Proactive, Connected, and Automated Transportation

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Proactive Transportation

Shifting Operations Mindset

Operate what we have

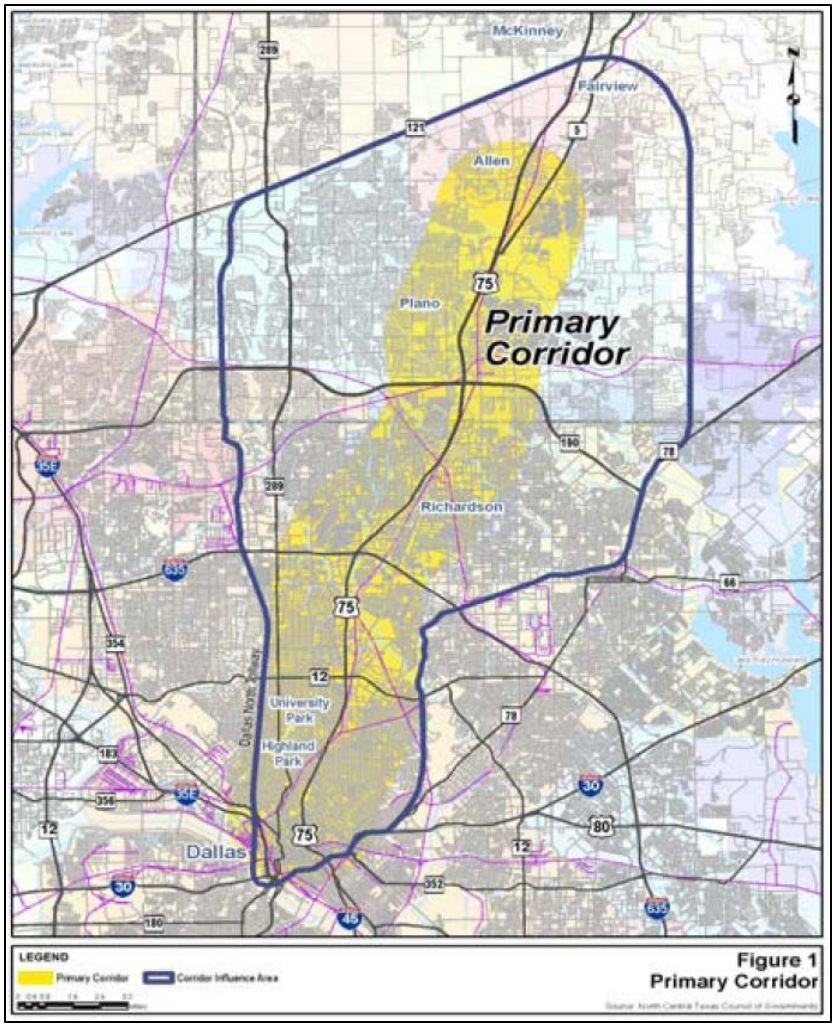
- Detection
- Field devices
- Communication
- Data quality

Operate what we have more effectively

- Predicting future conditions
- Adaptive/Responsive signals
- Variable speed limits
- System ramp metering

