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Seminar #294: Transforming Transportation Through Connectivity

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Portland State University
Spring 2014 Friday Transportation Seminar Series
6 June 2014

Seminar #294: Transforming Transportation Through Connectivity

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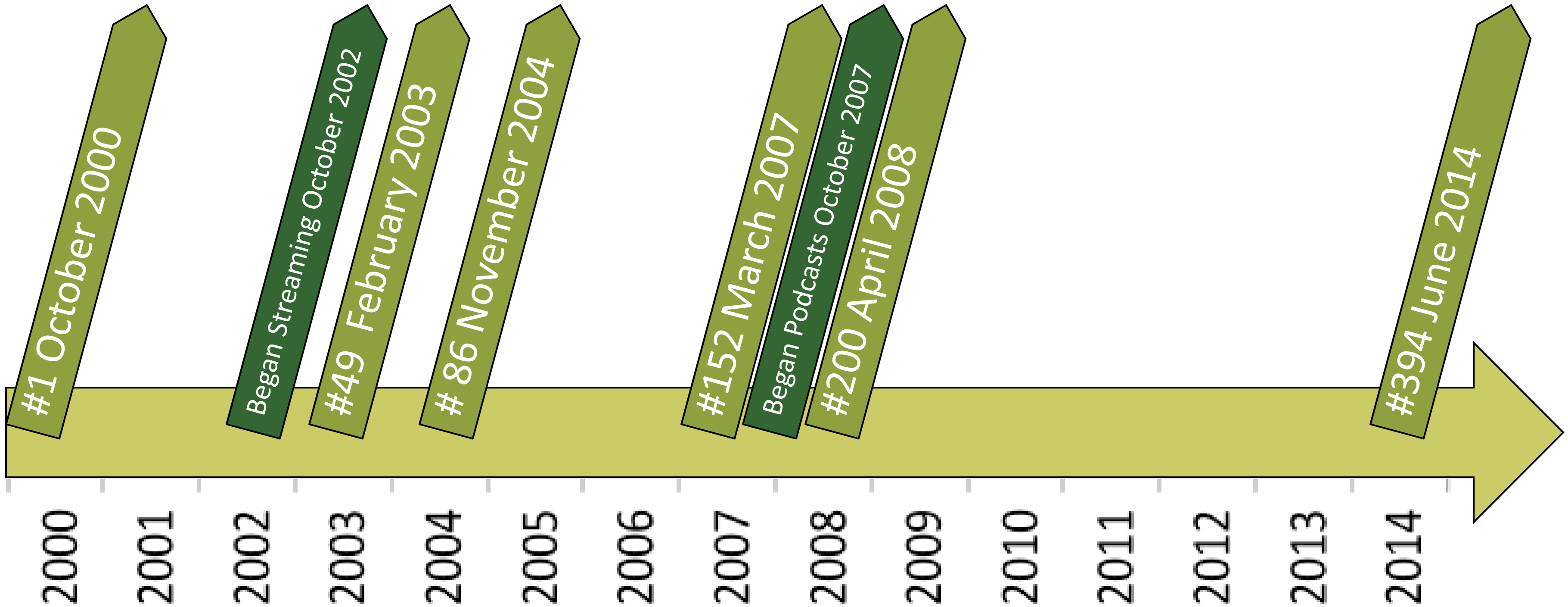
History of Seminar Series



- Inspired by Berkeley's *Transportation Science Seminar*, originated by G.F. Newell, 1965
- First seminar October 5, 2000, *Benefits of Archived ITS Data: Measuring Capacity at a Freeway Bottleneck*
- Venue for student/faculty interaction
- Strong involvement of transportation community

Transport Challenges

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Safety

- 34,080 fatalities in 2012
- 1.10 fatalities per 100 MVMT in 2011
- 2.2 M injuries in 2011
- 5.3 M crashes in 2011
- $230 B total cost (including medical)
- Leading cause of death for ages 4 to 34

Accessibility, Reliability and Mobility

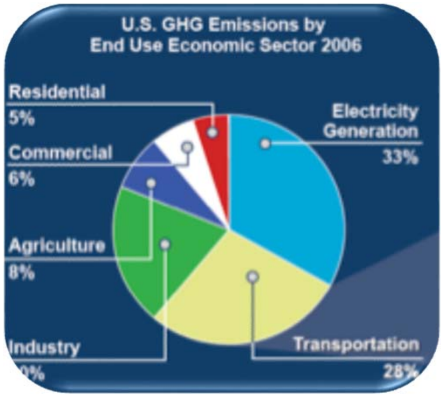
- 4.8B hours travel delay
- $115 billion cost of urban congestion

Household Market Basket

- Second biggest monthly expense, after housing

Sustainability

- 28% of GHG emissions (78% CO, 58% NO_x, 36% VOCs)
- 29% of energy consumed (mostly petroleum)
- 70% of petroleum consumption (60% imported)
- 3.9 billion gallons of wasted fuel
- Half of Americans live in areas that exceed air quality standards for at least one pollutant.



Evolution of U.S. ITS Program

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Congressional Legislation	Dates and Mission
Intermodal Surface Transportation Efficiency Act (**ISTEA**)	1991–1997 (extended to July 1998) ▪ Research and Development ▪ Operational Tests ▪ Technical assistance including architecture and standards
Transportation Equity Act for the 21st Century (**TEA-21**)	1998–2003 (extended to August 2005) ▪ Policy and Institutional Challenges to Deployment ▪ ITS Deployment Program (Congressionally designated) ▪ Model Deployment Initiatives
Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (**SAFETEA-LU**)	2005–2009 (extended to March 31, 2012) ▪ Research ▪ Mainstreaming ITS
Moving Ahead for Progress in the 21st Century (**MAP-21)**	2012-2014

Deployed Technologies

- CCTV Cameras
- Traveler Information
  - DMS ~90% of freeways
  - Social Networking 40%
  - HAR 60%
  - Subscription 35%
  - Web 90%
  - Email 50%
  - Phone 20%
  - 511 70%
- Electronic Toll Collection
- Ramp Control
- Sensors/Loops
- Automated Enforcement
- Lane Management
- Archived Data
- Probe Vehicles

ITS By the Numbers

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Years: **20**+
Funding: $**3**B federal + $**18**B by **75** top metro areas
Market: $**48**B ITS end-use products and servivces
Federal Programs: **3** (ISTEA, TEA21, SAFETEA-LU)
Electronic Toll Collection: **99**% of plazas/**94**% of lanes
Transit Automatic Vehicle Location: **77**% of **117** fixed route bus agencies
Transit Smart Cards: **16,00**0+ buses/**451** rail stations
Commercial Vehicle Electronic Screening: **40** states/**360** weigh stations/**70,000** companies/**500,000** trucks
Professional Capacity Building: **2,500** participants in 2010
Standards Participation: **106** published since 1995
Traffic Management Centers: **266**
Freeway Miles Under Surveillance: **7,70**0 roadside/**4,500** probe vehicles/**54**% of freeways in **75** metropolitan areas
Arterial Miles Under Surveillance: **2,500** roadside/**1,700** probe vehicles/**50**% of intersections in **75** metropolitan areas
511 Coverage: All or part of **38** states (**70**% of population)
Dynamic Message Signs: **4,200**/**109** freeway management agencies post information/**36** of **40** metro areas post travel times

Intelligent Vehicle in 1990

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- 1990 Honda Accord
  - Automatic shoulder belts
  - CD player
  - No ABS or airbags
  - EPA 19 mpg city, 26 mpg highway (combined 22 mpg)
- San Francisco – emphasis on earthquake safety

Intelligent Vehicle in 2014

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- 2014 Ford Focus
  - $21,900
  - EPA Rating 22 City/34 Highway
  - Adaptive Cruise Control with Forward Collision Warning
  - Blind Spot Information System (BLIS) with Cross-Traffic Alert
  - Rear View Camera
  - Lane-Keeping System
  - Active Park Assist
  - 911 Assist
  - Traffic Sign Recognition
  - Driver Alert
  - Pedestrian Alert Kit and Active City Stop

Data Revolution

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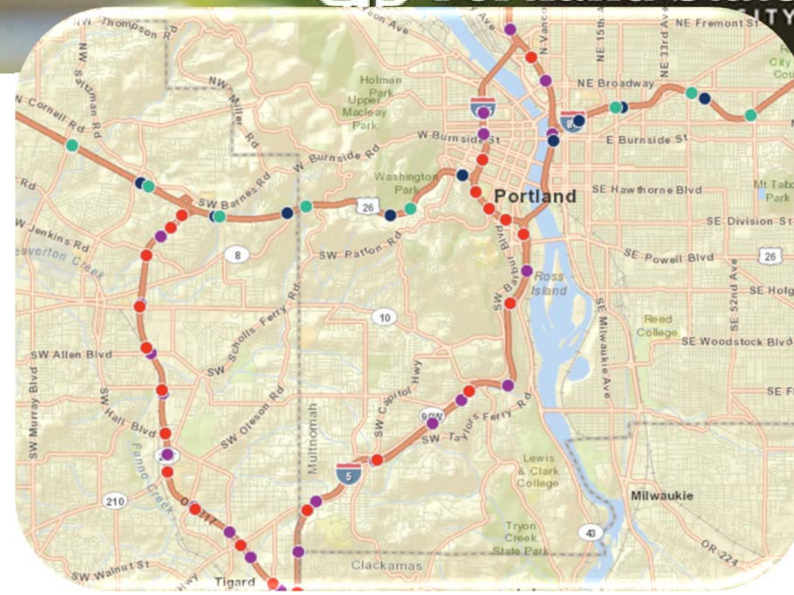
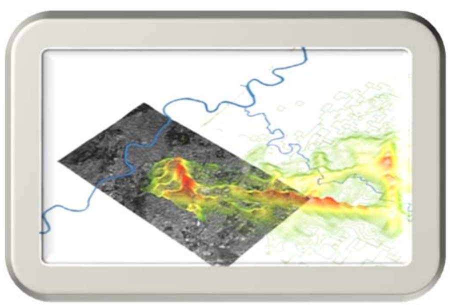
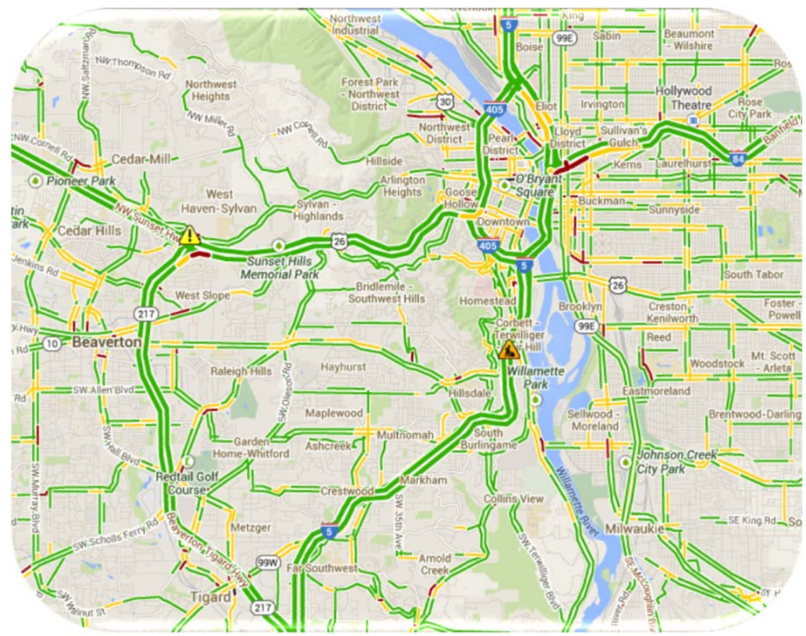
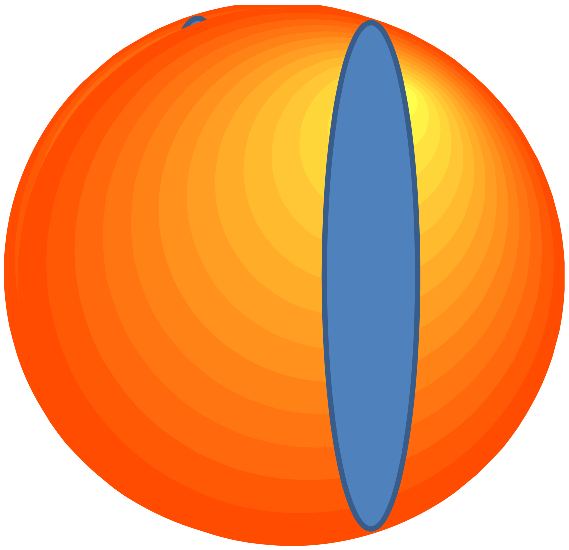


