The Vision of Vehicle Infrastructure Integration (VII)

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Cooperative Highways

SAFETY
- Collision Avoidance
- Emergency Alerts
- Weather Conditions

MOBILITY
- Signal Control
- Traveler Information
- Congestion Information
The Driving Forces

- 42,000 People Die Every Year on Our Roadways
  - Leading Cause of Death Between Ages 4 – 33
  - 50% of the Deaths Occur from Intersection Collision and Roadway Departure
- Traffic Crashes Cost the Economy $230 B/Yr
- Traffic Congestion Costs Americans $78 B/Yr
- Congestion Wastes Billions of Gallons of Fuel
Exceeding the Safety Challenge

- While crashworthiness standards have been and will continue to be very important, we are reaching the point of diminishing returns by focusing only on crashworthiness. The biggest return on investment in terms of lives saved and injuries prevented in the future will come from accelerated development and deployment of crash avoidance technologies.

—Jeffrey W. Runge M.D., Administrator NHTSA
# Cost of Congestion

<table>
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<tr>
<th>Year</th>
<th>Travel Delay (billions of hours)</th>
<th>&quot;Wasted Fuel&quot; (billions of gallons)</th>
<th>Congestion Cost (billions of dollars)</th>
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<td>0.8</td>
<td>0.5</td>
<td>$14.9</td>
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<td>1995</td>
<td>2.5</td>
<td>1.7</td>
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<td>2004</td>
<td>4.0</td>
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<td>2005</td>
<td>4.2</td>
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Source: Texas Transportation Institute
We Can Not Build Out More Roads
Weekday Peak-Period Congestion Has Grown in Several Ways in Our Largest Cities

Source: Analysis of data used in 2005 Urban Mobility Report, Texas Transportation Institute.
Cooperative Systems Can Help?

“Cars that refuse to have accidents …”
- If every car knows its neighbors speed, location and direction, eminent threats of collision can be mitigated with warnings to drivers followed by intrusive control.
- Can you envision a road network with no traffic signals?

Over a hundred Use Cases have been identified:
- Safety
- Mobility
- Convenience

Two basic types of communication:
- Vehicle-to-Vehicle
- Vehicle-to-Infrastructure
Safety Applications

- Approaching Emergency Vehicle Warning
- Blind Spot Warning
- Cooperative Forward Collision Warning
- Emergency Electronic Brake Lights
- Highway Merge Assistant
- Highway/Rail Collision Warning
- Lane Change Warning
- Pre-crash Sensing
- Vehicle-based Road Condition Warning
- Vehicle-to-vehicle Road Feature Notification
- Visibility Enhancer
- Wrong Way Driver Warning

- Curve Speed Warning
- Emergency Vehicle Signal Preemption
- Intersection Collision Warning
- In-vehicle Amber Alert
- Left Turn Assistant
- Low Bridge Warning
- Low Parking Structure Warning
- Pedestrian Crossing Information at Intersection
- Road Condition Warning
- Stop Sign Movement Assistance
- Stop Sign Violation Warning
- Traffic Signal Violation Warning
- Work Zone Warning
Mobility Applications

- Cooperative Adaptive Cruise Control
- In-vehicle Signage
- Weather Alert Notifications
- Icy Bridges Warnings
- ROW Planning
- Pot Hole Detection (maintenance)
- Signal Phasing (traffic flow optimization)
- Incident Observation and Mitigation
- Roadway Incidence Assistance

- Traffic Advisories (routing, re-routing assistance)
- Navigation Assistance
- Fleet Management (logistics control)
- Hazardous Material Path Enforcement
- Cargo Tracking
- Travel Information (available facilities, parking, special events, timing)
Consumer and Commercial Services

- Parking Location Assistance
- Parking Access (security / payment)
- Food Drive-through Payment
- Roadway Toll Payment
- Download Data Files (MP3, games)
- Software/Firmware Updates
- Remote Diagnostics
- Customer Relations Management
- Dealer Service Scheduling
- Personal Device Synchronization
- Home Network Content Synchronization
- Remote Control (home access, garage door, home lighting)
- Secure Access (Enterprise access)
- Just-in-time Repair Notification
- Safety Recall Notification
Initial “Day One” Applications

Gotta start somewhere!

- Traffic Signal Violation Warning
- Stop Sign Violation Warning
- In-vehicle Signage (road advisory and local info)
- Roadway Conditions (weather and potholes)
- Traffic Management and Control
- Alternate Route Guidance
- Traffic Information (OEM)
- Electronics Payments (tolls, gasoline and parking)
Vehicle Infrastructure Integration

Cellular Service Providers
Network Operations Center

Mobility & Safety Application Server

Traveler Information Systems

Traffic Management Systems

VII Network Operations Center

Cellular Communication System

GPS

Satellite-Vehicle

Vehicle-to-Vehicle

Vehicle-Cellular

Vehicle-Infrastructure

Roadside communication Equipment (RSE)
VII Systems Enablers

- Communications system
- Probe data collection
- Dynamic map database
- Lane accuracy positioning system
- On-board computers need:
  - Software provisioning
  - System diagnostics and maintenance
  - Configuration management
  - Security framework
  - Enhanced Human Machine Interfaces (displays, alarms)
VII Architecture Framework

Vehicle
- Onboard Equipment (OBE)
  - Applications processor
  - Vehicle services
  - Body chassis systems
- Other communications WiFi, Cellular etcetera
- GPS
- HMI

Roadside
- Roadside Equipment (RSE)
  - Signal controller
  - Local safety processor
  - I/O Controller
  - Router
- GPS Antenna
- GPS receiver