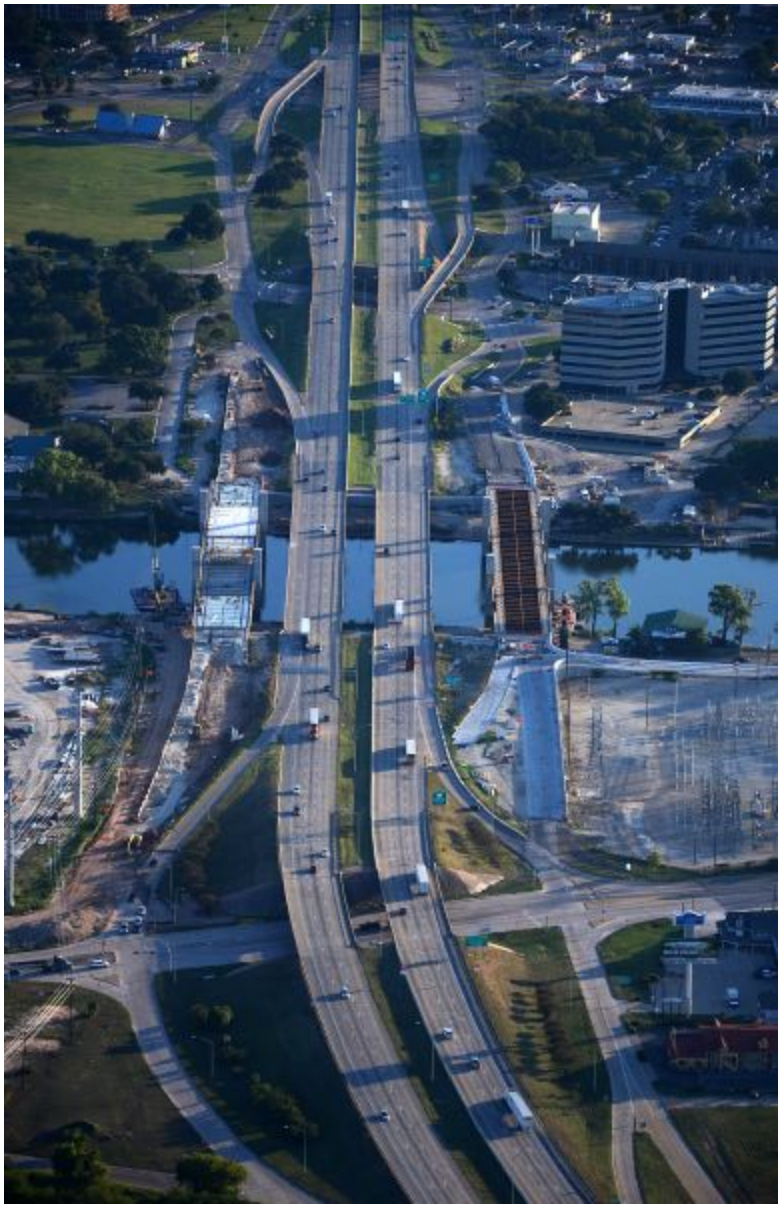
ICM Example

- US 75, Dallas, TX
  - Anticipating growth in congestion
  - Simulation of future conditions
  - Recommending alternate routes and modes



