OVERVIEW

- Connected Vehicles
  - Basic Connected Vehicle Concepts

- Connected Vehicles Pilot Deployment Program Overview
  - Program Goals
  - Organizing Principles
  - Deployment Requirements
  - Deployment Schedule

- Overview of CV Pilot Program Award Sites
  - Wyoming DOT (WYDOT) CV Pilot Deployment
  - New York City (NYC) DOT CV Pilot Deployment
  - Tampa (THEA) CV Pilot Deployment

- Planning for Connected Vehicles
  - Planning considerations for connected vehicles
Imagine a Transportation System in which
VEHICLES CAN SENSE &
COMMUNICATE
Things That You Can’t.
How Connected Vehicles Work

- A wireless device in a car sends basic safety messages 10 times per second

- Other nearby cars and roadside equipment receive the messages

- Drivers get a warning of a potential crash

*Source: NHTSA*
Connected Vehicles

Intersection Movement Assist:
Warns the driver when it is not safe to enter an intersection—for example, when something is blocking the driver’s view of opposing or crossing traffic.

Queue Warning and Speed Harmonization:
 Warns drivers of upcoming congestion and provides speed recommendations.

Eco Approach and Departure at Signalized Intersections:
 Presents information to drivers about traffic signal timing, allowing drivers to adapt their speed to pass the signal on green or decrease speed to a stop in the most eco-friendly way possible.
Autonomous & Driverless Vehicles:

- Array of sensors to detect other vehicles and obstacles
- Requires Detailed map
- Use machine learning to make software smarter
- Doesn’t rely on communication with other vehicles

Google’s automated vehicle
Autonomous Vehicles

Automation builds off current driver assistance technologies such as adaptive cruise control, lane departure warning and left turn assist

- NHTSA adopt SAE 6 levels of automation
- Level 0, 1, and 2 vehicles are on the road today

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Automation</td>
</tr>
<tr>
<td>1</td>
<td>Driver Assistance</td>
</tr>
<tr>
<td>2</td>
<td>Partial Automation</td>
</tr>
<tr>
<td>3</td>
<td>Conditional Automation</td>
</tr>
<tr>
<td>4</td>
<td>High Automation</td>
</tr>
<tr>
<td>5</td>
<td>Full Automation</td>
</tr>
</tbody>
</table>
Greatest benefits come from both together. In addition to safety benefits, there are estimated mobility and economic impacts:

- Crash reduction
- Capacity increases in current roadway systems
- Cost savings running through many industries, possibly starting with freight
- The potential for disruption is enormous

**With Platooning**

Automatic control means shorter gaps are possible without compromising safety.

However, empirical data are needed to more accurately assess the safety, fuel consumption, capacity, and emissions impacts of this CV application.
THE THREE PILOT SITES

- Reduce the number and severity of adverse weather-related incidents in the I-80 Corridor in order to improve safety and reduce incident-related delays.
- Focused on the needs of commercial vehicle operators in the State of Wyoming.

- Improve safety and mobility of travelers in New York City through connected vehicle technologies.
- Vehicle to vehicle (V2V) technology installed in up to 8,000 vehicles in Midtown Manhattan, and vehicle to infrastructure (V2I) technology installed along high-accident rate arterials in Manhattan and Central Brooklyn.

- Alleviate congestion and improve safety during morning commuting hours.
- Deploy a variety of connected vehicle technologies on and in the vicinity of reversible express lanes and three major arterials in downtown Tampa to solve the transportation challenges.
CV PILOT ORGANIZING PRINCIPLES

- CV Pilots are *pilot deployments*, that is, real-world environment deployments
  - The successful, deployed technologies are expected to remain as permanent operational elements

- Deployment concepts are *needs-driven*
  - Each site has different needs, focus and applications
    - That is, each pilot deployment will address critical problem(s)
    - The needs of each site will drive the deployment process

- Pilot deployments are expected to be both *large-scale with multiple applications*
  - *Large-scale* implies pilot deployments will have measureable impact, not a specific minimum geographic or vehicle fleet size
  - Sites will deploy *multiple applications* drawing on the products of USDOT and other connected vehicle research
CV PILOT DEPLOYMENT REQUIREMENTS

- Multiple connected vehicle applications will be deployed together
- Pilot deployments should leverage USDOT-sponsored research
- Pilot deployments include the capture of data from multiple sources
  - Integrated or carry-in devices for connected vehicles capable of generating an SAE J2735 Basic Safety Message (BSM)
  - Look to pilot deployment data while protecting privacy and intellectual property
- Dedicated Short Range Communications (DSRC) 5.9 GHz will be utilized as the communications technology
- Security and credentialing management system
- Well-defined, focused, quantitative performance measures
  - Support an independent evaluation effort
Phase 1: Concept Development (COMPLETE)
- Creates the foundational plan to enable further design and deployment
- Progress Gate: Is the concept ready for deployment?

