Connected Vehicle Technology: Enhancing Safety, Mobility, and the Environment

Richard Wallace, Director, Transportation Systems Analysis
Connected Vehicles Defined

• Connected vehicles use any of a number of different wireless communication technologies to communicate with:
  • Each other
  • Roadside infrastructure
  • The “Cloud”

• Goals for connected vehicles are to enhance
  • Vehicle and roadway safety
  • Mobility
  • Environment (e.g., reduced fuel consumption and emissions)
Major Surface Transportation System Challenges

- ~40,000 traffic-related deaths annually in U.S. (down to 34,000 in 2009)
  - Leading cause of death for those between ages 4 and 34
  - ~50% of the deaths occur from intersection crashes and vehicles leaving the roadway
  - Roughly 6 million vehicle crashes per year
- 4.8 billion hours of delay per year*
- 3.9 billion gallons of fuel wasted in delay per year*
- $115 billion annual cost of congestion*
- Yearly, average peak period traveler spends an extra 34 hours in travel time and consumes an additional 26 gallons of fuel: a cost of $808 per traveler*

*Texas Transportation Institute, *2010Urban Mobility Report* (based on 2009 data)
# Michigan Firsts

<table>
<thead>
<tr>
<th>Year</th>
<th>First Event</th>
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</thead>
<tbody>
<tr>
<td>1891</td>
<td>First international underwater railroad tunnel</td>
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<tr>
<td>1901</td>
<td>First automobile mass-produced in U.S.</td>
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<td>1909</td>
<td>First mile of concrete highway in U.S.</td>
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<td>1909</td>
<td>First painted centerline in U.S.</td>
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<tr>
<td>1911</td>
<td>First red/green traffic signal</td>
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<tr>
<td>1912</td>
<td>First painted centerline in U.S.</td>
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<td>1912</td>
<td>First highway materials testing lab in U.S.</td>
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<tr>
<td>1913</td>
<td>First moving assembly line for automobiles</td>
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<tr>
<td>1914</td>
<td>First car body made entirely of steel</td>
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<tr>
<td>1918</td>
<td>First red/yellow/green traffic light</td>
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<td>1920</td>
<td>First road marking system in U.S.</td>
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<td>1922</td>
<td>First practical snowplow in U.S.</td>
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<td>1927</td>
<td>First state to use yellow centerlines for &quot;no passing&quot; zones</td>
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<tr>
<td>1930</td>
<td>First international underwater automobile tunnel</td>
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<tr>
<td>1941</td>
<td>First four-lane divided expressway in U.S.</td>
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<tr>
<td>1955</td>
<td>First freeway-to-freeway interchange</td>
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</table>
More Recent Safety and Mobility Improvements

- Seat belts
- Anti-lock brakes
- Air bags
- Electronic stability control
- OnStar
- Navigation systems, including GPS
- Intelligent transportation systems
  - Traffic control, incident detection and management, etc.
- Lane-departure warning
- Blind-spot warning
- Rearview cameras
Evolving Vehicles in an Evolving Environment

Automotive Industry
Mechanical ⇒ Electronic and Connected

Driver
Mobile, Safe, and Connected

Vehicles

Infrastructure

Local, state, & federal agencies
Construction ⇒ Operations and Jobs

Telecommunications, Consumer Electronics
Wired ⇒ Seamless Connectivity

Infostructure
Three Components of Vehicle Connectivity

• Information broadcast from vehicles (mobile)
• Information broadcast from fixed locations (e.g., intersections)
• Ability to complete transactions with security and confirmation to both parties (a record made)
  • May be monetary (e.g., paying a toll)
  • Or not (e.g., signal pre-emption for emergency vehicles or wireless roadside inspections for trucks)
Sample Connected Vehicle Applications

<table>
<thead>
<tr>
<th>Safety</th>
<th>Mobility</th>
<th>Infrastructure Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronic Brake Lights</td>
<td>Traveler information</td>
<td></td>
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<tr>
<td>Traffic Signal Violation Warning</td>
<td>Weather Information</td>
<td></td>
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<tr>
<td>Stop Sign Violation Warning</td>
<td>Navigation</td>
<td></td>
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<tr>
<td>Curve Speed Warning</td>
<td>Ramp Metering</td>
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<tr>
<td>Display Local Signage</td>
<td>Signal Timing Optimization</td>
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<tr>
<td><strong>Electronic Payment</strong></td>
<td><strong>Infrastructure Management</strong></td>
<td></td>
</tr>
<tr>
<td>Tolling</td>
<td>Weather Information</td>
<td></td>
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<tr>
<td>Parking</td>
<td>Winter Maintenance</td>
<td></td>
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<tr>
<td><strong>Automotive</strong></td>
<td>Pothole Detection</td>
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<tr>
<td>Vehicle Diagnostics</td>
<td>Automated Mapping</td>
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<tr>
<td>Software Updates</td>
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</table>
Vehicle-to-Vehicle Safety Starts with Data Broadcast