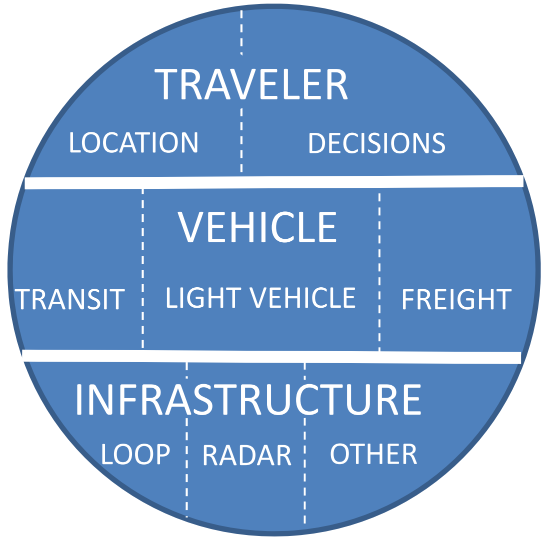


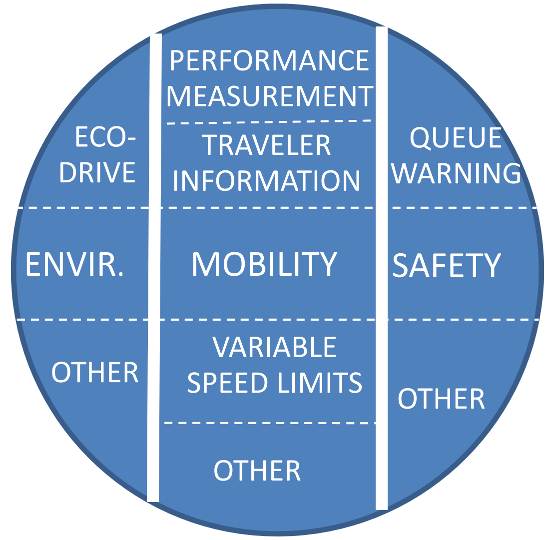


Data is Power

SOURCES USES

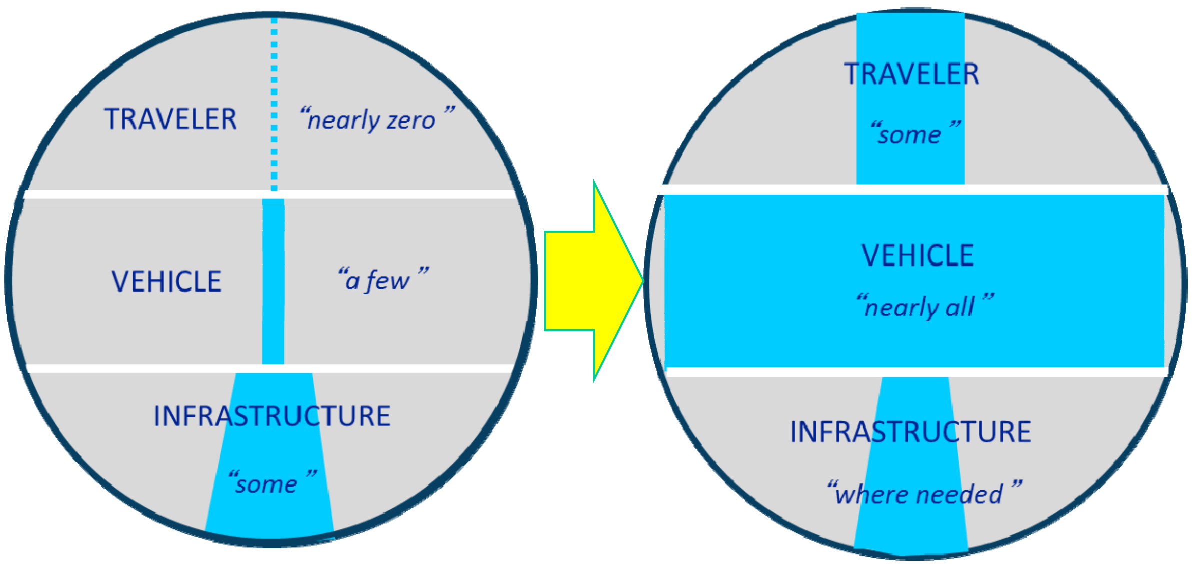






Current State

Potential End State



Data Environment Evolution

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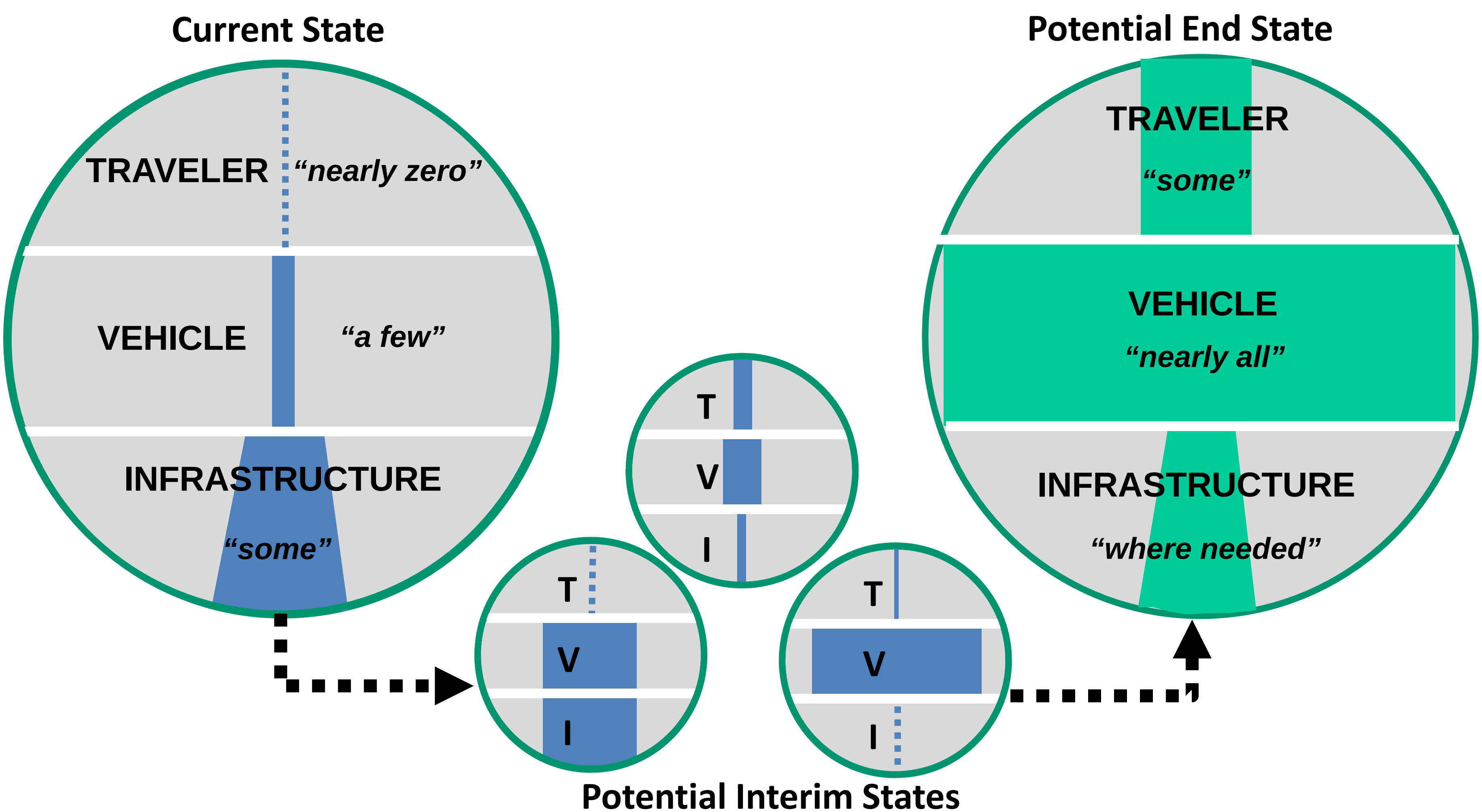