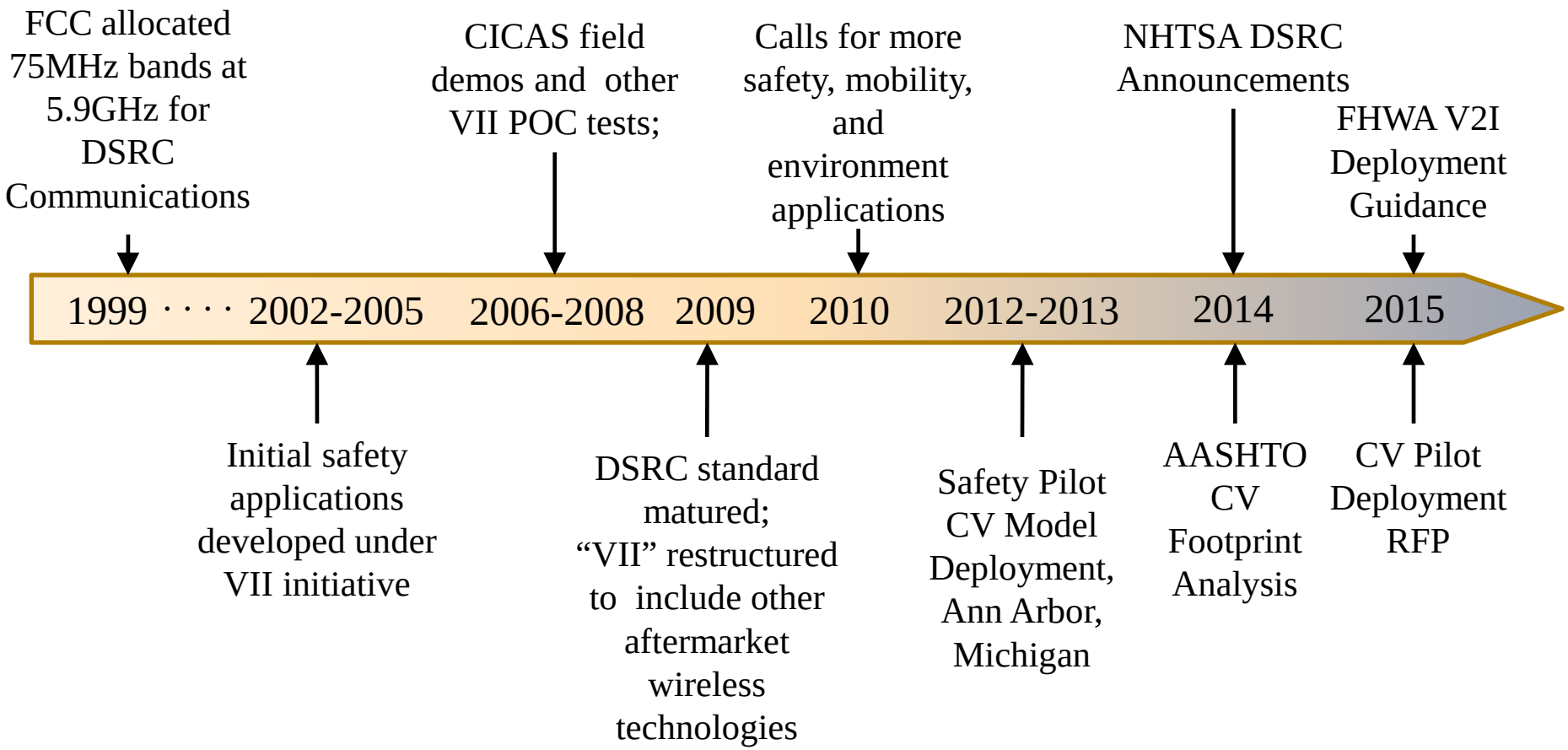
ICM Example

- I-35, Waco, TX
  - Predicting work zone related congestion
  - Negotiations with contractors on schedule
  - Advanced traveler information
  - Daily Evaluation



Connected Transportation

Recent History



NHTSA DSRC Rule Timeline

- February 3, 2014 Announcement
  - Intent of starting the process
  - Light-duty vehicles
- Potential Next Steps
  - Heavy-Duty vehicles Spring 2014
  - Notice of Proposed Rule Making ~2015
  - Rule Making 2016
  - Implementation ~2020
- Basic messages, but not applications

Communication

- Dedicated Short-Range Communication
  - 5.9 Ghz Radio
  - Nomadic / Handheld Devices
- Cellular 4G LTE
- Others
  - WiFi
  - Satellite
  - HD Radio

Connected

- Vehicle-to-Vehicle (V2V)
- Vehicle-to-Infrastructure (V2I)
- Infrastructure-to-Vehicle (I2V)
- Vehicle-to-Pedestrian (V2P)
- Pedestrian-to-Infrastructure (P2I)
- Vehicle-to-Bicycle (V2B)
- Vehicle-to-Motorcycle (V2M)

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-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

