U.S. Department of Transportation Announces up to $42 Million in Next Generation Connected Vehicle Technologies September 15, 2015

- New York City
- Tampa, FL
- Wyoming
Agenda

- Use cases
  - Regional metro area
  - Freight corridor
  - Urban

- Pilot Deployment
  - Tampa
  - Wyoming
  - New York City
Agenda

- Use cases
  - Regional metro area
  - Freight corridor
  - Urban

- Pilot Deployment
  - Tampa
  - Wyoming
  - New York City
Example CV Pilot
Deployment Concepts:
H.W. Halleck Expressway
The H.W. Halleck Expressway:
- Highly congested 10-mile urban freeway
- Multiple interchanges
- Natural bottleneck at the Colfax S-Curve
- Significant issue with incidents, both minor (frequent) and major
- Unreliable travel times
- Limited arterial diversion routes
Identify Key Transportation Challenges

- **Recurrent Congestion**
  - Colfax S-curve is a natural bottleneck
  - Multiple interchanges leads to merge/weave delays

- **Incidents**
  - Response to major incidents lack coordination among agencies
  - Frequent minor incidents makes travel times unpredictable

- **Diversion Management**
  - Arterial diversion routes have limited capacity, easily overwhelmed
  - Mass diversions lead to gridlock on local arterials
## Three Key Improvement Targets

<table>
<thead>
<tr>
<th>Goal</th>
<th>Performance Measure</th>
<th>Performance Target</th>
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<tbody>
<tr>
<td>Improve Colfax S-Curve throughput</td>
<td>Peak period throughput</td>
<td>Increase peak period throughput by 8%</td>
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<tr>
<td>Reduce major incident delays</td>
<td>Delays due to major incidents</td>
<td>Cut delay from major incidents by 25%</td>
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<tr>
<td>Manage diversions better</td>
<td>Number of gridlock events</td>
<td>“Zero tolerance” for arterial gridlock during freeway incidents</td>
</tr>
</tbody>
</table>
Applications Considered to Improve Bottleneck Throughput

**V2I Safety**
- Red Light Violation Warning
- Curve Speed Warning
- Stop Sign Gap Assist
- Spot Weather Gap Impact Warning
- Reduced Speed/Work Zone Warning
- Pedestrian in Signalized Crosswalk Warning (Transit)

**V2V Safety**
- Emergency Electronic Brake Lights (EEBL)
- Forward Collision Warning (FCW)
- Intersection Movement Assist (IMA)
- Left Turn Assist (LTA)
- Blind Spot/Lane Change Warning (BSW/LCW)
- Do Not Pass Warning (DNPW)
- Vehicle Turning Right in Front of Bus Warning (Transit)

**Road Weather**
- Motorist Advisories and Warnings (MAW)
- Enhanced MDSS
- Vehicle Data Translator (VDT)
- Weather Response Traffic Information (WxTINFO)

**Environment**
- Eco-Approach and Departure at Signalized Intersections
- Eco-Traffic Signal Timing
- Eco-Traffic Signal Priority
- Connected Eco-Driving
- Wireless Inductive/Resonance Charging
- Eco-Lanes Management
- Eco-Speed Harmonization
- Eco-Cooperative Adaptive Cruise Control
- Eco-Traveler Information
- Eco-Ramp Metering
- Low Emissions Zone Management
- AFV Charging / Fueling Information
- Eco-Transit
- Dynamic traffic
- Eco

**Mobility**
- Advanced Traveler Information System
- Intelligent Traffic Signal System (I-SIG)
- Signal Priority (transit, freight)
- Mobile Accessible Pedestrian Signal System (PED-SIG)
- Emergency Vehicle Preemption (PREEMPT)
- Dynamic Speed Harmonization (SPD-HARM)
- Queue Warning (Q-WARN)
- Cooperative Adaptive Cruise Control (CACC)
- Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
- Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)
- Emergency Communications and Evacuation (EVAC)
- Connection Protection (T-CONNECT)
- Dynamic Transit Operations (T-DISP)
- Dynamic Ridesharing (D-RIDE)
- Freight-Specific Dynamic Travel Planning and Performance
- Drayage Optimization

**Smart Roadside**
- Wireless Inspection
- Smart Truck Parking

---

**Improve Throughput**
# Applications Considered to Reduce Incident Delay

## V2I Safety
- Red Light Violation Warning
- Curve Speed Warning
- Stop Sign Gap Assist
- Spot Weather Impact Warning
- Reduced Speed/Work Zone Warning
- Pedestrian in Signalized Crosswalk Warning (Transit)

## V2V Safety
- Emergency Electronic Brake Lights (EEBL)
- Forward Collision Warning (FCW)
- Intersection Movement Assist (IMA)
- Left Turn Assist (LTA)
- Blind Spot/Lane Change Warning (BSW/LCW)
- Do Not Pass Warning (DNPW)
- Vehicle Turning Right in Front of Bus Warning (Transit)