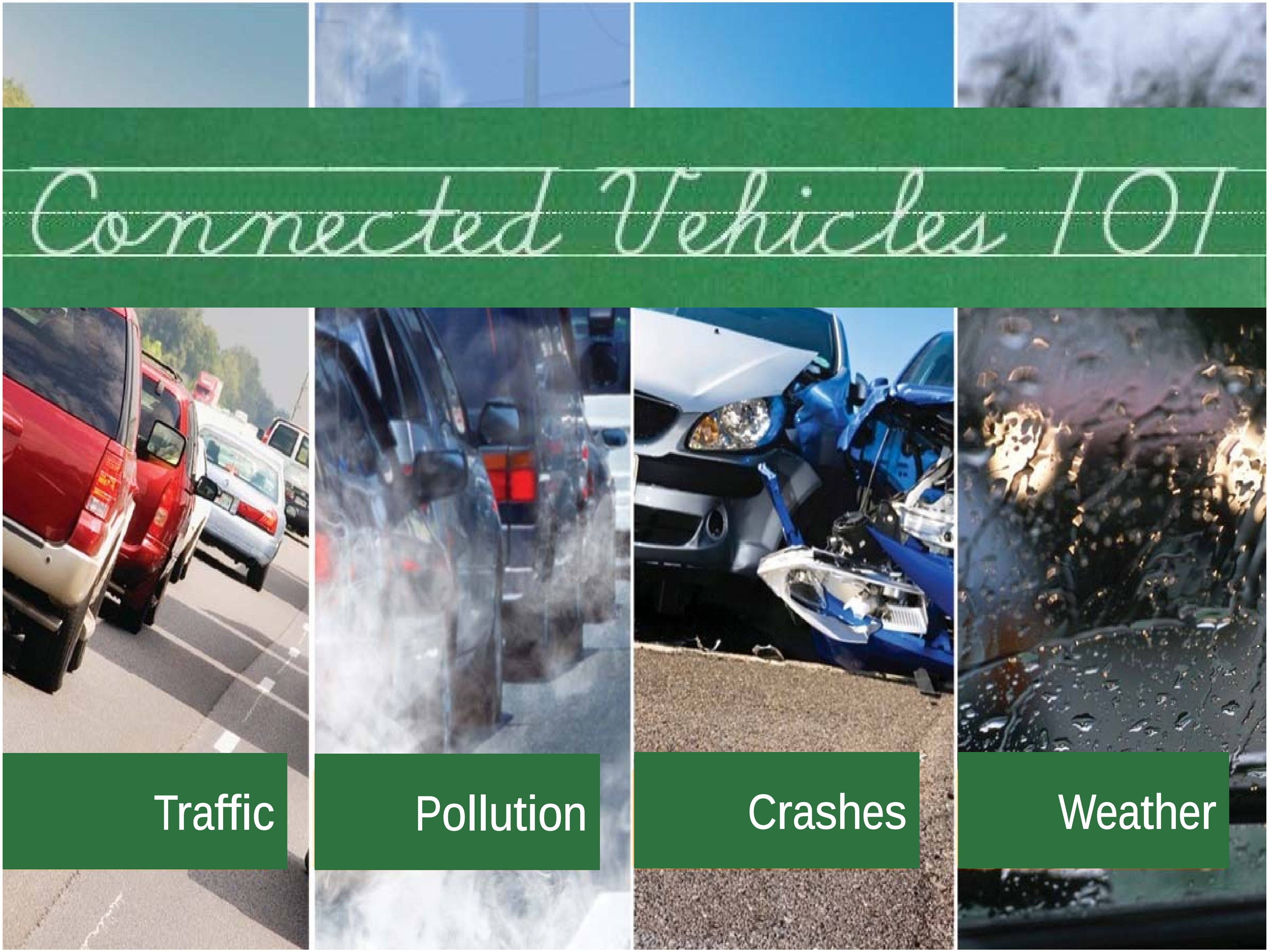

Connected Vehicles 101
Traffic
Pollution
Crashes
Weather

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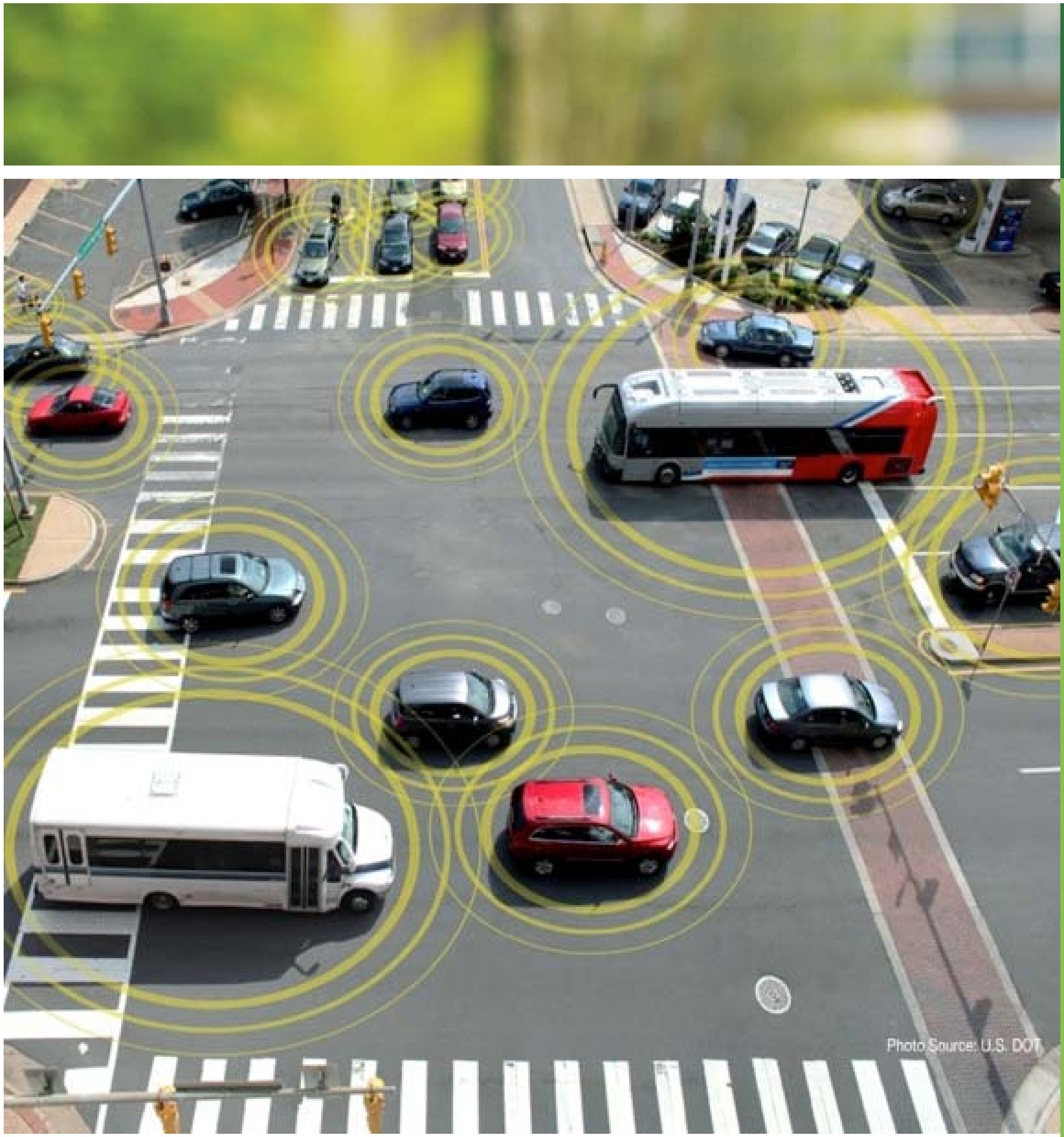
Connected vehicles can help.

They use wireless communication between vehicles and infrastructure to help prevent crashes, make travel easier, and curb pollution.

Photo Source: Thinkstock and Wikimedia Commons

Photo Source: Thinkstock

All vehicles, regardless of type, will communicate with each other using a wireless technology called Dedicated Short-Range Communications (DSRC).



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Connected vehicles have the potential to address up to 81% of unimpaired crash scenarios.

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Connected vehicles will provide drivers with warnings to help them avoid crashes.

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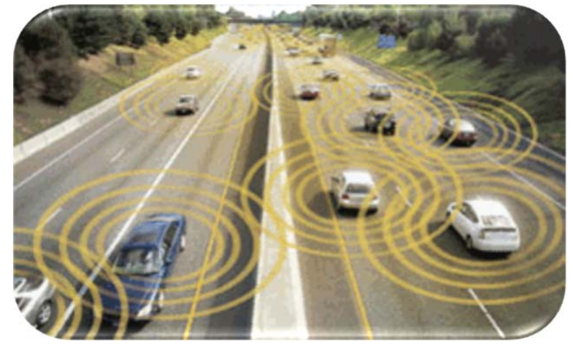
Imagine your car informing you of available parking on the next block, your cell phone telling you a cab or bus or train is approaching, or your car helping you find a rideshare partner.

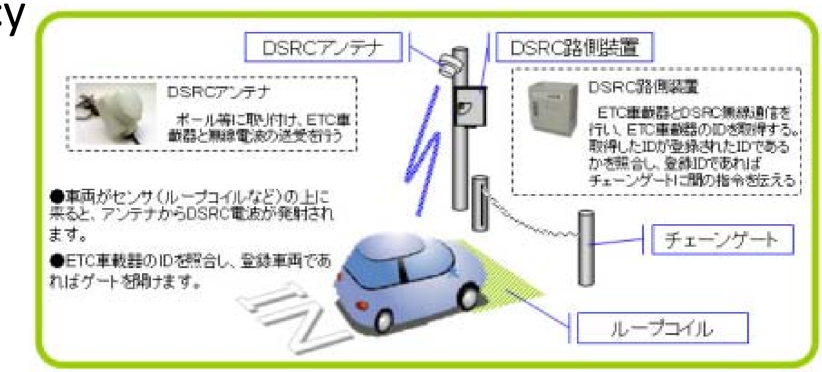
Consider the ways in which increased travel information can help the environment. *Connected vehicles can help.*

http://www.youtube.com/watch?v=Zuf2VNWGMnY

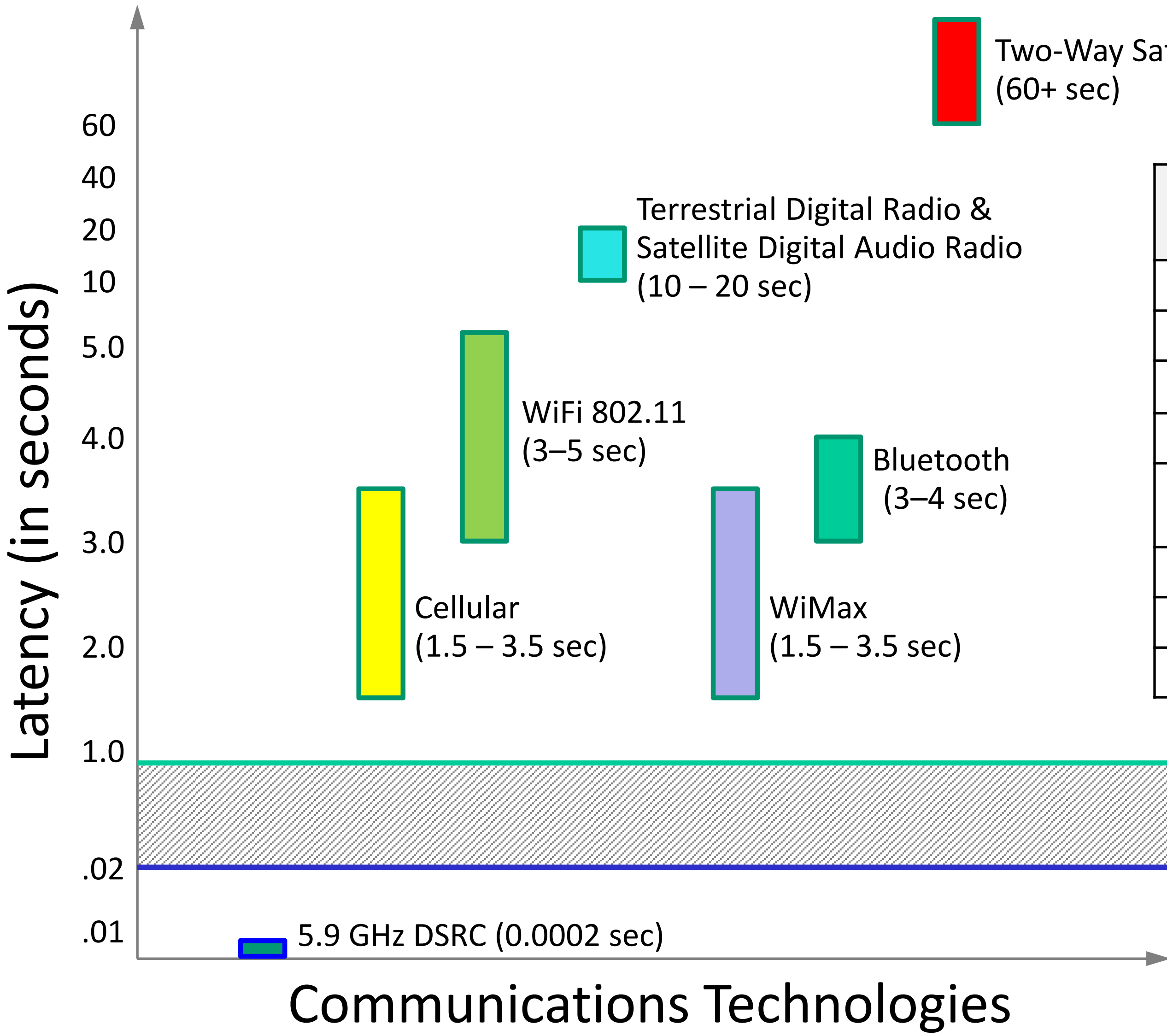
What is DSRC?

- "Dedicated Short Range Communications"
- Short to medium range communications service
- FCC authorized spectrum at 5.9 GHz for safety applications in 1999
- Europe allocated 5.9 GHz and Japan uses the 5.8 GHz
- Key ingredients: **standardization** and **interoperability**
- Other applications and other wireless technologies can be accommodated
- Older DSRC systems such as toll tags operate at 900 MH: no standard, several proprietary systems are in place
- Both vehicle to infrastructure and vehicle to vehicle communication environments
- **Complementary** to cellular communications
- Very high data transfer rates & minimal latency
- Range up to 1000 m
- Data Rate – 6 to 27 Mbps
- Channels – 7 Licensed Channels





Communications Technologies



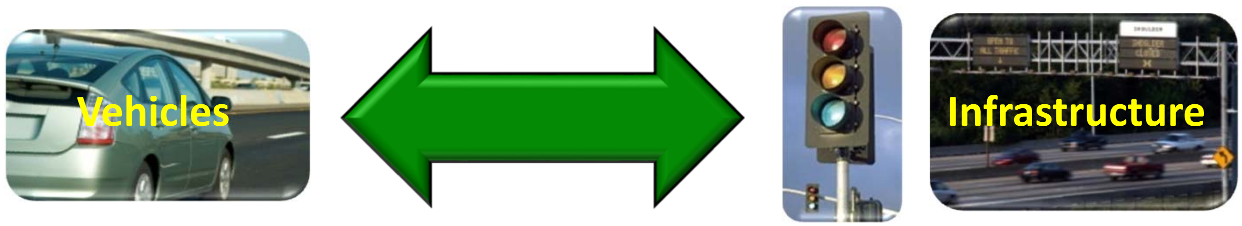
Active Safety Latency Requirements (sec)	
Traffic Signal Violation Warning	0.1
Curve Speed Warning	1.0
Emergency Electronic Brake Lights	0.1
Pre-Crash Sensing	0.02
Cooperative Forward Collision Warning	0.1
Left Turn Assistant	0.1
Lane Change Warning	0.1
Stop Sign Movement Assistance	0.1

Least Stringent Latency Requirement for Active Safety (1.0 sec)

Most Stringent Latency Requirement for Active Safety (0.02 sec)

Note: *y*-axis not to scale for illustration purposes
Data source: Vehicle Safety Communications Project – Final Report

