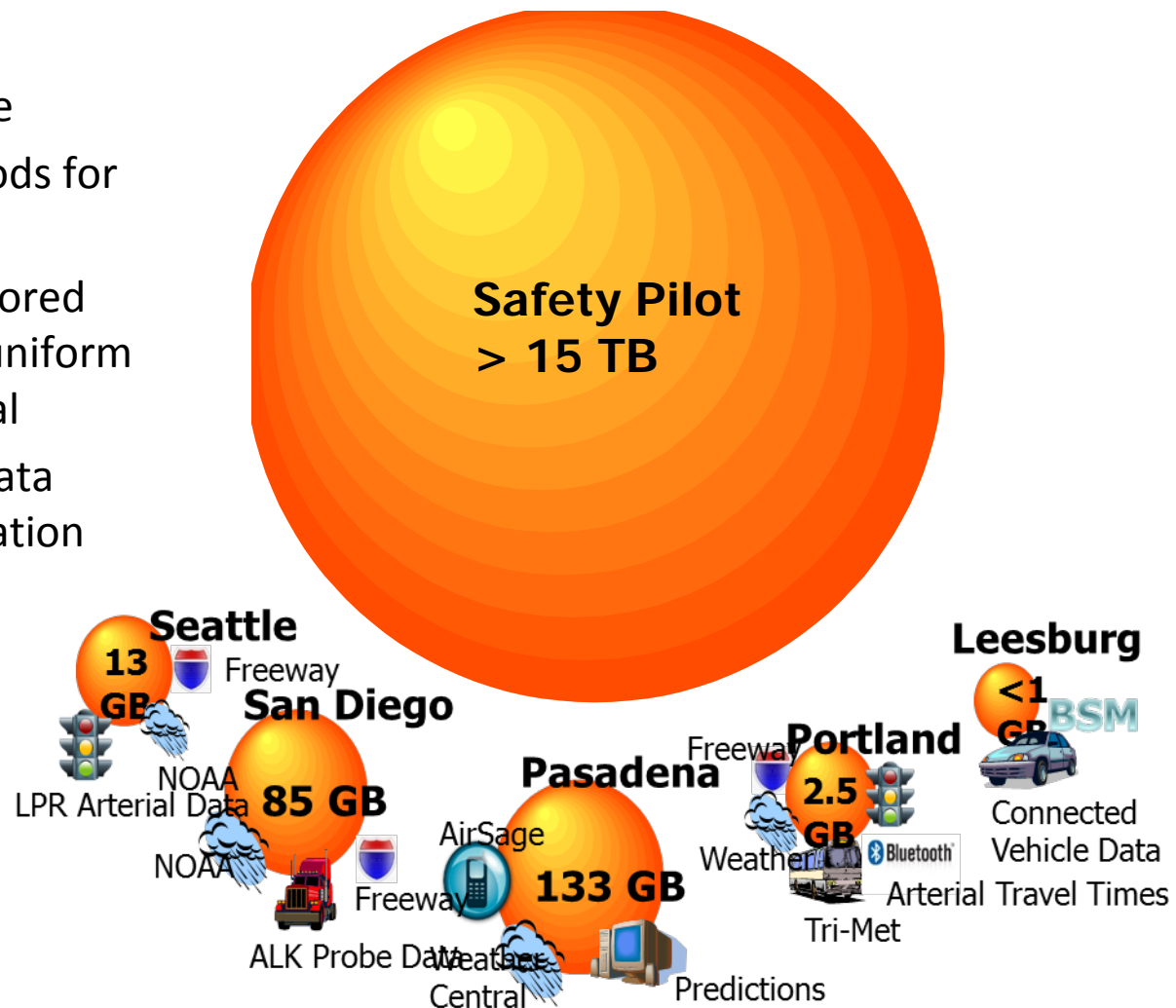
- The Research Data Exchange (RDE) is the connected system of data environments supporting application research and development

What is included in the RDE?

