TRANSPORTATION CHALLENGES
SAFETY, MOBILITY, ENVIRONMENT
Smarter transportation through the use of connected and automated vehicles will help the safety, mobility and environmental challenges.

**Safety**
- 33,561 highway deaths in 2012
- 5,615,000 crashes in 2012
- Leading cause of death for ages 4, 11-27

**Mobility**
- 5.5 billion hours of travel delay
- $121 billion cost of urban congestion

**Environment**
- 2.9 billion gallons of wasted fuel
- 56 billion lbs. of additional CO₂
TECHNOLOGY
CONNECTED AND AUTOMATED DRIVING
AUTOMATED DRIVING TECHNOLOGY: VEHICLE ARCHITECTURE
Research prototype truck architecture from Japan
Vehicle dynamics **modeling, simulation and validation**.

**Offline algorithm development** and testing. Excessive **hardware-in-the-loop** testing.

**Road testing** using fleet of connected and automated vehicles.

**CV Pilot Deployment** before full deployment of CV technology
Speed to be followed is calculated automatically based on curvature.
Convoy driving is possible.
Road friction coefficient is user defined for each segment.
GPS data from road (implementation is same as the one in experimental vehicle).
Stops at stop signs, collision avoidance using elastic band approach.
Effect of yaw stability problems are being investigated.
CONNECTED VEHICLE TECHNOLOGY: HETEROGENEOUS TRAFFIC

\[ a_1 \quad r_1 \quad L_1 \quad r_2 \quad L_2 \quad r_3 \quad L_3 \quad r_4 \quad L_4 \]
### CONNECTED VEHICLE TECHNOLOGY: TRUCK PLATOONING

#### Diagram:
- **Coupling/Decoupling**
- **Vehicle Speed control**
- **Lane-Tracking Control**
- **Obstacle Avoidance Control**
- **Closed Gap Distance Control**

#### Table:

<table>
<thead>
<tr>
<th>Control</th>
<th>Ahead Vehicle</th>
<th>Following Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coupling/decoupling</td>
<td>Semi-auto</td>
<td>Semi-auto</td>
</tr>
<tr>
<td>Gap distance within platoon</td>
<td>10m</td>
<td></td>
</tr>
<tr>
<td>Lane-keeping</td>
<td>Machine vision</td>
<td>Machine vision</td>
</tr>
<tr>
<td>Vehicle speed</td>
<td>ACC</td>
<td>CACC</td>
</tr>
<tr>
<td>Gap distance</td>
<td>• Laser</td>
<td>• Laser</td>
</tr>
<tr>
<td></td>
<td>• Radar(76GHz)</td>
<td>• Radar(76GHz)</td>
</tr>
<tr>
<td>Obstacle avoidance</td>
<td>Emergency Braking</td>
<td>5.8GHz V2V Communication</td>
</tr>
</tbody>
</table>
OPPORTUNITY
CV PILOT DEPLOYMENTS
Based on successful results of connected vehicle research program, and recent decision by NHTSA to pursue vehicle to vehicle communications safety technology for light vehicles, **robust connected vehicle pilots program envisioned as a mechanism to spur the implementation of connected vehicle technology**

U.S. DOT connected vehicle research program aims to **enable safe, interoperable networked wireless communications among vehicles, infrastructure, and personal communications devices**

Pilots will serve as initial implementations of connected vehicle technology deployed in real world settings with **aim of delivering near-term safety, mobility and environmental benefits to the public**
<table>
<thead>
<tr>
<th>Schedule Item</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional Pre-Deployment Workshop/Webinar Series</td>
<td>Summer-Fall 2014</td>
</tr>
<tr>
<td>Solicitation for Wave 1 Pilot Deployment Concepts</td>
<td>Early 2015</td>
</tr>
<tr>
<td>Wave 1 Pilot Deployments Award(s)</td>
<td>September 2015</td>
</tr>
<tr>
<td>Concept Development Phase (6-9 months)</td>
<td></td>
</tr>
<tr>
<td>Design/Build/Test Phase (10-14 months)</td>
<td></td>
</tr>
<tr>
<td>Operate and Maintain Phase (18 months)</td>
<td></td>
</tr>
<tr>
<td>Solicitation for Wave 2 Pilot Deployment Concepts</td>
<td>Early 2017</td>
</tr>
<tr>
<td>Wave 2 Pilot Deployments Award(s)</td>
<td>September 2017</td>
</tr>
<tr>
<td>Concept Development Phase (6-9 months)</td>
<td></td>
</tr>
<tr>
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</tr>
<tr>
<td>Operate and Maintain Phase (18 months)</td>
<td></td>
</tr>
<tr>
<td>Pilot Deployments Complete</td>
<td>September 2020</td>
</tr>
</tbody>
</table>
Two to five awards are expected in each wave, depending on the scope of the proposed deployments.

