



U.S. Department of Transportation
Office of the Assistant Secretary for Research and Technology

Smart Cities and Transportation

New Jersey Department of Transportation
Bureau of Research Brown Bag Session

February 20, 2018

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ITS Joint Program Office, OST-R
U.S. Department of Transportation

Overview

- Introduction

- Transportation Challenges
- MultiModal Coordination

- US DOT ITS Portfolio

- Connected & Automated Vehicles
- Emerging Technologies

- Building Blocks for Smart Cities

- Initial Thinking
- Smart City Challenge and Award
- A Work in Progress

- Opportunities to Transform the way Society Moves



Transportation Challenges



•SAFETY

- 37,461 highway deaths in 2016
- 6.29 million crashes in 2015
- Leading cause of death for ages 11, 16-24



•MOBILITY

- 6.9 billion hours of travel delay
- \$160 billion cost of urban congestion



•ENVIRONMENT

- 3.1 billion gallons of wasted fuel
- 56 billion lbs of additional CO₂

Data Sources:

Quick Facts: 2016 Data, National Highway Traffic Safety Administration (October, 2017); 2015 Annual Urban Mobility Report, Texas Transportation Institute (Aug 2015); Centers for Disease Control

COORDINATING THE ITS ENVIRONMENT

Intelligent Transportation Systems Joint Program Office



U.S. Department of Transportation
Federal Highway Administration



U.S. Department of Transportation
Maritime Administration



U.S. Department of Transportation
Federal Transit Administration



U.S. Department of Transportation
Federal Motor Carrier Safety Administration



U.S. Department of Transportation
National Highway Traffic Safety Administration

•Automation

•Information
Technology

•SCMS: Security Credential
Management System

•Spectrum

•Knowledge
Transfer

•Standards
&
Architecture

•Smart
Infrastructure

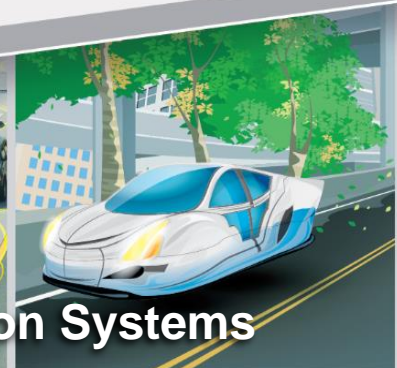
•Capacity
Building

•Big
Data

•Evaluation

•Certification

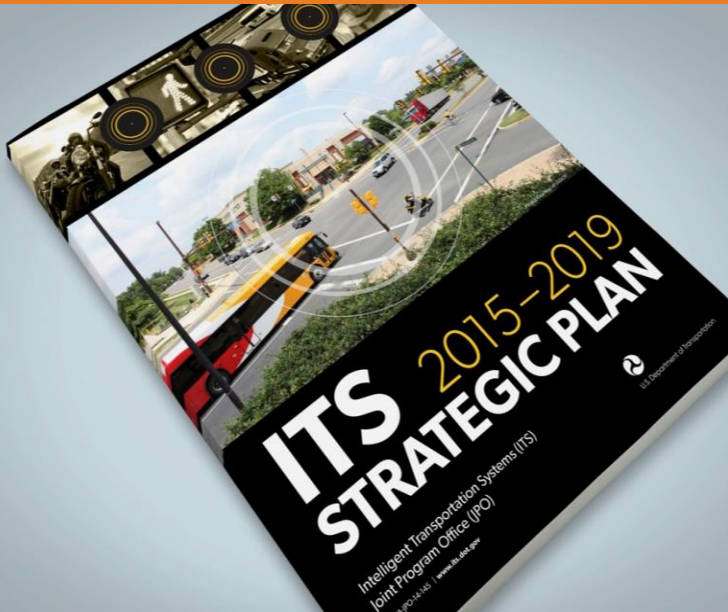
•Research
Projects



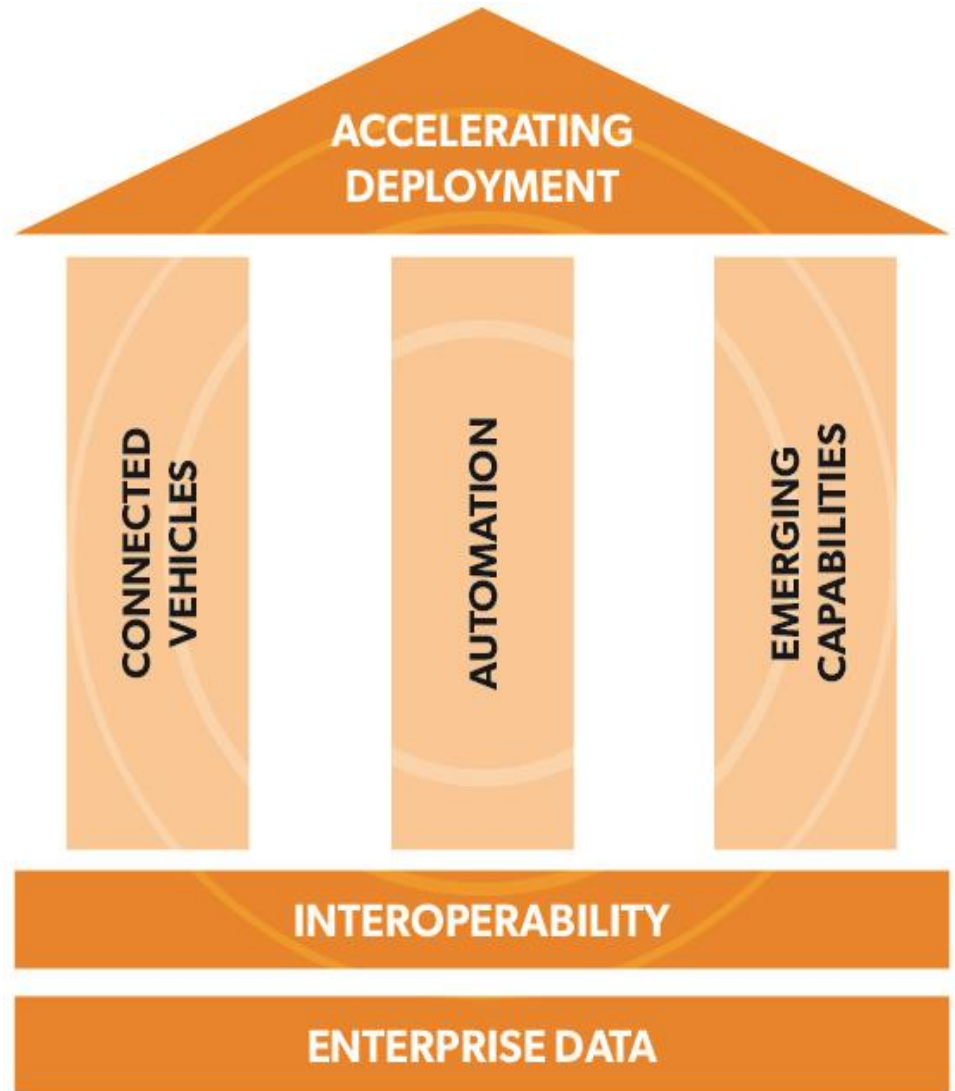
Connected, Automated, Smart Transportation Systems

Strategic Plan

Program Categories



<http://its.dot.gov/strategicplan/index.html>





- Secretary Elaine L. Chao
- U.S. Department of Transportation
- TG7 Transport Ministers Meeting

“Connected and automated driving -- technologies that are on the verge of transforming how we drive, work and live. In the not too distant future, automated vehicles will be talking to each other—and the surrounding infrastructure”

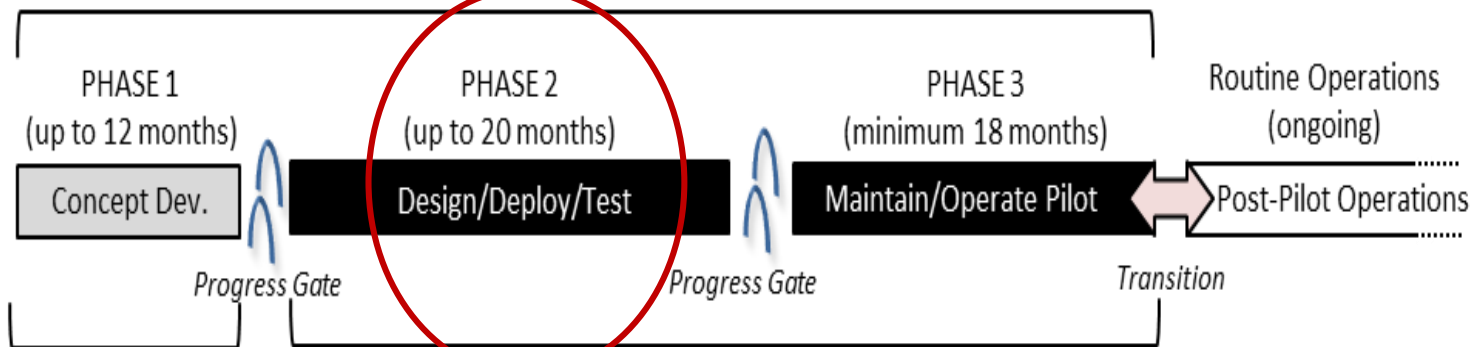
Imagine a Transportation System in which
**VEHICLES CAN SENSE &
COMMUNICATE**
Things That You Can't.