Phase 2: Design/Deploy/Test (CURRENT PHASE - began September 1, 2016)
- Detailed design and deployment followed by testing to ensure deployment functions as intended (both technically and institutionally)
- Progress Gate: Does the system function as planned?

Phase 3: Maintain/Operate
- Focus is on assessing the performance of the deployed system
- Post Pilot Operations (CV tech integrated into operational practice)
Objective:
- Reduce the number and severity of adverse weather-related incidents (including secondary incidents) in the I-80 Corridor in order to improve safety and reduce incident-related delays.
  - Focused on the needs of the commercial vehicle operator in the State of Wyoming

Approach:
- Equip fleet vehicles (combination of snow plows, maintenance fleet vehicles, emergency vehicles, and private trucks) that frequently travel the I-80 corridor to transmit basic safety messages (BSMs), collect vehicle and road condition data and provide it remotely to the WYDOT TMCs
- Deploy DSRC roadside equipment (RSE) to supplement existing assets and initiatives
- Road weather data shared with freight carriers who will transmit to their trucks using exiting in-vehicle systems
Wyoming I-80 Corridor – Connected Vehicle Map

Source: Wyoming CV Pilot Deployment Team
## WYDOT Pilot Deployment Proposed CV Application-Fleet Distribution

<table>
<thead>
<tr>
<th>CV Application</th>
<th>WYDOT Fleet</th>
<th>Integrated Commercial Trucks</th>
<th>Retrofit Vehicles</th>
<th>Basic Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100</td>
<td>150-200</td>
<td>20-30</td>
<td>100-150</td>
</tr>
<tr>
<td>1. Forward Collision Warning</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>2. Spot Weather Impact Warning</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>3. Work Zone Warnings</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4. Situational Awareness</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>5. Distress Notification</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>✔</td>
</tr>
</tbody>
</table>

Other related traffic management and traveler information services:

- Setting and removing variable speed limits along the I-80 corridor
- Supporting 511 and other traveler information
- Supporting road weather advisories and freight-specific travel guidance through CVOP
WYDOT Pilot Deployment Vision

400 Equipped Trucks:
- 100 WYDOT Fleet
- 150 Integrated Commercial Trucks
- 25 Retrofit Vehicles
- 125 Basic Vehicles

Note: The number is a rough estimate for the concept development phase.

402 Miles of I-80

122 VSL Signs

75 RSU

55 Parking Locations

Available Truck Parking

Low Visibility / VSL

High Wind Warning Lifted

Zero Trucks Blown Over

Open to Light, High Profile Vehicles

Traffic Management Center

Onsite Meteorology

Roadside Equipment (RSU)

55 Parking Locations

402 Miles of I-80

Note: The number is a rough estimate for the concept development phase.
Objective:
- Improve safety and mobility of travelers in New York City through connected vehicle technologies
  - Aligned with the NYC’s Vision Zero initiative, which seeks to reduce crashes and pedestrian fatalities, and increase safety of travelers in all modes of transportation

Approach:
- Equip up to 8,000 vehicles (taxis, buses, commercial fleet delivery trucks, and City-owned vehicles) that frequently travel in Midtown Manhattan and Central Brooklyn to transmit and receive connected vehicle data
- Install V2I technology at high-accident rate arterials:
  - Upgrade 310 traffic signals along 1st, 2nd, 5th, and 6th Avenues in Manhattan and Flatbush Avenue in Central Brooklyn (emergency evacuation route)
  - Deploy Roadside equipment (RSE) along FDR Drive
NYCDOT PILOT DEPLOYMENT SITE

Manhattan Grid
- Closely spaced intersections (600’ x 250’)
- Day vs. Night conditions
- Residential/commercial mix
- High accident rate (red dot) (2012-2014)
  - 20 fatalities
  - 5,007 injuries
  - 204 intersections