## Road Weather
- Motorist Advisories and Warnings (MAW)
- Enhanced MDSS
- Vehicle Data Translator (VDT)
- Weather Response Traffic Information (WxTINFO)

## Environment
- Eco-Approach and Departure at Signalized Intersections
- Eco-Traffic Signal Timing
- Eco-Traffic Signal Priority
- Connected Eco-Driving
- Wireless Inductive/Resonance Charging
- Eco-Adaptation
- Eco-Vehicle
- Eco-Smart Parking
- Dynamic Eco-Routing (light vehicle, transit, freight)
- Eco-ICM Decision Support System

## Mobility
- Advanced Traveler Information System
- Intelligent Traffic Signal System (I-SIG)
- Signal Priority (transit, freight)
- Mobile Accessible Pedestrian Signal System (PED-SIG)
- Emergency Vehicle Preemption (PREEMPT)
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- Incident Scene Pre-Arrival Staging
- Guidance for Emergency Responders (RESP-STG)
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- Connection Protection (T-CONNECT)
- Dynamic Transit Operations (T-DISP)
- Dynamic Ridesharing (D-RIDE)
- Freight-Specific Dynamic Travel Planning and Performance
- Drayage Optimization

## Agency Data
- Probe-based Pavement Maintenance
- Probe-enabled Traffic Monitoring
- Vehicle Classification-based Traffic Studies
- CV-enabled Turning Movement & Intersection Analysis
- CV-enabled Origin-Destination Studies
- Work Zone Traveler Information

## Smart Roadside
- Wireless Inspection
- Smart Truck Parking
### Applications Considered to Manage Diversions Better

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<thead>
<tr>
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<th><strong>Mobility</strong></th>
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### Zero tolerance for Arterial Gridlock

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<tr>
<td>Emergency Electronic Brake Lights (EEBL)</td>
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## Connected Vehicle Applications Selected in Performance-Driven Approach

### Improve Bottleneck Throughput
- Speed Harmonization and Queue Warning
- Emergency Electronic Brake Lights and Forward Collision Warning

### Reduce Incident Delay
- Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
- Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)

### Manage Diversions Better
- EnableATIS
- Intelligent Signal Control (I-SIG)
Projected Synergies and Impacts from Bottleneck Throughput Applications in the Deployment Concept

**Bottleneck Throughput Apps:**
- Speed Harmonization
- Queue Warning
- Forward Collision Warning
- Emergency Electronic Brake Lights

**Projected Impacts:**
- Smoother traffic into and out of the Colfax S-curve reduces incidents and raises bottleneck throughput by 8%
- Drivers warned far in advance of bottleneck shockwaves, assisted by in-vehicle warnings for crash avoidance
- Reduced frequency of incidents also reduces number of diversions
- Improved bottleneck flow facilitates faster major incident response
Projected Synergies and Impacts from Incident Management Applications in the Deployment Concept

**Incident Management Apps:**
- Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
- Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)

**Projected Impacts:**
- Improved coordination and incident scene management cuts major incident delay by 25%
- Improved incident management improves bottleneck throughput
- Reduced impact from major incidents reduces risk of over-diversion to arterials
Projected Synergies and Impacts from Diversion Management Applications in the Deployment Concept

**Projected Impacts:**
- Crowdsourced arterial travel times quantifies diversion alternatives
- Coordinated traveler information provision (public and private) manages diversion rates
- Driver decision data from private sector information service providers allows for fine-tuning of signal control
- Significantly reduced risk of arterial gridlock conditions
Integrated Concept for H. W. Halleck Expressway

- Messages for V2V Safety Applications also Support Incident Zone Management Safety
- Vehicle Probe Data Integrated with Freeway Sensors to Harmonize Flow
- Aggregated Data From Traveler Information Services Used To Predict
- Coordinated Multi-Agency Response Planning
- Signals Adapt to Prevent Gridlock
Agenda

- Use cases
  - Regional metro area
  - Freight corridor
  - Urban

- Pilot Deployment
  - Tampa
  - Wyoming
  - New York City
Example CV Pilot Deployment Concepts: I-876 Productivity Corridor
I-876 Productivity Corridor

- 112 Mile multi-state facility connecting ports and intermodal facilities in Northeastern U.S.
- Significant truck movement among urban centers and facilities
- Competition with other regions on Eastern seaboard for travel reliability
- LDM is 18th busiest airport in U.S.
Stakeholders Convene and Identify Key Transportation Challenges

- **Freight Productivity**
  - Heavy congested freeways interferes with timely and reliable freight movement and hinders economic development
  - Underutilized freight facilities, infrastructure, and mobile assets
  - Frequent empty moves within the corridor create non-optimal utilization of assets
  - Port, airport and inter-modal access subject to surge demand and long waits

