Traffic Management through C-ITS and Automation: a perspective from the U.S.

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Shared Mobility

Electrification

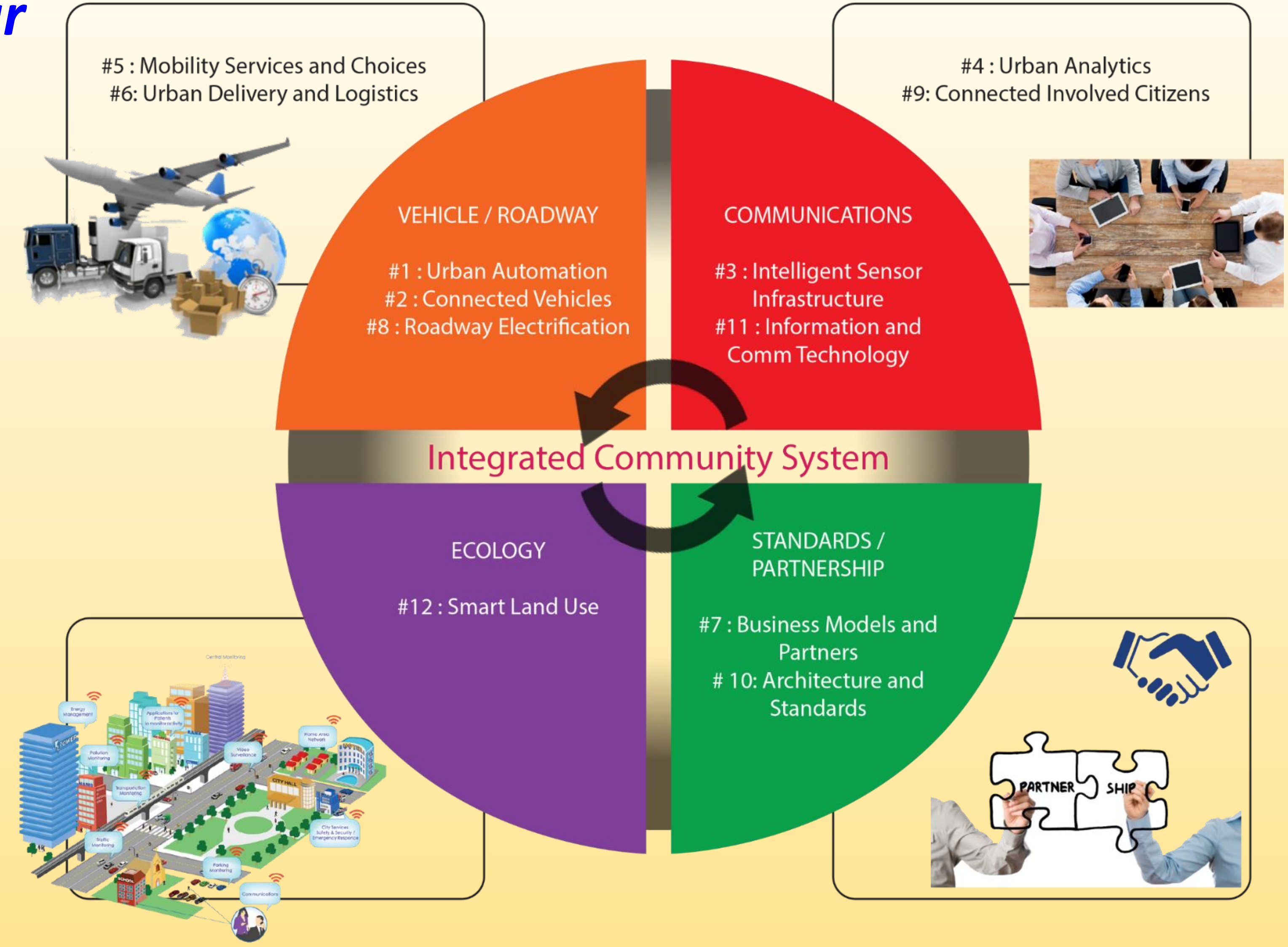
Connected

Automated

SMART CITIES: THE WAVE OF THE FUTURE FOR CITIES

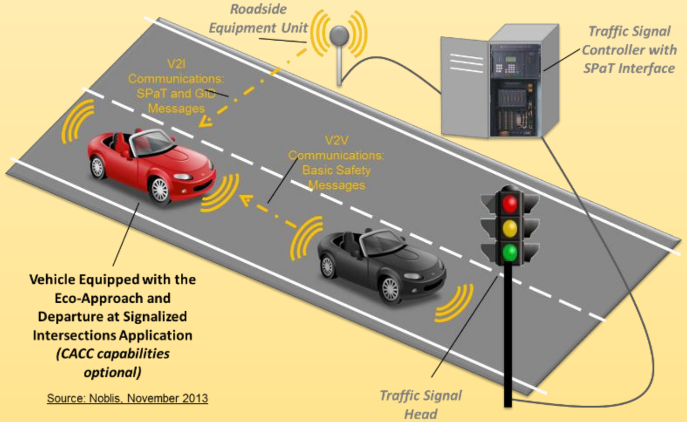
US DOT: Twelve elements in four areas make up a smart city :

- Urban Automation
- Connected Vehicles
- Intelligent Sensor Infrastructure
- Urban Analytics
- Mobility Services
- Urban Delivery
- Business Models & Partners
- Roadway Electrification
- Connected Citizens
- Architecture & Standards
- Information and Communication Technology
- Smart Land Use



Vehicle Connectivity:

- Many forms of vehicle connectivity exist: cellular, short range radios, 5G
- Connectivity includes V2V, V2I, V2X
- Connectivity in vehicles is being mandated for safety reasons; there are many secondary benefits for mobility and energy
- Enables many more applications



C-ITS Applications in the U.S. (see https://local.iteris.com/cvria/)

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

Road Weather

- Motorist Advisories and Warnings (MAW)
- Enhanced MDSS
- Vehicle Data Translator (VDT)
- Weather Response Traffic Information (WxTINFO)