- Real-time and Archived Data
- Research Projects
- Advanced Search Capabilities
- FAQs
- External Links
- Contact Information
- Standard Metadata documentation

Expanding RDE to Handle Big Data

- RDE Data in Cloud Storage
- Expanding delivery methods for large data sets
- Federating to remotely stored data environments with uniform access through data portal
- Research into real-time data quality checks and integration



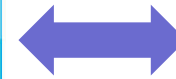
Transition to Connected Data Systems

- Connected Data Systems will support:
 - The move from connected vehicle research to deployment
 - Crowdsourcing and other mass data collection trends
 - Automated vehicles and “connected cities” initiatives
- Objectives involve developing the ability to gather, manage, and use huge amounts of data



Crowdsourcing: Travelers/Citizens as Potential Data and Information Sources

- **Crowdsourcing** = the practice of obtaining needed services, ideas, or content by soliciting contributions from a large group of people and especially from the online community rather than from traditional employees or suppliers¹
- Types of crowdsourcing:
 - **Active** = users explicitly provide input
 - **Passive** = data automatically collected
 - Agency collects **directly** from users
 - Agency purchases from private, 3rd party **suppliers**
- Key issues and challenges that need to be addressed include: privacy, incentivization, and data reliability



Example (Passive):
“Mining” social media or using social Media for a two-way dialogue



Example (Active):
Traveler provides input via an agency-developed smartphone application

¹ <http://www.merriam-webster.com/dictionary/crowdsourcing>, accessed 9/3/2014

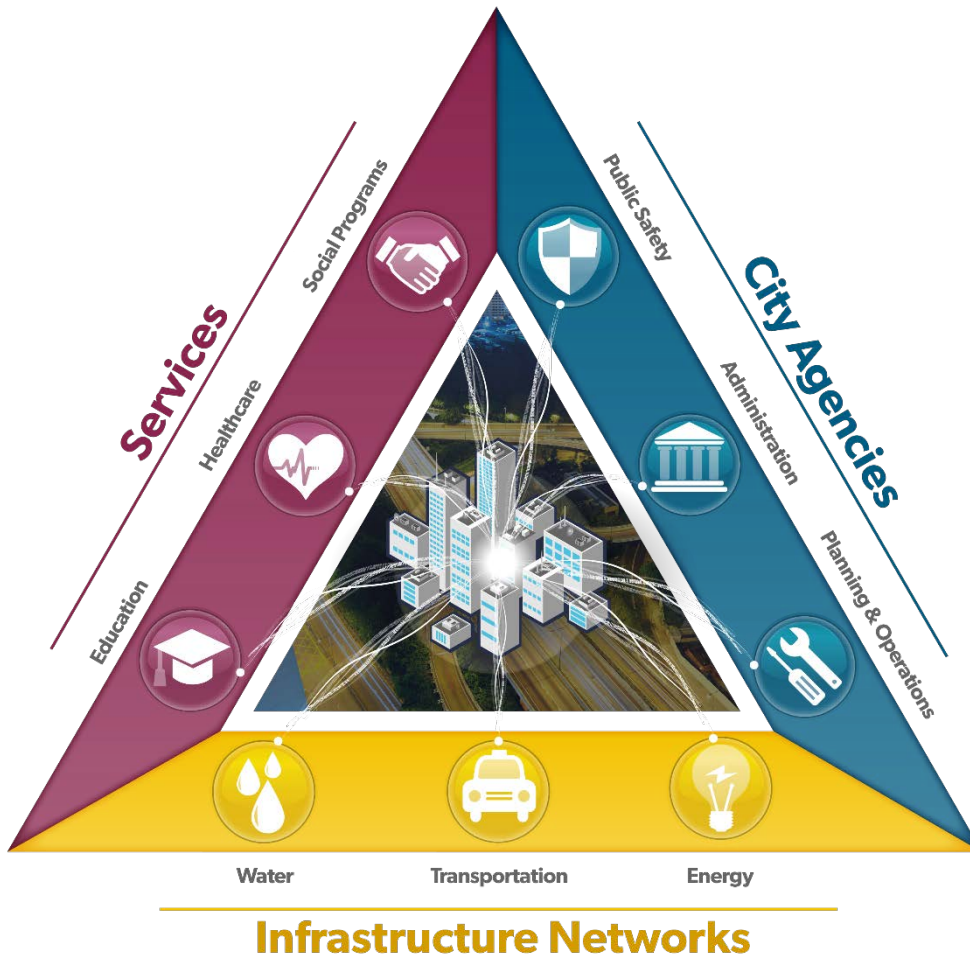


Examples of Current USDOT Crowdsourcing Research

- **Benefits of Crowdsourced Data for Transportation Management Centers**
 - State of the practice
 - Public vs. private roles
 - Value of data for specific activities
 - Challenges and issues
- **Nomadic Devices**
 - For mobility data capture and more effective and flexible tools for acquiring travel decision data
 - Two awards in 2013:
 - University of Minnesota: SmartTrAC - Smartphone app fusing sensor data with maps and strategic user queries to learn traveler behavior
 - Massachusetts Institute of Technology: CloudCar - Smartphone app integrated with prototype vehicle-based mobility data capture system and online data environment