Connected Vehicle Pilot Deployment Program



Connected Vehicle Pilot Deployment (up to 50 months)



Follow-On Cooperative Agreement

PILOT SITES



New York City

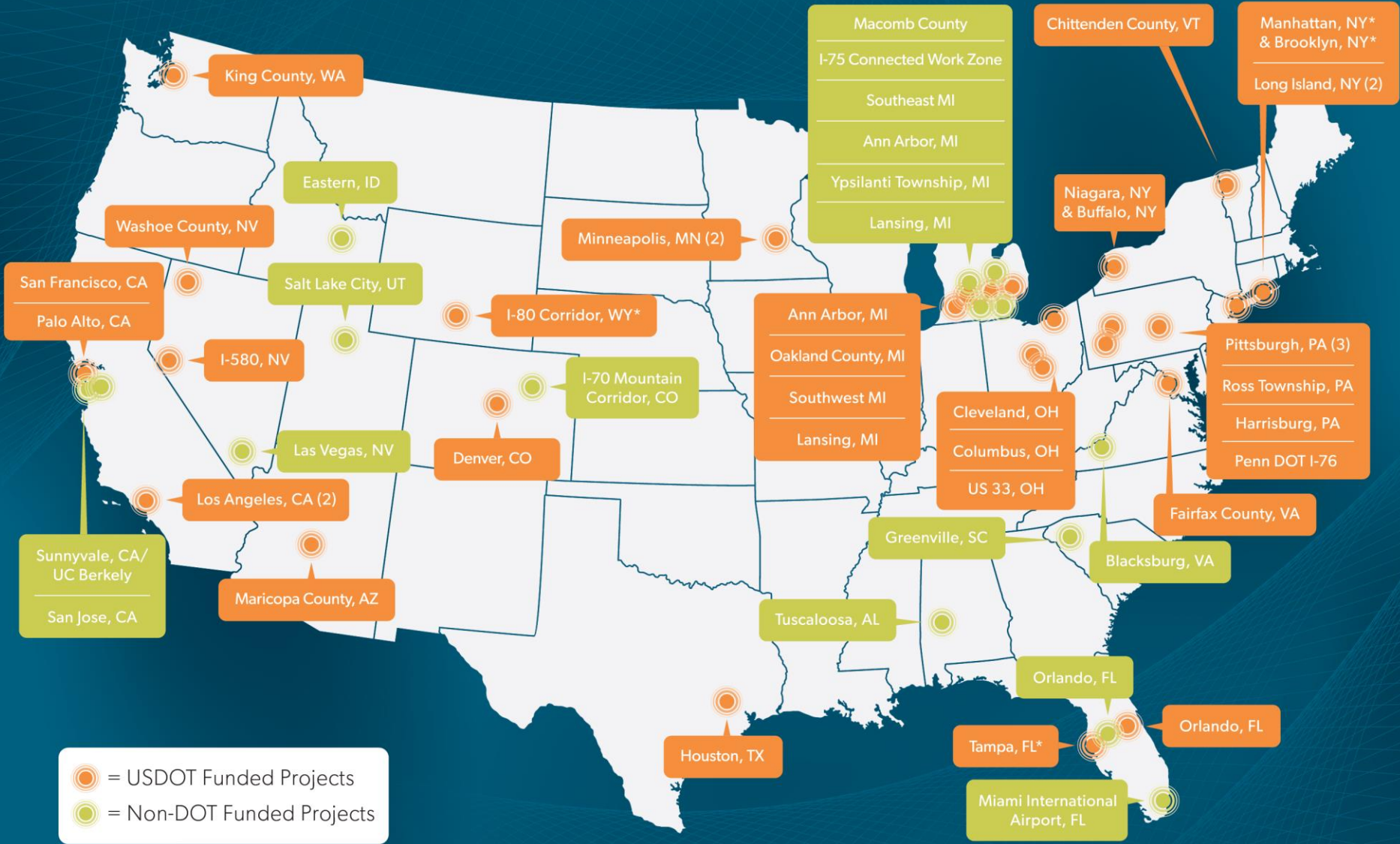


ICF/Wyoming



Tampa (THEA)

Connected Vehicle Deployment Locations



* Planned deployments in 2017

Source: Volpe – The National Transportation Systems Center (USDOT)

Number of Vehicles: 72,556

Number of Devices (V2V and V2I): 65,665

Connectivity Unleashes the Full Potential of Automated Vehicles

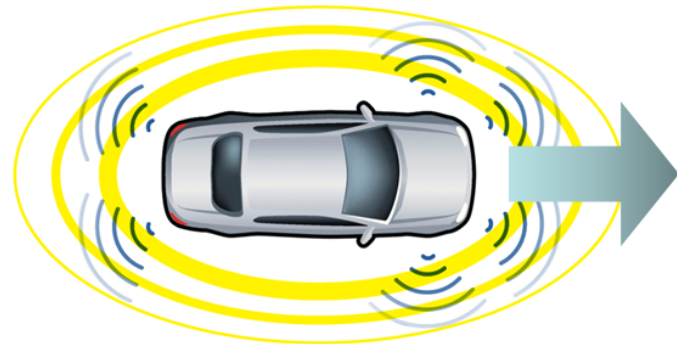
Connected Vehicle

Communicates with nearby vehicles and infrastructure; Not automated



Connected Automated Vehicle

Leverages autonomous automated and connected vehicles



Autonomous Vehicle

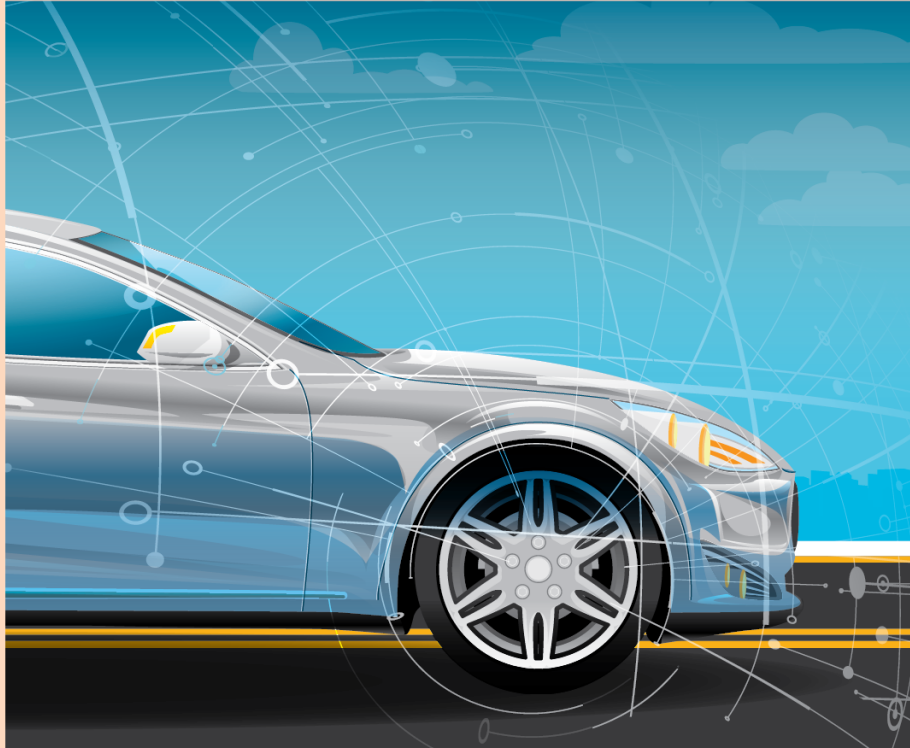
Operates in isolation from other vehicles using internal sensors



FROM CONNECTED TO AUTOMATED

•Connected-Automated Vehicles

- Self-driving cars will need connected vehicle technology



•Situational Awareness

•Multi-Sensor Integration

•Connectivity

•Cybersecurity

•Interoperability

PROVIDING A VISION FOR SAFE AUTOMATION...

AUTOMATED DRIVING SYSTEMS

2.0

A Vision for Safety



U.S. Department of Transportation



Intelligent Transportation Systems and the Internet of Things



- Ken Leonard@dot.gov
- <http://www.its.dot.gov/>

Advanced Technologies and Smart Cities

Technology convergence will revolutionize transportation, dramatically improving safety and mobility while reducing costs and environmental impacts

Connected Vehicles

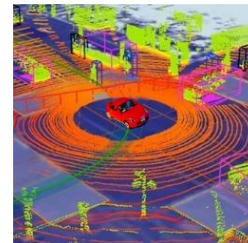
Vehicle Automation

Internet of Things

Machine Learning

Big Data

Sharing Economy



Connected-Automated Vehicles



Smart Cities

Benefits

- Order of magnitude safety improvements
- Reduced congestion
- Reduced emissions and use of fossil fuels
- Improved access to jobs and services
- Reduced transportation costs for gov't and users
- Improved accessibility and mobility

What Makes Connected Cities and Communities Smart?

Cities are Changing, Citizens are Changing, Vehicles are Changing, Business Models are Changing, Interactions with and within Communities are Changing

- Certain trends are taking hold that deeply impact our lives and the communities in which we live.
 - Widespread adoption of smartphones and wireless devices
 - Crowdsourcing, social media, gamification, and incentivization
 - Urban data analytics
 - The potential of connected vehicles and automated vehicles
 - Differing views, needs and uses of transportation among generations
 - An economy where access is as or more important than ownership
 - Opportunities for new technology to be integrated into the transportation system
 - New business models and partnering
- Technology trends are enabling people, the transportation industry, and our cities to change the economics of mobility decisions. Leveraging capabilities allows system users and operators to get information and act on it—impacting on how we live, work, and move.

Smart City

“A city that uses information and communications technology (ICT) to enhance its livability, workability, and sustainability.”

The Smart Cities Council

Connected Infrastructure Technology Makes a Smart Community

Connected Vehicles

Connected vehicles and travelers send and receive information about their movements in the network – offering cities unprecedented opportunities to provide more responsive and efficient mobility solutions in real-time and long term.

Sensor-Based Cities (IoT)

Connected cities contain and use a collective “intelligent infrastructure” that can sense what’s around and/or sense their own status. These data allow city operators to know how the city is operating and how its performance can be enhanced using real-time information to monitor performance and trends of the city – transportation is part of that. A connected vehicle is another sensor.

Low-Cost ICT/Efficient ICT

ICT infrastructure, technologies and services are a critical part of a connected city; success depends upon affordable ICT, from both a public and personal perspective, and data efficiency (data use/reuse, open data, big data).

Smart Grid & Critical Infrastructure

A connected city supports programmable and efficient energy transmission and distribution system (with supporting telecommunication and computing sub-networks) that responds to dynamic demands and is resilient and closely integrated with electric vehicles. Peak performance of ITS uses critical infrastructure.