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

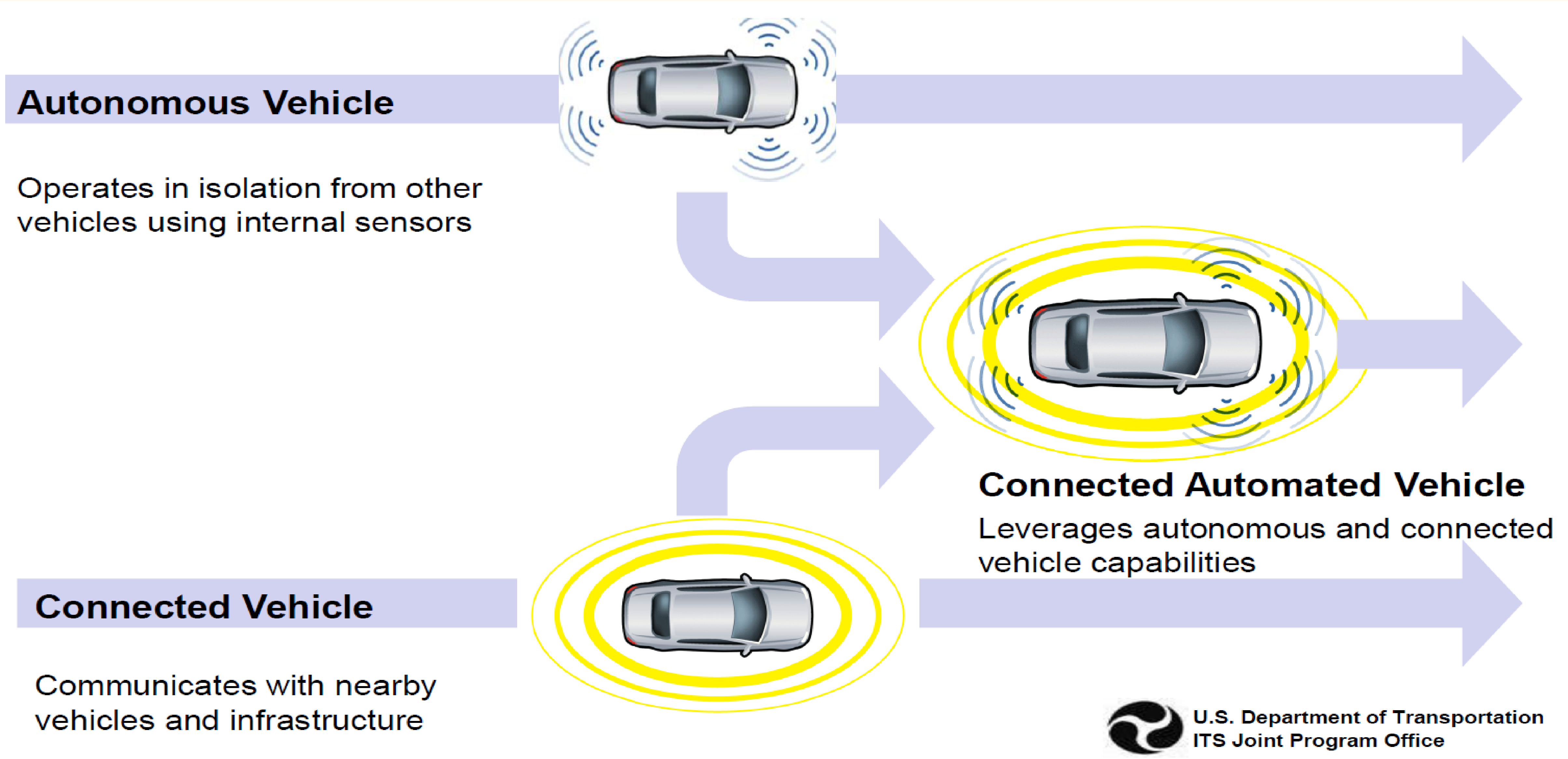
Smart Roadside

- Wireless Inspection
- Smart Truck Parking

Automation:

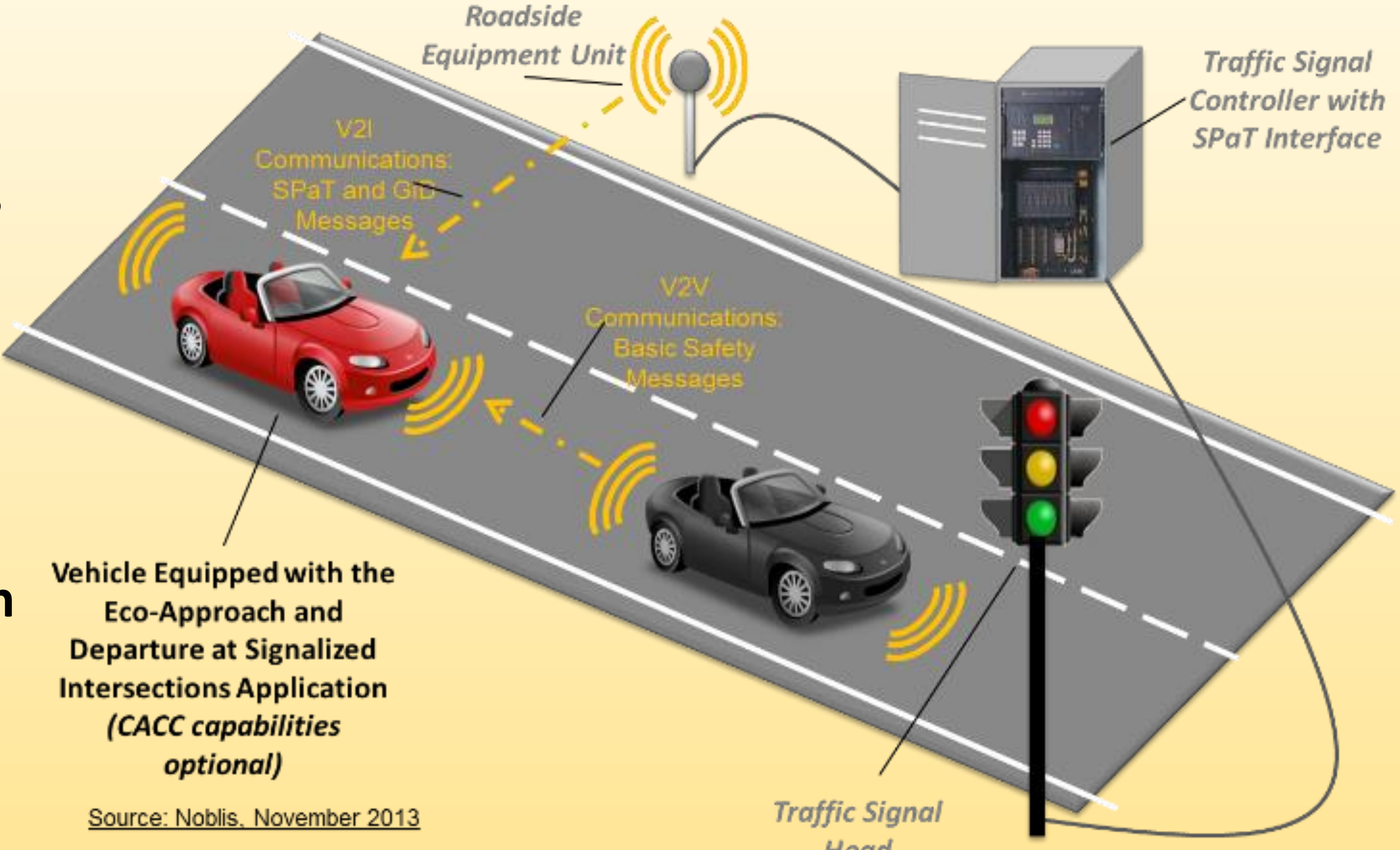
- **Automated and autonomous vehicles**
- **Level of automation:**
  - **Level 0: 100% human control**
  - **Level 1: Individual module is automated**
  - **Level 2: 2+ modules are automated in unison**
  - **Level 3/4: conditional automation for specific scenarios**
  - **Levels 5: 100% automation**
- **Personalized automated vehicles can lead to a significant increase in traffic, worse air quality, and wasted fuel**
- **When matched with shared mobility and electric drive, automation benefits can fully be realized**