Connected Cities Research



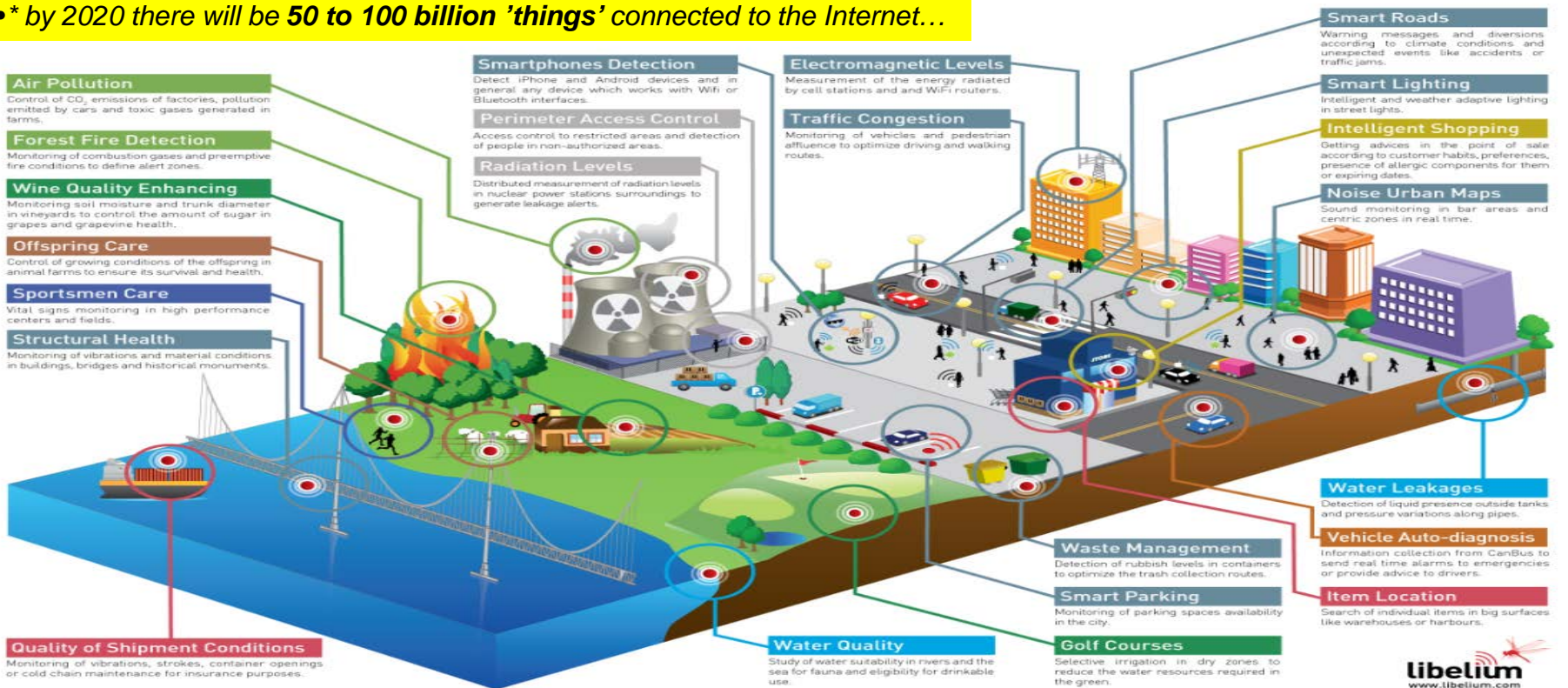
- **Connected City** = a system of interconnected systems that communicate with and leverage each other to provide synergistic benefits.
 - Use collective **“intelligent infrastructure”** to sense what’s around them and/or their own status to provide rich situational awareness
 - Utilize new **analytical processes**
 - Engage the connected citizen, allowing and encouraging **fully informed personal mobility** and other choices
 - Utilize solutions across **all transportation modes**, including transit, bicycle, electric vehicles and shared mobility services.



Internet of Things (IoT)

- A digital “nervous” system for the things that comprise our surroundings
- Pervasive sensors and actuators on fixed and mobile devices
- Data made widely accessible via networks

• * by 2020 there will be 50 to 100 billion 'things' connected to the Internet...