Central Brooklyn – Flatbush Ave
- Over-Height restrictions
  - Tillary St.; Brooklyn Bridge
- High accident rate (red dots) (2012-14)
  - 1,128 injuries
  - 8 fatalities
- Average AM speed 15 mph
- 35 intersections

Manhattan – FDR Drive
- Limited access highway
- Excludes trucks/buses
- Short radius of curvature
- Over-Height restrictions
- $1,958,497 in Over-Height incident delay costs (2014)
  - 24% of City-wide total

Source: NYC DOT
### NYCDOT Pilot Deployment Proposed CV Application - Fleet Distribution

<table>
<thead>
<tr>
<th>CV Application</th>
<th>Taxi &amp; Limousine</th>
<th>NYC DOT/ Sanitation</th>
<th>MTA/ NYCTA Buses</th>
<th>Commercial Vehicles</th>
<th>Pedestrian</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Speed Compliance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2. Red Light Violation Warning</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3. Ped. in Signalized Crosswalk Warn.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>4. RT Vehicle in Front of Bus Warning</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Mobile Accessible Ped Signal Sys.</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>6. Curve Speed Compliance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>7. Oversize Vehicle Compliance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>8. Work Zone Speed Compliance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>9. I-SIG</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>10-14. V2V Applications (5)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>15. Evacuation Information</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
NYCDOT Pilot Deployment Vision

1,050 Sanitation & DOT vehicles

700 MTA Buses

1,050 Sanitation & DOT vehicles

5,850 Taxis

353 RSU

11 PED Detection System

400 UPS Vehicles

100 Vulnerable Road User Device

Note: The numbers are rough estimates for the concept development phase.
TAMPA (THEA) PILOT DEPLOYMENT OVERVIEW

Objective:
- The primary objective of this deployment is to alleviate congestion and improve safety during morning commuting hours.
- Deploy a variety of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) safety, mobility, and agency data applications to create reinforcing benefits for motorists, pedestrians, and transit operation.

Approach:
- Deploy a variety of connected vehicle technologies on and in the vicinity of reversible express lanes and three major arterials in downtown Tampa to solve the following transportation challenges:
- Morning peak hour queues, wrong-way entries, pedestrian safety, bus rapid transit (BRT) signal priority optimization, trip time and safety, streetcar trolley conflicts, and enhanced signal coordination and traffic progression.
Tampa Hillsborough Expressway Authority – Connected Vehicle Map

LEGEND: Connected Vehicle Application

**V2I Safety**
- End of Ramp Deceleration Warning (ERDW)
- Wrong Way Entry (WWE)
- Pedestrian in Signalized Crosswalk (PED-X)
- Mobile Accessible Pedestrian Signal (PED-SIG)

**V2V Safety**
- Emergency Electronic Brake Light (EEBL)
- Forward Collision Warning (FCW)
- Intersection Movement Assist (IMA)
- Vehicle Turn Right in Front of Transit Vehicle (VTRFTV)

**V2I Mobility**
- Intelligent Traffic Signal System (I-SIG)
- Transit Signal Priority (TSP)

**V2I Agency Data**
- Probe Data Enabled Traffic Monitoring (PDETM)
<table>
<thead>
<tr>
<th>Use Case No.</th>
<th>Description</th>
<th>Applications Involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Morning Backup</td>
<td>End of Ramp Deceleration Warning, Intelligent Signal Control, Emergency Electronic Brake Light, Forward Collision Warning</td>
</tr>
<tr>
<td>2</td>
<td>Wrong Way Entry</td>
<td>Wrong Way Entry, Intelligent Signal Control, Intersection Movement Assist</td>
</tr>
<tr>
<td>3</td>
<td>Pedestrian Safety</td>
<td>Pedestrian in a signalized crosswalk warning, Mobile Accessible Pedestrian Signal, Intelligent Signal Control</td>
</tr>
<tr>
<td>4</td>
<td>Transit Signal Priority</td>
<td>Intelligent Signal Control, Transit Signal Priority, Intersection Movement Assist</td>
</tr>
<tr>
<td>5</td>
<td>Trolley Conflicts</td>
<td>Intelligent Signal Control, Mobile Accessible Pedestrian Signal, Pedestrians in Signalized Crosswalk, Vehicle Turning in Front of a Transit Vehicle</td>
</tr>
<tr>
<td>6</td>
<td>Traffic Progression</td>
<td>Intelligent Signal Control, Probe Data Enabled Traffic Monitoring, Intersection Movement Assist</td>
</tr>
</tbody>
</table>
Tampa (THEA) Pilot Deployment Vision

Note: The numbers are rough estimates for the concept development phase.