Data Makes a Connected Community

Data Management and Urban Analytics

In a data-rich environment, cities are increasingly able to deploy (previously unavailable, and now open) datasets to address complex urban problems – connected vehicles and connected travelers are one source of data.

Data Policy

Innovative policies which enable large scale implementation and roll out of city service strategies. Defined roles and responsibilities of the involved entities, governance, authority, compliance, enforcement and institutional approaches to efficient data sharing and quality assurance. Policies must increase interoperability and remove barriers and failures in data sharing.

Data Standards Architectures and Interoperability

The ICT in connected communities, including telecommunications and computing, need to be resilient, secure and respect privacy; it would also support and be supported by standards harmonization, common technology architectures and integration and resilience policies so that if one part of the system fails or is compromised, the entire system does not collapse, and the gap in service is bridged effectively and restored quickly.

People Make a Connected Community

Connected, Involved Citizens

Connected cities use new analytical processes and applications that are facilitated by ICT advances and that engage the connected citizen, allowing and encouraging fully informed choices – particularly with respect to personal mobility – and both generating and sharing information in new and useful ways.

User-Focused Mobility/Service Choice

Connected cities support sustainable mobility including traveler-oriented strategies that deliver innovative solutions across all transportation modes including transit, bicycling, electric vehicles, and shared mobility services. Connected vehicle technologies are likely to foster further innovation in these areas, particularly with respect to automation. Also includes freight and related services.

New Business Models and Partnering Opportunities Exist

Both the public and private sectors are pushing innovation, creating new opportunities and models for governance and interagency partnerships.

Why Make a Connected, Smart Communities? Outcomes!

Safety

Safety benefits of many kinds can accrue to a connected city that didn't exist before, including vastly improved safety for drivers, pedestrians, bicyclists, motorcyclists, and ordinary citizens as they move through the city daily.

Achieve Efficiency in Transportation ICT Services

Leverage multimodal aspects of personal and freight mobility to enhance transportation service quality, timeliness and convenience.

User Focused Mobility Services

Fully use multimodal aspects of personal travel with an emphasis on the transportation service quality, timeliness and convenience desired.

Service Focused Delivery and Logistics

Explore opportunities to enhance movement of freight and goods.

Efficiently Integrate all City Community ICT Services

Coordinate and integrate transportation data and applications with other essential community services at reduced cost and increased efficiency, effectiveness, timeliness and convenience for the community.

Digging a Bit Deeper

From “Connected” to “Smart”

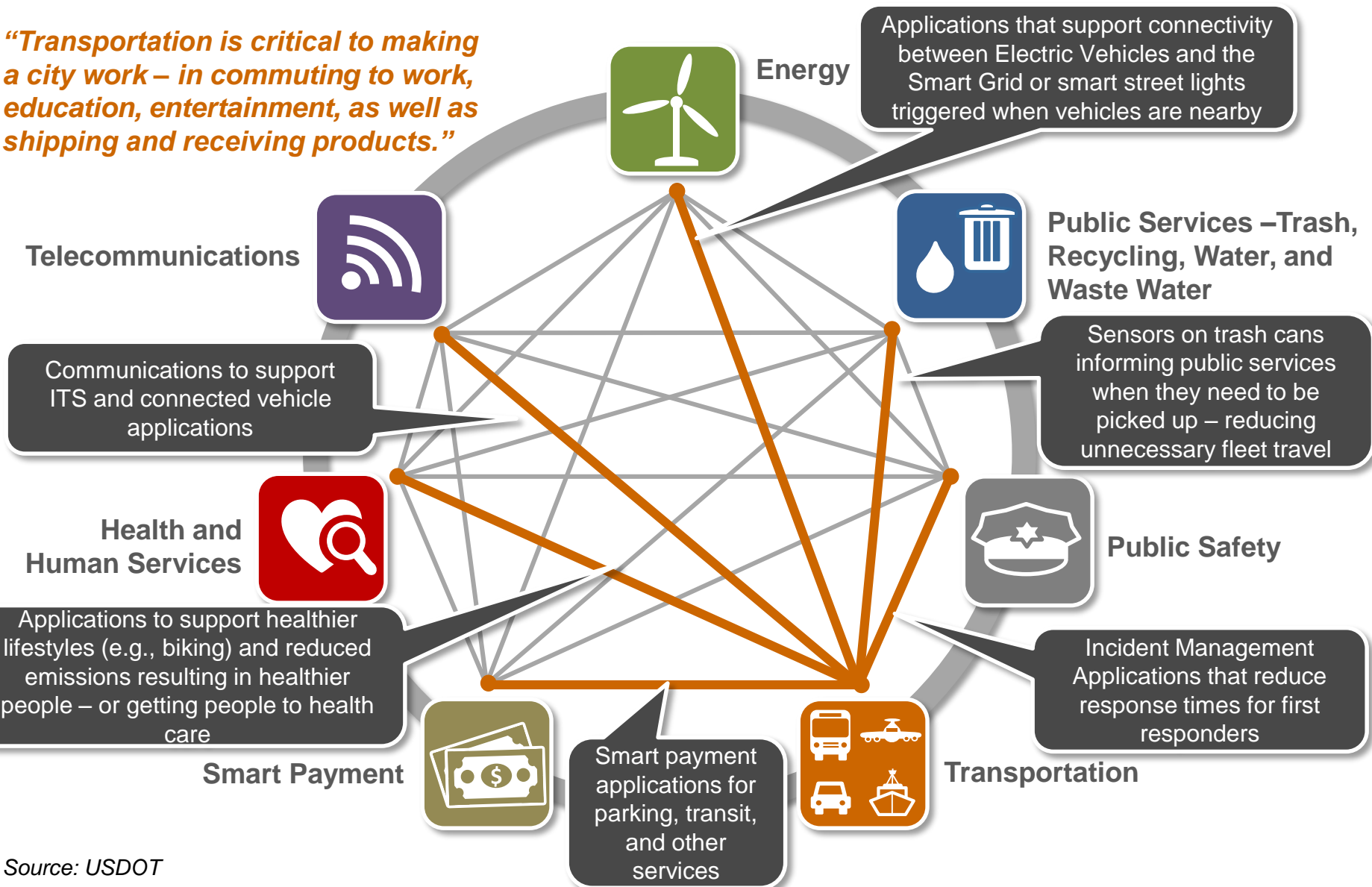
- All critical city/community systems—transportation, energy, public services, public safety, health care, telecommunications are capable of communicating with each other to allow coordination and improve efficiency. They are capable of generating, transmitting and processing data about a wide variety of related activities within the city.
- **If** a “smart city” is a system of systems that use ICT to communicate with and leverage each other to improve vital city operations,
- **Then** the ITS JPO’s Connected Cities/Communities Research Program is designed to examine the opportunities created where these systems interface with transport and mobility.

In other words, where **the connected city, the connected citizen and the connected vehicle meet** and interact.

The Connected Cities/Communities Research Program seeks to maximize and leverage the benefits of connected transportation by integrating those transport services, vehicles and related technologies and data with other data enabled innovations in a city

Example Components of a Connected City

“Transportation is critical to making a city work – in commuting to work, education, entertainment, as well as shipping and receiving products.”



Some Questions That Focused Our Thinking

▪ Overarching Issues

- What are some **critical transportation issues and challenges facing today's cities and communities**? How can connected and automated vehicle technologies, communications, data and/or applications help address these issues?
- How will the integrated and connected nature of today's cities and communities be of critical importance to the **likelihood of success of the eventual deployment of connected and automated vehicles**?
- How do **transportation services and connected vehicle technologies, data and applications intersect with other sectors of the city** and how can these be **leveraged** to the overall benefit of a jurisdiction?
- What are the **proper performance measures** when speaking of connected and automated vehicles operating in a smart community?
- Who are the **core stakeholders** at the nexus of the connected traveler and the smart city, both inside and outside of transportation? How can necessary partnerships and other relationships among them be developed?

Some Questions on Strategy and Applications

- **Specific Strategies and Applications**

- What is the role of connected and automated vehicle technologies and applications in **traffic operations**?
- What are the implications for connected and automated vehicles with respect to **shared-use mobility**?
- What types of **crowdsourcing, social media, gamification and incentivization** can be used?
- Impacts on modal shift including **better management and integration of bicycle traffic** into a city's overall transportation network?
- How might connected vehicle technologies **accelerate or foster electric vehicle adoption**?
- How might electric vehicles **align with vehicle automation**?
- What is the relationship between the **smart grid and the transportation system**
- Other questions that **YOU** think are critical?

Some Questions on Data and Analysis

- **Data and Analysis**

- What **data gaps** exist?
- From what variety of sources can transportation data be collected? What technologies and methodologies are most useful?
- How can all these **data be efficiently managed, used and re-used, in a connected city?**
- What is the role of **analytics**? How can connected vehicle data –be integrated to create **innovative and informative techniques to support decision making** by public agencies and connected travelers?
- With **limited resources** available, how can agencies efficiently leverage and implement smart solutions?
- Are there examples of **public-private partnerships** where connected vehicle data is being used?

Where Do We Go From Here?

- **Identify** how cities and city agencies can harness the power and potential of connected vehicle data, technologies and applications
- **Explore** how cities and agencies might leverage the opportunities presented by location-aware internet-connected mobile communications technologies and apps – and the data they collect and
- **There are many interesting topics:**
 - City-Wide Data Flows and User Needs
 - Interagency Data Exchange
 - Service-Focused Urban Automation
 - Smart, Connected Asset Management,
 - Reducing Barriers, Unifying Communities
 - Innovative Business Models and Partnering
 - Mobility As A Service / Shared Use Mobility



Connected Communities: “Working” Vision

Incorporate and expand connected transportation to ensure that connected transportation data, technologies and applications – as well as connected travelers – are fully integrated with other systems across a city, and fulfill their potential to improve safety, mobility and environmental outcomes in a complexly interdependent and multimodal world that supports a more sustainable relationship between transport and the city.

Source: USDOT

The Smart City Challenge

- Encourage cities to put forward their best and most creative ideas for innovatively addressing the challenges they are facing.
- Demonstrate how advanced data and intelligent transportation systems (ITS) technologies and applications can be used to reduce congestion, keep travelers safe, protect the environment, promote efficient resource use, connect underserved communities, meet citizen and community needs and support economic vitality.