Merging of Connected Vehicles and Automation



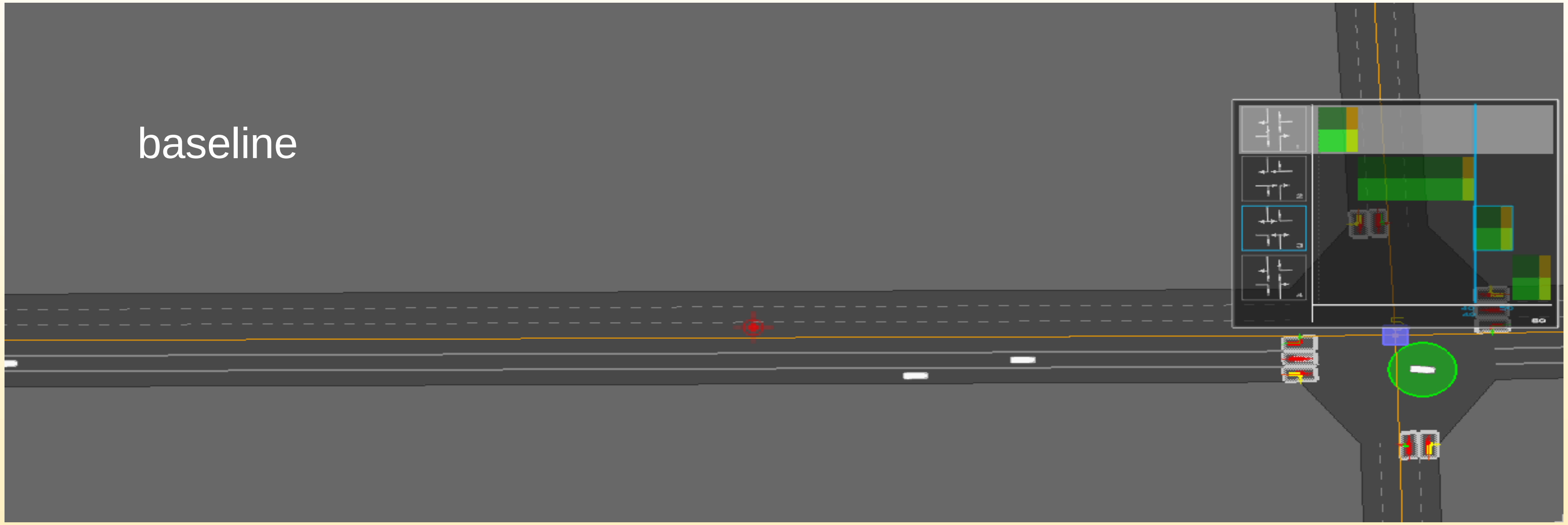
Near-Term Deployment: Eco-Approach and Departure at Signalized Intersections (aka GLOSA, TOSCo, Intelligent Signals, etc.)

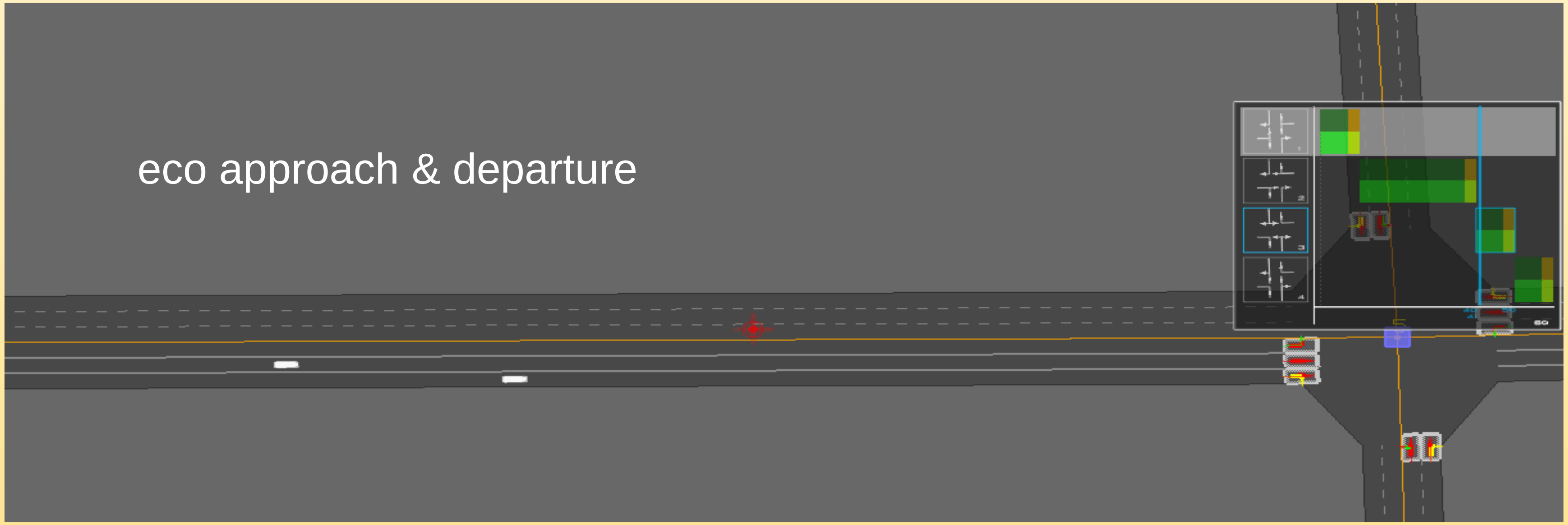
- Application utilizes traffic signal phase and timing (SPaT) data to provide driver recommendations that encourage “green” approaches to signalized intersections
- Example scenarios:
  - Coast down earlier to a red light;
  - Modestly speed up to make it (safely) through the intersection on green
- Mobility Improvements: 5% - 20%
- Energy Savings: 10% - 20%