- 1,600 vehicles equipped with OBU
- 10 equipped buses
- 10 equipped trolleys
- 500 equipped pedestrians
- 40 intersections (I-SIG, TSP, PED-SIG)

Data exchange will use DSRC (Dedicated Short Range Communications) or other wireless media. SCMS (Security Credential & Management System) will be used where appropriate.
# Overview of Pilot Deployment Proposed CV Applications

<table>
<thead>
<tr>
<th>Category</th>
<th>WYDOT – CV Application</th>
<th>Category</th>
<th>NYCDOT – CV Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>V2V Safety</td>
<td>Forward Collision Warning (FCW)</td>
<td></td>
<td>Speed Compliance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Curve Speed Compliance</td>
</tr>
<tr>
<td>V2I/I2V Safety</td>
<td>I2V Situational Awareness*</td>
<td></td>
<td>Speed Compliance/Work Zone</td>
</tr>
<tr>
<td></td>
<td>Work Zone Warnings (WZW)*</td>
<td></td>
<td>Red Light Violation Warning</td>
</tr>
<tr>
<td></td>
<td>Spot Weather Impact Warning (SWIW)*</td>
<td></td>
<td><strong>Oversize Vehicle Compliance</strong></td>
</tr>
<tr>
<td>V2I and V2V Safety</td>
<td><strong>Distress Notification (DN)</strong></td>
<td></td>
<td>Emergency Communications and Evacuation Information</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category</td>
<td>Tampa (THEA) – CV Application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V2I Safety</td>
<td>End of Ramp Deceleration Warning (ERDW)</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Pedestrian in Signalized Crosswalk Warning (PED-X)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wrong Way Entry (WWE)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V2V Safety</td>
<td>Emergency Electronic Brake Lights (EEBL)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Forward Collision Warning (FCW)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intersection Movement Assist (IMA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vehicle Turning Right in Front of a Transit Vehicle (VTRFTV)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobility</td>
<td>Mobile Accessible Pedestrian Signal System (PED-SIG)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intelligent Traffic Signal System (I-SIG)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Transit Signal Priority (TSP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agency Data</td>
<td>Probe-enabled Data Monitoring (PeDM)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category</th>
<th>NYCDOT – CV Application</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V2I/I2V Safety</td>
<td>Pedestrian in Signalized Crosswalk</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V2V Safety</td>
<td>Pedestrian in Signalized Crosswalk</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mobile Accessible Pedestrian Signal System (PED-SIG)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mobile Accessible Pedestrian Signal System (PED-SIG)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mobile Accessible Pedestrian Signal System (PED-SIG)</td>
<td></td>
</tr>
<tr>
<td>Mobility</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The applications have mobility/efficiency as a secondary benefit.*
### Overview of Pilot Deployment Proposed CV Devices

<table>
<thead>
<tr>
<th>WYDOT – Devices</th>
<th>Estimated Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadside Unit (RSU)</td>
<td>75</td>
</tr>
<tr>
<td>WYDOT Fleet Subsystem On-Board Unit (OBU)</td>
<td>100</td>
</tr>
<tr>
<td>Integrated Commercial Truck Subsystem OBU</td>
<td>150</td>
</tr>
<tr>
<td>Retrofit Vehicle Subsystem OBU</td>
<td>25</td>
</tr>
<tr>
<td>Basic Vehicle Subsystem OBU</td>
<td>125</td>
</tr>
<tr>
<td><strong>Total Equipped Vehicles</strong></td>
<td><strong>400</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NYCDOT – Devices</th>
<th>Estimated Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadside Unit (RSU) at Manhattan and Brooklyn Intersections and FDR Drive</td>
<td>353</td>
</tr>
<tr>
<td>Taxi Equipped with Aftermarket Safety Device (ASD)*</td>
<td>5,850</td>
</tr>
<tr>
<td>MTA Fleet Equipped with ASD*</td>
<td>700</td>
</tr>
<tr>
<td>UPS Truck Equipped with ASD*</td>
<td>400</td>
</tr>
<tr>
<td>NYCDOT Fleet Equipped with ASD*</td>
<td>800</td>
</tr>
<tr>
<td>DSNY Fleet Equipped with ASD*</td>
<td>250</td>
</tr>
<tr>
<td>Vulnerable Road User (Pedestrians/Bicyclists) Device</td>
<td>100</td>
</tr>
<tr>
<td>PED Detection System</td>
<td>10 + 1 spare</td>
</tr>
<tr>
<td><strong>Total Equipped Vehicles</strong></td>
<td><strong>8,000</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tampa (THEA) – Devices</th>
<th>Estimated Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadside Unit (RSU) at Intersection</td>
<td>40</td>
</tr>
<tr>
<td>Vehicle Equipped with On-Board Unit (OBU)</td>
<td>1,600</td>
</tr>
<tr>
<td>Pedestrian Equipped with App in Smartphone</td>
<td>500</td>
</tr>
<tr>
<td>HART Transit Bus Equipped with OBU</td>
<td>10</td>
</tr>
<tr>
<td>TECO Line Street Car Equipped with OBU</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total Equipped Vehicles</strong></td>
<td><strong>1,620</strong></td>
</tr>
</tbody>
</table>