USDOT Vision Elements

TECHNOLOGY ELEMENTS



Vision Element #1
Urban Automation



Vision Element #2
Connected Vehicles



Vision Element #3
Intelligent, Sensor-Based Infrastructure

INNOVATIVE APPROACHES TO URBAN TRANSPORTATION ELEMENTS



Vision Element #4
User-Focused Mobility Services and Choices



Vision Element #5
Urban Analytics



Vision Element #6
Urban Delivery and Logistics



Vision Element #7
Strategic Business Models & Partnering

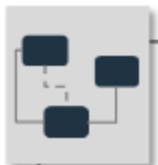


Vision Element #8
Smart Grid, Roadway Electrification, & EVs



Vision Element #9
Connected, Involved Citizens

SMART CITY ELEMENTS



Vision Element #10
Architecture and Standards



Vision Element #11
Low-Cost, Efficient, Secure, & Resilient ICT

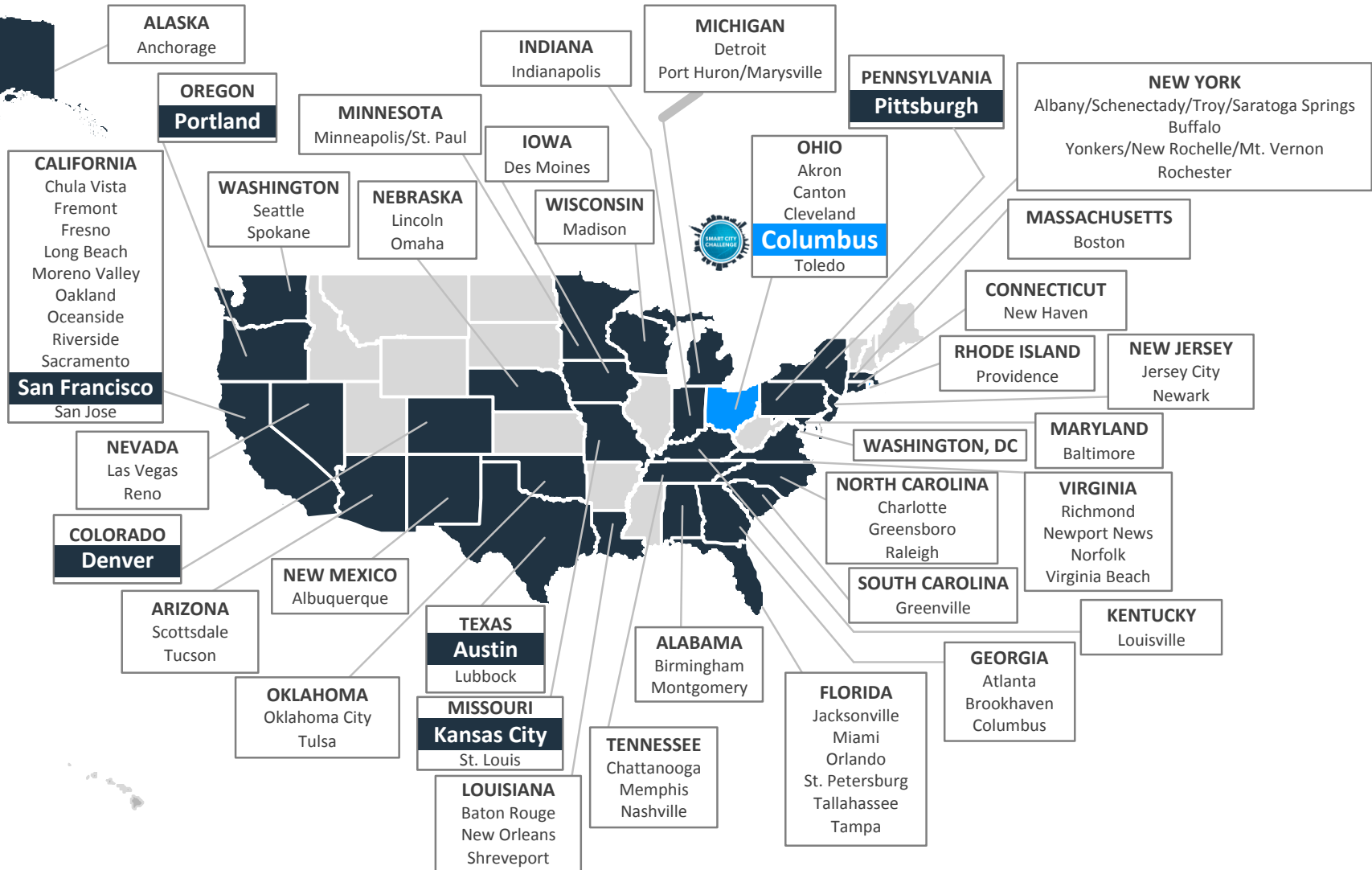


Vision Element #12
Smart Land Use

Expected Goals of the Demonstration

- Identify the transportation challenges and needs
- Determine technologies, strategies, applications, and institutional arrangements to address the challenges
- Support and encourage cities to take the evolutionary and revolutionary steps to integrate advanced technologies into the management and operations of the city
- Demonstrate, quantify, and evaluate the impact towards improved safety, efficiency, and sustainable movement of people and goods.
- Examine the technical, policy, and institutional mechanisms
- Assess the reproducibility of interoperable solutions and provide knowledge transfer to other cities facing similar challenges
- Accelerate the deployment of clean transportation and connected and automated vehicle technologies

Smart City Challenge



SMARTCOLUMBUS

4

Districts

10

National
Partners

17

Local
Partners

\$50M

Vulcan+
USDOT

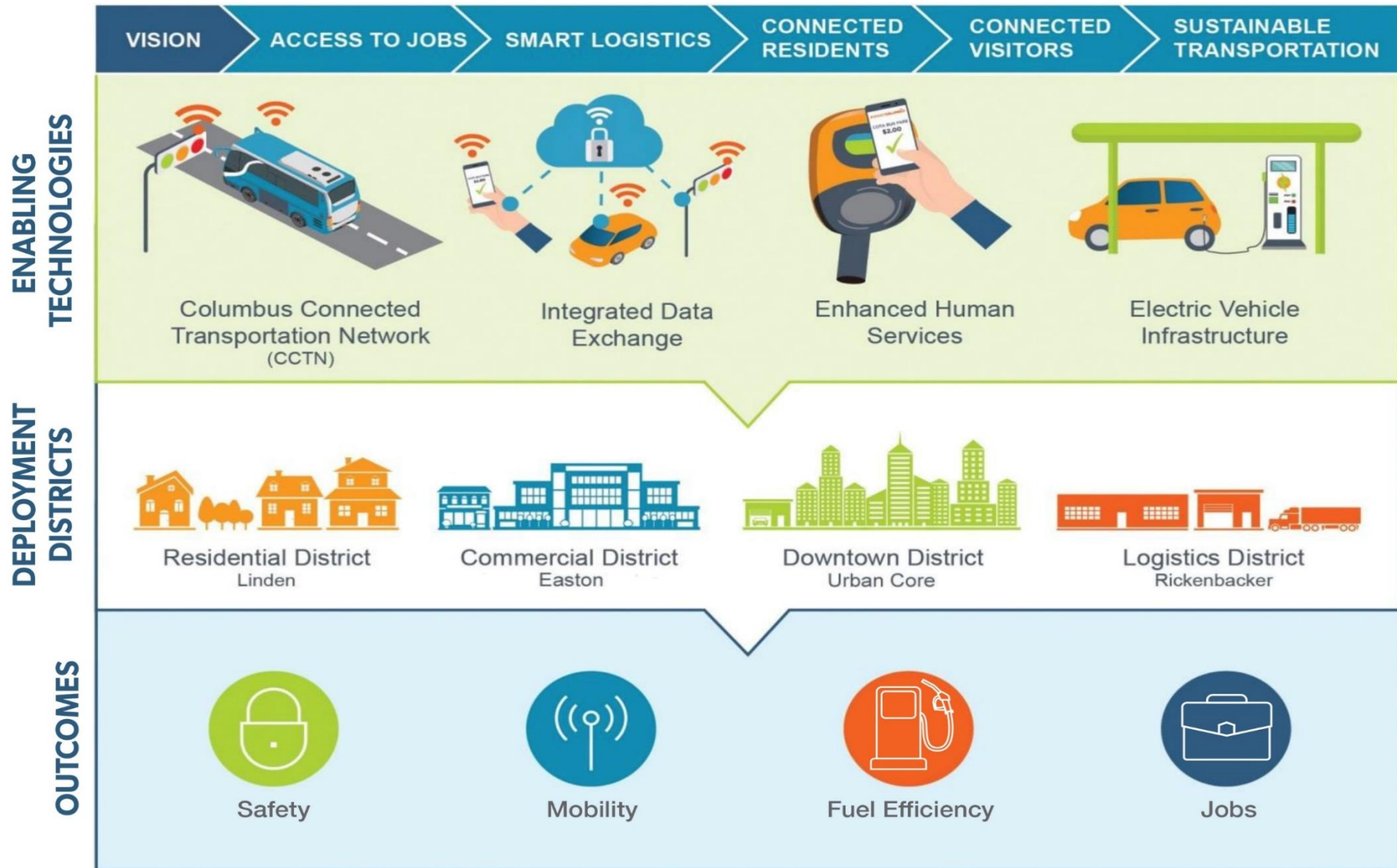
\$90M

Columbus
Investment

\$140M

Total
SMARTCOLUMBUS
Investment

SmartColumbus



Columbus Connected Transportation Network (CCTN)

- Enhanced emergency vehicle preemption passage through intersections
- Transit signal priority to improve transit operations
- Real-time changes for signal timing based on real-time data
- Pedestrian detection and red light safety applications for improved intersection safety
- Increased school zone visibility to connected vehicles
- Transit and travel options for increased resident connectivity
- Increased student access to education tools