- **Truck Safety**
  - Truck-vehicle conflicts in hilly merge/weave sections near interchanges
  - Truck-involved crashes caused by lane changing and blind spots
## Stakeholder Set Three Key Improvement Targets

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<thead>
<tr>
<th>Goal</th>
<th>Performance Measure</th>
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<tr>
<td>Improve Truck Travel Times</td>
<td>Freight travel times</td>
<td>Reduce freight vehicles travel times by 17%</td>
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<td>Reduce Number of Wasted Trips</td>
<td>Number of wasted truck trips</td>
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<tr>
<td>Improve truck safety</td>
<td>Number of truck related conflicts</td>
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### Applications Considered for Improving Freight Reliability

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<td>U.S. Department of Transportation</td>
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</tbody>
</table>

**U.S. Department of Transportation**

**ITS Joint Program Office**
# Applications Considered for Improving Truck Safety

## V2I Safety
- Red Light Violation Warning
- Curve Speed Warning
- Stop Sign Gap Assist
- Spot Weather Impact Warning
- Reduced Speed/Work Zone Warning
- Pedestrian in Signalized Crosswalk Warning (Transit)

## V2V Safety
- Emergency Electronic Brake Lights (EEBL)
- Forward Collision Warning (FCW)
- Intersection Movement Assist (IMA)
- Left Turn Assist (LTA)
- Blind Spot/Lane Change Warning (BSW/LCW)
- Do Not Pass Warning (DNPW)
- Vehicle Turning Right in Front of Bus Warning (Transit)

## Environment
- Eco-Approach and Departure at Signalized Intersections
- Eco-Traffic Signal Timing
- Eco-Freight Mobility
- Wireless Lanes Management
- Eco-Speed Harmonization
- Eco-Cooperative Adaptive Cruise Control
- Eco-Traveler Information
- Eco-Ramp Metering
- Low Emissions Zone Management
- AFV Charging / Fueling Information
- Eco-Smart Parking
- Dynamic Eco-Routing (light vehicle, transit, freight)
- Eco-ICM Decision Support System

## Agency Data
- Probe-based Pavement Maintenance
- Probe-enabled Traffic Monitoring
- Vehicle Classification-based Traffic Studies
- CV-enabled Turning Movement & Intersection Analysis
- CV-enabled Origin-Destination Studies
- Work Zone Traveler Information

## Mobility
- Advanced Traveler Information System
- Intelligent Traffic Signal System (I-SIG)
- Signal Priority (transit, freight)
- Mobile Accessible Pedestrian Signal System (PED-SIG)
- Emergency Vehicle Preemption (PREEMPT)
- Dynamic Speed Harmonization (SPD-HARM)
- Queue Warning (Q-WARN)
- Cooperative Adaptive Cruise Control (CACC)
- Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
- Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)
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- Dynamic Ridesharing (D-RIDE)
- Freight-Specific Dynamic Travel Planning and Performance
- Drayage Optimization

## Smart Roadside
- Wireless Inspection

## Smart Truck Parking

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**U.S. Department of Transportation**

**ITS Joint Program Office**
# Connected Vehicle Applications Selected in Performance-Driven Approach

## Improve Freight Productivity
- Freight Advanced Traveler Information System (FRATIS)
- Drayage Optimization (DRG-OPT)
- Freight Signal Priority (FSP)

## Improve Truck Safety
- Smart Truck Parking
- Curve Speed Warning (CSW)
- Do Not Pass Warning (DNPW) /Lane Change Warning (LCW)
Projected Synergies and Impacts from Truck Safety Apps in the Deployment Concept

Truck Safety Apps
- Smart Truck Parking
- Curve Speed Warning (CSW)
- Do Not Pass Warning (DNPW) /Lane Change Warning (LCW)

Projected Impacts:
- Reduced number of truck-vehicle conflicts and crashes
- Reduced crashes improves freight reliability, particularly around hilly interchanges
- Improved freight data helps improve overall corridor mobility
Projected Synergies and Impacts from Freight Reliability Applications in the Deployment Concept

**Freight Reliability Apps**
- Freight Advanced Traveler Information System (FRATIS)
- Drayage Optimization (DRG-OPT)
- Freight Signal Priority (FSP)

**Projected Impacts:**
- 20% decrease in late arrival of goods
- Reduced number of empty moves
- Optimized use of freight trucks by cargo need
- Signals optimized for access to intermodal facilities when wait times are short
Integrated Concept for I-876 Corridor

- Roadside infrastructure used for both electronic inspections and safety applications
- In-Vehicle Truck Technologies Support Both V2V and V2I Applications
- Intermodal Facility Wait Times Measured and Shared
- Drayage Movements Dynamically Optimized
- Signals Timed to Prioritize for Gate Demand at Intermodal Facilities
Agenda