**MTA:** Metropolitan Transportation Authority; **DSNY:** City of New York Department of Sanitation

*In addition, 600 spare ASDs will be purchased.*
Join us for the *Getting Ready for Deployment* Series

- Discover more about the CV Pilot Sites
- Learn the Essential Steps to CV Deployment
- Engage in Technical Discussion

Website: [http://www.its.dot.gov/pilots](http://www.its.dot.gov/pilots)
Twitter: [@ITSJPODirector](https://twitter.com/ITSJPODirector)
Facebook: [https://www.facebook.com/USDOTResearch](https://facebook.com/USDOTResearch)

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- Govind Vadakpat, THEA Site AOR
  G.Vadakpat@dot.gov
Planning for Connected Vehicles

What should be considered?
Knowing is half the battle…
- Planners need to become familiar Connected Vehicle technologies and applications

Planners don’t need to know “guts” of technology but need to track developments
- Conceptual knowledge of systems and technological readiness
- Timeframes for implementation (is implementation referring to technology or project?)
- Funding – who pays and how?
- Societal/organizational impacts
- Understand data outputs to support planning needs
Fundamental Consideration

- **Data Collection, Processing and Analysis**
  - Allowing transportation agencies to use data
    - Privacy, ownership and security concerns to be addressed
    - Coordination with private parties
    - Compatibility with current and planned DOT systems
  - Need to aggregate and turn large amounts of data into useful information
  - Applications for real-time systems analysis and operational planning
  - Applications for asset management – possible replacement of labor-intensive methods
  - Making efficient use of the data across multiple functions
Fundamental Consideration

- Long-Term Infrastructure Investment
  - Larger questions about future capital investment strategies
    - Will capacity improvements from CV reduce need for physical expansion?
    - Will safety improvements from CV reduce need for safety infrastructure investments?
    - Will roadway configurations have to change during period of mixed fleet operation? Separation of automated and non-automated vehicles?
    - What are impacts on major transit investments? Will automated vehicles replace or supplement some transit services?
    - What functions will be handled solely by the vehicle and what functions will need agency support?
## Typical Planning Products

| Non-constrained | Strategic | MPO Long Range Plan  
|                 |          | State Long Range Plan |
|                 |          | MPO Congestion Management Plan  
|                 |          | MPO Transit Development Plan  
|                 |          | MPO Non-motorized Plan  
|                 |          | Statewide Freight Plan  
| Constrained     | Project (or Activity) Focused | ITS Architecture & Operations/ITS Plan  
|                 |          | Statewide Transportation Improvement Program  
|                 |          | MPO Transportation Improvement Program  
|                 |          | State DOT Highway Safety Improvement Program  
|                 |          | Unified Planning Work Program |
Non-constrained Strategic Plans

Consideration #1: Baseline Analysis

- MTPs will need to identify existing infrastructure to be upgraded/integrated to support CV
  - MPOs have the opportunity to schedule CV upgrades during planned replacements/maintenance of infrastructure
- Estimates of the regional CV market penetration will be needed to anticipate the extent of CV impacts on all modes/projects in the MTP over the next 20 years
  - MPOs should establish a regular process for reviewing CV technology and trends to help inform the MTP baseline analysis
Consideration #2: Revisit Vision Statement…consider adding words like "connected" or "integrated"