We expect each wave to include various scales of effort including:
- smaller focused deployments ($2-$5 million in federal funds),
- medium-sized deployments ($5-$12 million in federal funds), and
- larger deployments ($12-$20 million in federal funds).

Because of resource constraints, we anticipate at most two larger deployments to be awarded, and deployments larger than $20 million in federal funds will not be considered.

Resources outside of federal funding can be used to result in larger deployments.

Budgets are for all three phases.
WASHINGTON – Today, U.S. Transportation Secretary Anthony Foxx made a major announcement on the future of vehicles that will make driving safer, cleaner, and more efficient. At the New York City Joint Management Traffic Center, the Secretary revealed that New York City, Wyoming, and Tampa, FL will receive up to $42 million to pilot next-generation technology in infrastructure and in vehicles to share and communicate anonymous information with each other and their surroundings in real time, reducing congestion and greenhouse gas emissions, and cutting the unimpaired vehicle crash rate by 80 percent.
RECENT AWARD FOR
WAVE 1 SOLICITATION ANNOUNCED

• New York will install vehicle to vehicle (V2V) technology in up to 10,000 city-owned cars, buses and limousines, and vehicle to infrastructure (V2I) technology in traffic signals in Manhattan and Brooklyn.

• Tampa will receive $17 million to solve peak rush hour congestion in the downtown section of the city and protect pedestrians by outfitting their smartphones with the same technology being installed into vehicles.

• The Wyoming DOT will distribute V2V and V2I technology to vehicles in an effort to collect information on the I-80 east-west corridor, which is critical to commercial vehicles that travel through the northern part of the United States. According to DOT, 11,000 to 16,000 vehicles travel along that corridor daily.
RECENT AWARD FOR WAVE 1
SOLICITATION ANNOUNCED: TAMPA

Source: THEA_CV_PILOT_VOLUME_201.pdf
RECENT AWARD FOR WAVE 1
SOLICITATION ANNOUNCED: TAMPA

Source: THEA_CV_PILOT_VOLUME_201.pdf
## Connected Vehicle Applications

### 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)

### 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

### 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 (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

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Not all applications are available!
EXAMPLES OF AVAILABLE CV APPLICATIONS

Commercial Vehicle Retrofit Safety Device (RSD)

Overview

SwRI has developed a complete hardware and software retrofit kit for commercial vehicles to provide vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) safety applications for vehicles operating in the USDOT Safety Pilot Model Deployment.

Approach

A fundamental goal of the RSD project was to develop a modular, on-board safety system that could be installed and used on commercial vehicles, regardless of the make or model of the vehicle. The project implemented the following system components:

- J1939 CAN interface
- IEEE 1609.2 ONSRC security interface
- A data acquisition system (DAS) capable of recording:
  - J1939 CAN data
  - Forward radar data
  - Video from up to 4 cameras mounted in the vehicle
  - Safety application events
  - Periodic GPS and system status
- The following safety applications:
  - Forward Collision Warning (FCW)
  - Emergency Electronic Brake Lights (EEBL)
  - Curve Speed Warning (CSW)

Similar retrofit unit and integrated unit for commercial vehicles also available from Battelle.

TTI Successfully Tests Algorithm as Part of USDOT Prototype Development Project

Thanks to a successful prototype demonstration, researchers with the Texas A&M Transportation Institute (TTI) contributed to the growing evidence that a roadway can indeed become one big communications system. Vehicles, the roadside and traffic management centers (TMCs) can communicate with one another, seamlessly and near-instantaneously.