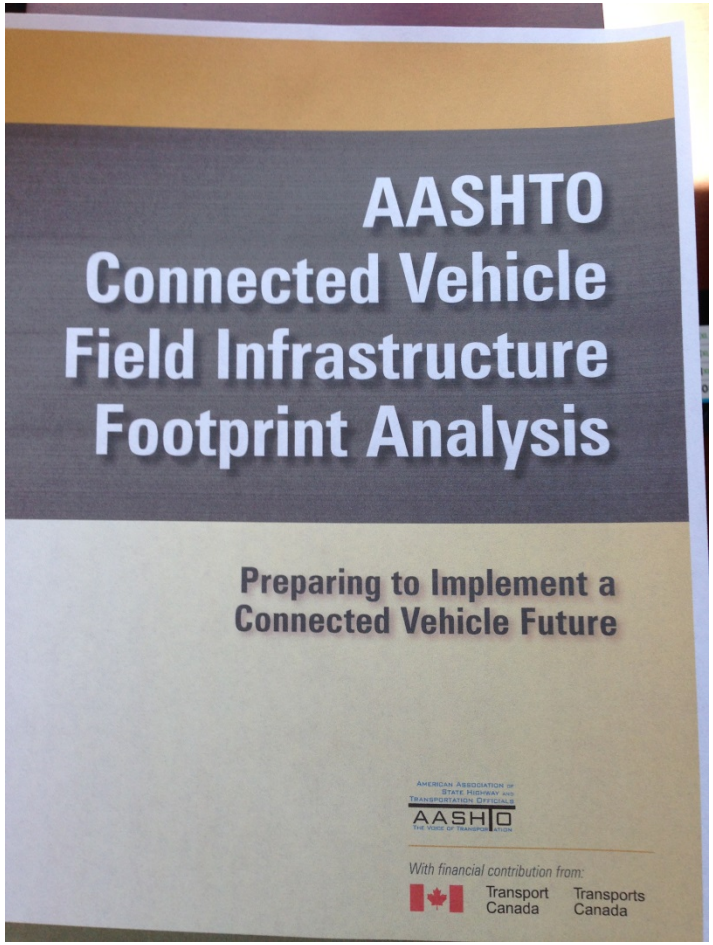
Mobility

- 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)
- 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

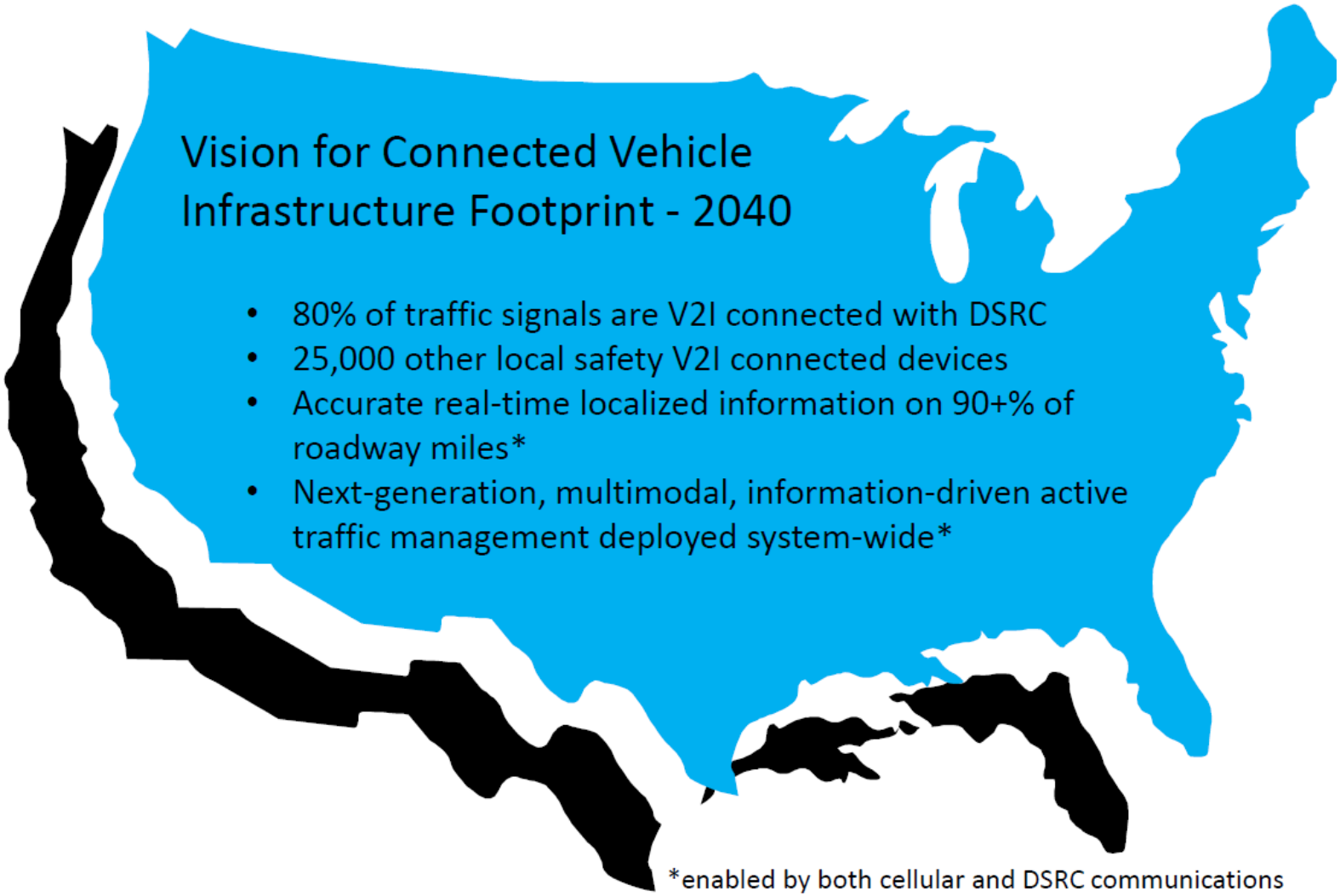
- Wireless Inspection
- Smart Truck Parking