Centers
- VII IPv6 Network
  - VII Message Switch
  - Registrations
  - Subscriptions
  - Operations
  - Rules
  - Management
  - Maintenance
- Gateway to other communication systems
- Other Message Switches
- GSA Certification Authority (CA)
- Map and differential corrections server

Users
- OEM/ISP applications
- TOCs and other public sector users
- OBE Provisioning server
- OBE

Note: Grayed boxes are peripheral and not part of the core VII architecture
DSRC Radio

- FCC has allocated 75MHz at 5.9GHz
  - Safety Applications (1st priority)
    - Other applications acceptable
  - Licensed Spectrum
    - stability with minimum Interference

- Dedicated Short Range Communications (DSRC)
  - Based on variation of WiFi → IEEE 802.11p
  - Line of sight
  - 300 to 1000 feet range (power modulation possible)
  - Low Latency/fast connecting/priority attributes
DSRC 10 MHz Channel Usage Plan

Shared Public Safety/Private

- Control
- Med Rng Service
- Short Rng Service

Dedicated Public Safety

- Veh-Veh
- Intersections

Power Limit

- 44.8 dBm
- 40 dBm

Uplink

- 33 dBm
- 23 dBm

Downlink

- 44.8 dBm
- 23 dBm

Public Safety Veh-Veh Ch 172

Public Safety/Private Ch 174

Public Safety/Private Ch 176

Control Channel Ch 178

Public Safety/Private Ch 180

Public Safety/Private Ch 182

Public Safety Intersections Ch 184

Frequency (GHz)
Multiple Communications Technologies

- Traffic Management Systems
- Satellite-Vehicle Communication Equipment (RSE)
- VII Network Operations Center
- Cellular Communication System
- Mobility & Safety Application Server
- Traveler Information Systems
- Traffic Management Systems
- GPS
- Satellite-Vehicle
- Vehicle-to-Vehicle
- Vehicle-Cellular
- Vehicle-Infrastructure
- Roadside Communication Equipment (RSE)
- Mobility & Safety Application Server
- Traveler Information Systems
- Traffic Management Systems
- GPS
- Satellite-Vehicle
- Vehicle-to-Vehicle
- Vehicle-Cellular
- Vehicle-Infrastructure
- Roadside Communication Equipment (RSE)
The Partnership

- **AASHTO**
  - Policy leadership & advocacy at state level
  - Technical participation & field tests

- **USDOT**
  - National leadership
  - Technical management
  - Funding

- **Automobile Manufacturers**
  - Private leadership & advocacy
  - Technical participation & field tests
Structure of working relationships

National Working Group is comprised of all member stakeholders

VII National Working Group needs are Supported by senior management Executive Leadership Team

Organizational Support as required
Institutional Issues

- Privacy
- Liability
- Data Ownership
Protecting Privacy is Essential

- Public entities have access to vehicle VII data
- VII System design does not have access to driver or vehicle identification
  - Does not support law enforcement
  - Private services available on Opt-in basis only
- Drafted Privacy Principles
Core Non-Technical Issues

1. Funding for Deployment
2. Deployment of roadside equipment
3. Operations Management
4. Governance Structure
5. Data Availability and Accessibility
7. Other Issues
Long Deployment Delays Safety Vision

- Full safety benefits come from all vehicles participating
- Non-participating vehicles, pedestrians and animals are non-visible to VII vehicles
- Autonomous safety systems are needed to fill the gap
VIIVII--Equipped Vehicle Population Projection

Assumes:
250 million vehicles on road
16 million built each year
Aftermarket VII Devices May Accelerate Deployment

Assumes:
- 250 million vehicles on road
- 16 million built each year

- Antique and Collector vehicles not converted

- Improved densities

New Cars Equipped from Factory
Total Vehicles on Roadway
Total Vehicles on Roadway

% Vehicle Population

2010 2015 2020 2025 2030
ITS Relationships

ITS Domain

VII
- Cooperative Highways (automated / data only V2V and V2I)
  - Traffic Signal Violation Warning
  - Electronic Brake Signal
  - Tolling

Telematics
- Call Center Services (voice / data)
  - Accident Collision Notification
  - Remote Door Unlock

Navigational Aids
- On-board navigation

Independent Vehicle Systems
- Forward Collision Warning
- Lane Departure

Independent Highway Systems
- Signal Timing Optimization (loop detectors)
- Cameras as sensors
VII Function vs **Vehicle Density**

Assumes full coverage area

- Traffic Info
- Safety Warnings
- Roadway Situational Awareness
- Active Controls
- Traffic Management
- Crash Avoidance
- Automated Highways

Crashes

Timeline

Historical Data vs Future Projections

- 2010
- 2060

VII Equipped Vehicles — 100%

VII Equipped Population

UMTRI
Detroit Test Environment

- Initial VII development project between OEMS and USDOT
- VII Proof of Concept Confirmation
  - Testing concept hardware and software
  - Concept applications selected for system performance confirmation
- Vehicle fleet tested at a facility located in Novi, MI.
  - Small fleet (25 vehicles) gathering probe data over 2 months
  - UMTRI provided 5 vehicles for full system performance and application testing and verification
  - Fleet to be equipped and operated by Roush Engineering under VIIC Contract
California Proof of Concept Test Bed

- Innovative Mobility Showcase 2005
- Network of DSRC devices
  - 12 currently, 40 planned
  - Backhaul network T1 wireline, 3G cellular, WiMax
- Bay area has 60 miles of freeways & arterials deployed
- Testing applications
  - Signal information
  - Curve warning
  - Vehicle probes
  - In-vehicle signing
Major demonstrations of ITS and vehicle-roadway communications systems

Permanent installations to stay in New York

2008 demonstration intended to showcase VII for public and private sector decision makers
Thank You