- **Use cases**
  - Regional metro area
  - Freight corridor
  - **Urban**

- **Pilot Deployment**
  - Tampa
  - Wyoming
  - New York City
Example CV Pilot Deployment Concepts:
Downtown Sunnyside
Downtown Sunnyside

Sunnyside's central business district:
- Busy signalized network in Southern U.S.
- Complex, congested intersections
- Limited parking options
- Transit corridor
- High pedestrian traffic
- Poor localized “hot spot” air quality
Stakeholders Convene and Identify Key Transportation Challenges

- **Mobility**
  - Heavy congestion at peak times
  - Transit vehicles schedule reliability

- **Safety**
  - Pedestrian-vehicle conflicts
  - Crashes in unprotected left hand turns

- **Environment**
  - Emissions/Air Quality hot spots
  - Poor progression results in wasted fuel
## Stakeholder Set Three Key Improvement Targets

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<tr>
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<tbody>
<tr>
<td>Increase transit reliability</td>
<td>Transit schedule adherence</td>
<td>Transit vehicles on schedule 90% of the time</td>
</tr>
<tr>
<td>Improve pedestrian safety</td>
<td>Pedestrian-vehicle conflicts</td>
<td>Reduce pedestrian-vehicle conflicts by 50%</td>
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<tr>
<td>Improve hot spot air quality</td>
<td>Emissions</td>
<td>Reduce emissions by 20%</td>
</tr>
</tbody>
</table>
### Applications Considered for Improving Transit Reliability

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- Red Light Violation Warning
- Curve Speed Warning
- Stop Sign Gap Assist
- Spot Weather Impact Warning
- Reduced Speed/Work Zone Warning
- Pedestrian in Signalized Crosswalk Warning (Transit)

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- Emergency Electronic Brake Lights (EEBL)
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- Connected Eco-Driving
- Wireless Inductive/Resonance Charging
- Eco-Lanes Management
- Eco-Carrier and Cargo Cruise Control
- Eco-Traveler Information
- Eco-Ramp Metering
- Low Emissions Zone Management
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- Eco-Smart Parking
- Dynamic Eco-Routing (light vehicle, transit, freight)
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#### Mobility
- Advanced Traveler Information System
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- Weather Response Traffic Information (WxTINFO)

#### Smart Roadside
- Wireless Inspection
- Smart Truck Parking
### Applications Considered for Improving Pedestrian Safety

#### V2I Safety
- Red Light Violation Warning
- Curve Speed Warning
- Stop Sign Gap Assist
- Spot Weather Impact Warning
- Reduced Speed/Work Zone Warning
- Pedestrian in Signalized Crosswalk Warning (Transit)

#### V2V Safety
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- Forward Collision Warning (FCW)
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- Do Not Pass Warning (DNPW)
- Vehicle Turning Right in Front of Bus Warning (Transit)

#### Environment
- Eco-Approach and Departure at Signalized Intersections
- Eco-Traffic Signal Timing
- Eco-Ramp Metering
- Low Emissions Zone Management
- AFV Charging / Fueling Information
- Eco-Smart Parking
- Dynamic Eco-Routing (light vehicle, transit, freight)
- Eco-ICM Decision Support System

#### Agency Data
- Probe-based Pavement Maintenance
- Probe-enabled Traffic Monitoring
- Vehicle Classification-based Traffic Studies
- CV-enabled Turning Movement & Intersection Analysis
- CV-enabled Origin-Destination Studies
- Work Zone Traveler Information

#### Mobility
- Advanced Traveler Information System
- Intelligent Traffic Signal System (I-SIG)
- Signal Priority (transit, freight)
- Mobile Accessible Pedestrian Signal System (PED-SIG)
  - Emergency Vehicle Preemption (PREEMPT)
  - Dynamic Speed Harmonization (SPD-HARM)
  - Queue Warning (Q-WARN)
  - Cooperative Adaptive Cruise Control (CACC)
  - Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
  - Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)
  - Emergency Communications and Evacuation (EVAC)
  - Connection Protection (T-CONNECT)
  - Dynamic Transit Operations (T-DISP)
  - Dynamic Ridesharing (D-RIDE)
  - Freight-Specific Dynamic Travel Planning and Performance
  - Drayage Optimization

#### Road Weather
- Motorist Advisories and Warnings (MAW)
- Enhanced MDSS
- Vehicle Data Translator (VDT)
- Weather Response Traffic Information (WxTINFO)

#### Smart Roadside
- Wireless Inspection
- Smart Truck Parking
# Applications Considered for Improving the Environment

## V2I Safety
- Red Light Violation Warning
- Curve Speed Warning
- Stop Sign Gap Assist
- Spot Weather Gap Warning
- Reduced Speed/Work Zone Warning
- Pedestrian in Signalized Crosswalk Warning (Transit)