AASHTO CV Footprint Analysis



- Conduct analysis leading to a *preliminary*, *general concept* of a national connected vehicle field infrastructure footprint.
- Tool for analyzing needs for infrastructure and extent of investment.
- Set of generic design concepts with actions needed for deployment.

AAHSTO CV Vision



Applications Assessment

Application Packages

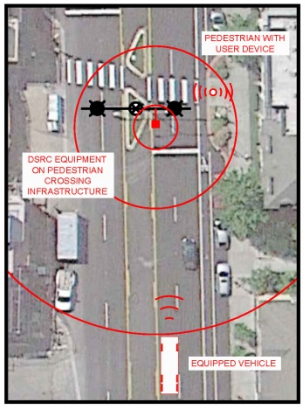
- V2I Safety
- Mobility/Environment
- Road Weather
- Smart Roadside
- Int. Border Crossings
- Fee Payments
- Agency Operations

Application Requirements

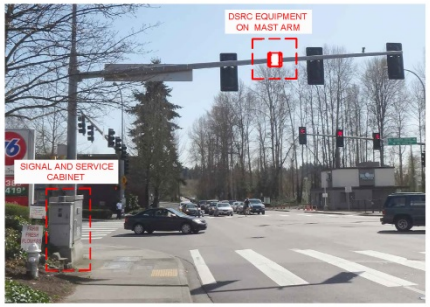
- Data from Vehicles and Infrastructure
  - Basic Safety Message
  - Probe Message
  - Signal Phase and Timing
- Communication Modes
  - DSRC, Cellular
- Backhaul Options
- Back Office

Urban Intersection Example

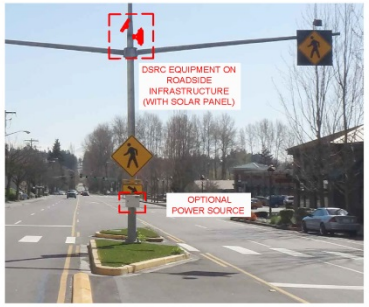
1 - INTERSECTION



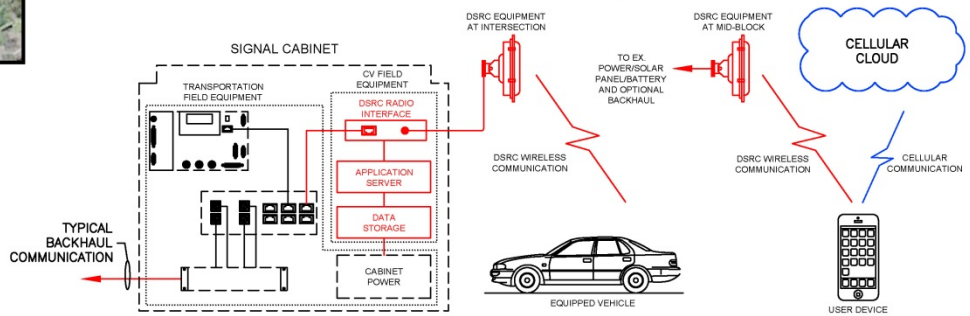
2 - MID-BLOCK (OPTIONAL)



1 - INTERSECTION INSTALLATION



2 - OPTIONAL MID-BLOCK PEDESTRIAN CROSSING



3 - COMMUNICATION AND POWER SCHEMATIC

LEGEND

- Existing Mast Arm
- Existing Cabinets
- DSRC Radio
- DSRC Comm.