Source: Noblis

USDOT Automation Program Goal

The USDOT automation program will position industry and public agencies for the wide-scale deployment of partially automated vehicle systems that improve safety and mobility and reduce environmental impacts.



Agency Readiness for Big Data: Transitioning to a Data Culture

- How is big data different from current approaches?
- What new tools and workforce capabilities may be needed?
- How much will be contracted from the private sector?
- How to link to broader trends transforming transportation agencies?
- Are new relationships with Information Technology (IT) departments needed?

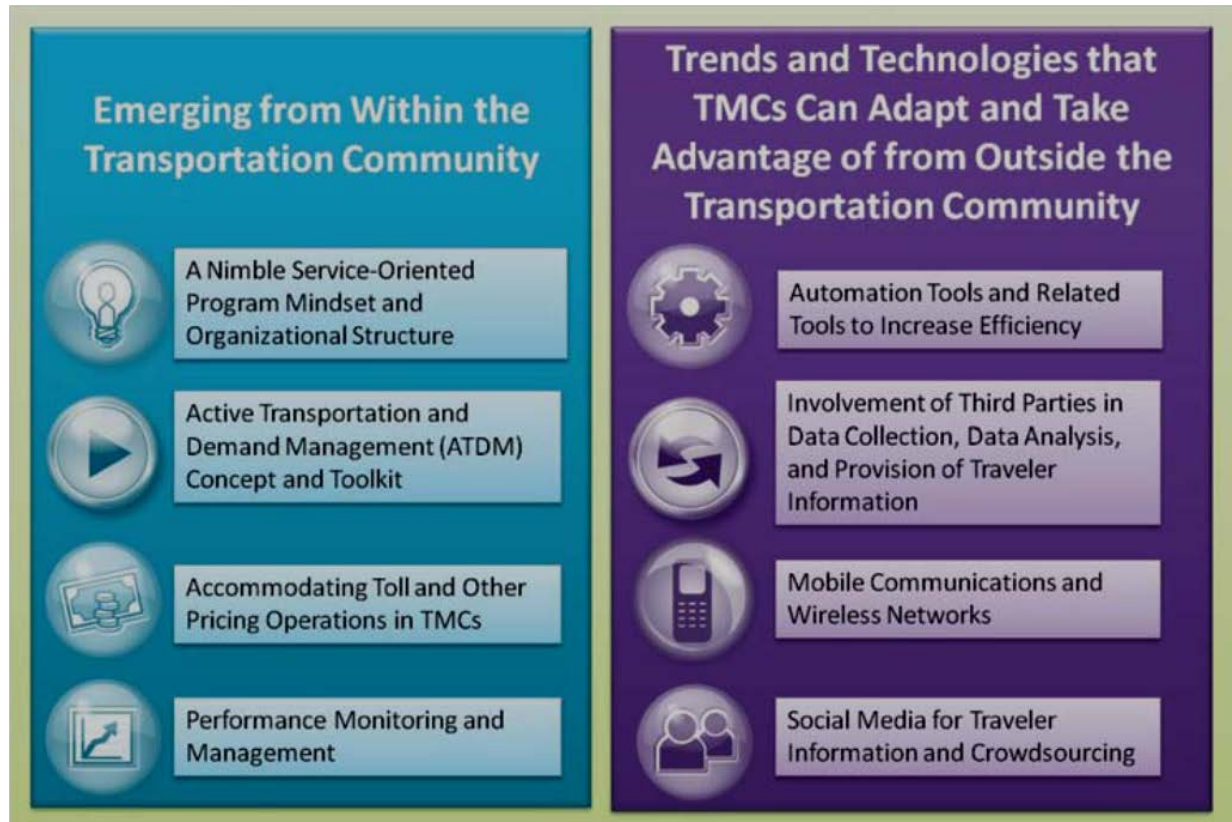


Image Source: USDOT-FHWA/Parsons Brinkerhoff. "Impacts of Technology Advancements on Transportation Management Centers." January 2013

Research Plans – Data Program

- Research and test methods for collecting and processing the petabytes of data that will be generated by connected vehicles, mobile devices, and roadside sensors
- Develop, adapt, and provide data visualization techniques that will facilitate the use of Big Data for research
- Develop traffic analysis and management techniques that take advantage of crowd-sourced data from thousands of connected travelers using social media
- Coordinate the operation of mobile devices carried by travelers who are passengers on transit vehicles which are themselves generating connected vehicle messages
- Develop techniques such as Dynamic Interrogative Data Capture that will reduce the amount of data that needs to be saved depending on the situation.