Original Vision



Vision for Connected Future

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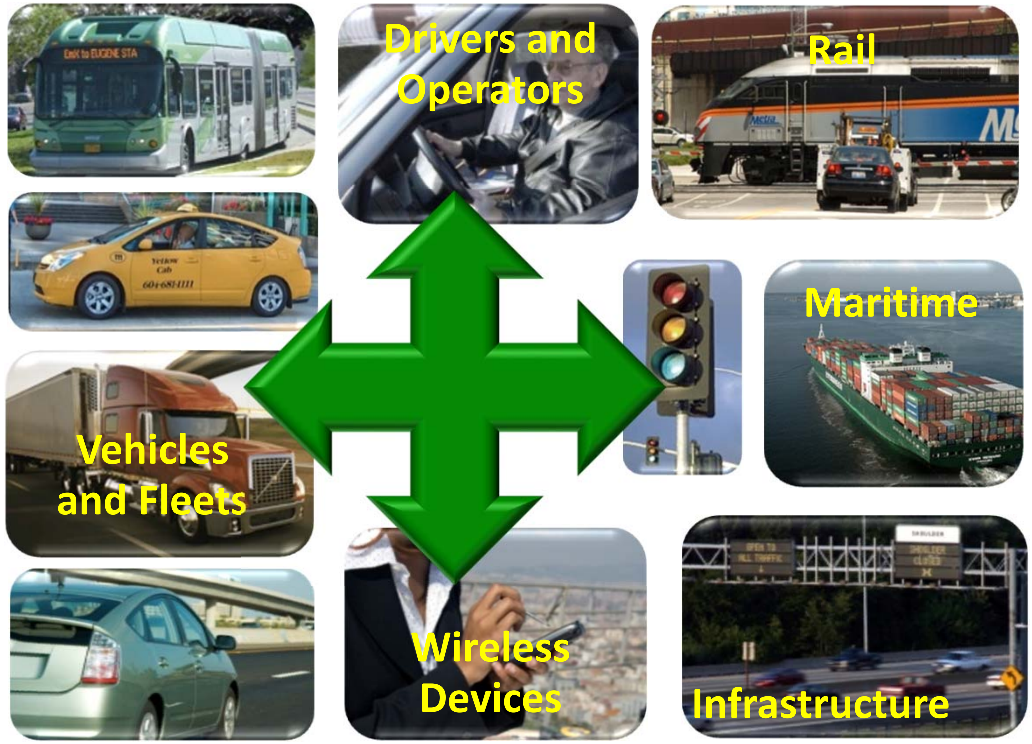

Vision for Connected Future

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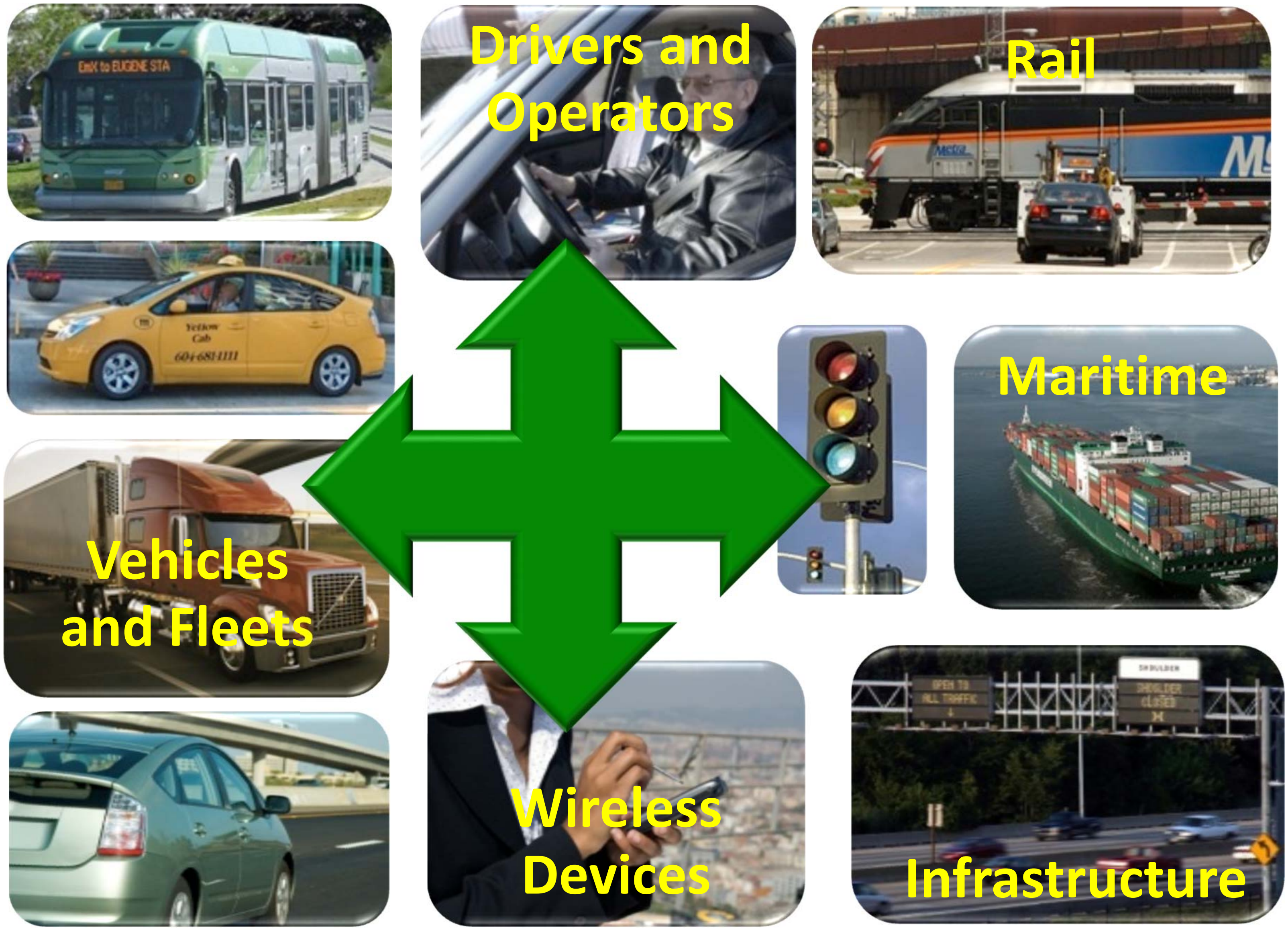
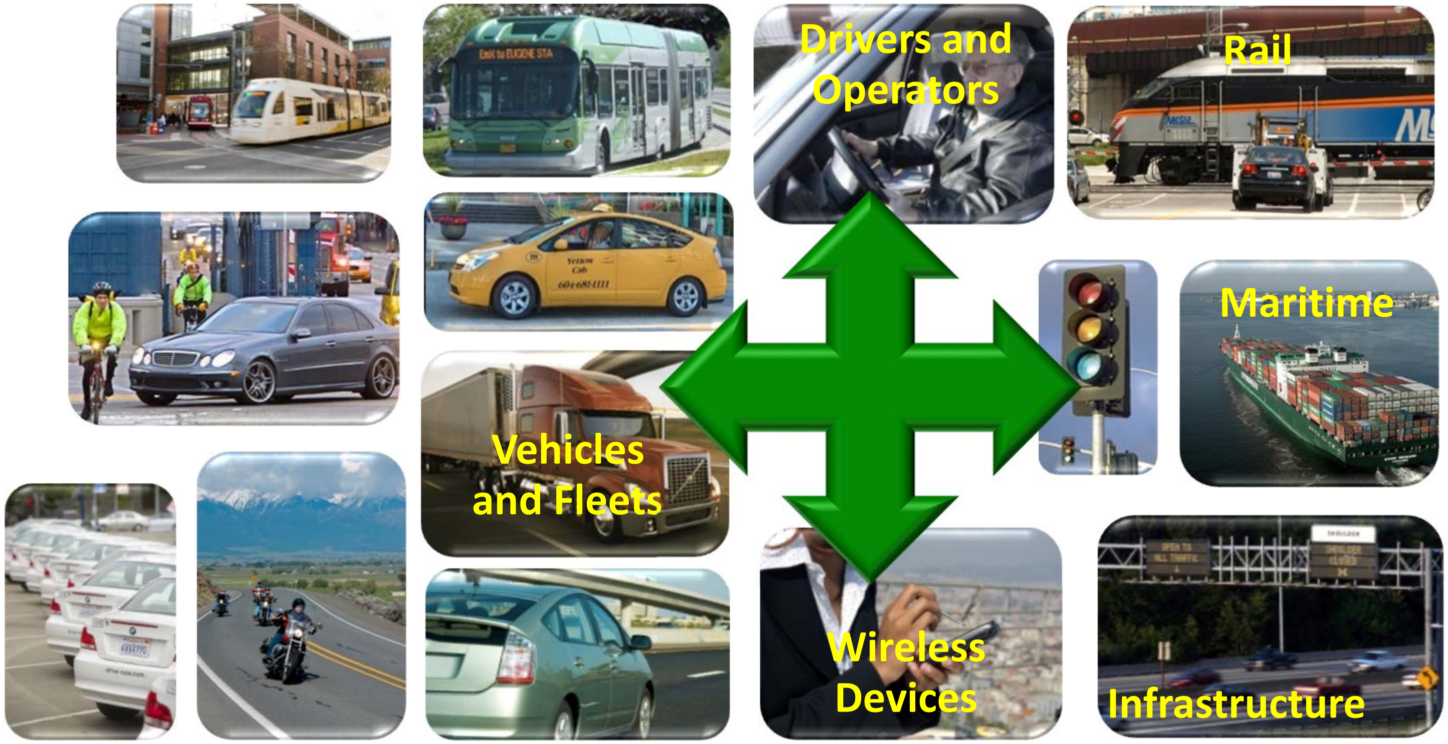


Vision for Connected Future



- Multi-modal surface transportation system—connectivity as its core.
- Vehicles (cars, trucks, buses, fleets of all kinds) ←→ Drivers and operators ←→ Infrastructure ←→ Mobile Devices
- Leverage technology to maximize safety, mobility and the environment—enabled through wireless communications—in all modes.
- First priority is safety: crash and injury prevention (80% of crash scenarios).