TYPICAL SETTING FEATURES

urban intersections are junctions of two or more roads within a city setting which typically includes curbing, designated lane markings, and pedestrian crossings.

CONCEPT EXAMPLE

DSRC antennas communicate towards all approaches of the intersection and at a mid-block location to communicate with vehicles on the roadway.

OTHER EXAMPLE APPLICATIONS

- Red Light Violation Warning and Stop Sign Violation
- Driver Gap Assist at Signalized Intersections and Stop Signs
- Multimodal Intelligent Traffic Signal Systems
- Advanced Arterial Management and Operations
- Advanced Signal Operations

Urban Intersection Deployment Concept

NATIONAL CONNECTED VEHICLE FIELD INFRASTRUCTURE FOOTPRINT ANALYSIS

M:\12\12131.00 – Connected Vehicle General Concept for Deployment\Engineering\CAD\Sheets\Concept 3 – Urban Intersection.dwg<Concept 3>Karl Typolt 8/16/2013 4:05 PM

NOT FOR CONSTRUCTION

AASHTO THE VOICE OF TRANSPORTATION

CONCEPT 3

Potential Intersection Sites

- Signalized intersections (311,000 total)

Deployment Fraction	Objective	Number of Deployment Sites
20%	Deploy only at highest volume intersections (50% of intersection crashes)	62,200
50%	Deploy at half of all intersections (80% of intersection crashes)	155,500
80%	Deploy at all intersections where warranted	248,800

DSRC Unit Deployment Costs

- DSRC RSU deployment costs were surveyed from existing and planned deployments

Deployment Site	Michigan	Arizona	Virginia	TFHRC	Average
Connected Vehicle DSRC Hardware	$9,850.00	$4,200	$8,400	$6,100	$7,450
Installation Labor	$4,000	$3,000	$3,800	$3,400	$3,550
Design and Planning	$7,300	$5,900	$6,900	$6,400	$6,600
Total Direct Connected Vehicle Costs	**$21,150**	**$13,100**	**$19,100**	**$15,900**	**$17,600**

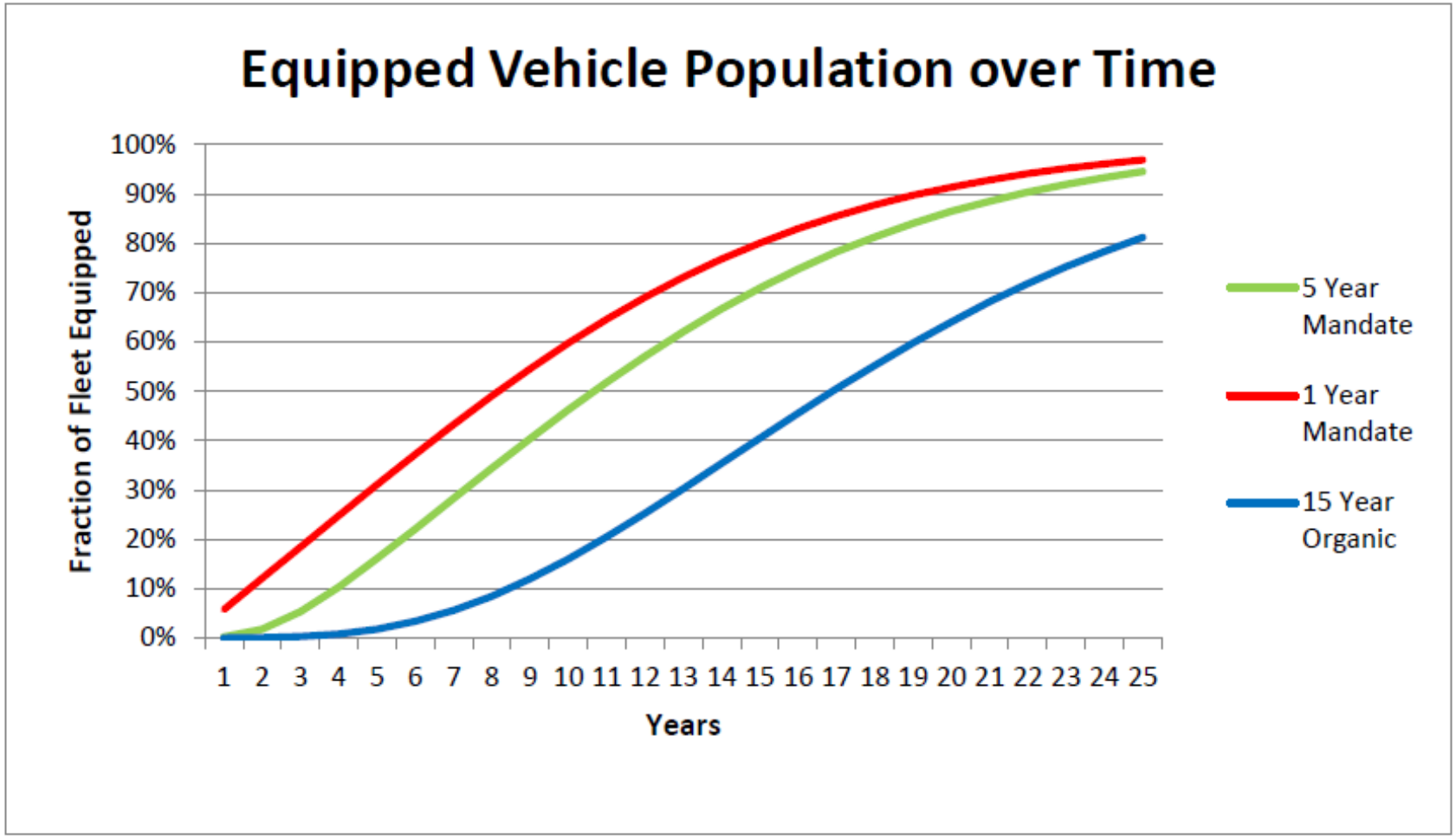
Compared to $150K to upgrade an intersection, DSRC deployment would add 10-15%