## V2V Safety
- Emergency Electronic Brake Lights (EEBL)
- Forward Collision Warning (FCW)
- Intersection Movement Assist (IMA)
- Left Turn Assist (LTA)
- Blind Spot/Lane Change Warning (BSW/LCW)
- Do Not Pass Warning (DNPW)
- Vehicle Turning Right in Front of Bus Warning (Transit)

## Road Weather
- Motorist Advisories and Warnings (MAW)
- Enhanced MDSS
- Vehicle Data Translator (VDT)
- Weather Response Traffic Information (WxTINFO)

## Environment
- **Eco-Approach and Departure at Signalized Intersections**
- Eco-Traffic Signal Timing
  - Eco-Traffic Signal Priority
  - Connected Eco-Driving
  - Wireless Inductive/Resonance Charging
  - Eco-Lanes Management
  - Eco-Speed Harmonization
  - Eco-Cooperative Adaptive Cruise Control
  - Eco-Traveler Information
  - Eco-Ramp Metering
  - Low Emissions Zone Management
  - AFV Charging / Fueling Information
  - Eco-Smart Parking
  - Dynamic Eco-Routing (light vehicle, transit, freight)
  - Eco-ICM Decision Support System

## Mobility
- Advanced Traveler Information System
- Intelligent Traffic Signal System (I-SIG)
- Signal Priority (transit, freight)
- Mobile Accessible Pedestrian Signal System (PES-SIG)
- Emergency Vehicle Preemption (PREEMPT)
- Dynamic Speed Harmonization (SPD-HARM)
- Cooperative Adaptive Cruise Control (CACC)
- Incident Scene Pre-arrival Staging and Guidance for Emergency Responders (RESP-STG)
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## Agency Data
- Probe-based Pavement Maintenance
- Probe-enabled Traffic Monitoring
- Vehicle Classification-based Traffic Studies
- CV-enabled Turning Movement & Intersection Analysis
- CV-enabled Origin-Destination Studies
- Work Zone Traveler Information

## Smart Roadside
- Wireless Inspection
- Smart Truck Parking
## Connected Vehicle Applications Selected in Performance-Driven Approach

### Improve Transit Reliability
- Connection Protection (T-CONNECT)
- Transit Signal Priority

### Improve Pedestrian Safety
- Mobile Accessible Pedestrian Signal System (PED-SIG)
- Pedestrian in Signalized Crosswalk Warning
- Intersection Movement Assist (IMA)

### Improve Hot Spot Air Quality
- Eco-Approach and Departure at Signalized Intersections
- Eco-Traffic Signal Timing
Projected Synergies and Impacts from Transit Applications in the Deployment Concept

Addition of Transit Apps
- Connection Protection (T-CONNECT)
- Transit Signal Priority

Projected Impacts:
- Fewer missed transit connections
- Transit vehicles on schedule 90% of the time; better transit reliability
- Reduced emissions from transit vehicles
- Higher transit ridership
Projected Synergies and Impacts from Pedestrian Safety Apps in the Deployment Concept

Projected Impacts:
- 50% decrease in pedestrian-vehicle conflicts
- Improved mobility for pedestrians and vehicles
- Reduced emissions due to better traffic flow

Addition of Pedestrian Safety Apps:
- Mobile Accessible Pedestrian Signal System (PED-SIG)
- Pedestrian in Signalized Crosswalk Warning
- Intersection Movement Assist (IMA)
Projected Synergies and Impacts from Environmental Apps in the Deployment Concept

Addition of Environmental Apps

- Eco-Approach and Departure at Signalized Intersections
- Eco-Traffic Signal Timing or Intelligent Traffic Signal System (I-SIG)

Project Impacts

- 20% decrease in vehicle emissions
- Improved overall intersection throughput
- 10% reduction in vehicle delay
- Sunnyside can optimize for mobility or environment depending on need
Integrated Concept for Downtown Sunnyside

- Messages support several applications
- Integration of a suite of applications results in additional benefits
- Information from BSM generating devices and other vehicles
- Integrated data from sensors and new technologies
Agenda

- **Use cases**
  - Regional metro area
  - Freight corridor
  - Urban

- **Pilot Deployment**
  - Tampa
  - Wyoming
  - New York City
CONNECTED VEHICLE PILOT DEPLOYMENT PROGRAM

PROGRAM GOALS

- Spur Early CV Tech Deployment
- Measure Deployment Benefits
- Resolve Deployment Issues
- Wirelessly Connected Vehicles
- Safety
- Technical
- Infrastructure
- Mobility
- Institutional
- Environment
- Financial

PILOT SITES

- NYCDOT
- ICF/Wyoming DOT
- Tampa (THEA)