Solutions for 80% of Crashes

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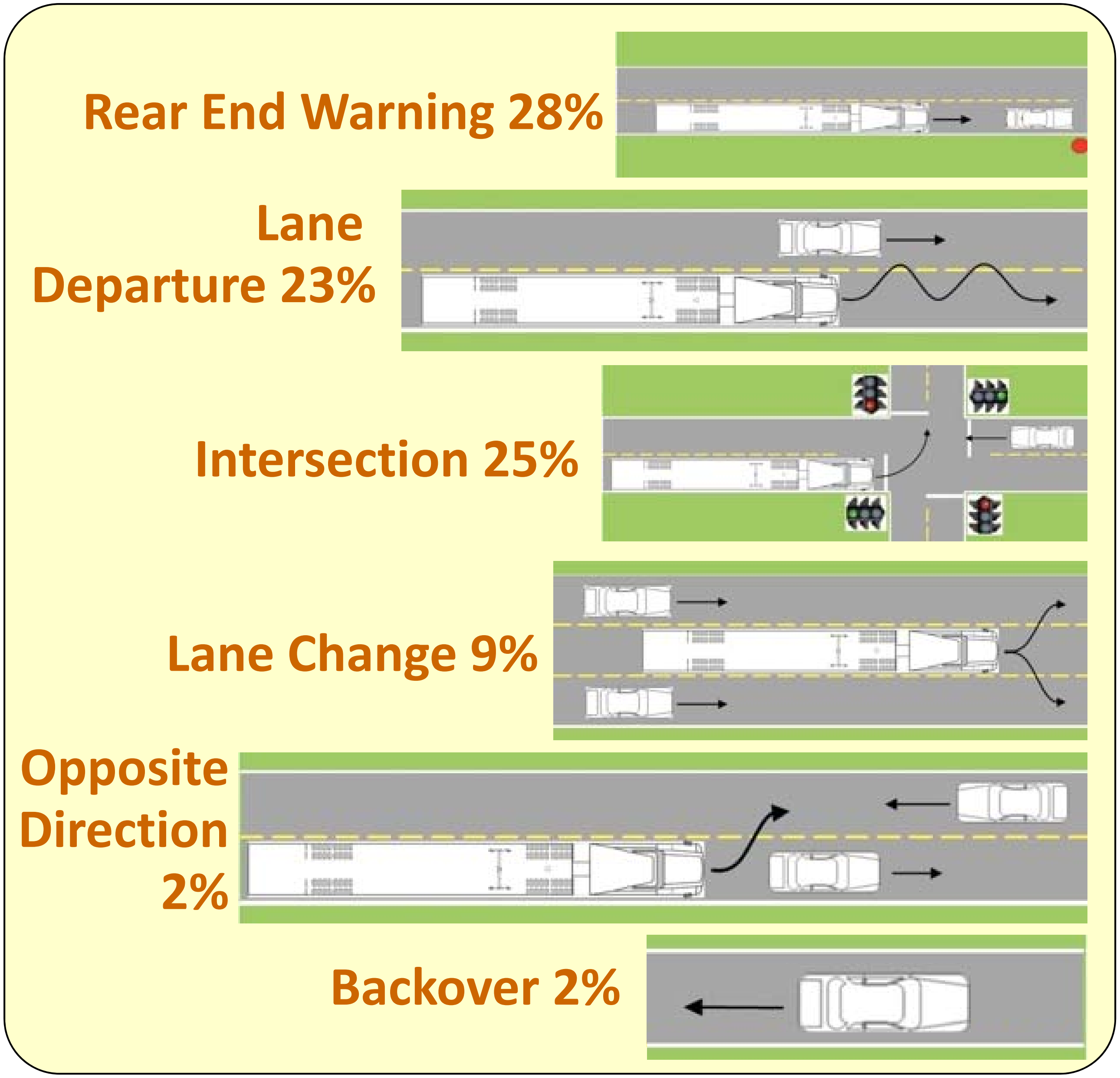
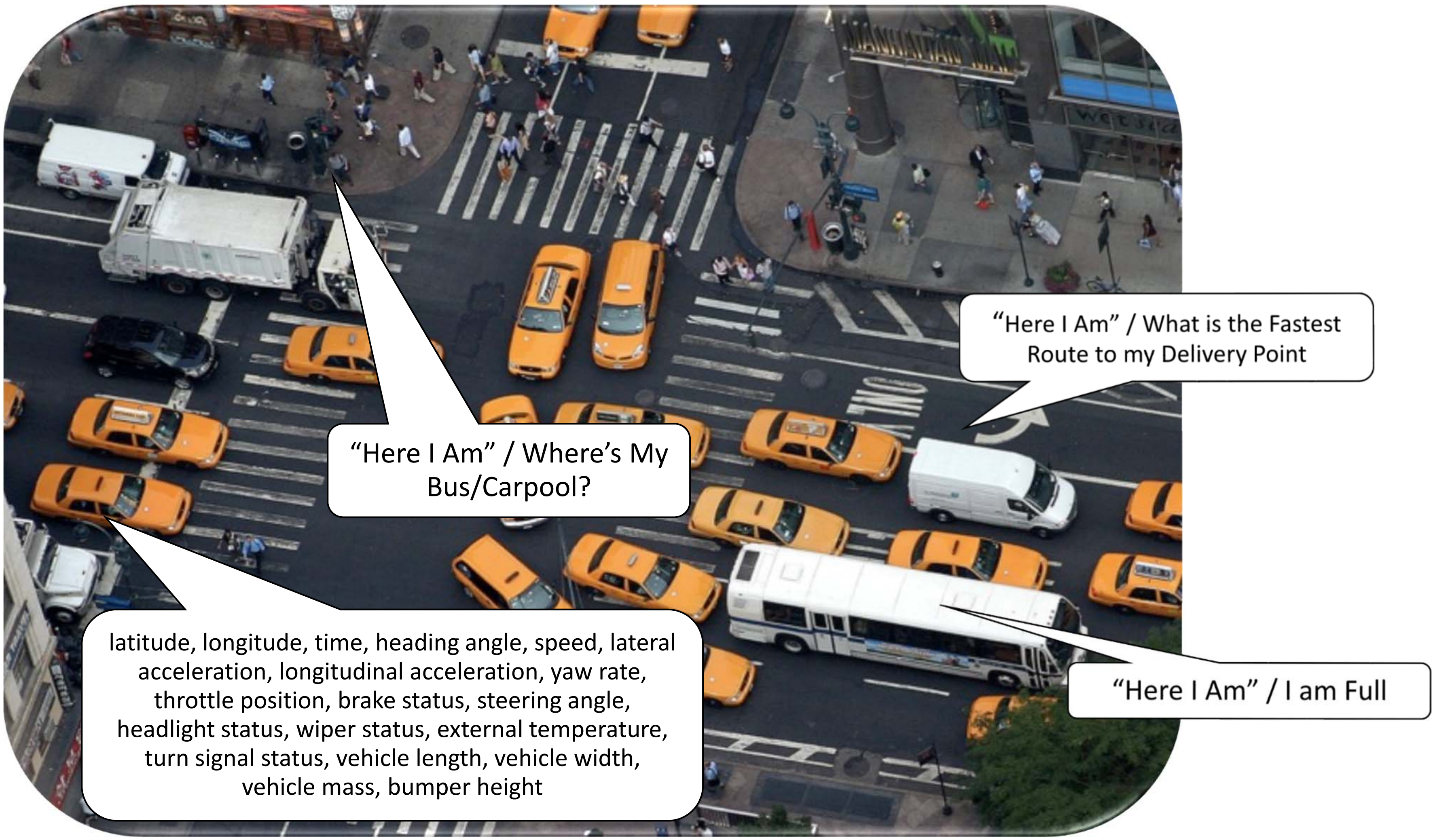


SAE J2735 Basic Safety Message

Basic Safety Message
Temporary ID
Time
Latitude
Longitude
Elevation
Speed
Heading
Acceleration
Brake System Status
Vehicle Size

Connected Vehicles and Travelers



Safety Pilot 2011-2013

- Major field test and real world implementation
  - Multiple vehicle types: cars, fleets, trucks, buses
  - Fully integrated systems & aftermarket devices
  - Prototype security mechanisms
  - Certification processes
- Goals
  - Support real world V2V & V2I applications with data rich environment
  - Establish benefits data in support **of NHTSA 2013 Agency Decision**
  - Public awareness & determine user acceptance
- Outcomes
  - Benefits and user acceptance data for supporting future federal actions
  - Archived road network data for supporting mobility, environmental, and other research
  - Multiple supplier sources for devices and infrastructure
  - Better understanding of the operational policy issues associated with the deployment of V2V and V2I

SAFETYPILOT

Six Driver Clinic Sites

Ann Arbor Model Deployment Site

Safety Pilot – 2836 Vehicles

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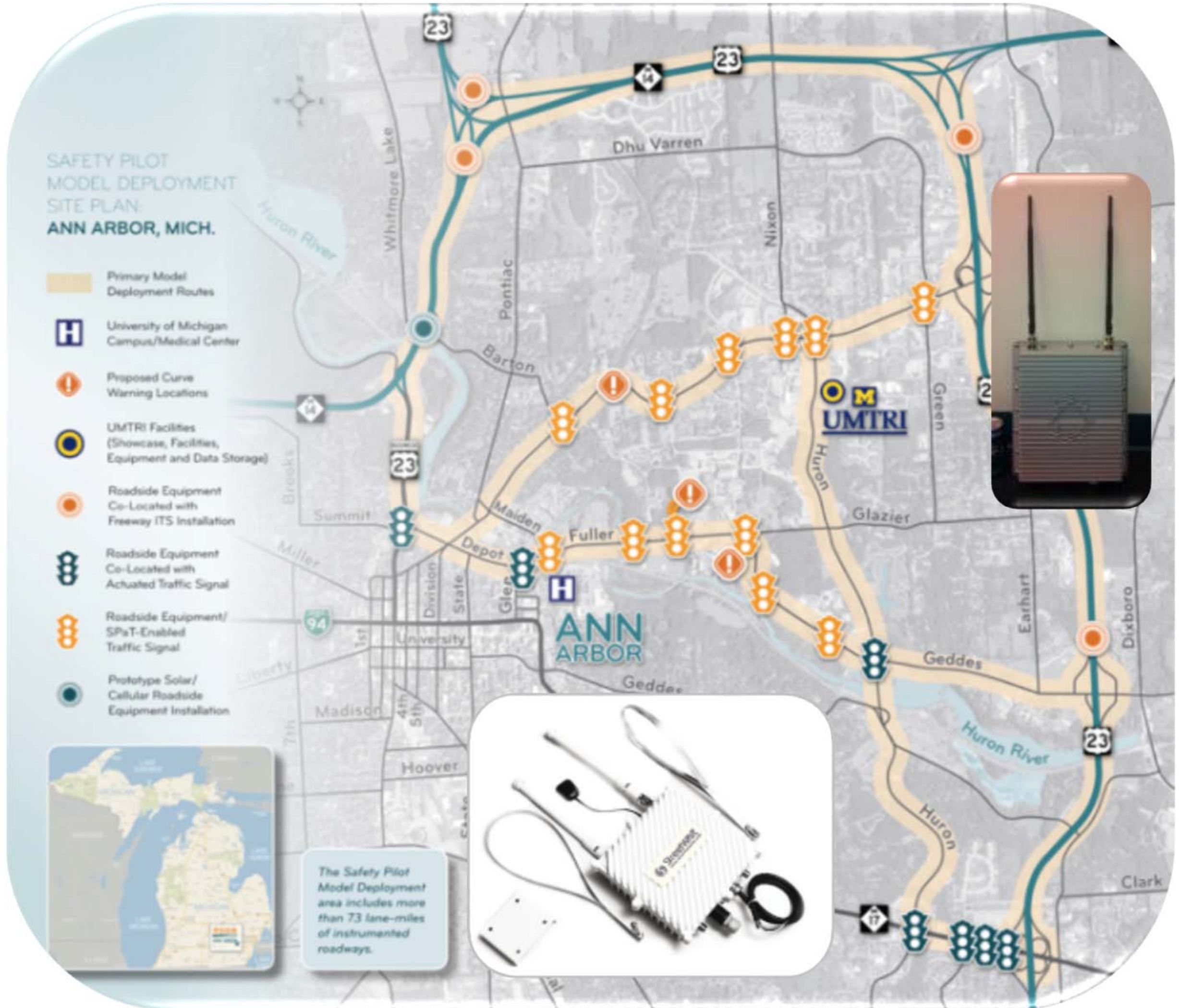
V2V

Forward Collision Warning
Emergency Electronic Brake Light
Intersection Movement Assist
Blind Spot Warning/Lane Change Warning
Do Not Pass Warning
Left Turn Across Path/Opposite Direction
Right Turn in Front

V2I

Signal Phase and Timing
Curve Speed Warning
Railroad Crossing Warning
Pedestrian Detection



Informed NHTSA Decision February 2014

Model Deployment Fleet

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Connected Vehicle Device	Vehicle Type	Vehicle Source	Total Units in Model Deployment
Integrated Devices	Light Vehicles	CAMP	64
Integrated Devices	Commercial Trucks	Battelle Team	3
Vehicle Awareness Devices	Light Vehicles	UM, Ann Arbor	2200
Vehicle Awareness Devices	Local Truck Fleets	Con-Way, Arbor Springs	50
Vehicle Awareness Devices	Heavy Duty	University Fleet	100
Vehicle Awareness Devices	Transit Vehicles	AATA	100
Aftermarket Safety Devices	Light Vehicles	UM, Ann Arbor	300
Retrofit Devices	Local Truck Fleets	Con-Way, Sysco	16
Retrofit Devices	Transit Vehicles	UM Buses	3
		Total	**2836**

Vehicle Examples

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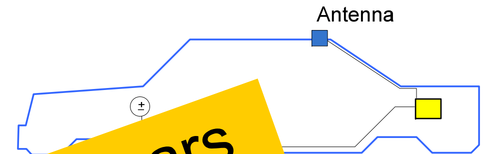
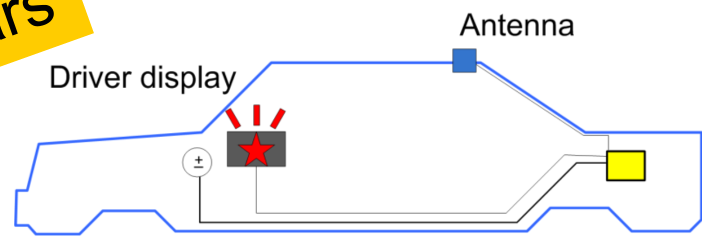
Fully Integrated Safety Devices (ISD)

Vehicle Awareness Device (VAD)



Retrofit Safety Devices (RSD)

Aftermarket Safety Device (ASD)