Source: Noblis, November 2013

Simulation Modeling…



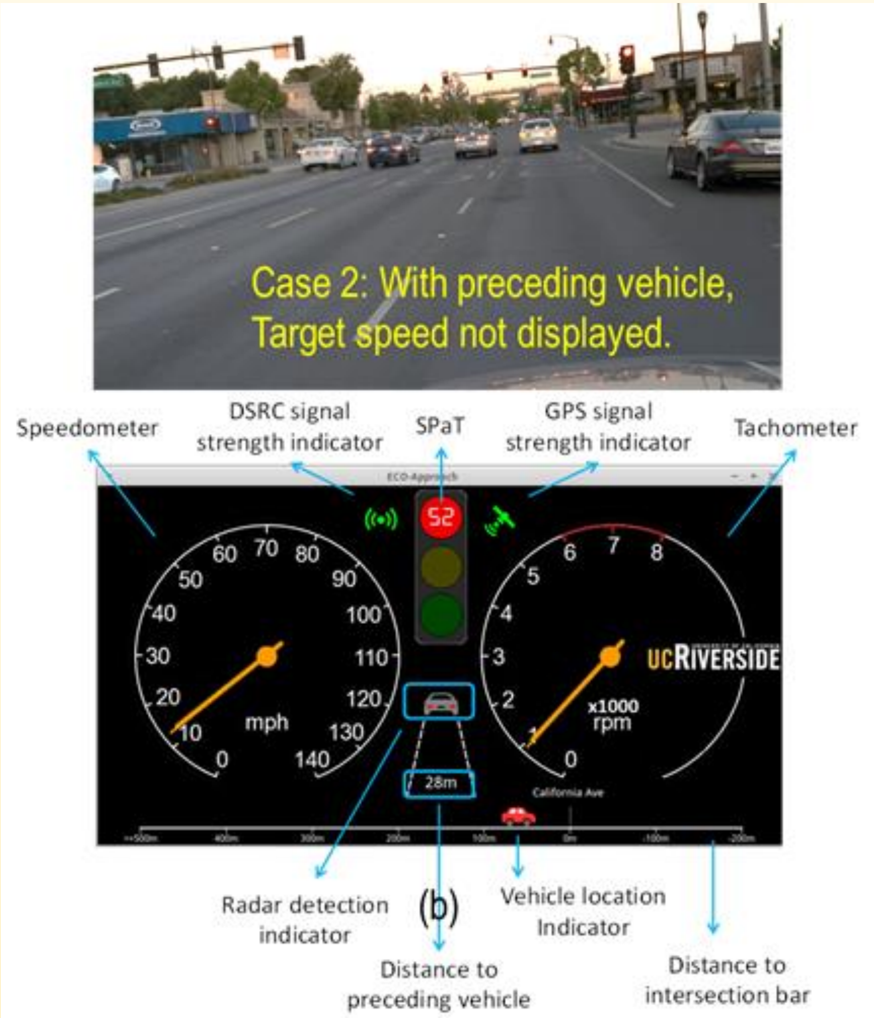


Eco-Approach and Departure at Signalized Intersections: Various Field Studies across the United States

Technology	Location	Scenario	Communication	Energy Savings	Ref
EAD with Fixed Signals	Richmond, CA	1	4G/LTE	14%	[1]
	Riverside, CA	1	DSRC	11%-28%	[2]
	McLean, VA	1	DSRC	2.5%-18%	[2]
EAD with Actuated Signals	Riverside, CA	1	DSRC	5-25%	[3]
	Palo Alto, CA	2	DSRC	7%	[4]
GlidePath (HMI-assisted)	McLean, VA	1	DSRC	10-20%	[5]
TOSCo	Ann Arbor, MI	2	DSRC	TBD	TBD
	Conroe, TX	2	DSRC	TBD	TBD

Scenario 1: Single Vehicle; Scenario 2: Mixed Traffic

Field Testing in Palo Alto, California



Case Study: City of Riverside Innovation Corridor

- Six mile section of University Avenue between UC Riverside and downtown Riverside
- All traffic signal controllers are being updated to be compatible with SAE connectivity standards
- UCR/City have installed Dedicated Short Range Communication modems at each traffic signal
- Plans to also equip corridor with new generation air quality sensors
- Corridor will be used for connected and automated vehicle experiments (ARPA-E hybrid bus, light-duty vehicles, etc.)