MWCOG TPB Vision Statement

In the 21st Century, the Washington metropolitan region remains a vibrant world capital, with a transportation system that provides efficient movement of people and goods. This system promotes the region's economy and environmental quality, and operates in an attractive and safe setting--it is a system that serves everyone. The system is fiscally sustainable, promotes areas of concentrated growth, manages both demand and capacity, employs the best technology, and joins rail, roadway, bus, air, water, pedestrian and bicycle facilities into a fully interconnected network.
Consideration #3: Goals and objectives are typically based on federally prescribed planning factors and may be impacted by connected vehicles (e.g., changes in travel behavior and data collection; access to new technology).

- Scenario planning around CV can help MPOs understand the range of potential impacts.
  - Planners will need to evaluate a wider range of possible demographic, economic and transportation system scenarios.

- MPOs should proactively factor in these issues while envisioning CV infrastructure and policies.
Consideration #4: Revisit Performance Measures...

- Connected vehicle deployments are anticipated to have a significant impact on performance measure targets.

  - For example, connected vehicle deployments are projected to reduce crash rates over time and, therefore, impact safety performance measures and targets.

- The types of performance measure that are able to be collected will likely expand with new data available from connected vehicle deployments.
Consideration #5: Revisit strategies…

- Strategies that include connected vehicle applications should be considered.

- New models may be necessary to evaluate alternate strategies that include connected vehicles.
## Typical Planning Products

<table>
<thead>
<tr>
<th>Non-constrained</th>
<th>Strategic</th>
<th>Project (or Activity) Focused</th>
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<tbody>
<tr>
<td></td>
<td>MPO Long Range Plan</td>
<td>ITS Architecture &amp; Operations/ITS Plan</td>
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<td></td>
<td>State Long Range Plan</td>
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<tr>
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<td>MPO Congestion Management Plan</td>
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<td>MPO Transit Development Plan</td>
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<td>MPO Non-motorized Plan</td>
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<td>Statewide Freight Plan</td>
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<td>State DOT Highway Safety Improvement Program</td>
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<td>Unified Planning Work Program</td>
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Regional and statewide ITS architecture are the primary example of a non-constrained project centric plan. IT architecture need to be updated to include connected vehicle applications.

- Generally, CV will significantly impact statewide ITS architectures by:
  - Enhancing current ITS services
  - Strengthening the linkage between operations and planning of ITS
  - Changing and introducing new priorities in ITS operations planning

- Reference the Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) in order to assess how connected vehicle applications (or services) should be incorporated in regional ITS architecture.

- ARC-IT Link: [https://local.iteris.com/arc-it/](https://local.iteris.com/arc-it/)
## Typical Planning Products

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</table>
Consideration #1: Agencies responsible for developing State and regional transportation programs need to revisit project selection and prioritization process to ensure that connected vehicle projects are adequately considered.

- Agencies should evaluate whether their project selection criteria can accommodate CV projects, and work to make changes in the criteria if needed.
  - It may be difficult to quantitatively rank CV projects in the beginning because traditional evaluation metrics, such as cost-benefit ratios, are still preliminary for CV technology.

- CO-PILOT is available for high-level cost estimation
  [https://co-pilot.noblis.org/CVP_CET/](https://co-pilot.noblis.org/CVP_CET/)

- Public involvement in selecting early CV projects should accommodate the general public’s likely limited awareness of CV with educational components.
Consideration #2: Initial Connected Vehicle infrastructure investments will likely be CV supporting infrastructure or demonstration projects. These type of projects generally do not require public involvement.

Examples CV supporting infrastructure projects:
- Backhaul communications infrastructure for transmission of CV data to TOCs and other recipients
- Replacement of field equipment, such as signal controllers, should accommodate V2I technology; for example incorporating DSRC units
- Data management initiatives
Training Resources

- Connected Vehicle Impacts on Transportation Planning – Primer (Technology Summary)
- Connected Vehicles 101
- Connected Vehicles 102 - Applications and Planning for Implementation
- ITS PCB archived webinars:
  - CV Basics
  - National Connected Vehicle Field Infrastructure Footprint Analysis
- ITS ePrimer (Module 13: Connected Vehicles)

- ITS JPO Connected Vehicle Deployment Resources for Planners
  https://www.its.dot.gov/research_areas/cv_planners.htm