CCTN Components

200 DSRC Roadside Units

3,000 Connected Vehicles

200 Smart Street Lights with Wi-Fi

350 Mobileye Shield + and Enhanced Transit Safety Retrofit

12 Bus Stop Pedestrian Warning Systems

100 Traffic Signal Controller Upgrades

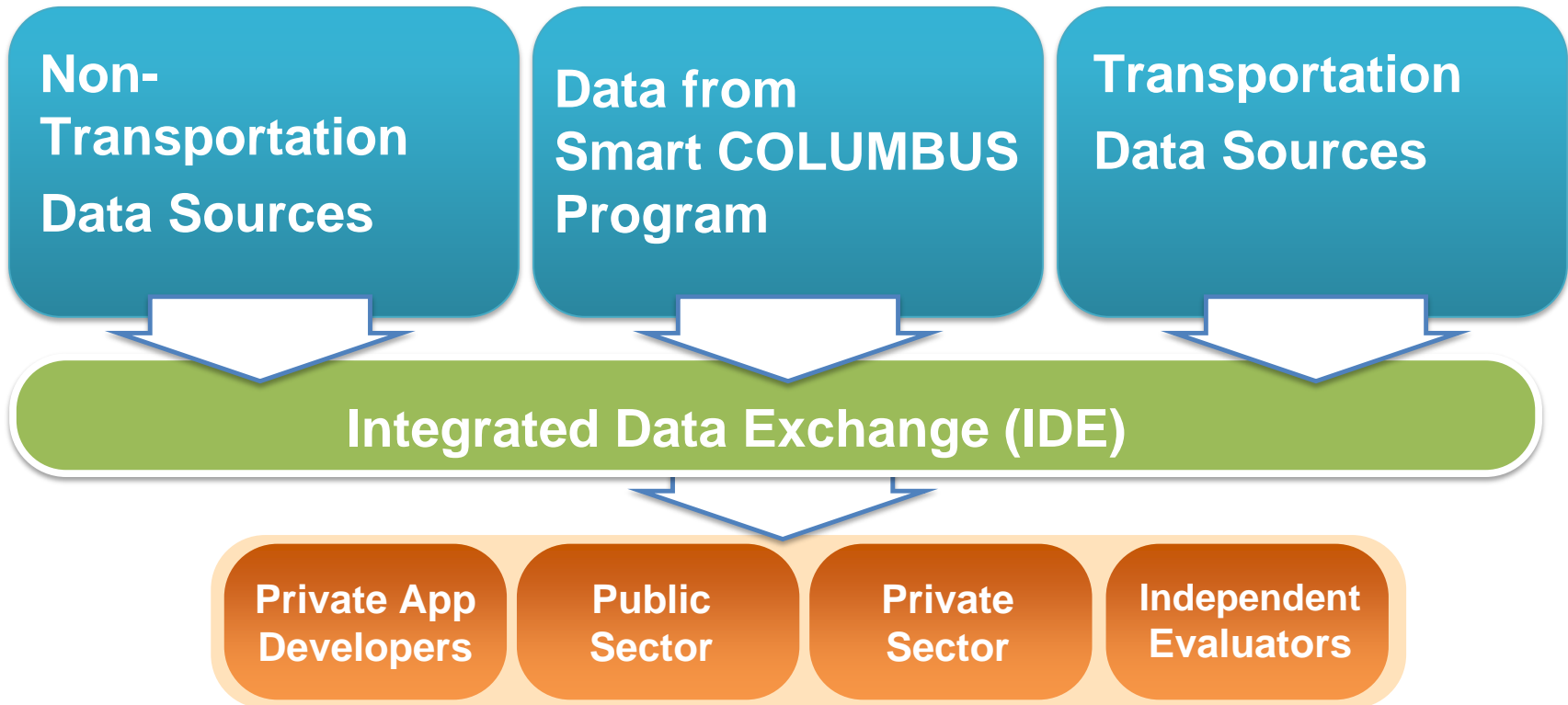
10 Multimedia Kiosks

10 Parking Detection Systems

50,000 RFID Customized Windshield Stickers

10 Point of Service RFID Readers

Integrated Data Exchange (IDE)



Source: The City of Columbus

Enhanced Human Services (EHS)



Source: The City of Columbus

Electronic Vehicle Infrastructure

Electric Supply Decarbonization

Fleet Electrification

- 300 public fleet electric vehicles
- 30 carshare/rideshare electric vehicles
- 448 private fleet electric vehicles

Transit, Automated, and Multimodal Systems

- 6 EAVs
- 50 EV Pedal Assist Bicycles

Driving Consumer Adoption

- 3,200 Registered EVs by 2018

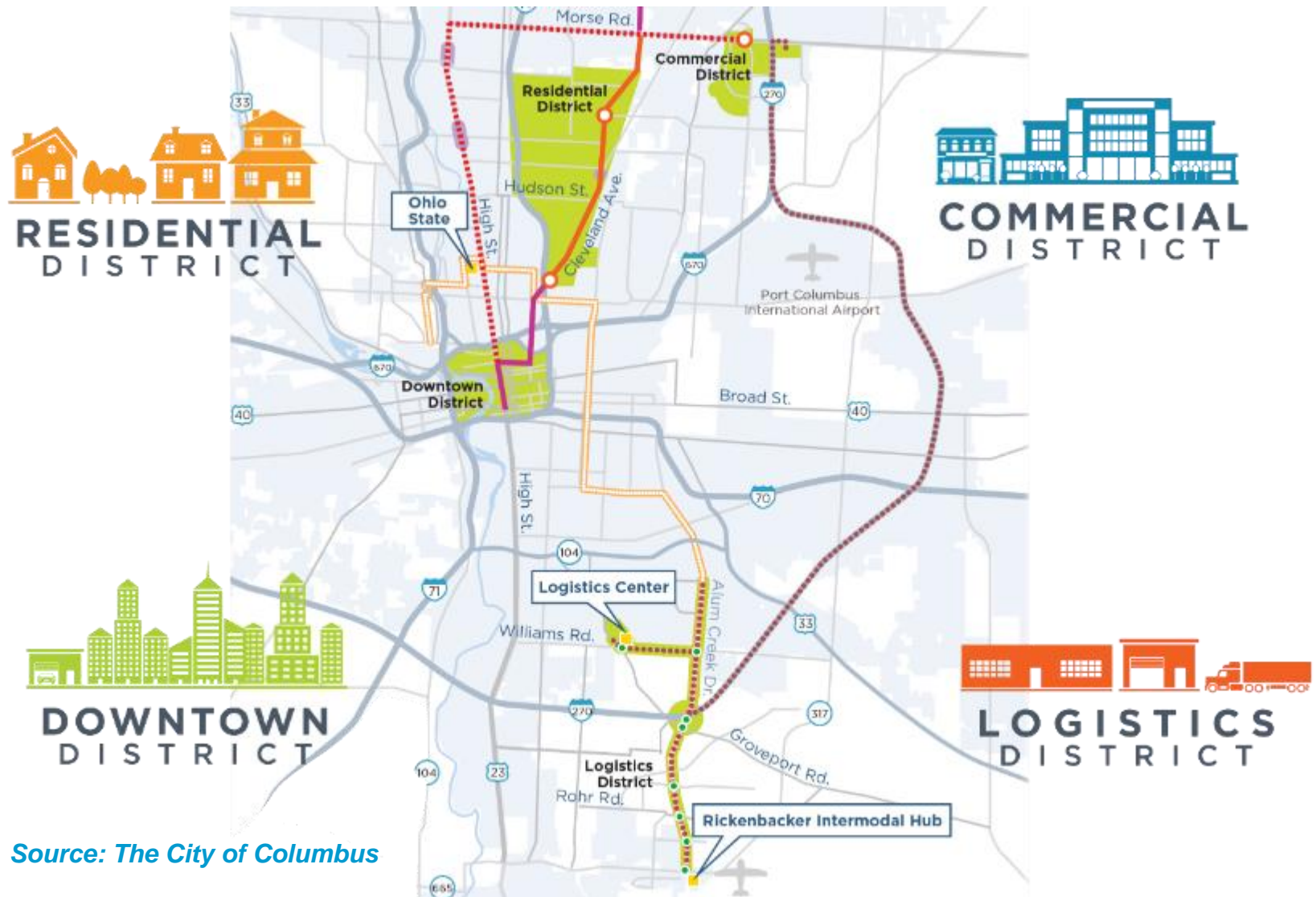
Charging Infrastructure

- 1,600 New Level 1 Chargers
- 300 New Level 2 Chargers



Source: The City of Columbus

SMARTCOLUMBUS Districts



Residential District

Challenges

- Socio-economic challenges force many residents to be transit-reliant
- Planning and completing a trip to access employment and services can be difficult
- First mile / last mile challenges
- Lacking facilities at bus stops
- Unsafe Intersections
- Dim or missing street lighting
- High infant mortality



Source: The City of Columbus

SMARTCOLUMBUS Solutions

- Leverage the new COTA CMAX Bus Rapid Transit (BRT) Line
- Equip intersections with DSRC technologies
- Provide new mobility and safety applications
- Create neighborhood hubs providing a variety of transportation options
- Deploy Smart Lighting with Wi-Fi to improve safety, make the neighborhood more walkable, and provide access to information

Proposed Applications

- Dynamic Transit Operations
- Connection Protection
- Dynamic Ridesharing
- Integrated Multi-Modal Electronic Payment
- Enhanced Human Services
- Transit Signal Priority
- Transit Stop Pedestrian Warnings
- Pedestrian in Signalized Crosswalk Warnings
- Vehicle Turning Right in Front of Bus Warnings
- Forward Collision Warning
- Emergency Brake Light Warning
- Eco-Approach and Departure

Commercial District



Challenges

- Lack of reliable transportation services due to congestion and commercial growth in the area
- Insufficient parking facilities
- First mile / last mile challenges
- Safety issues – pedestrian and vehicle conflicts
- Poor air quality and high levels of emissions