Case Study: City of Riverside Innovation Corridor

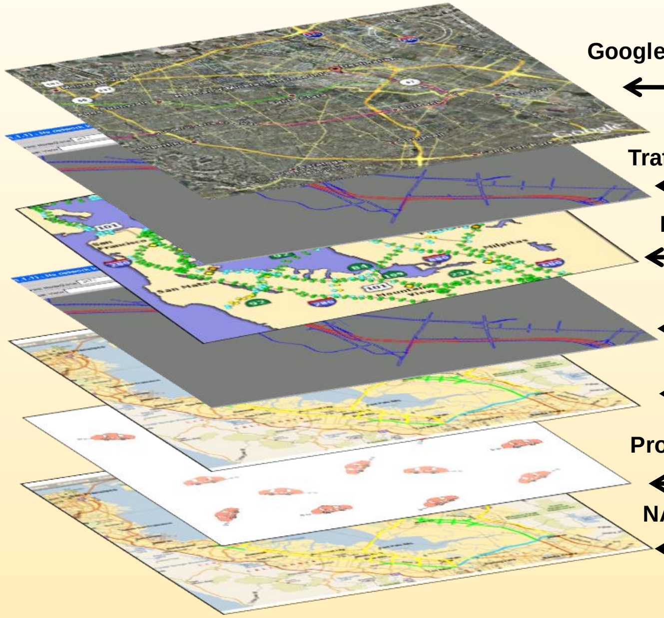
Infrastructure

Traffic Controller

Red light

Red light detection
and countdown

On-Board Driver's Aid



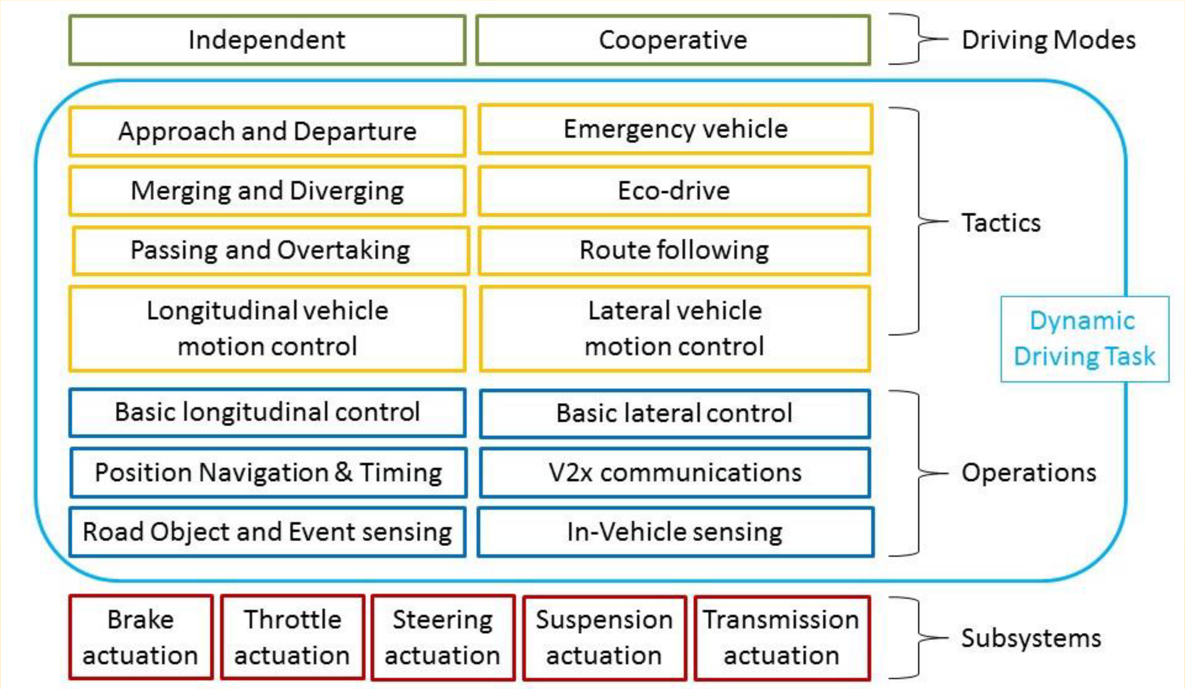
Big Data Integration

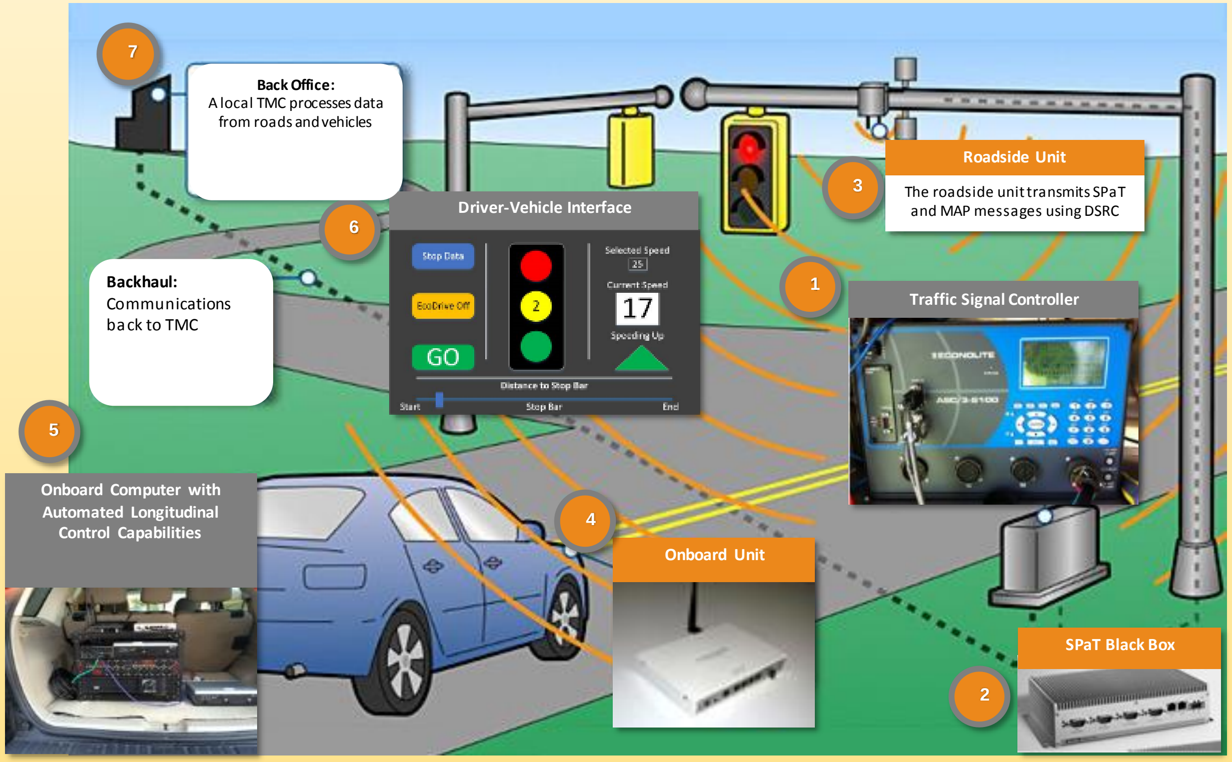
City Traffic
Management
Center

Connected with Automation:

FHWA GlidePath Project

- **Automates longitudinal control of vehicle**
- **Research with US Federal Highway Administration**
- **Energy benefits without automation: ~7%**
- **Energy benefits with automation: ~25%**

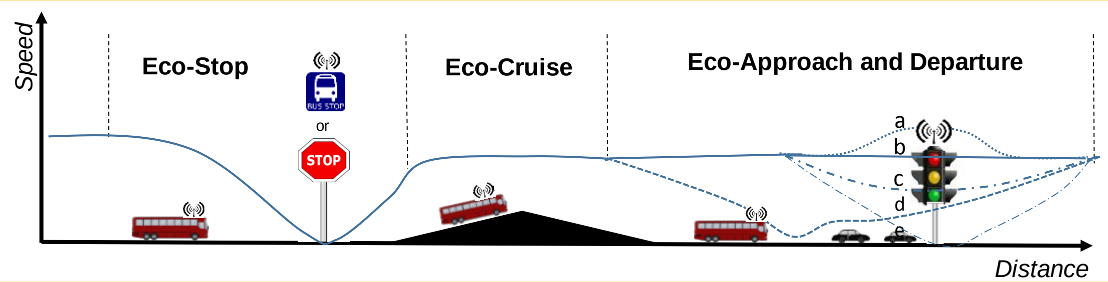




Applying Connectivity to Transit Buses:

Connected Eco-Bus

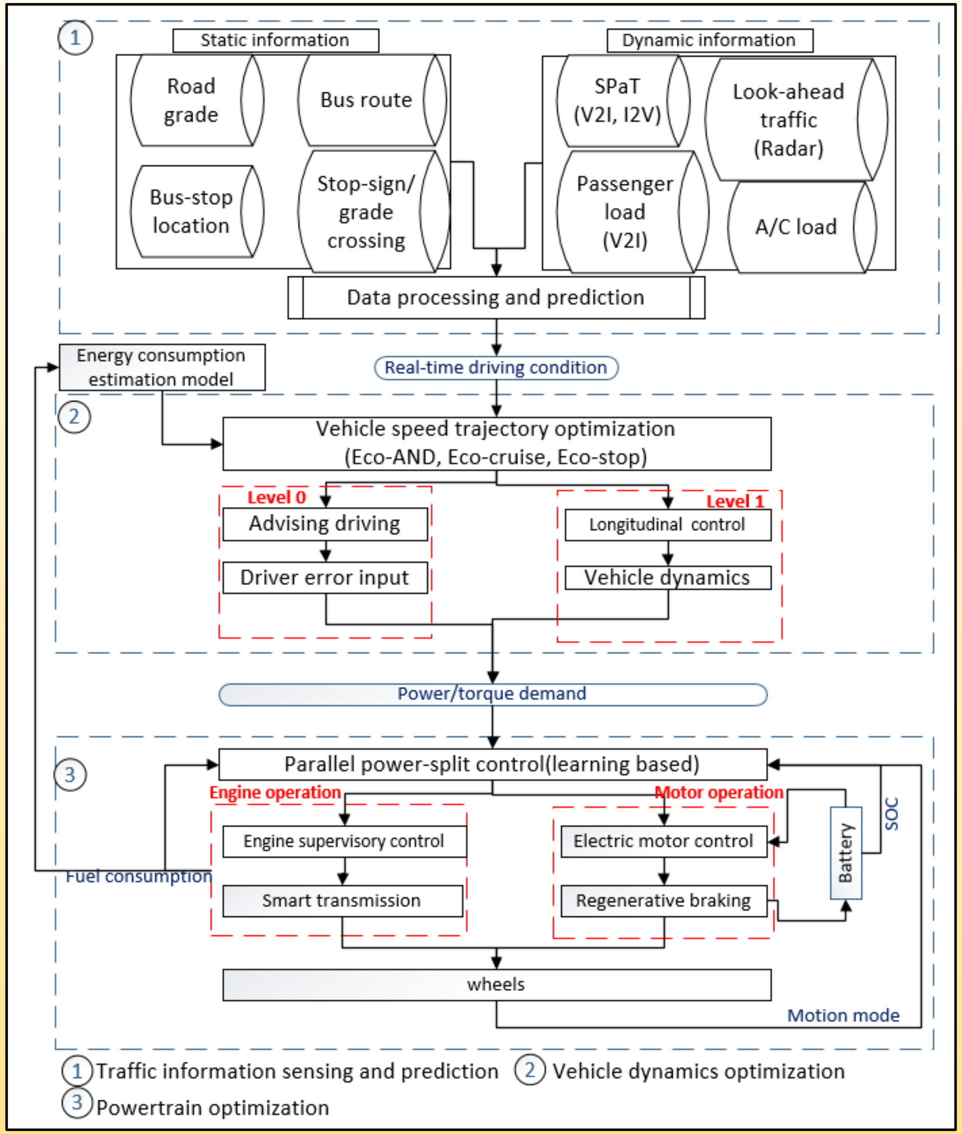
- **ARPA-E NextCar Program**
- **Integrates Powertrain and Vehicle Dynamics Controls**
- **dynamic parameter selection**
- **> 20% fuel & emission savings**
- **potential level-2 automation**



Traffic and Road Grade Info:

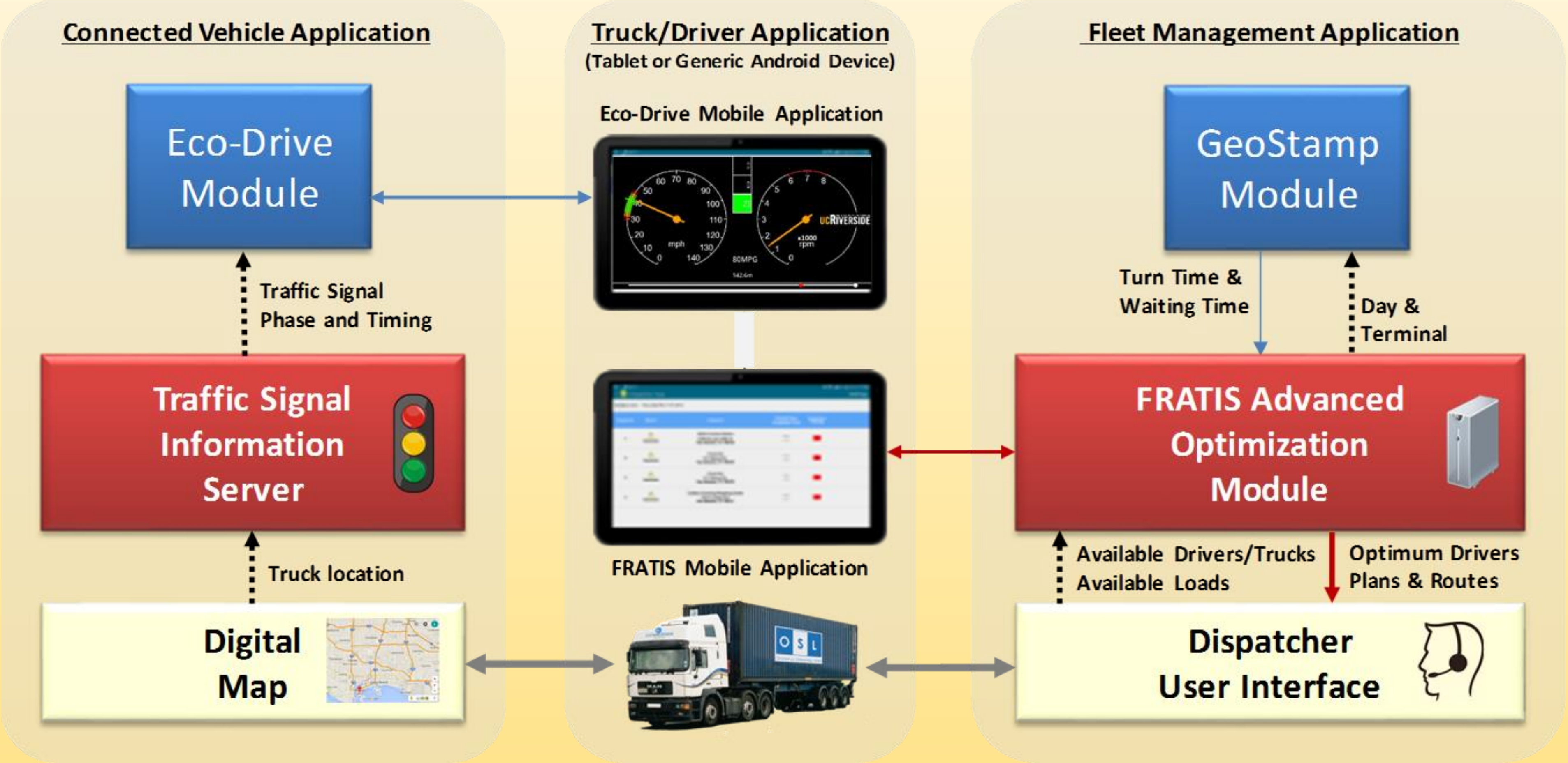
Vehicle Dynamics controls:

Powertrain controls:



Applying Connectivity to Heavy Duty Trucks: ECO-FRATIS

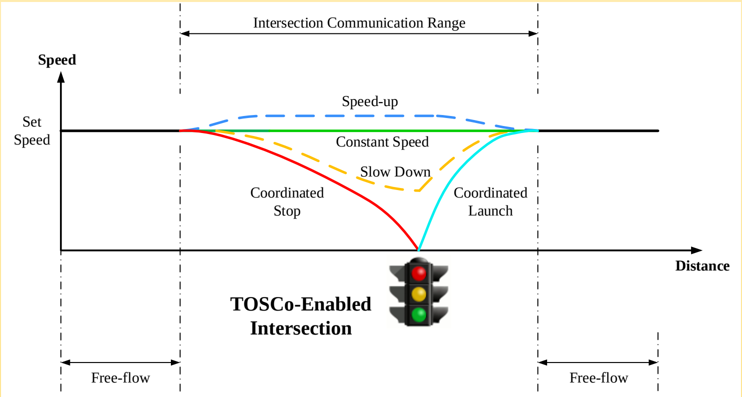
- **Test site near Ports of Los Angeles and Long Beach; 15 intersections**
- **Instrumenting 20 Heavy-Duty Trucks with Ecodriving Aids (including EAD)**
- **SPaT is being communicated via cellular 4G network**



Traffic Optimization for Signalized Corridors (TOSCo)

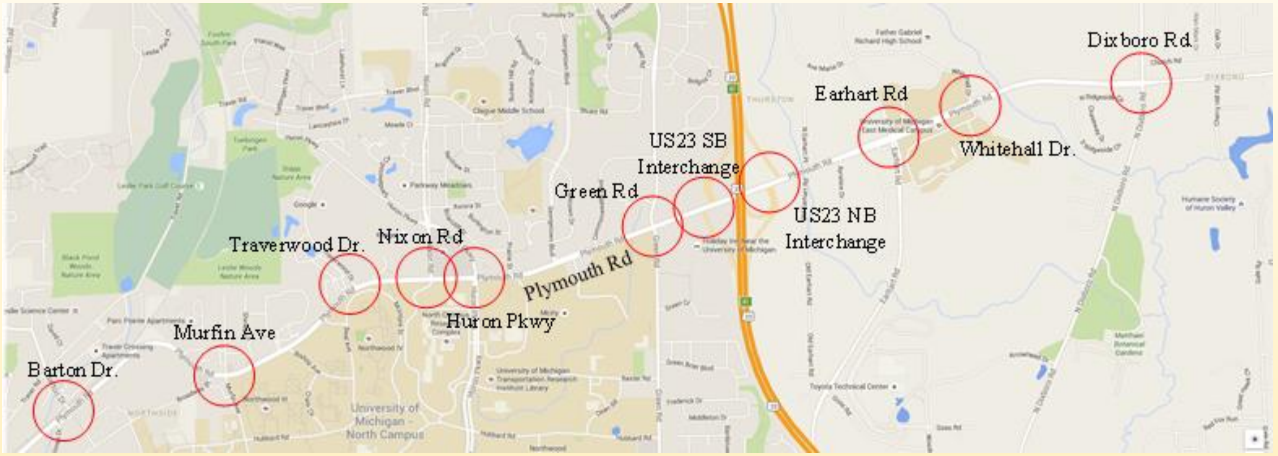
- TOSCo system employs communications between Infrastructure and connected vehicles to optimize vehicle fuel economy, emissions reduction and traffic mobility along a signalized corridor
- TOSCo algorithms are hosted on-board a vehicle, collects Signal Phase and Timing (SPaT), intersection geometry (SAE J2735 MAP Data Message, or MAP) and essential information contained in a Roadside Safety Message (RSM) using V2I communications as well as data from nearby vehicles using Vehicle-to-Vehicle (V2V) communications
- Given data, vehicles calculate optimal speed to pass through one or more traffic signals on a green light or to decelerate to a stop and subsequently launch in a performance optimized manner

CAMP LLC
Vehicle to Infrastructure (V2I) Consortium



Traffic Optimization for Signalized Corridors (TOSCo)

- **Plymouth Corridor (Ann Arbor, MI)**
- **11 intersections**
- **Speed range: 35 mph – 50 mph**



- **State Highway 105 (Conroe, TX)**
- **15 intersections**
- **Speed range: 45 mph – 55 m**