For More Information

United States Department of Transportation
Office of the Assistant Secretary for Research and Technology
Intelligent Transportation Systems
Joint Program Office

Planning for the Future of ITS
ITS 2015-2019 STRATEGIC PLAN

The U.S. Department of Transportation's plans for the future of ITS Research are available now!

FREE ITS TRAINING

Public Meetings & Webinars

Connected Vehicle TEST BED

CV Pilots Deployment Project

ITS & YOU

Current Research

- + Safety
- + Mobility
- + Environment
- + Road Weather
- + Policy
- + Connected Vehicle Technology
- + Short-Term, Intermodal Research
- + Exploratory
- + ITS Cross-Cutting Support
- + Success Stories

All Research >>

Spotlight

December 10, 2014
The U.S. Department of Transportation Plans for the Future of Intelligent Transportation Systems (ITS) ...
Read more

December 10, 2014
The Connected Vehicle Reference Implementation Architecture (CVRIA) Training Course Is Now Available ...
Read more

August 12, 2014
The USDOT Connected Vehicles Pilot Deployment Program Webinar Series Part 1: Concept, Phases, Waves, and Partnerships with Kate Hartman ...
Read more

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Thank You!



Questions or Comments?



Backup Slides



Big Data Research Questions

- Our research will be addressing such transportation-related Big Data questions as:
 - How do transportation services and connected vehicle technologies, data, and applications intersect with other sectors of the economy (i.e., energy, telecommunications, public safety, public works, public transit, logistics, industry, public health, retail, etc.) and how can these sectors leverage technology for the overall benefit of a jurisdiction?
 - How can connected vehicle data—along with transportation data and other data available in a smart/connected city—be used to create innovative and informative real-time visualization techniques to support decision making by public agencies and connected travelers?
 - What are the most effective and innovative real-time data visualization techniques for transportation decision making by public agencies and connected travelers? Who is doing state of the art real-time data visualization—both in transportation and in other sectors? What products and associated trends are resulting from these efforts?



Enterprise Data

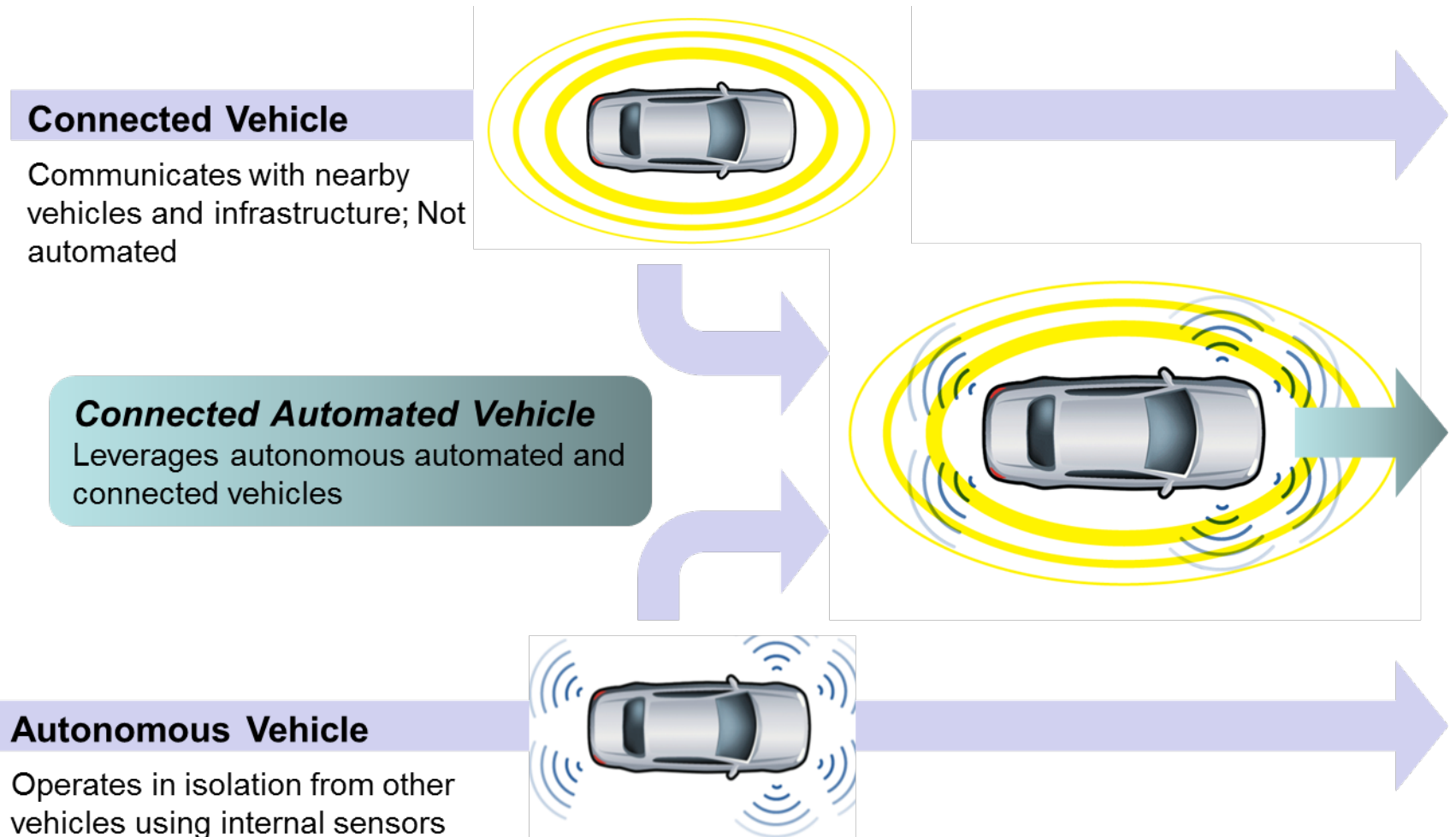
We want to facilitate transportation information sharing as part of a Connected City:

- Connected data systems
- Connected cities – sharing and using data to improve operations
- Decision support systems to perform real-time analytics
- Support transportation in the Internet of Things



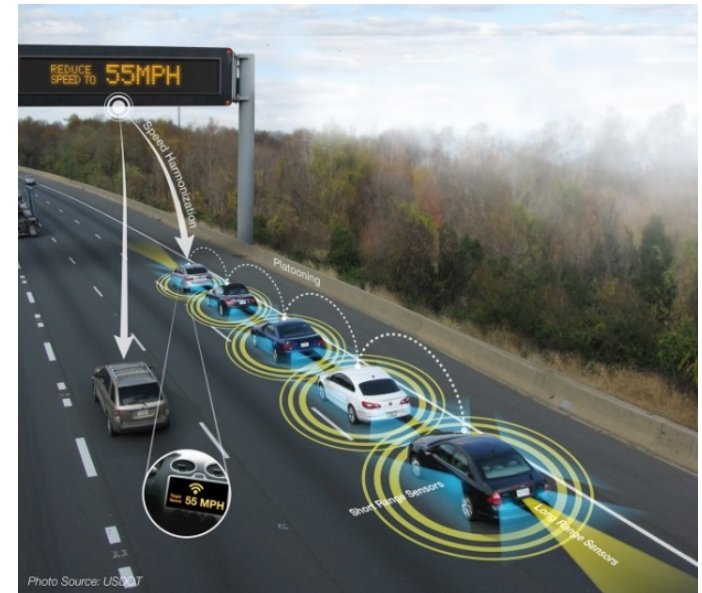
From Connected to Automated Vehicles

The path toward connected vehicles will ultimately lead to automated vehicles.



Automation in Transportation

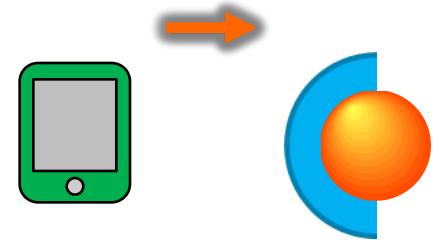
- Full automation has the potential to revolutionize the transportation system but requires careful study
- Partial automation will likely provide significant transportation system benefits
- Connectivity is critical to safe and efficient operations



Operational Data Environment Roles

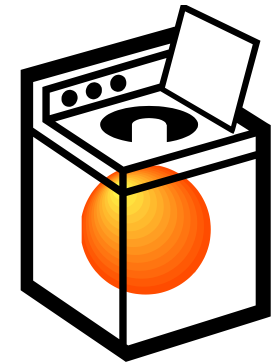
Data Collector

- Receives data from mobile and infrastructure sources
- Deals with security issues