Source: The City of Columbus

SMARTCOLUMBUS Solutions

Electric Autonomous Vehicles

Three fixed routes supporting FMLM equipped with inductive charging stations

Enhanced Human Service

Available via both a smartphone application and deployed kiosks

CCTN Build Out

SPaT & MAP, Emergency Vehicle Preemption, and Signal Priority



Source: The City of Columbus

Downtown District



Challenges

- The Downtown District experienced an 8 percent increase in residents in 2015 and anticipates an increased pace of growth over the next several years
- Lack of parking facilities
- Increased congestion and roadway blockages result from delivery or service vehicles double-parking



Source: The City of Columbus

SMARTCOLUMBUS Solutions

Event Parking Management

- Partnership with Experience Columbus and associated agencies that collectively manage more than 42,000 parking spaces
- Partnership with HERE for a multilingual, multi-modal trip planning application allowing travelers to “reserve and book” parking

Loading Zone Parking Management

- Video equipment capable of monitoring loading zones
- Partnership with Truck Smart Parking Services, Inc. (TSPS) and HERE to install and operate a real-time parking availability service for freight delivery

Permit-Only Parking

- RFID stickers to collect information on the permitted vehicles in zones

Transit Benefit Program

Logistics District



Challenges

- The Columbus region is crossed by eight major Interstate highways and is a major hub for long-haul trucks
- Freight-induced congestion and queuing
- Major incidents at bridges and over-passes from trucks exceeding weight and height restrictions
- Accommodating long-distance freight haulers to achieve hours-of-service requirements



Source: The City of Columbus

SMARTCOLUMBUS Solutions



- Driver-assisted Truck Platooning (DATP)
- Intelligent truck warning and routing application to minimize incidents due to low bridges or narrow roads
- Regional Truck Parking Information and Management System



Source: The City of Columbus

Lessons in Progress

- The success of “Smart Columbus” won’t just be a series of successful projects
- Identify measureable outcomes beyond the individual projects
- Recognize limits of current organizational structures and capabilities
- Be prepared to muster the appropriate resources
- Demand Excellence and Interoperability
- Mature Systems of Systems Engineering and Integration Skills base and Knowledge
- Traditional approaches may not be sufficient
- Multidisciplinary integration in and beyond Transportation disciplines
- Recognize institutional complexity and resources required to manage partnerships
- Understand the value of data
- Have a bias toward Open Data

The Heart of Smart Columbus

•Open Data Delivery Platform:

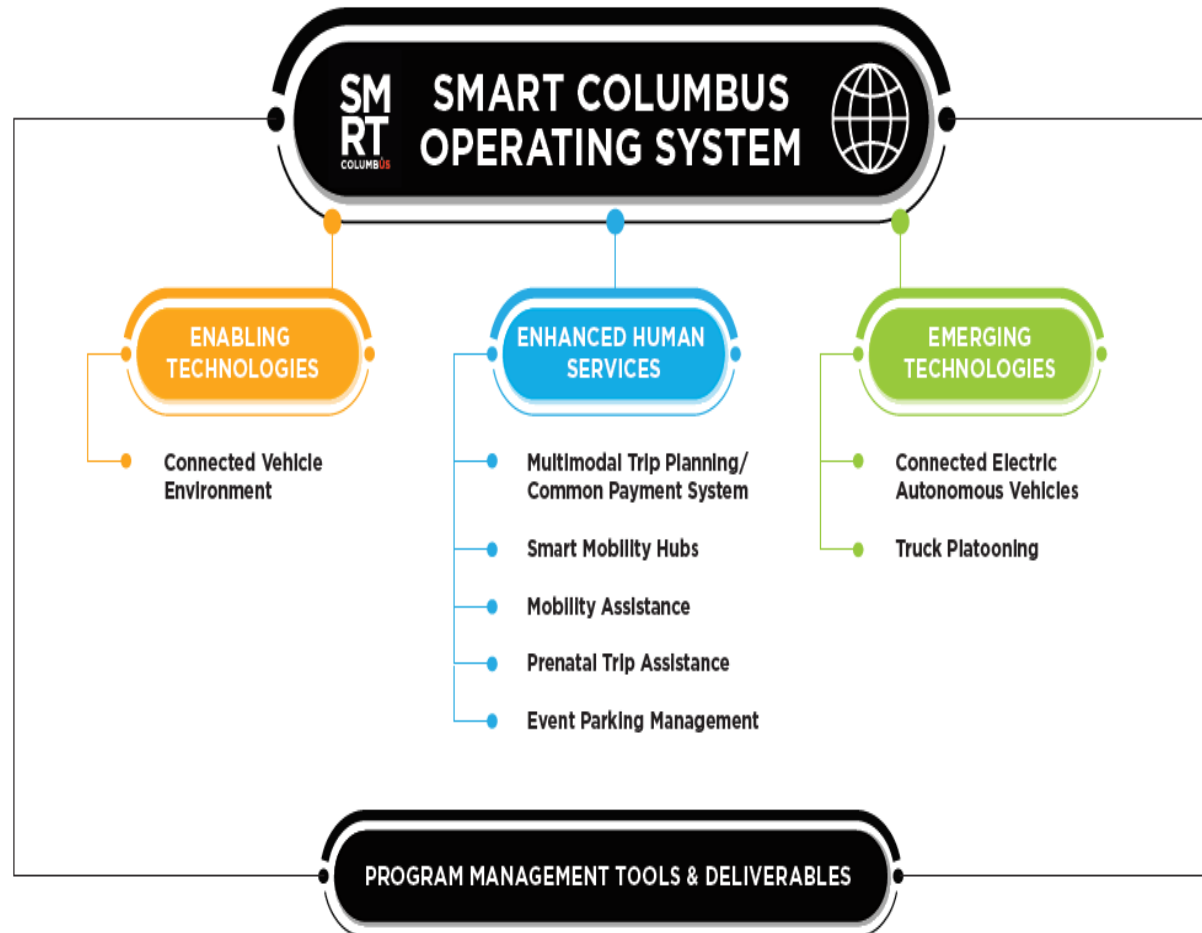
A place for powerful visualization of data sourced from multiple tenants

enables consumption, ingestion, dissemination and publication of multisource data.

affords quick, easy access to data in other systems

pathway for developers to produce data rich applications

fuses connected, automated and smart infrastructure system data to create more meaningful data sets



SMARTCOLUMBUS

Examples of Measurable Outcomes



SAFETY

Reduce truck accidents

Leverage Columbus'

Connected Traffic Signal System
upgrades to safely move people



MOBILITY

Minimize travel times

Increase mobility options, including
FMLM options

Improve employment
opportunity for residents in the most
underserved neighborhoods

Improve air quality resulting
from truck congestion

Increase the number of EV
charging stations



Smart City Challenge Demonstration Program

Federal Team Organization

Version 3.3, 8/2/2016

Coordination Committee

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Subject Matter Experts

- Automated Vehicles
- Connected Vehicles
- Transit
- Freight
- Data and Analytics
- Performance Measurement
- Security and Privacy
- Ladders of Opportunity
- Smart Land Use
- Safety and Human Use Approval

Technical Working Groups



Data Technical Working Group

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EV Technical Working Group

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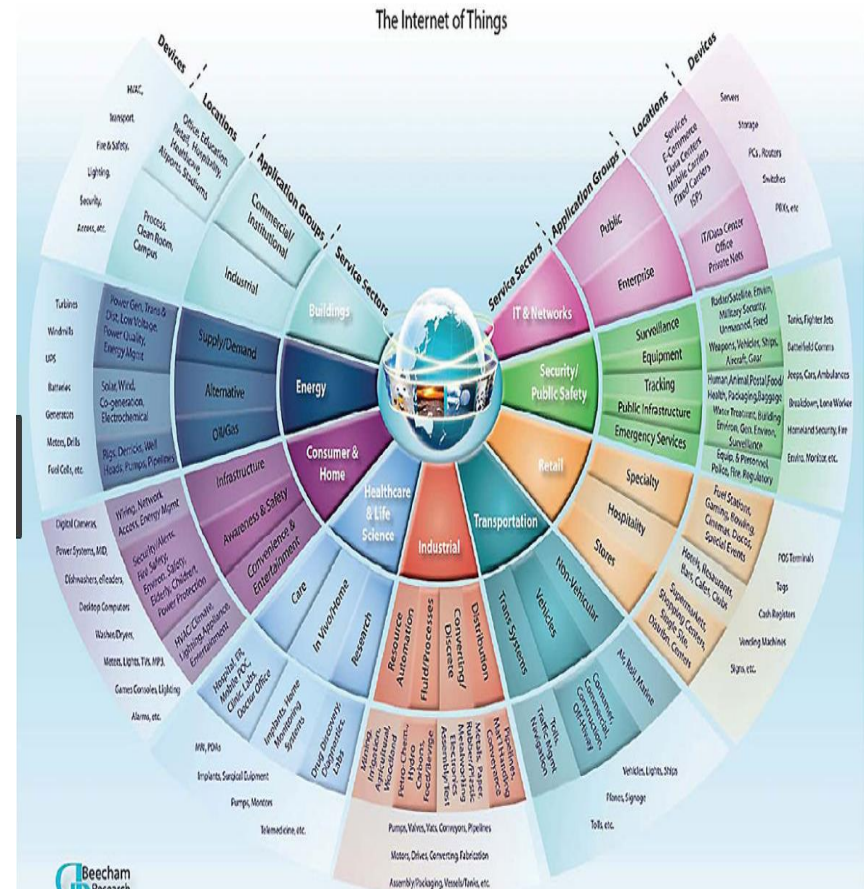
Elina Zlotchenko, ITS JPO
Egan Smith, ITS JPO