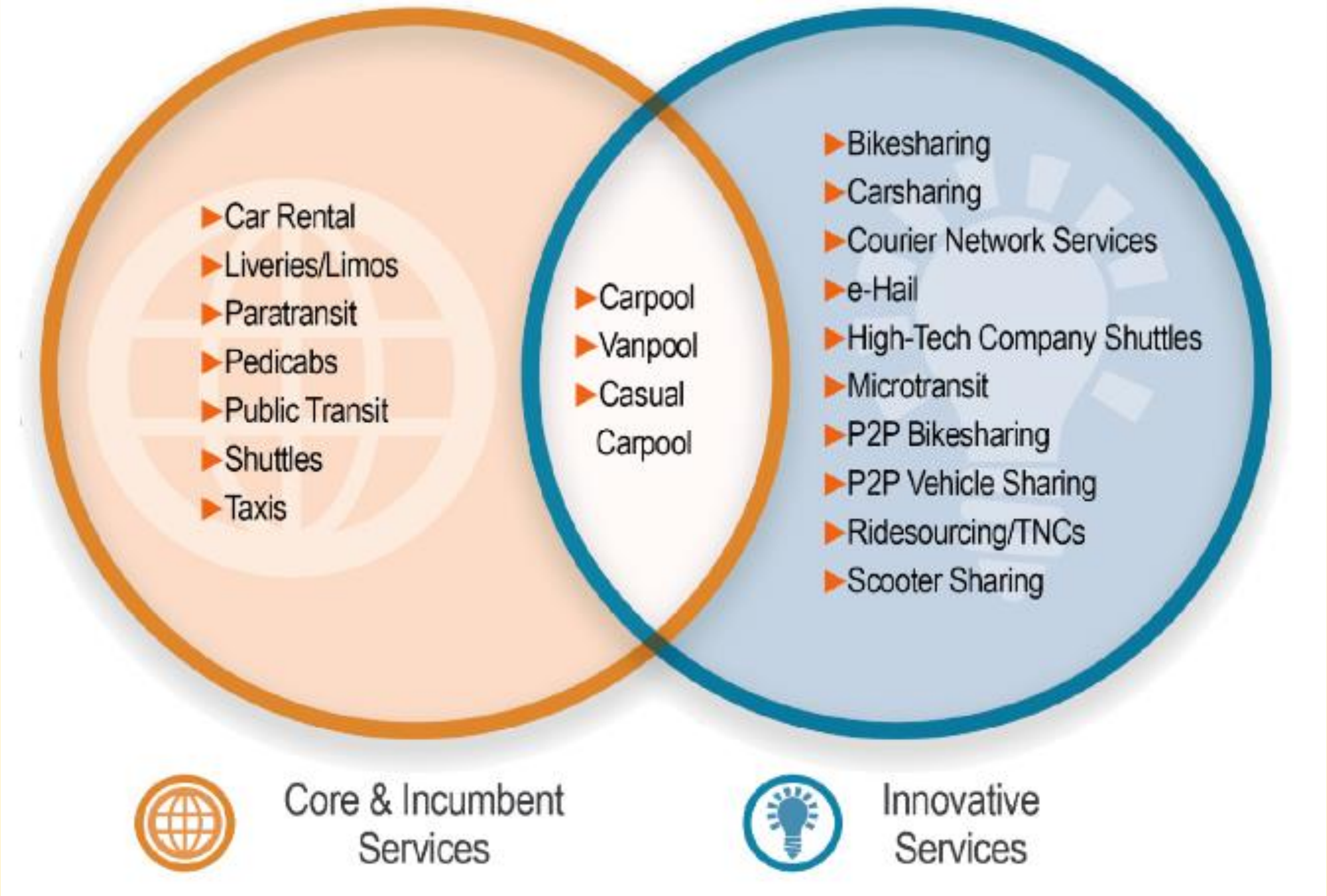
Goal: Permanent Installations

Future Activities

- Operate Pilots and Field Deployment to learn long-term benefits
- Examine costs: operations, vehicles, cost-benefit ratios
- How do we make C-ITS systems compatible with future communications systems?
- How do we transition to permanent, sustainable systems?
- What is the right mix of automation in connected vehicles?

Shared Mobility:

- **There are many forms of Shared Mobility**
- **Shared mobility can greatly improve land use and be used as a tool to manage excessive travel demand**
- **Shared trips tend to be more efficient, reducing energy use and producing less emissions**

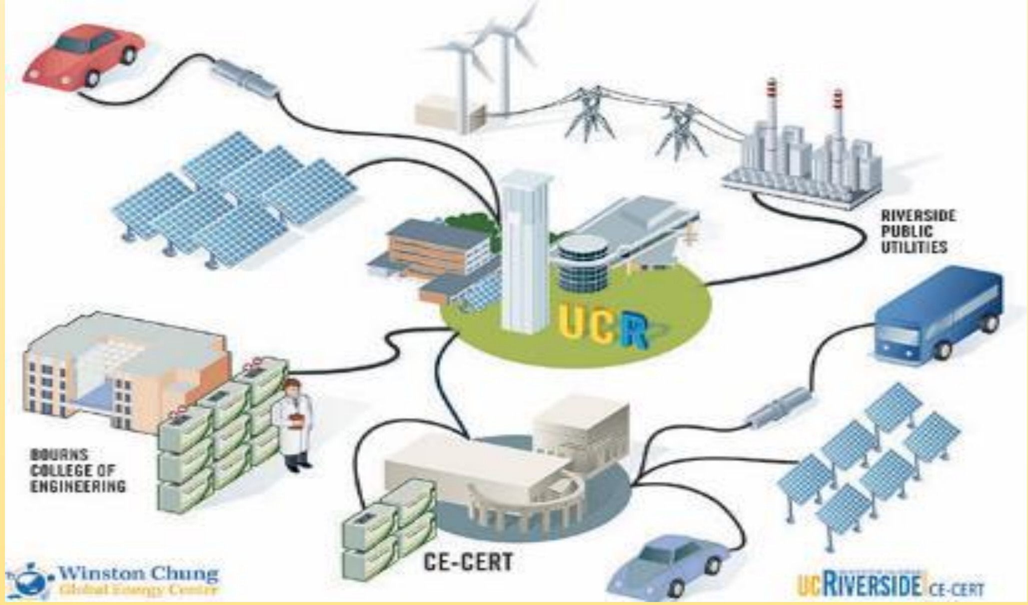


Shared Mobility Eco-System
(from Susan Shaheen, UC Berkeley)

UC Riverside's IntelliShare campus carsharing system

Electrification:

- Electric-drive vehicles have tremendous energy and air quality benefits
- Several traditional OEM companies entering electric-drive arena across modes
- Range and charge-time constraints can be managed when made part of a shared mobility option
- Vehicle Electrification must also consider infrastructure (necessity of microgrids)



Shared Electric Connected Automated Vehicle Research

	Safety	Mobility	Vehicle Kilometers Traveled	Environmental Quality
Shared Mobility	↑	solo-passengers → multi-passengers ↑	solo-passengers ↗ multi-passengers ↓	↑
Electrification	→	↓	↓	↑
Connectivity	↑	↑	→	↑
Automation	↑	autonomous → automated ↑	↑	↓ ↑

Potential Impacts if Deployed Separately, Compared to Current Personalized Car Travel

Shared Electric Connected Automated Vehicle Research

	Safety	Mobility	Vehicle Kilometers Traveled	Environmental Quality
Shared Mobility	↑	↑	↓	↑
Electrification				
Connectivity				
Automation				

Potential Impacts of Coordinated Deployment

Key Questions and Next Steps…

- **How do we move from "pilot studies" in C-ITS and automation to continuous operation in a city…**
- **If we implement elements of C-ITS and automation, how do we manage induced demand and its negative impacts…**
- **How do cities become "automation-ready"…**
- **How can we manage and integrate elements of shared mobility, electrification, connectivity, and automation…**


Thank you!