Latitude, Longitude, time, heading angle, speed, lateral acceleration, longitude acceleration, yaw rate, throttle position, brake status, steering angle, headlight status, turn signal status, vehicle length, vehicle width, vehicle mass, bumper height

Image source: USDOT RITA
Connectivity for Safer Driving

- Greater situational awareness
  - Your vehicle can detect all nearby vehicles and knows roadway conditions that you cannot see

- Reduce or even eliminate crashes through:
  - Driver advisories
  - Driver warnings
  - Vehicle control

*Connected vehicle technology has the potential to address 82% of the vehicle crash scenarios involving unimpaired drivers.*
Intersection Crash Avoidance with SPAT* Broadcast

*SPAT=Signal Phase and Timing
Traffic Reports of the Future with IntelliDrive℠ and Aftermarket

“...there is congestion on the road ahead. Your quickest route to Union Station is to exit westbound at 55th street, travel north on Princeton Avenue...”

dash/ipod: http://www.crunchgear.com/wp-content/photos/dloventmount.jpg
map: http://www.traffic.com/
map: http://www.bing.com/maps
International Example: Sentience for Green and Connected Driving

- Developed by Ricardo and tested in the U.K.
- Integrates GPS, V2I, and vehicle controls
- Achieved 5-10% reduction in fuel consumption on a hybrid powertrain (more recent tests have even higher savings)
Primary Options for Vehicle Communications

• Dedicated Short-Range Communications (DSRC)
  • Operates at 5.9 GHz in U.S.
  • Especially promising for applications that require very fast, highly reliable transmission, such as cooperative safety with active braking (V2V)
  • Range up to 300 m
  • Could require fairly extensive and expensive build out

• Cellular
  • Much infrastructure already in place, but many planned applications require third generation (3G) or beyond network (4G, LTE, WiMax)
  • Works well for OnStar and like applications; also works for traffic probe data collection (as done by companies such as INRIX)

• Wi-Fi
  • Mobile Wi-Fi networks beginning to emerge, but they tend to use 3G for backhaul; thus, not promising for CAR2X communications
Michigan Connected Vehicle Test Sites

Legend:
- CICAS-V
- Rock Financial
- Telegraph 15 Mile
- DTE Test Bed
- Telegraph 12 Mile
- RCOC
- Farmington
- Chrysler
- CVPC Southfield

Planned SPaT Corridor
MDOT, MICHIGAN INTERNATIONAL SPEEDWAY

ANNOUNCE R&D TESTING PARTNERSHIP

DETROIT (Jan. 26, 2009) — The Michigan Department of Transportation (MDOT) and Michigan International Speedway (MIS) announced today a unique partnership for research, development and safety innovation that could serve as a catalyst for job creation and growth opportunities for the state.

Source: Research and Development in Industry: 2007, National Science Foundation

* Does not include Federally Funded R&D
International Examples: Strategic Platform for Intelligent Traffic Systems (SPITS)

- Open platform for intelligent transportation
- Backed by the Dutch Government and Consortium of 13 organizations (public and private)
- Demonstrated capabilities under a “shockwave” scenario – phantom traffic jam
  - 12 to 25% increase in traffic flow

Image From: Traffic Technology International, June/July 2010
Ubiquitous Vehicle Communications

Privacy-Preserving Vehicular CA

Service Providers

Infrastructure Network

DSRC  Cellular  WiFi

Seamless Roaming

Secure e2e communication

Privacy-preserving secure one and multi-hop V2V communication

Source: Telcordia Technologies
Data Are Critical (and Potentially Lucrative)

- Data drive connected-vehicle applications and services

<table>
<thead>
<tr>
<th>Entities Interested in Data…</th>
<th>May Create Markets for</th>
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<tbody>
<tr>
<td>DOTs</td>
<td>Probe data, asset management data, road-weather information</td>
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<tr>
<td>Auto manufacturers</td>
<td>Vehicle diagnostics and prognostics, driver behavior</td>
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<tr>
<td>OE Suppliers</td>
<td>Component diagnostics and prognostics</td>
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<tr>
<td>Drivers and passengers</td>
<td>Real-time route guidance, map updates, media downloads, infotainment…</td>
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<tr>
<td>Marketers and providers of location-based services</td>
<td>Driver behavior, vehicle location</td>
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<tr>
<td>Insurance industry</td>
<td>Driver behavior</td>
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Regulatory Environment Is Critical

• Automotive companies do not expect connected-vehicle safety applications (in-vehicle signage, cooperative crash avoidance, etc.) to be mandated anytime soon (based on CAR studies)
  • Telematics industry informants less confident in this view
  • NHTSA has set 2013 decision date on proposed rule-making for vehicle-to-vehicle safety (crash avoidance) for light vehicles
    • 2014 for heavy vehicles