STAY CONNECTED

- Visit Program Website for Updates: http://www.its.dot.gov/pilots
- Contact: Kate Hartman, Program Manager, Kate.hartman@dot.gov
Sites are wrapping up Phase 1; projected Phase 2 Start in September 2016

- Phase 1: Concept Development *(Current Phase)*
  - Creates the foundational plan to enable further design and deployment
  - **Progress Gate: Is the concept ready for deployment?**
- Phase 2: Design/Deploy/Test
  - 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)
CONNECTED VEHICLE PILOT
Deployment Program

Tampa Pilot Site
Extended Stakeholder Impact Area

Source: HNTB
The stated goals of the USDOT CV Pilot Deployments research experiment are improving Mobility, Safety, Environment and Agency Efficiency through CV technology.

- **Goal 1:** Develop and Deploy CV Infrastructure and Applications to Evaluate Effectiveness in Addressing the Identified Issues/Needs
- **Goal 2:** Improve Mobility in the Central Business District (CBD)
- **Goal 3:** Reduce the Number of Safety Incidents within the Pilot Area
- **Goal 4:** Reduce Environmental Impacts within the Pilot Area
- **Goal 5:** Improve Agency Efficiency
- **Goal 6:** Develop Business Environment for Sustainability
Number of Roadside Units: 40

Number of Onboard Units - Vehicles:

- 10 HART Buses
- 10 HART (TECO Line) Trolley Cars
- 1500 privately owned cars and light trucks
- TBD number of nomadic devices, (smart phones, tablets, wearable bluetooth devices etc.)

- Primary cost here is for application. Number of participants thereafter is only limited by enrollment.

- Targets for recruiting in this segment are downtown condo associations and major office building tenant groups.
DEPLOYMENT CONCEPT

Source HNTB/Siemens
Use Cases

- Morning Peak Hour Queues
- Wrong Way Entries
- Pedestrian Safety
- Transit Signal Priority
- Streetcar Conflicts
- Enhanced Signal Coordination
<table>
<thead>
<tr>
<th>Performance Pillars</th>
<th>Performance Measures</th>
<th>UC1 Morning Peak Hour Queues</th>
<th>UC2 Wrong Way Entries</th>
<th>UC3 Pedestrian Safety</th>
<th>UC4 BRT Signal Priority</th>
<th>UC5 Trolley Conflicts</th>
<th>UC6 Enhanced Signal Coordination Progression</th>
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</thead>
<tbody>
<tr>
<td>Mobility</td>
<td>Travel time</td>
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<tr>
<td></td>
<td>Travel time reliability</td>
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<td>✅</td>
<td></td>
<td>✅</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Queue length</td>
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<td>✅</td>
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<tr>
<td></td>
<td>Vehicle delay</td>
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<td>✅</td>
<td></td>
<td>✅</td>
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<td></td>
<td>Throughput</td>
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<td>✅</td>
<td>✅</td>
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<td>✅</td>
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<tr>
<td></td>
<td>Percent (%) arrival on green</td>
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<td>✅</td>
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<tr>
<td></td>
<td>Bus travel time</td>
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<tr>
<td></td>
<td>Bus route travel time reliability</td>
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<td></td>
<td>Percent (%) arrival on schedule</td>
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<td>Signal priority:</td>
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</tr>
<tr>
<td></td>
<td>Number of times priority is requested and granted</td>
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</tr>
<tr>
<td></td>
<td>Number of times priority is requested and denied</td>
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<tr>
<td></td>
<td>Number of times priority is requested, granted and then denied due to a higher priority (i.e. EMS vehicle)</td>
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<tr>
<td>Environmental</td>
<td>Emissions reductions in idle</td>
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<td>✅</td>
<td></td>
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<tr>
<td></td>
<td>Emissions reductions in running</td>
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<td>✅</td>
<td>✅</td>
<td></td>
<td>✅</td>
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</tbody>
</table>

- 6 Use Cases
- 11 CV Apps
- 40 RSUs
- 4 Evaluation “Pillars”
  - Mobility
  - Environmental
  - Safety
  - Agency Efficiency
- 3 Experimental Designs
- 22 Potential Measures
### Metrics Identified PMESP (continued)

<table>
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<th>UC6 Enhanced Signal Coordination Progression</th>
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</thead>
<tbody>
<tr>
<td>Safety</td>
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<td>Crash rate</td>
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<tr>
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<td>Type of conflicts / near misses</td>
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<td>✓</td>
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<tr>
<td></td>
<td>Severity of conflicts / near misses</td>
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<td></td>
<td>Percent (%) red light violation/running</td>
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<td>Approaching vehicle speed</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Number of wrong way entries and frequency</td>
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<tr>
<td>Agency Efficiency</td>
<td>Mobility improvements through the mobility pillar analysis</td>
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<td>✓</td>
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<td>✓</td>
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<tr>
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<td>Safety improvements through the safety pillar analysis</td>
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<td>✓</td>
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</tr>
<tr>
<td></td>
<td>Customer satisfaction through opinion survey and/or CV app feedback</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