National Deployment Unit Cost and O&M Cost

Cost Element	Total Unit Cost
Number of Sites	87,200
(DSRC) Equipment and Site Deployment	$17,600
Backhaul Upgrades and Deployment	$26,800
Traffic Signal Controller Upgrades	$3,200
Total Unit Cost (2013$)*	**$47,600**

Cost Element	Per Site Cost per year
Number of Sites	1
Power	$100
Regular Maintenance and Replacement	$2,950
Total O&M per year	**$3,050**

Timeline


Equipped Vehicle Population over Time
Fraction of Fleet Equipped
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Years
5 Year Mandate
1 Year Mandate
15 Year Organic

Connected Work Zone

- Application of the USDOT FRATIS
- Freight corridor optimization with work zone lane closure information
- In-vehicle warnings of lane closures, delay, and end-of-queue
- Cellular, DSRC

Automated Transportation

Connected vs. Automated

- Automated
  - Sensors (cameras, radar, lidar or combination) used to guide vehicle
  - Problems with unexpected conditions
    - Work zones, incidents, inclement weather
- Connected-Automated
  - Connected information represents another sensor
  - Issues of reliability, quality, timeliness

SAE Levels of Automation

NHTSA Automation Level		
Zero	No Automation	Human performs all functions
One	Driver Assistance	Single function automation
Two	Partial Automation	Lateral and longitudinal driver assist
Three	Conditional Automation	Automation with request for driver to intervene
Four	High Automation	Automation even if driver does not respond to intervene
Five	Full Automation	Full performance by automated driving system

NHTSA Levels of Automation

NHTSA Automation Level		Forecasted Range
One	Function-Specific	Now
Two	Combined Function	Now to 3 years away
Three	Limited Self-Driving	3 to 10+ years away
Four	Full Self-Driving	7 to 12+ years away

Early Deployments

- Automated valet parking
- Truck platooning
- Controlled environments
  - Military bases
  - Special events
  - Gated communities

Looking Ahead

How will Agencies be Engaged?

- Deployments may start with active agencies
  - AASHTO Deployment Coalition
  - CTS Pooled Fund Study
- Agencies must see a “value proposition” – greater savings or more efficiency
- Agencies looking to improve safety, mobility, environment, border crossings, operations
- Meeting political and public expectations

Issues for Consideration

- Infrastructure Investment
- Data Management / Storage
- Staffing Skills and Abilities
- New business models

Questions?

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