Mobility Program

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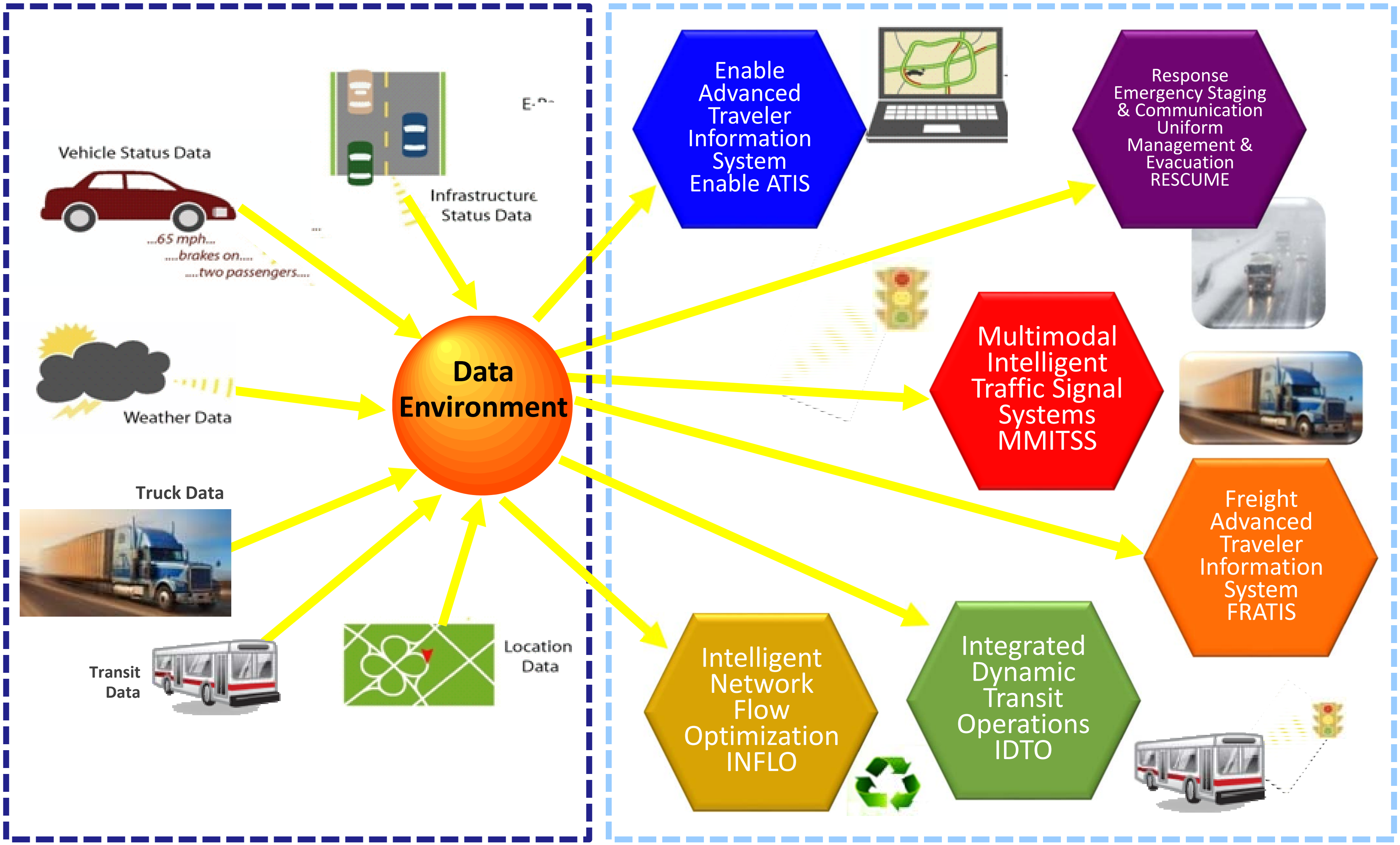
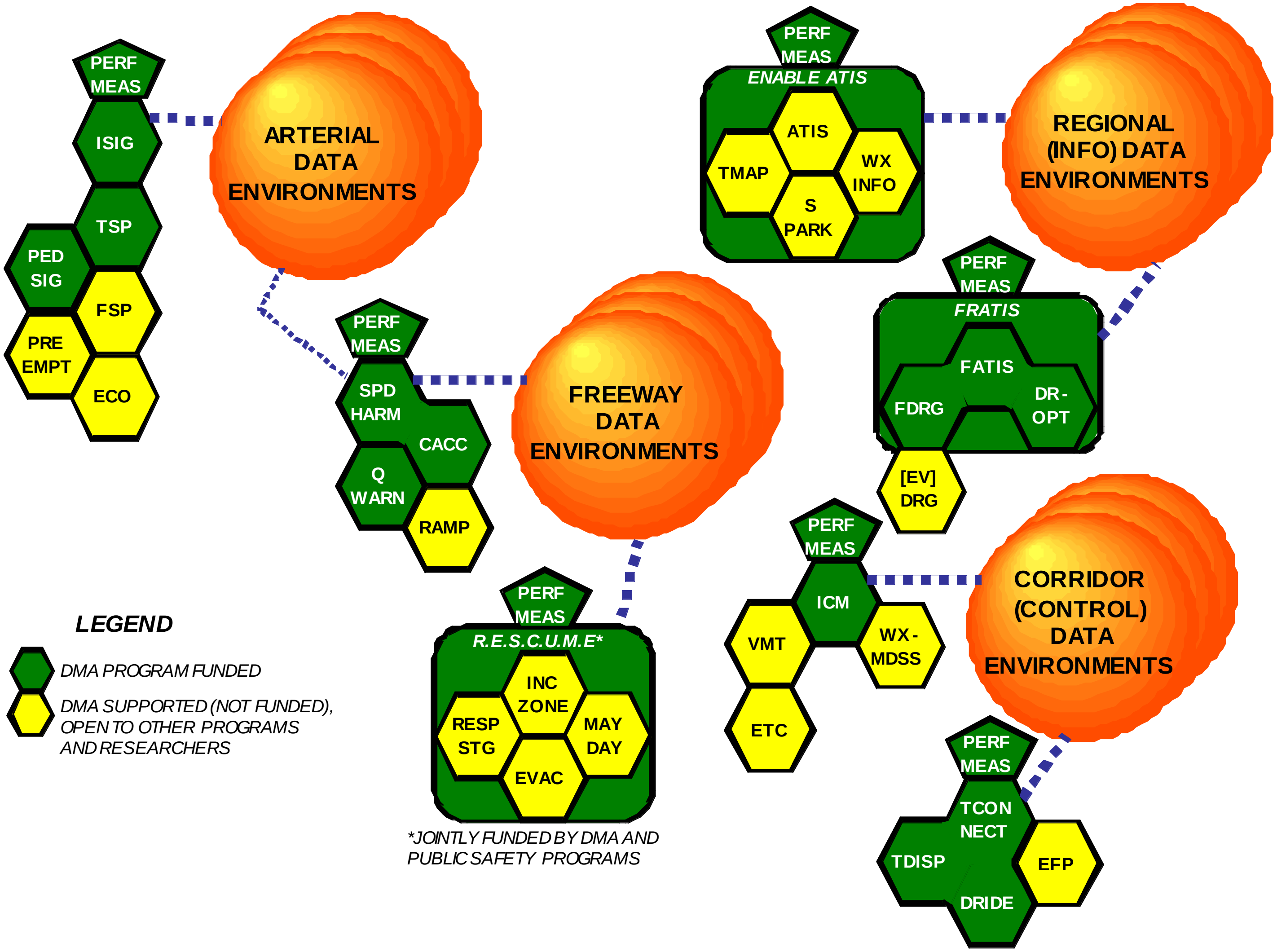
Real-time Data Capture & Management | **Mobility Applications**



High Priority Mobility Applications



Dynamic Mobility Applications

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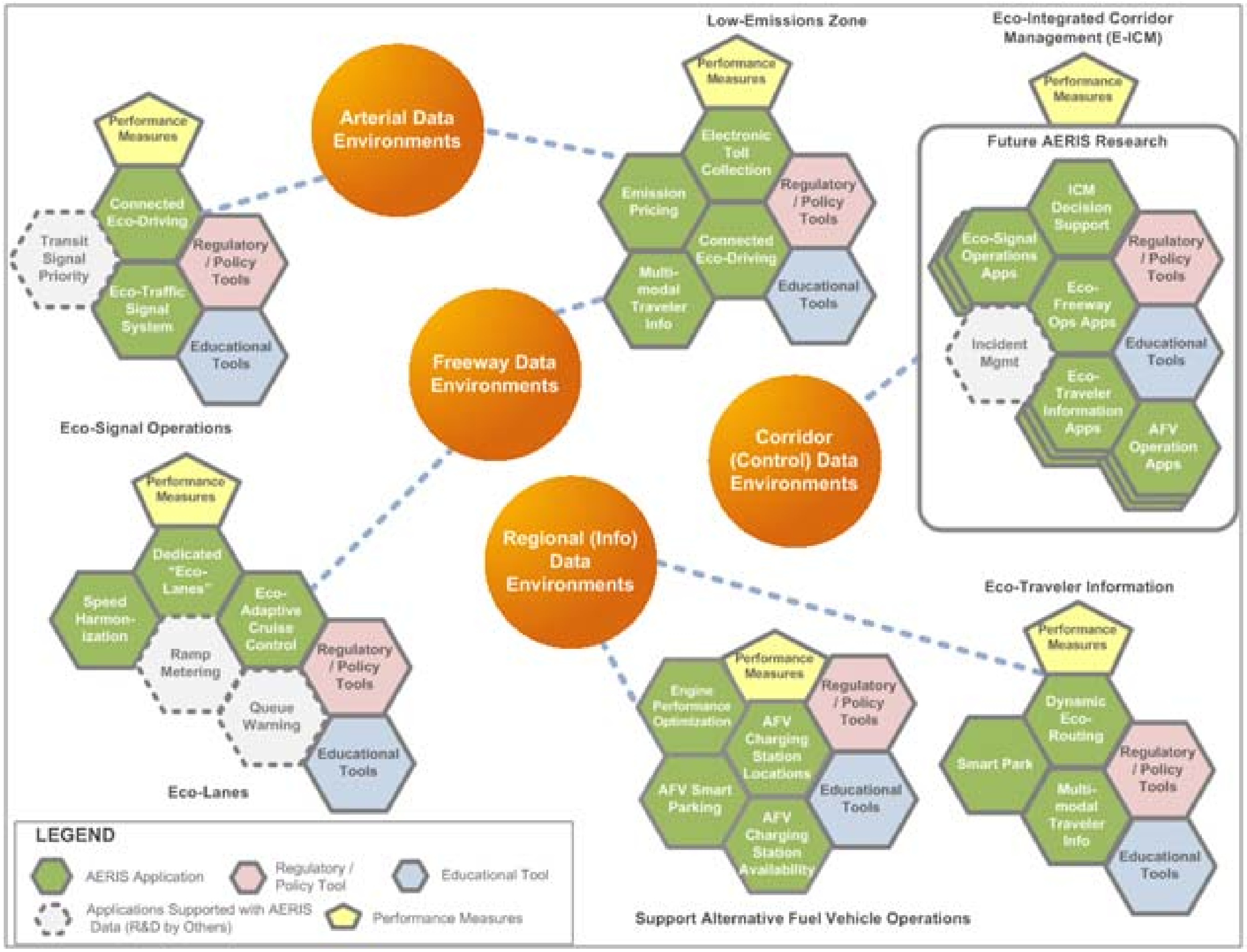
- Enable Advanced Traveler Information System (EnableATIS)
- Freight Advanced Traveler Information Systems (FRATIS)
- Integrated Dynamic Transit Operations (IDTO)
- Intelligent Network Flow Optimization (INFLO)
- Multi-Modal Intelligent Traffic Signal Systems (MMITSS)
- Response, Emergency Staging and Communications, Uniform Management, and Evacuation (R.E.S.C.U.M.E.)