- 6 Use Cases
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- 40 RSUs
- 4 Evaluation “Pillars”
  - Mobility
  - Environmental
  - Safety
  - Agency Efficiency
- 3 Experimental Designs
- 22 Potential Measures
Random Design – Treatment and Control groups, random assignment, compare average treatment effect, desirable but always achievable

Quasi-Experimental – Used when random assignment not possible, selection bias reduced by using methods like propensity score matching, matching algorithm, difference in difference

Before/After – Time series analysis, no control and treatment groups, confounding factor identification, baseline data required

<table>
<thead>
<tr>
<th>Experimental Design</th>
<th>UC1 Morning Peak Hour Queues</th>
<th>UC2 Wrong Way Entries</th>
<th>UC3 Pedestrian Conflicts at Courthouse</th>
<th>UC4 Bus Rapid Transit Signal Priority Optimization Trip Times and Safety</th>
<th>UC5 TECO Line Streetcar Trolley Conflicts</th>
<th>UC6 Enhanced Signal Coordination and Traffic Progression</th>
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</thead>
<tbody>
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<td>Before/ After</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tbody>
</table>
Systems Engineering – Challenges / Lessons Learned

- Application maturity not as evolved as expected
- Evolving standards
- Concurrent planning documents development
- More direct interaction with other teams
- Use of non-CV technology as part of solution
- Security
Program Management – Challenges / Lessons Learned

- **Challenges**
  A. Distributed Team Locations – Logistics
  B. Aggressive Delivery Schedules
  C. Balancing High Energy, Super Talented Teams with Need to have Centralized PM
  D. HIGH Number of Stakeholders with Initially Low Level of Comprehension

- **Lessons Learned**
  A. Importance of face to face progress meetings followed by breakout sessions
  B. **Critical documents have overlapping/redundant content.**
     a) Each progressive document must be reconciled with prior documents
     b) QC/QA should include dedicated staff having no other project involvement
     c) Reconciliation document for tracking these connected changes
  C. Balance needed between empowering team leads to operate autonomously and maintaining centralized program management to keep all teams informed and connected
  D. Need to not only engage early but to educate early as to the “Benefits” of the program and why their participation is key to success.
**Challenges**

A. Deployment in an area undergoing significant redevelopment will likely complicate dealing with confounding factors

B. Identification of performance targets more difficult than developing measures and methods.

**Lessons Learned**

A. **Cross functional coordination is absolutely critical**

B. **Early involvement in activities such as System Requirements helps facilitate meaningful measurement**

C. **Early definition of needs and role of Independent Evaluator would be helpful**
Wyoming Pilot Site
Wyoming’s I-80 Corridor

Heavy Freight Traffic
• Major E/W Freight corridor
• Freight over half of annual traffic

Severe Weather Conditions
• Roadway elevation,
• Heavy winds, heavy snow and fog
• Severe blowing snow and low visibility

Adverse Impacts on Truckers
• Higher than normal incident rates
• Multi-vehicle crashes
• Fatalities

Source: WYDOT (Dec 17, 2015)
WYDOT Pilot: DSRC-Based

CV Environment
75 Roadside Units on I-80
400 Vehicles with DSRC Connectivity

V2V Applications
Forward Collision Warning
Distress Notification

V2I Applications
Situational Awareness
Spot Weather
Work Zone Warning
WYDOT Pilot: Freight Focused

CV Trucks
~150-200 large trucks
~100 small/medium trucks

Fleet Partners
National and Local Truck Companies

Freight Partners
CVOP Users (800 firms)
Wyoming Trucking Association
Third Party Intermediaries
WYDOT Pilot: Integrated with TMC

- Supports I-80 Traveler Information
- Supports VSL and other traffic mgmt. strategies
- Integrated with TMC Management Systems

WYDOT’s VSL, 511 and other services will rely on CV data
WYDOT Pilot: Integrated with WYDOT Fleets

- Environmental Probe Data Collection
- Leverage existing technology
- ~100 DSRC-enabled snow plows and highway patrol vehicles

WYDOT’s use of its own fleets in the CV pilot will allow for continued operations post pilot
CV Applications Overview

On-Board Applications
- Applications available to equipped vehicles

TMC Ops Applications
- Support for WYDOT Traveler Information and Traffic Management
Lessons Learned (1 of 3)

1. Be prepared for concept evolution – must meet real needs!
2. Leverage existing resources but understand limitations with respect to pilot
3. Developing verifiable system requirements is challenging in the CV arena
4. Develop an approach to integrate CV pilot with existing transportation systems management and operations
Lessons Learned (2 of 3)

- Address commercial operator’s priorities and concerns (privacy, liability, flexibility)
- Once initial concept and user needs are stable, engage with vendors
- Plan with post-pilot operation in mind
- Balance data needs (privacy/security vs. performance measurement)
Formalized agreements with private partners take time. Start with initial letters of support.