• Important regulatory entities
  • US DOT NHTSA
  • EPA
  • FCC
Illustrative Example from Regulatory History

- Electronic Stability Control (ESC)
  - Must be OE on 100% of new vehicles by September 1, 2011
  - Took many years for full cycle to be completed
### Vehicle to Vehicle Safety Application Research Plan

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<tr>
<td><strong>Complete CAMP-V SC-A</strong></td>
<td><strong>Define Initial Performance Requirements</strong></td>
<td><strong>Select Applications</strong></td>
<td><strong>Final Standards &amp; Protocols</strong></td>
<td></td>
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<tr>
<td><strong>IntelliDrive℠ System Engineering</strong></td>
<td><strong>Complete Message and Communication Standards</strong></td>
<td><strong>Data Authentication</strong></td>
<td><strong>Development Tests</strong></td>
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<tr>
<td><strong>Security &amp; Privacy (Certificate Authority)</strong></td>
<td><strong>Define Performance Measures</strong></td>
<td><strong>Field Trials</strong></td>
<td><strong>Performance Requirements</strong></td>
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<td></td>
<td><strong>Develop Objective Tests</strong></td>
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<td><strong>Regulation or NCAP Decision</strong></td>
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<td><strong>Adapt ACAT Methodology</strong></td>
<td><strong>Conduct Objective Tests</strong></td>
<td><strong>Safety Benefits Estimate</strong></td>
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<td><strong>Define &amp; Build Prototype Safety Application Vehicles</strong></td>
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<td></td>
<td><strong>DVI Effectiveness – Multiple Warnings</strong></td>
<td><strong>Driver Workload Issues</strong></td>
<td><strong>Driver Acceptance</strong></td>
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<tr>
<td><strong>IntelliDrive℠ Principles</strong></td>
<td><strong>Retrofit &amp; Aftermarket Req’s</strong></td>
<td><strong>5.9 Enforcement</strong></td>
<td><strong>Governance (V2V)</strong></td>
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<td><strong>Security &amp; Privacy Policy (V2V)</strong></td>
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<td><strong>Update Crash Scenarios</strong></td>
<td><strong>Define Performance Reqs and Measures</strong></td>
<td><strong>Develop and Conduct Objective Tests</strong></td>
<td><strong>Driver Workload Issues and Acceptance</strong></td>
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**TRACK 0**
Current Activities

**TRACK 1**
Crash Scenario Frame Work

**TRACK 2**
Interoperability

**TRACK 3**
Benefits Assessment

**TRACK 4**
Application Development

**TRACK 5**
Driver Issues

**Track 6**
IntelliDrive℠ Policy Issues

**Track 7**
Commercial Vehicle

**Track 8**
Transit Vehicle

(TBD)
USDOT Connected Vehicle Safety Pilot

- Major effort underway to gather data needed to inform 2013 NHTSA regulatory decision
- Consists of two related programs
  - Smart Pilot Driver Clinics
  - Smart Pilot Model Deployment
Smart Pilot Driver Clinics

- Focused on how motorists react to in-vehicle safety warnings derived from connected vehicle technology
- Will take place in multiple locations throughout the U.S.
- Will use controlled test-track environment
- Participating motorists will have limited exposure to the technology
Smart Pilot Model Deployment

- USDOT RITA has released an RFP for a large-scale test of V2V safety in real-world conditions
  - Using drivers recruited from the general population in a single locale over a period of many months

- Test will include thousands of vehicles
  - Some equipped with full-functioning DSRC device (two-way communications, display, etc.)
  - Two thousand or more equipped with Here I Am devices (one-way broadcast)
  - Some with aftermarket DSRC-based safety devices

- Test fleet will include a mix of vehicle types, ideally including passenger vehicles, heavy trucks, and buses

- Test will also include a limited amount of V2I capability
Concluding Remarks

- Vehicle communications will be a vital element of new vehicles for years to come
- They will support a variety of safety, mobility, environmental, and other applications
- Ultimate vision for these technologies includes:
  - Zero traffic-related fatalities (goal of 90% reduction by 2030)
  - Zero unexpected delay
  - Reduced fuel consumption and emissions
- Which technologies will prevail remains an open question
- Auto companies are pursuing multiple paths, and suppliers, dealers, aftermarket suppliers, and transportation agencies have roles to play
- Connectivity will be built in, brought in, and beamed in
For Further Information

- **US DOT:**
  - [http://www.its.dot.gov/connected_vehicle/connected_vehicle.htm](http://www.its.dot.gov/connected_vehicle/connected_vehicle.htm)

- **MDOT:**
  - [http://www.michigan.gov/mdot/0,1607,7-151-9621_11041_38217---,00.html](http://www.michigan.gov/mdot/0,1607,7-151-9621_11041_38217---,00.html)