AERIS Program

- Low Emission Zone
- Eco-integrated Corridor Management
- Eco-Signal Operations
- Eco-Lanes
- Support Alternative Fuel Vehicle Operations
- Eco-Traveler Information



Archived Data Investments

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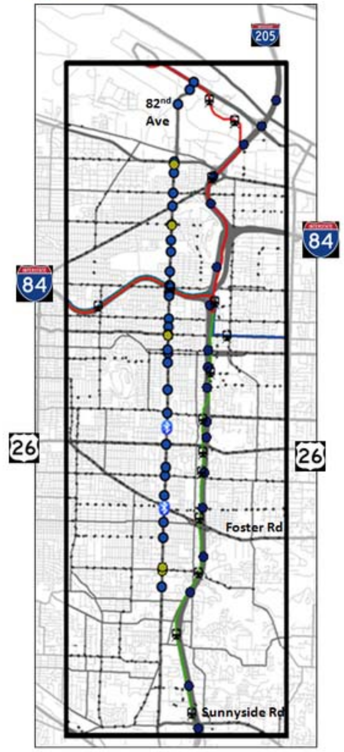
PORTAL | Home | Systems | Highways | Stations | Downloads | FHWA Data | Data Quality | News & Info | Support

Multimodal Data Set for Portland Oregon Region
Test Data Set for the FHWA Connected Vehicle Initiative
Real-Time Data Capture and Management Program

U.S. Department of Transportation Federal Highway Administration

The Portland State University Multimodal Test Data Set submission contained on this web site consists of Freeway, Transit and Arterial data for the I-205 Corridor in Portland, Oregon. The selected corridor ranges along the I-205 Freeway from Sunnyside Road near milepost 14 to the end of the detection, near the Oregon/Washington State line. The corridor is approximately 10 miles long. The figure below displays many of the data sources that are included in the data set submission. The data set contains freeway loop detector data, weather data, incident data, arterial count data, signal phase and timing data, limited Bluetooth traveltime data and bus and light rail data. As shown in the figure, I-205 is the major north-south freeway in the corridor and 82nd Avenue is the primary north-south arterial. Transit service consists of busses running along and across 82nd Avenue and light rail lines that run along the I-205 freeway. This data set provides a two-month multi-modal data set for use in testing Connected Vehicle Applications.



Arterial

Documentation

- Arterial Data Documentation.pdf
- 82nd Avenue Timing Plans.zip

Data

- ArterialData.zip
- AterialPhaseTimingData.zip

Freeway

Documentation

- Freeway Data Documentation.pdf
- RampMeterPlans.zip
- AggregationAnalysis.pdf

Data

- IncidentWeatherData.zip
- FreewayData.zip

Transit

Documentation

- Transit Data Documentation.pdf

Data

- TransitBusData.zip
- TransitLightRailData.zip

Test Bed Investments

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Autonomy vs. Cooperation

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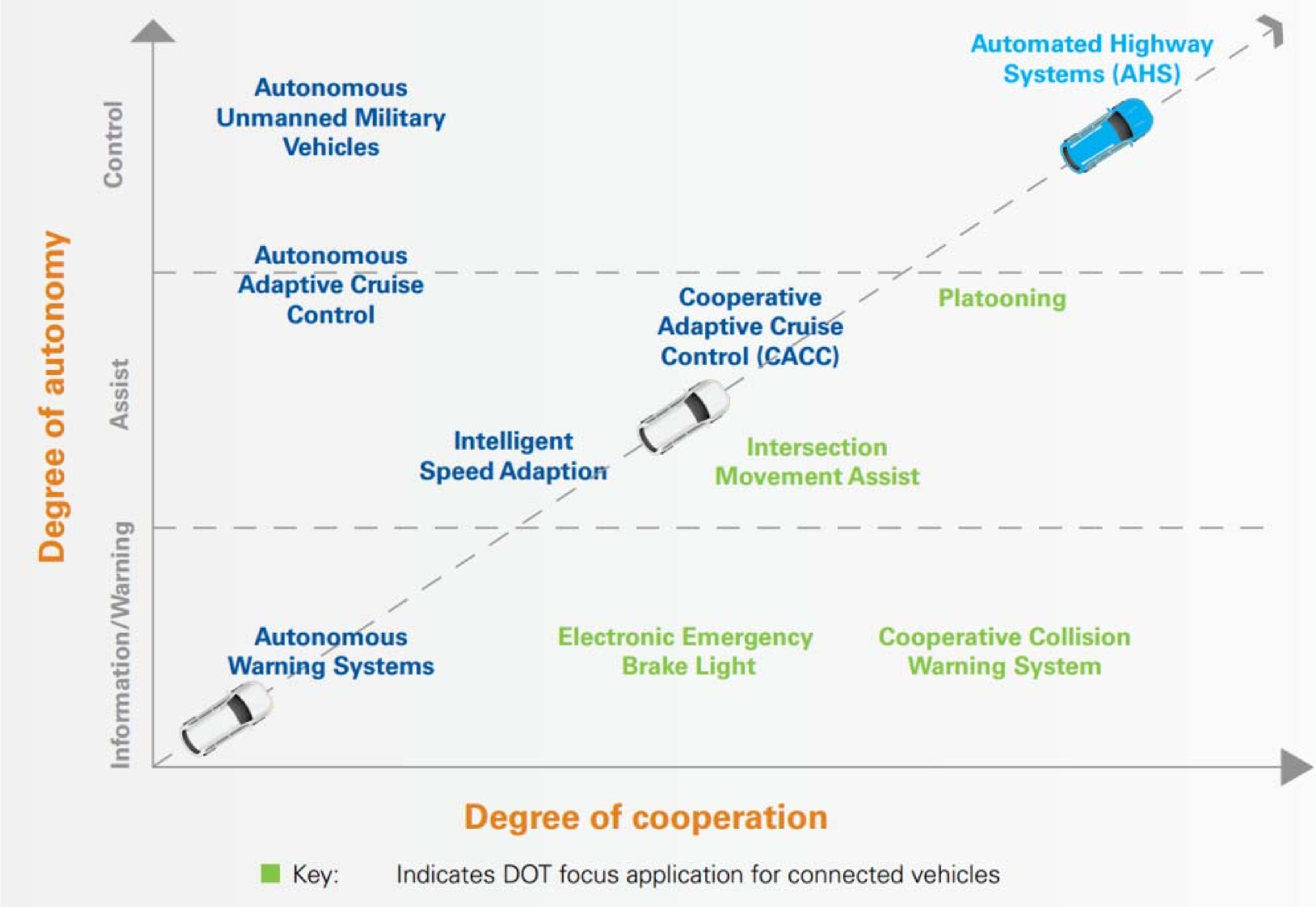

Levels of Automation

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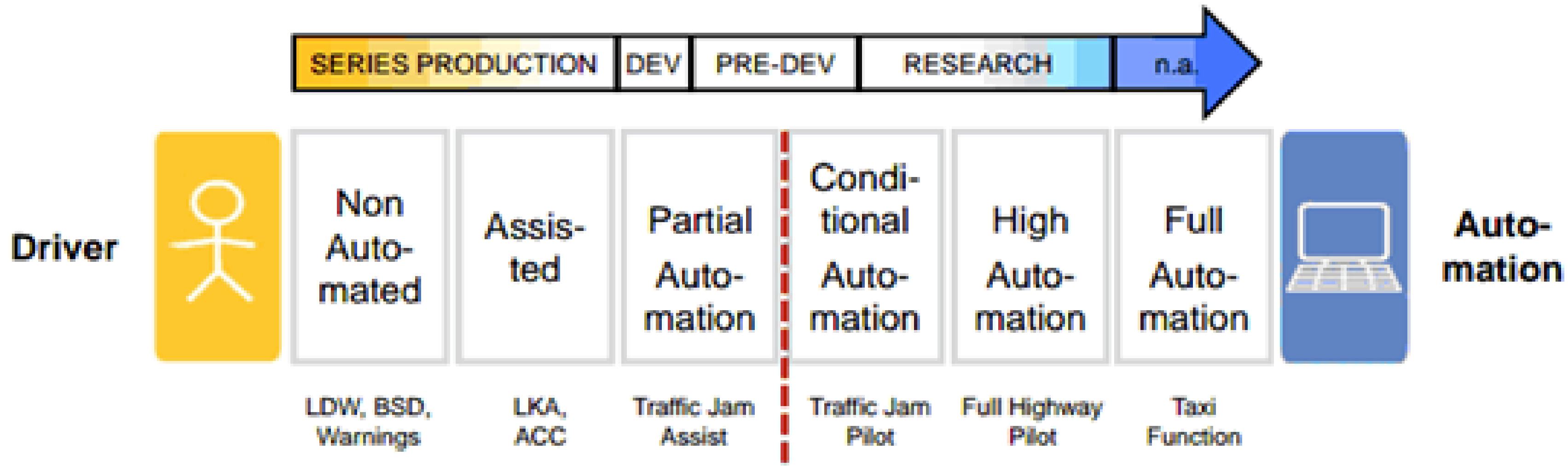
NHTSA level	SAE level	SAE name	SAE narrative definition	Execution of steering and acceleration/ deceleration	Monitoring of driving environment	Backup performance of *dynamic driving task*	System capability (*driving modes*)
	***Human driver* monitors the driving environment**						
0	**0**	**Non-Automated**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	**1**	**Assisted**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	**2**	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
	***Automated driving system* ("system") monitors the driving environment**						
3	**3**	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task* with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	**4**	**High Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
	5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

Taxonomy

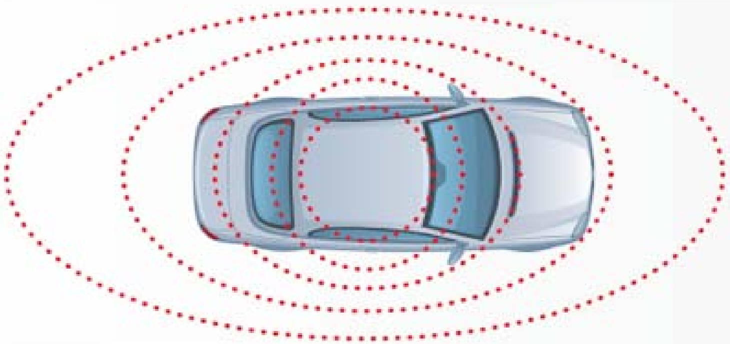


Driver in the loop	*yes (must!)*	*no*	
Reaction time	*~ 1 s*	*~ 10 s*	*~ 10 min*
Secondary tasks	*none*	*texting*	*sleeping*
Minimal Risk Cond.	*none*	*some*	*always (must!)*

Autonomy + Connectivity

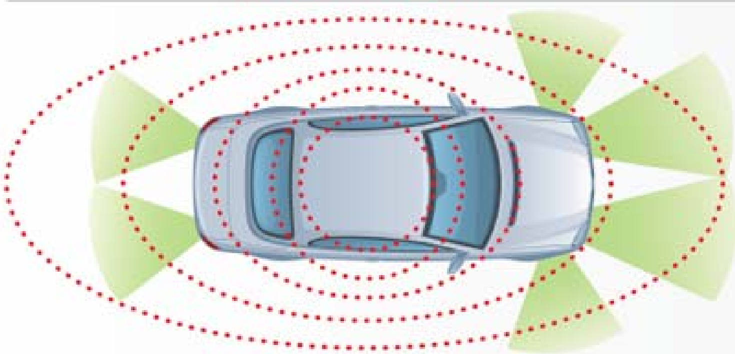
Sensor-Based Solution Only

- Cannot sufficiently mimic human senses
- Not cost-effective for mass market adoption
- Lack of adequate 360º mapping of environment in urban grids



Connected Vehicle Solution Only

- DSRC does not currently work with pedestrians, bicyclists, etc.
- DSRC-based V2I might require significant infrastructure investment
- V2V requires high market penetration to deliver value reliably

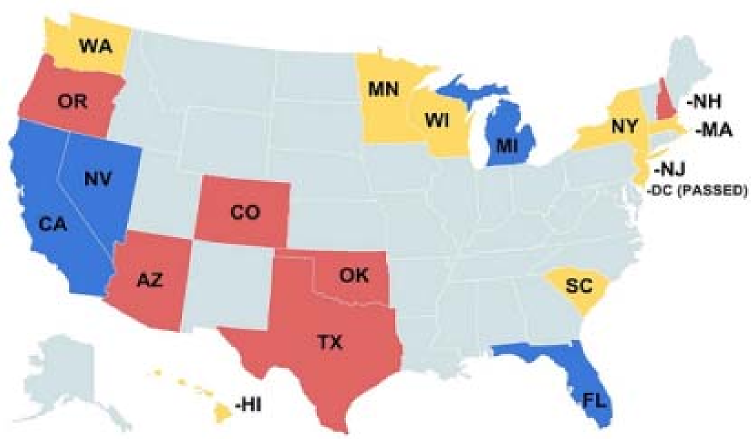


Converged Solution

- Convergence will facilitate adequate mimicking of human senses
- Convergence will reduce need for an expensive mix of sensors and reduce the need for blanket V2I investment
- Convergence will provide the necessary level of functional redundancy to ensure that the technology will work 100 percent of the time

Predictions

- 2015: Audi plans to market vehicles that can autonomously steer, accelerate and brake at lower speeds, such as in traffic jams.
- 2015: Cadillac plans vehicles with "super cruise": autonomous steering, braking and lane guidance.
- 2015: Nissan expects to sell vehicles with autonomous steering, braking, lane guidance, throttle, gear shifting, and, as permitted by law, unoccupied self-parking after passengers exit.
- Mid-2010’s: Toyota plans to roll out near-autonomous vehicles dubbed Automated Highway Driving Assist with Lane Trace Control and Cooperative-adaptive Cruise Control.
- 2016: Tesla expects to develop technology that operates autonomously for 90 percent of distances driven.
- 2018: Google expects to release their autonomous car technology.
- 2020: Volvo envisages having cars in which passengers would be immune from injuries.
- 2020: Mercedes-Benz, Audi, Nissan and BMW all expect to sell autonomous cars.
- 2025: Daimler and Ford expect autonomous vehicles on the market.