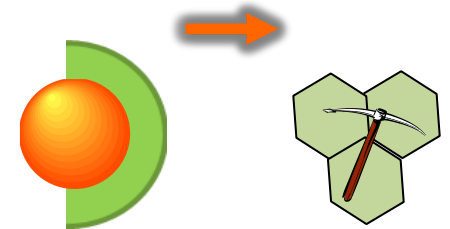
Data Cleaner

- Aggregates data
- Checks for quality and validity of the data



Data User

- Subscribes to the data
- Uses data to run a particular real-time application

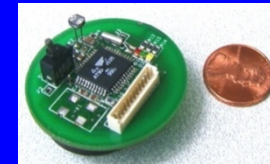


Dynamic Interrogative Data Capture (DIDC)

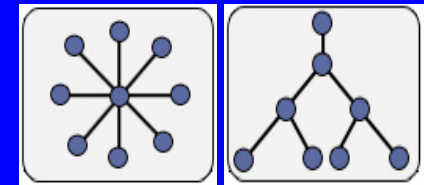
- A technique to manage the amount of data collected from connected vehicles, mobile devices, and associated roadside infrastructure
- The amount of data collected by any specific device, the level of data aggregation, and the frequency of transmission can vary dynamically based on the situation
- Potential to cut communications and energy costs up to 99% compared with fixed interval approaches -- with same impact

Example of DIDC Concept

*Wireless Sensor Networks (WSNs):
Adaptive management of
data flow in complex systems*



*Mote
Technology*



Example WSN Topologies



Graph Analytics for Connected Vehicles – Bottleneck Prediction

Pre-Processing

Divides network into boxes and calculates box speeds for every minute

Defined 30.5 m (100 ft) long boxes using ArcGIS (91,266 on network)



Speeds for each box at 1-min intervals



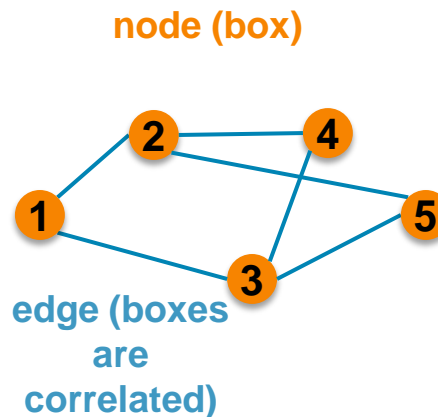
SP BSM tables

Box IDs, speeds

Pattern Recognition

Generates graph network of correlated boxes

Hypothesis: Behaviors observed in a box will be repeated in boxes that are highly correlated



Graph networks of correlated boxes

Prediction

Predicts congestion states based on observed behaviors in correlated boxes on similar days*

Predicted congestion state* for a box on given day at a future time step is:



Congestion state for box on given day at current time step



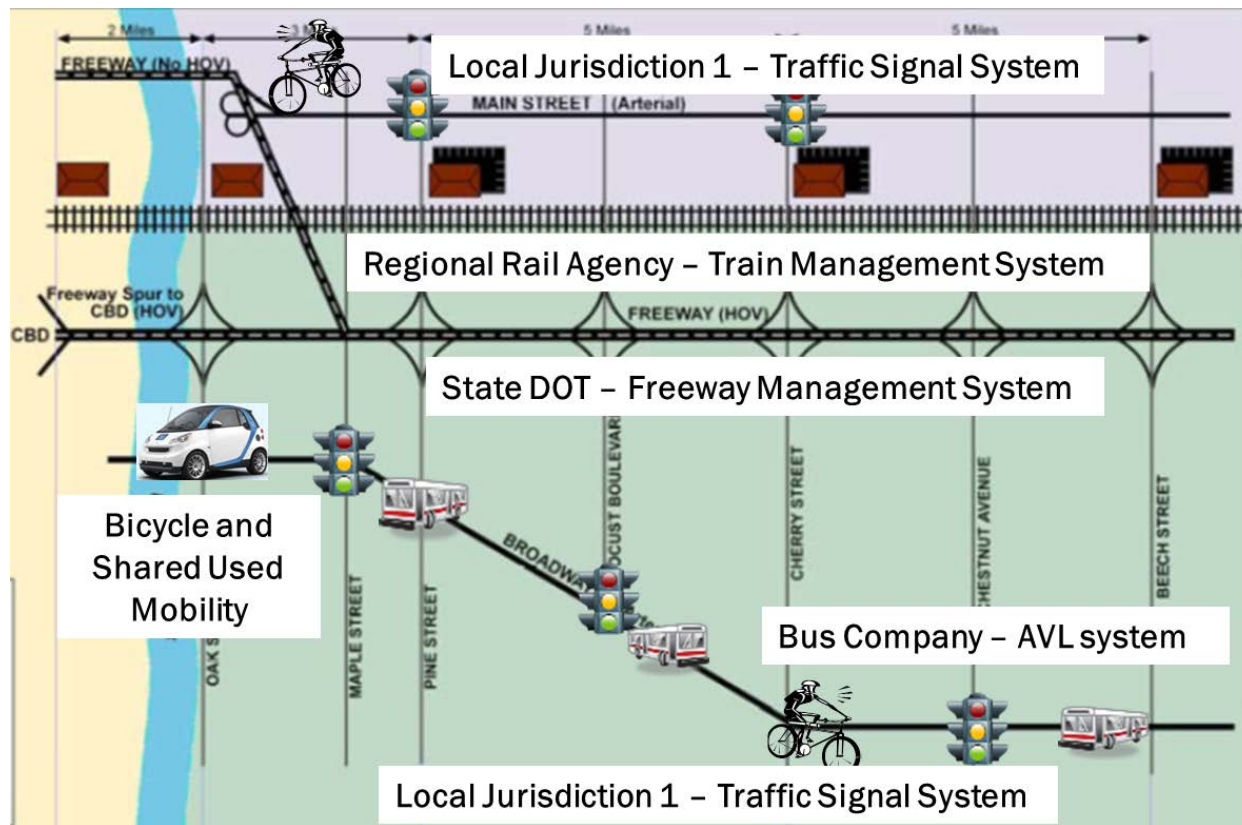
Changes observed in congestion state during the future time step on similar training days