ITS Interoperability

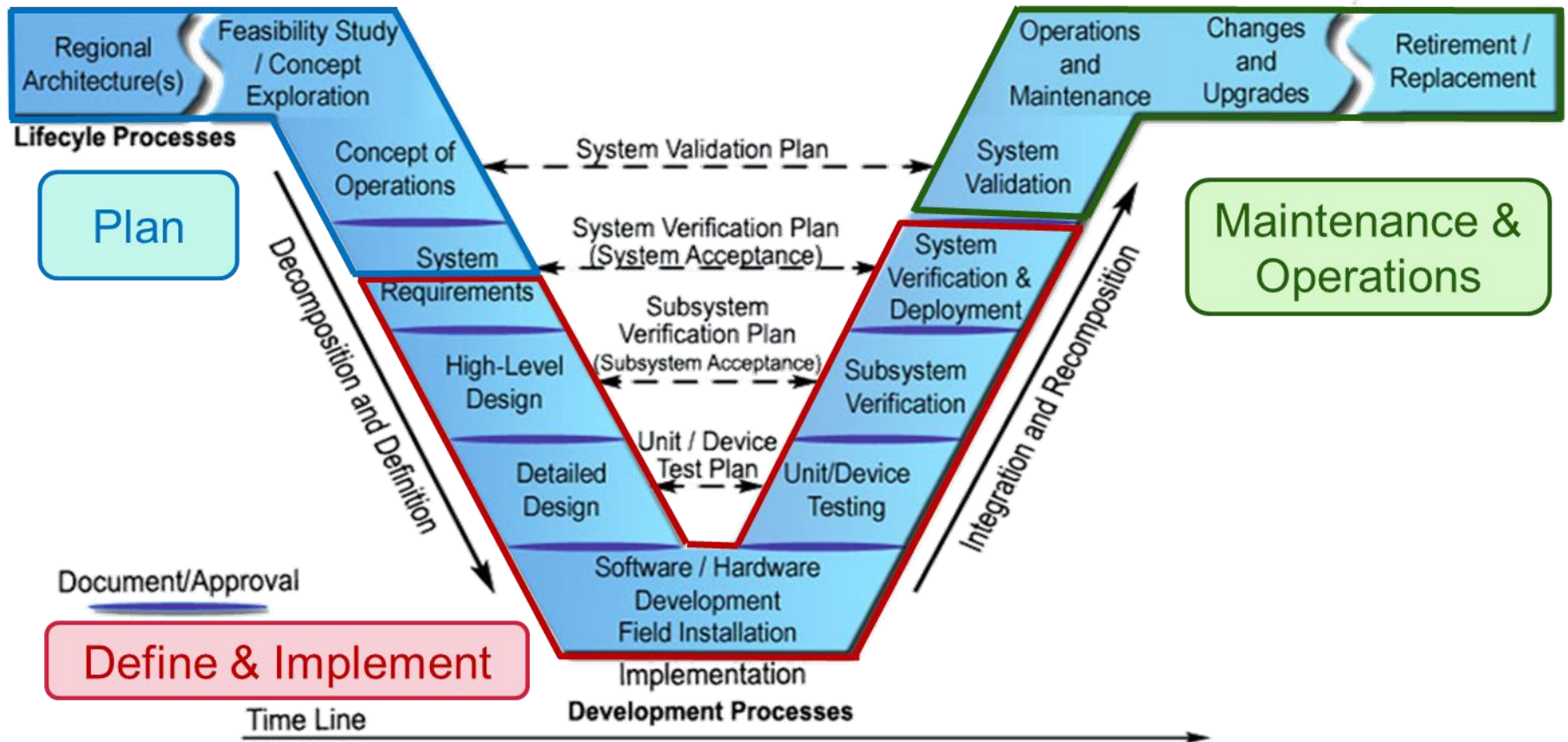


Engineering Complex Systems

- Engineering – application of scientific principles to practical ends; as the design, construction and operation of efficient and economical structures equipment or systems
- Complex – systems in which the elements are diverse and have intricate relationships with each other
- Systems – a set of interrelated components working together toward some common objective



Systems Engineering “V” Diagram



Applying Agile to SMART COLUMBUS

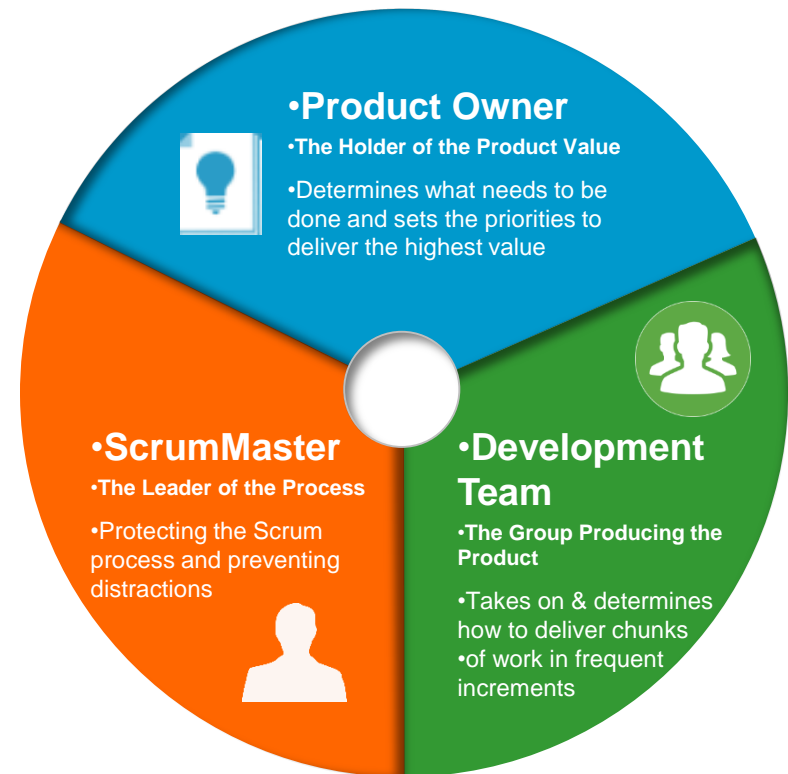


- Key components of a smart city are digital in nature and may use other **incremental and iterative development concepts**, such as agile software development, to deliver applications.
- Agile:
 - Allows the development team to provide an **initial capability followed by successive/iterative deliveries** to reach the desired final product.
 - Consider adaptive planning, evolutionary development, early delivery, continuous improvement, and encourage rapid and flexible response to change.
 - Help to keep the solution **open and flexible to accept new features and technologies**. These techniques can be used to **reduce the risk of failure** and enable the ability to test and deploy so that features may be added often and put into production easily.
 - Allow the development team to **engage with end users incrementally to identify pain points** and prioritize activities according to users needs.
 - Emphasizes **velocity and adaptability** throughout the entire lifecycle.



SMART COLUMBUS[★] and Scrum

- Columbus is applying a Scrum process to support the development of their Smart Columbus Operating System (SCOS)
- Scrum relies on a cross-functional team working together to address complex adaptive problems, while productively and creatively delivering products through an iterative series of development sprints and incremental product releases
- Roles in the Scrum Process include:
 - **Product Owner** – holds the vision for the product
 - **ScrumMaster** – helps the team best use Scrum to build the product
 - **Development Team** – builds the product
- Scrum was a new process for the city – appropriate resources and training were needed