Policy Issues

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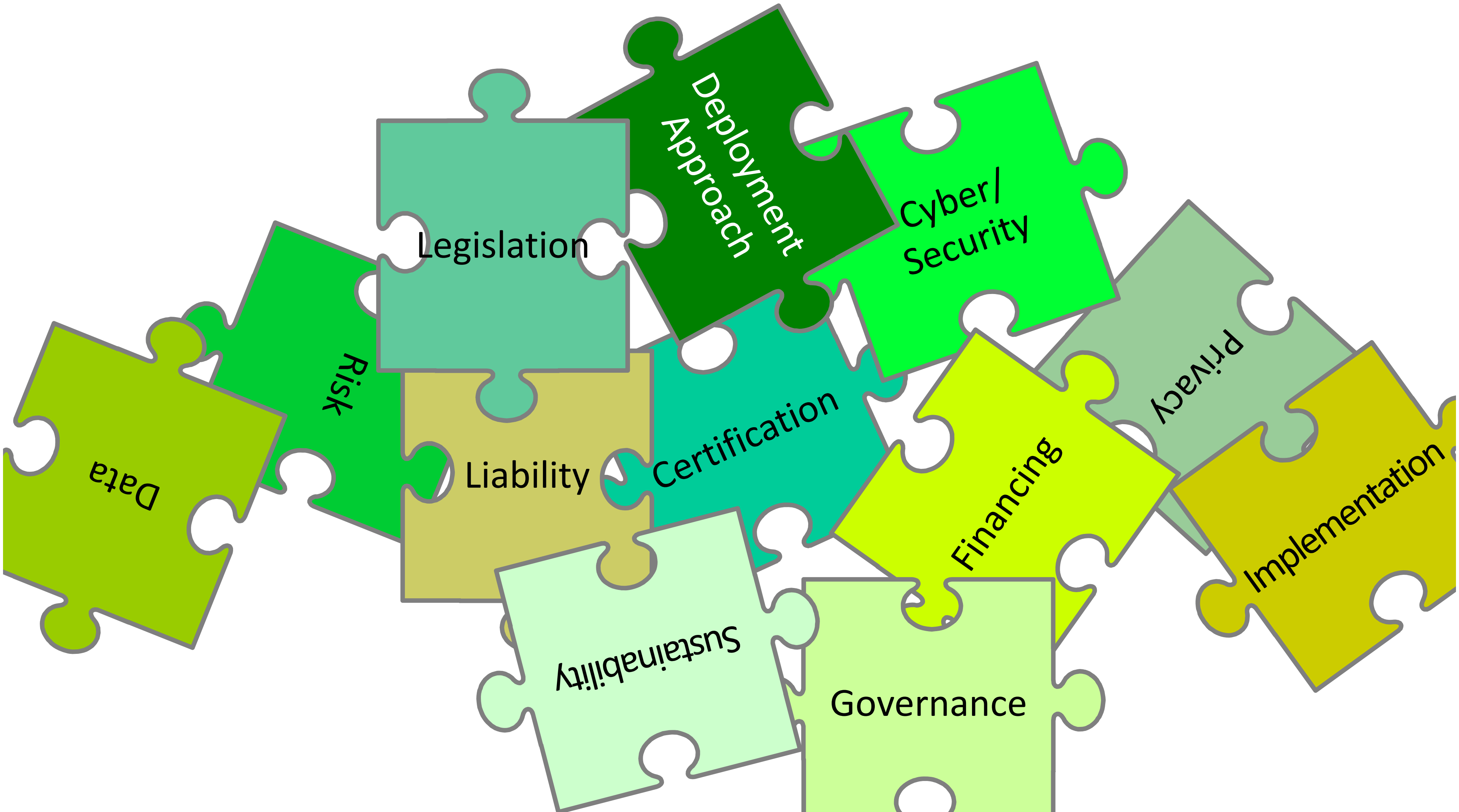

Policy Issues

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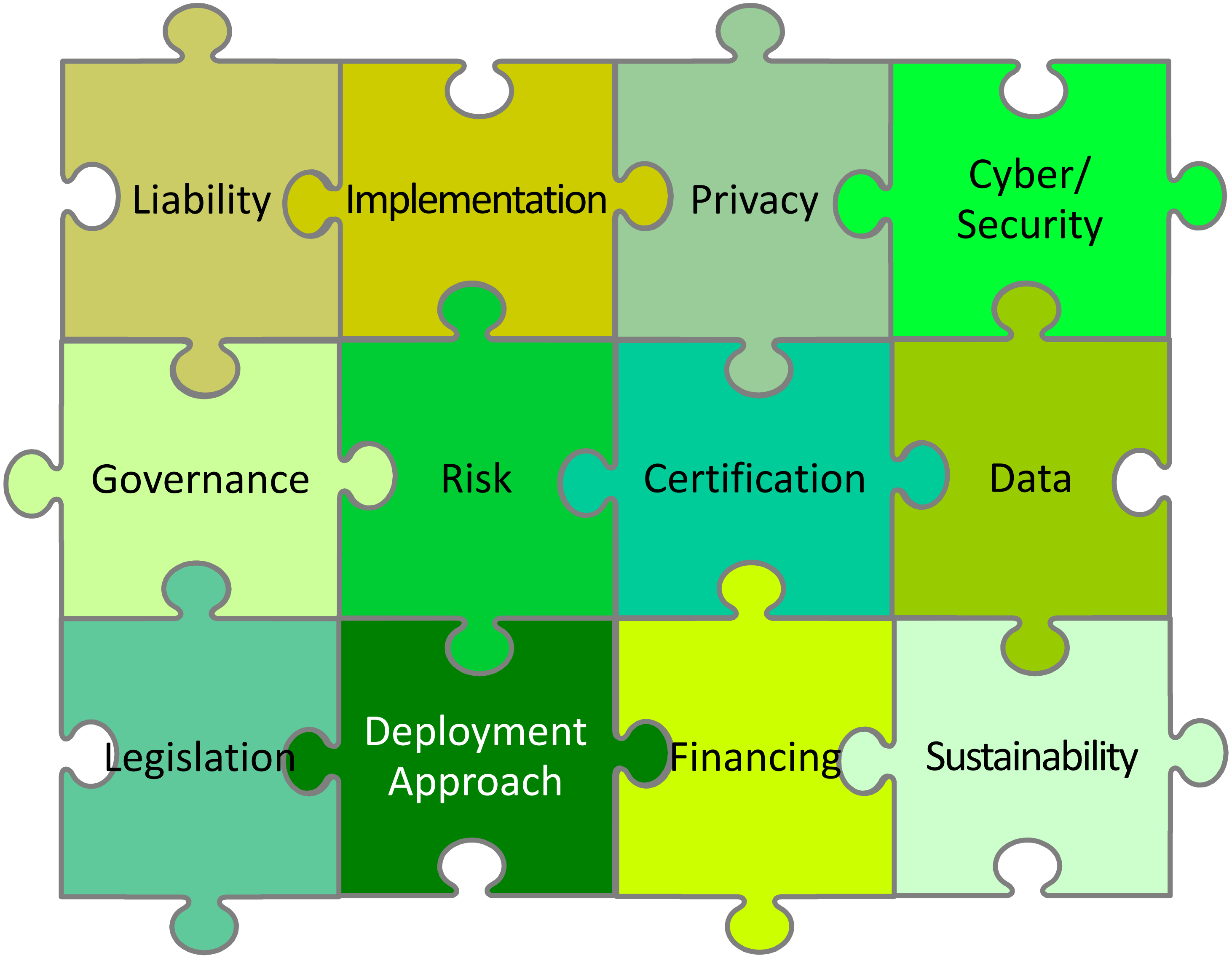

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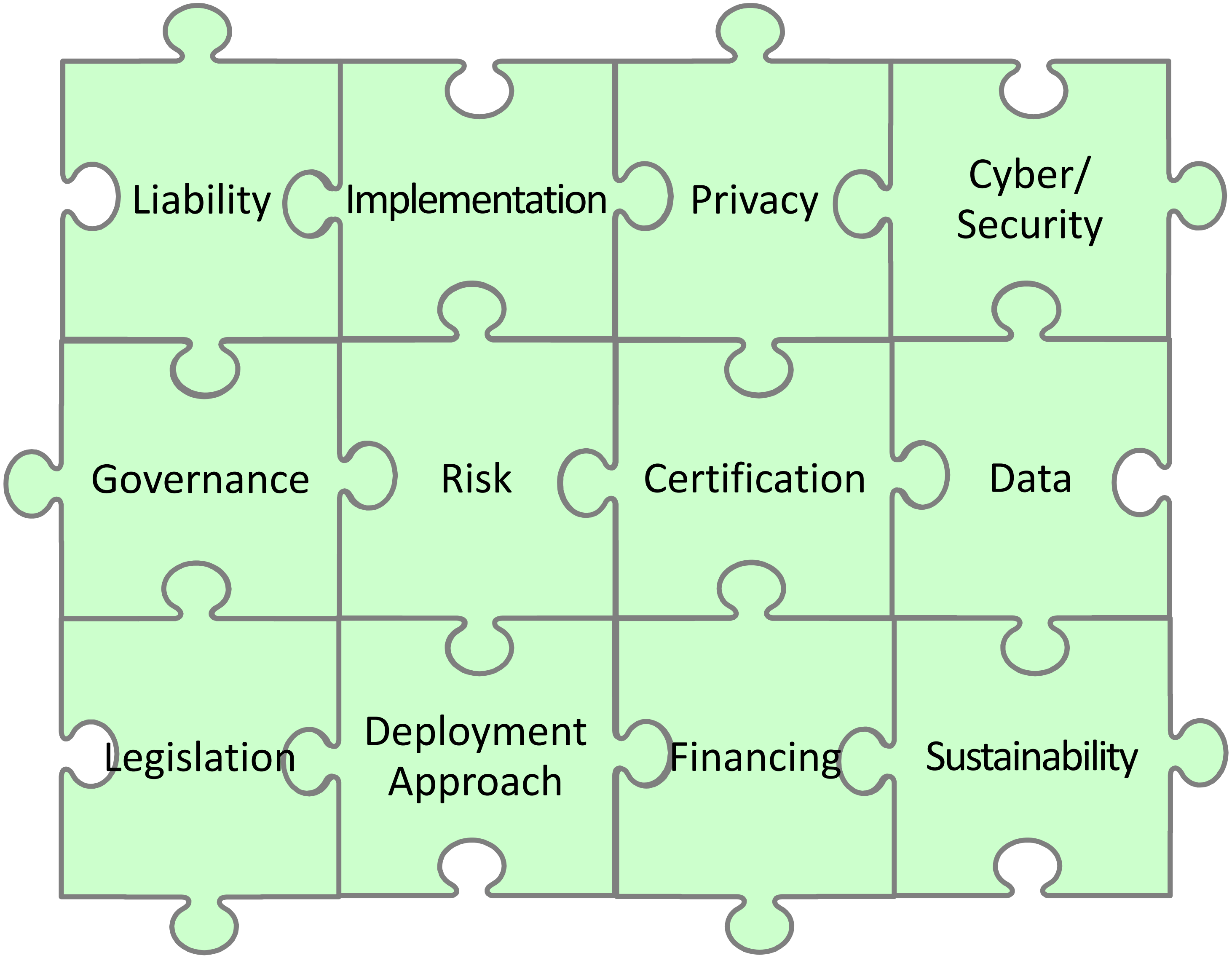

Seminar Perspectives

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- Organized by graduate students?
- More social interaction before/after?
- More point/counterpoint?
- We're open to other ideas!
- More modes of transportation?
- Other topics we haven't covered?

Thank You for Your Attention

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