*Congestion states defined based on speeds.



Big Data for Next Generation Integrated Corridor Management (ICM)

- How can big data techniques support:
 - Integration and sharing** of connected vehicle and traveler data?
 - Incorporation of additional **operational objectives**, such as economic, freight, transit
 - Situational awareness** (fusing data to assemble a comprehensive picture of real-time multi-modal system conditions)
 - Decision Support Systems**, including predicting conditions and recommending responses?



Integrated Corridor Management =
Actively managing a transportation corridor as an integrated, multi-modal system to spread demand over available capacity in time and space to enhance mobility

Image Source: USDOT

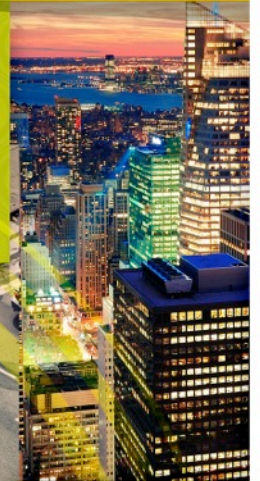


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ITS Joint Program Office



Photo Courtesy: MTA New York City Transit

New York City



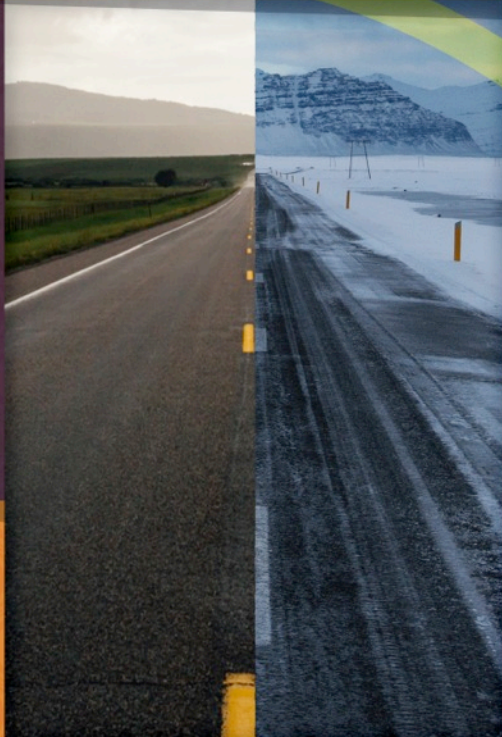


Tampa, Florida





Wyoming



Summary of USDOT ITS Program

- USDOT is successfully developing diverse ITS transportation solutions across vehicles and infrastructure
- ITS research is delivering real capability and value to states, industry, and the public
- The ITS JPO is addressing strategic issues in transportation in:
 - Connected Vehicles
 - Automated Vehicles
 - Enterprise Data
 - Interoperability
 - Technical Assistance and Deployment
 - Emerging Capabilities
- The *ITS Strategic Plan 2015-2019* is available at:
<http://www.its.dot.gov/strategicplan/>