The demonstration was conducted May 6-7 in Columbus, Ohio, the hometown of the Battelle Memorial Institute. Working collaboratively, Battelle integrated TTI-developed algorithms into a vehicle-based system and corresponding infrastructure, which produced simulated traffic data that were fed into the system, resulting in the successful display of simulated warnings and speed recommendations as generated by the algorithms, just like the messages that would be sent in an actual connected transportation system.

Analysts believe that within the next 20 years — when all vehicles, roadside infrastructure and
SOME AVAILABLE OBE AND RSU EXAMPLES FOR CV APPLICATIONS
POSSIBLE SOLUTIONS
A CV PILOT DEPLOYMENTS POSSIBILITY
STAKEHOLDERS HAVE IDENTIFIED THE FOLLOWING KEY CHALLENGES

• **Environmental Issues**
  • *Air pollution* is a significant problem due to too many vehicles using route, environmentally unfriendly vehicle acceleration and deceleration patterns and due to traffic congestion)
  • Roads in and around the city of Columbus are **covered with snow most of the winter** resulting in adverse driving conditions.
  • Poor progression results in **wasted fuel**.

• **Mobility Issues**
  • *Traffic congestion* is a problem due to large number of vehicles at peak hours and in the presence of disturbances like accidents, snow removal during the winter and repairs during the summer.

• **Safety Issues**
  • Frequent accidents take place. There is a need to reduce the total number of accidents.
  • *Bicyclist-vehicle and pedestrian-vehicle conflicts*. Bicyclists share part of the route. Safety of bicyclists and pedestrians is a significant concern.
<table>
<thead>
<tr>
<th>GOAL</th>
<th>PERFORMANCE MEASURE</th>
<th>PERFORMANCE TARGET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment: reduce emissions and lower fuel usage</td>
<td>Emissions, fuel consumption</td>
<td>Reduce emissions by 10%, reduce fuel consumption by 10%</td>
</tr>
<tr>
<td>Mobility: increase transit throughput</td>
<td>Peak period throughput Throughput during snow</td>
<td>Increase peak period throughput by 10% Increase throughput by 20%</td>
</tr>
<tr>
<td>Safety: reduce number of accidents, reduce bicyclist/pedestrian -vehicle conflicts</td>
<td>Number of accidents Number of bicyclist/pedestrian -vehicle conflicts</td>
<td>Reduce by 50% Reduce by 50%</td>
</tr>
<tr>
<td>GOAL</td>
<td>CV APPLICATION</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>---------------------------------------------------------------------</td>
<td></td>
</tr>
</tbody>
</table>
| Environment: reduce emissions and lower fuel usage | Eco-Lanes Management  
Eco-Speed Harmonization  
Eco-Cooperative Adaptive Cruise Control |
| Mobility: increase transit throughput     | Dynamic Speed Harmonization  
Cooperative Adaptive Cruise Control  
Weather Response Traffic Information (WxTINFO) |
| Safety: reduce number of accidents, reduce bicyclist-vehicle conflicts | Emergency Electronic Brake Lights  
Forward Collision Warning  
Vehicle-Bicyclist/Pedestrian Conflict Warning |
# Connected Vehicle Applications

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## Smart Roadside
- Wireless Inspection
- Smart Truck Parking
Cooperative Adaptive Cruise Control (CACC)

- Drivers have the convenience of setting their desired speed and having the vehicle safely maintain the speed.
- The CACC systems recognize the presence of a slower vehicle ahead and road grade and then automatically adjusts the speed to follow the other vehicle safely.

CACC and Eco-Speed Harmonization

- CACC systems may accept target speeds established by the traffic management centers (TMCs) that can optimize traffic performance for the environment.
- By having all CACC vehicles maintain the same speed that allows the best traffic/environmental performance, "speed harmonization" is achieved as the traffic stream moves smoothly and efficiently.

CACC and Eco-Lanes

- Eco-Lanes are specially managed targeted at optimizing performance for the environment.
- TMCs can set target speeds and recommend closer following (shorter gaps) between CACC vehicles for which drivers can agree to accept ("opt-in")
- Shorter gaps, combined with speed harmonization can help minimize congestion and reduce emissions.

Figure 5-1: Varying Levels of CACC (Source: Noblis, 2013)
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