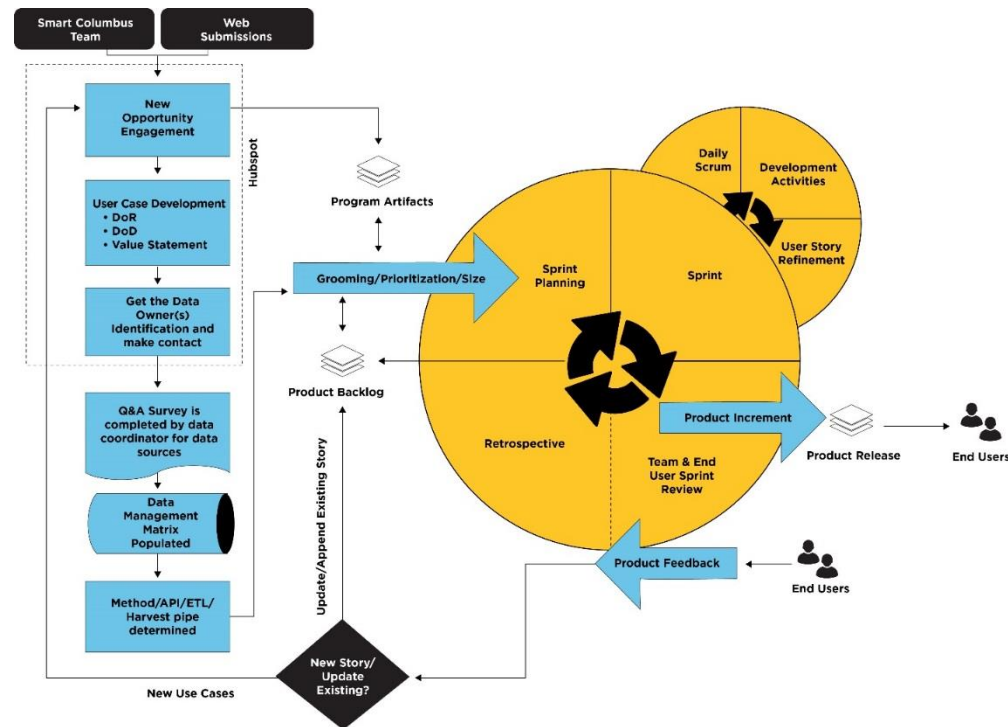


•Adapted from: Scrum Alliance

SMART COLUMBUS[★]: Scrum Workflow

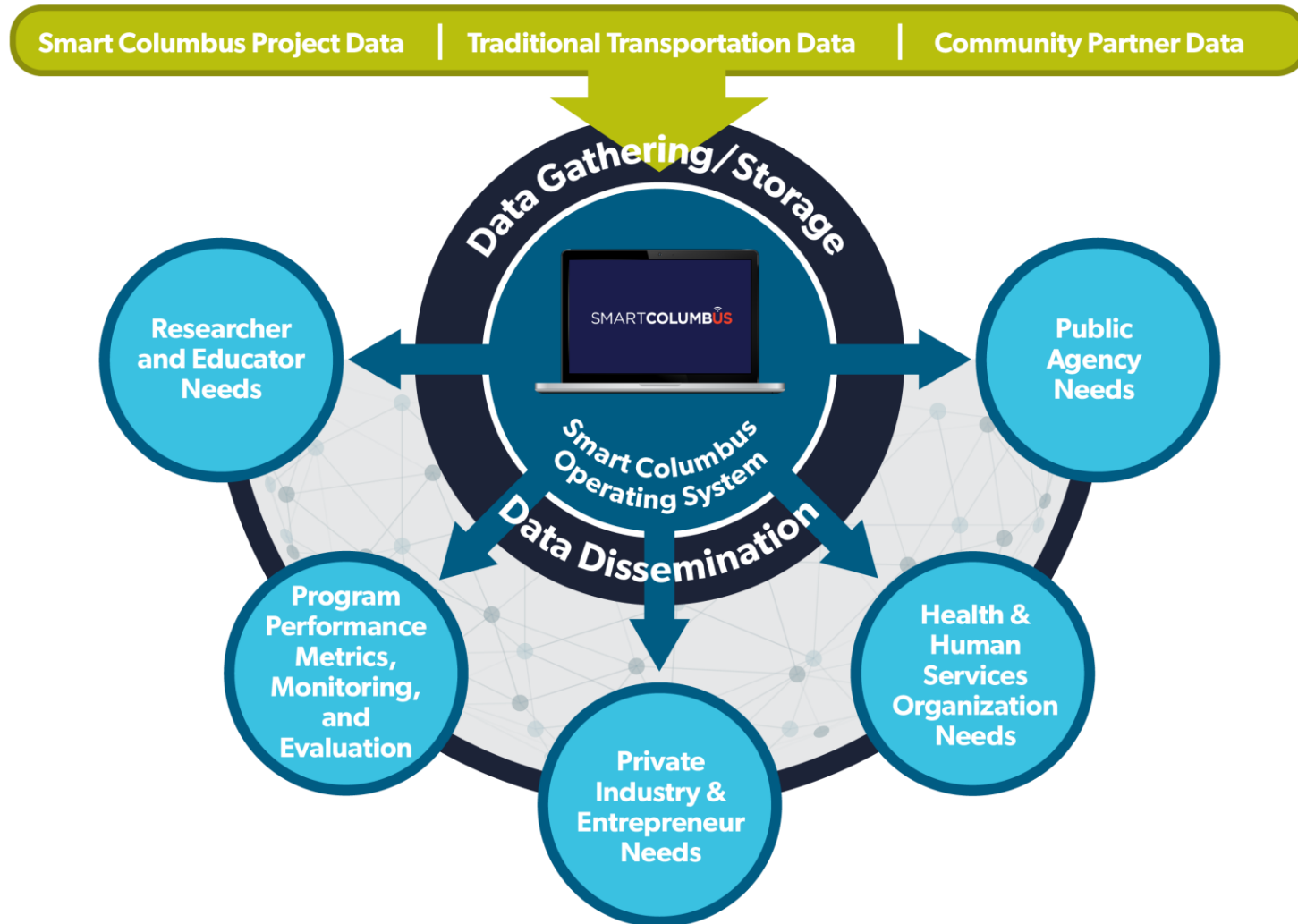
The Scrum Workflow

1. The Product Owner creates a prioritized wish list called a **product backlog**.
2. During sprint planning, the Development Team pulls a small chunk from the top of that wish list, a **sprint backlog**, and decides how to implement those pieces.
3. The team has two weeks – a **sprint** – to complete its work, but it meets each day to assess its progress (daily Scrum).
4. Along the way, the ScrumMaster keeps the team focused on its goal.
5. At the end of the sprint, the work should be ready to hand to a customer or show to a stakeholder.
6. The sprint ends with a **sprint review** and retrospective.
7. As the next sprint begins, the team chooses another chunk of the product backlog and begins working again.



*Image from the Smart Columbus Systems Engineering Management Plan

Smart Columbus Operating System (SCOS)



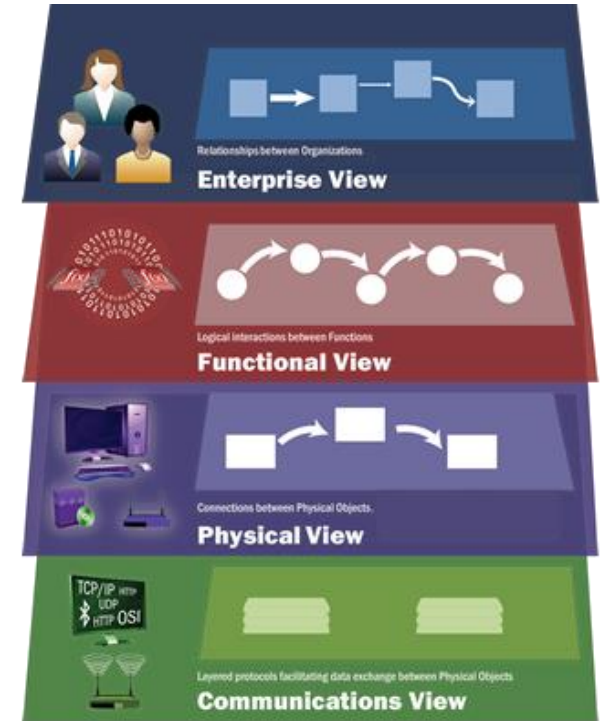
What Can ITS JPO Offer?

- US DOT 5-year Vision towards strategic priorities.
- Technology assistance for efficient, interoperable, secure and cost-effective ITS infrastructure, including connected and automated vehicle deployments.
- ITS reference architecture development and deployment support
- Architecture and Standards frameworks and tools designed for development and deployment of ITS Systems.
- Cooperative relationships across Departmental, State, local and industry stakeholders
- Access to Standards Development Organizations (SDOs)
- International Harmonization Coordination
- Federal and contracted access to subject matter experts in ITS through the Professional Capacity Building program



ITS National Reference Architecture

- Architecture Reference for Cooperative and Intelligent Transportation (“ARC-IT”, www.arc-it.org)
 - Companion software toolsets support customized regional and project architecture development
 - Deployment support includes training materials, customized workshops for State and local customers
 - Content informed by stakeholder needs, technology evolution
 - 4 distinct views to meet diverse customer needs
 - Publicly available at no-cost



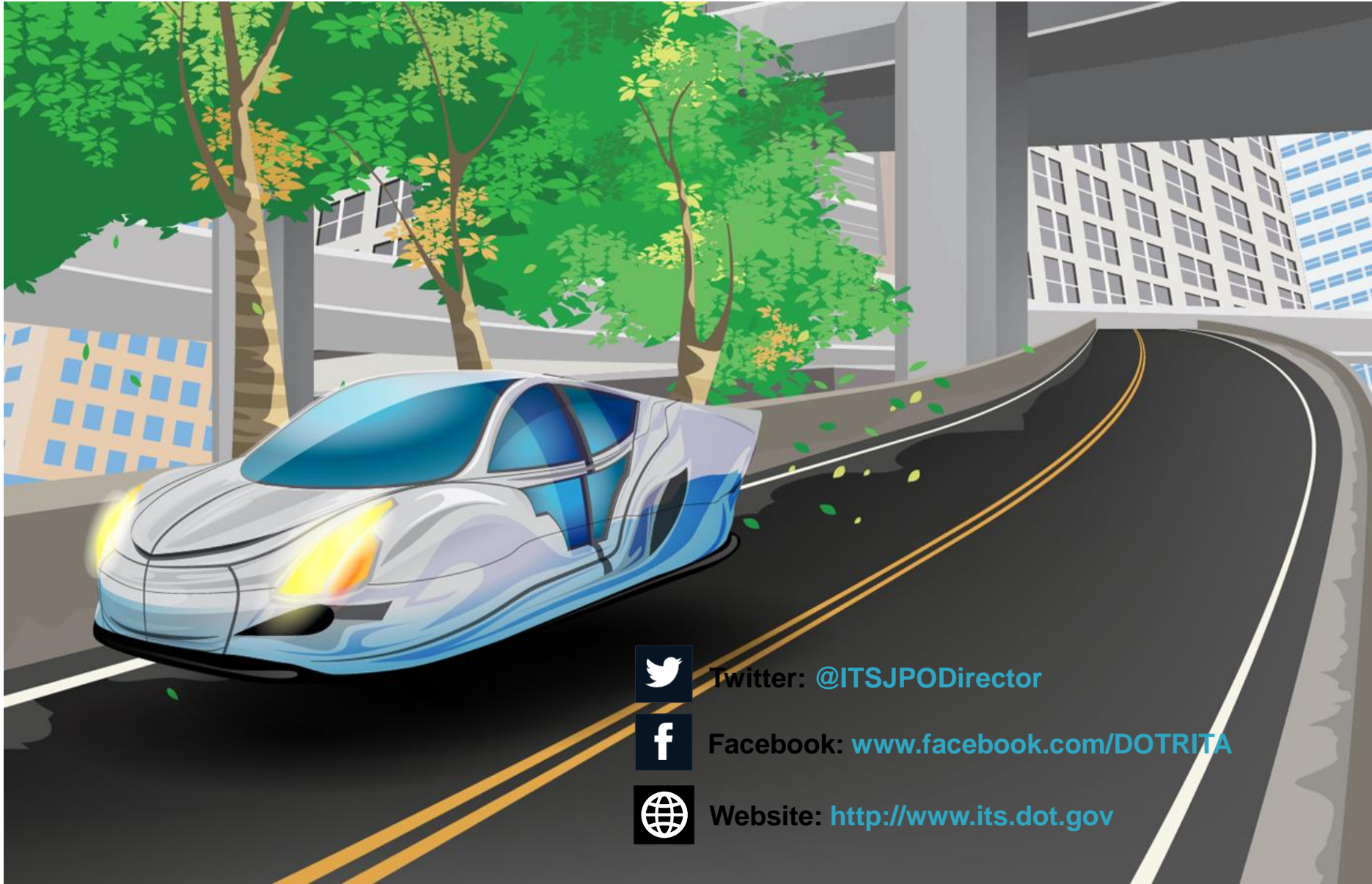
Training the ITS Workforce of the Future

ITS Professional Capacity Building Program

- Build and sustain a capable and technically proficient ITS workforce
- Provide comprehensive, accessible, flexible ITS learning for the transportation industry
- Focus on current and future transportation professionals—developing their knowledge, skills, and abilities while furthering career paths



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