Engage procurement and contracting personnel early.

Leverage local stakeholders and champions. Engage leadership early.

Be opportunistic. Take advantage of evolving trends and interest.
New York City Pilot Site
Stakeholders

- NYCDOT Bureau of Traffic Operations
- NYCDOT Fleets
- Department of Sanitation Fleet Operations
- Metropolitan Transportation Authority / NYC Transit
- UPS
- Taxi & Limousine Commission
- New York State Motor Truck Association
- Pedestrians for Accessible and Safe Streets (PASS)
- Department of Information Technology and Telecommunications (DoITT) (NYCWiN)
- NYCDOT IT Department (Security issues)
CV Applications - 1

V2V Safety Applications

- Vehicle Turning Right in Front of Bus Warning
- Forward Collision Warning
- Emergency Electronic Brake Light
- Blind Spot Warning
- Lane Change Warning/Assist
- Intersection Movement Assist

V2V applications based on existing demonstrations and prior developments and documentation
CV Applications - 2

V2I Safety Applications

- Red Light Violation Warning
- Speed **Compliance**
- Curve Speed **Compliance**
- Speed **Compliance**/Work Zone
- Oversize Vehicle **Compliance**
  - Prohibited Vehicle (Parkways)
  - Overheight
- Emergency Communications and Evacuation Information  *(Using the traveler information features)*
CV Applications - 3

Other Applications

- Mobile [Visually Impaired] Ped Signal System
- Pedestrian in Signalized Intersection Warning
- CV Data for Intelligent Traffic Signal System

Operations, Maintenance, and Performance Analysis

- RF Monitoring
- Firmware Update
- Parameter Up/Down Loading
- Traffic data collection
- Event History Recording
- Event History Up Load
Equipment

- Deployment of CV Technology in a Dense Urban Environment
  - Up to 8,000 **fleet vehicles** with After Market Safety Devices (ASDs):
    - ~5,850 Taxis (Yellow Cabs)
    - ~1,250 MTA Buses
    - ~500 Sanitation & DOT vehicles
    - ~400 UPS vehicles
  - Pedestrian ~100 units
  - Roadside Units (RSU) at
    - ~371 Locations
    - ~8 on FDR
    - ~28 on Flatbush Ave
    - ~202 Manhattan Ave
    - ~97 Manhattan Cross
    - ~36 Support locations (airports, river crossings, terminal facilities)

Source: USDOT
Performance Measures Evaluation

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Reduce Crashes</td>
<td>FCW EEBL BSW LCW IMA</td>
<td>4a</td>
<td>Fatality crash counts</td>
<td>Do the number of reportable crashes decrease?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4b</td>
<td>Injury crash counts</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4c</td>
<td>Property damage only crash counts</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>4d</td>
<td>Time to Collision (vehicle to vehicle)</td>
<td></td>
</tr>
</tbody>
</table>

Other questions for evaluation (see Performance Measures webinar for others):

- Do the number and severity of red light violations at each studied intersection decrease?
- Do the number of bus / right turn vehicle crashes decrease?
- Does speed limit adherence and speed variability within the vehicle fleet on a given study roadway segment for a given time period (cycle length basis) decrease?
- Is this accompanied by an overall increase, decrease or no change in average segment speed?
- Do the number of curve speed violations on each applicable studied roadway segment decrease?
- Do the number of work zone speed violations on each applicable studied roadway segment decrease?
- Do the number of pedestrian related crashes decrease?
Concept of Operations Lessons

- Basic design issue
  - **Basic system premise: protect privacy**
    - Performance measurement compromises privacy because it requires knowing vehicle identity
    - Protect privacy vs data collection needs of IE
    - FFP contract became open ended data collection
    - Scalable data collection – remember assumptions
- Pedestrian safety issue
  - Visually challenged pedestrians
  - User need: notify about ALL vehicles
  - Resolution: notify vehicles only
- Security
  - Integrating with existing security systems/policies can be a time consuming challenge
  - Effects existing infrastructure – IT networks and equipment
- Regulatory speeds drive the needs and not the vehicle kinematics
- FCC RSU licensing for “mobile” attenuator vehicles – not permitted (USDOT is working this issue)
Deliverables are highly interdependent

- Integrating USDOT-identified task interdependencies creates this diagram....

- Stovepipe approach by task is NOT recommended

Source: USDOT
John M Broemmelsiek, PE
FHWA – Louisiana Division
john.broemmelsiek@dot.gov