

TODAY'S MOBILE SOURCE DATA: AN OVERVIEW

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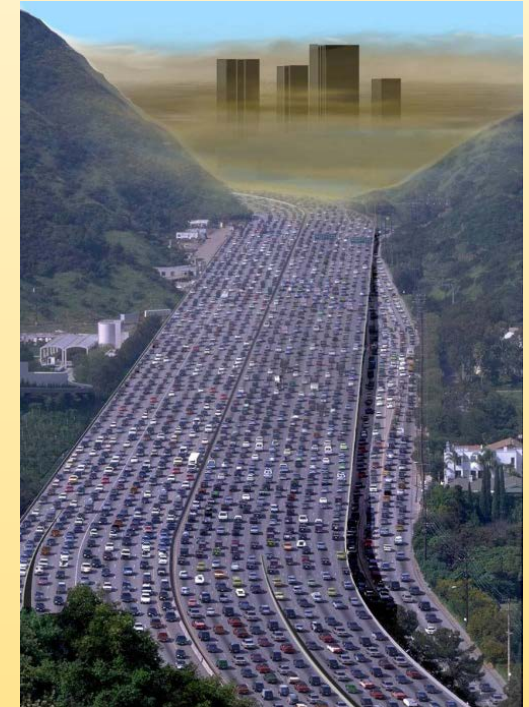
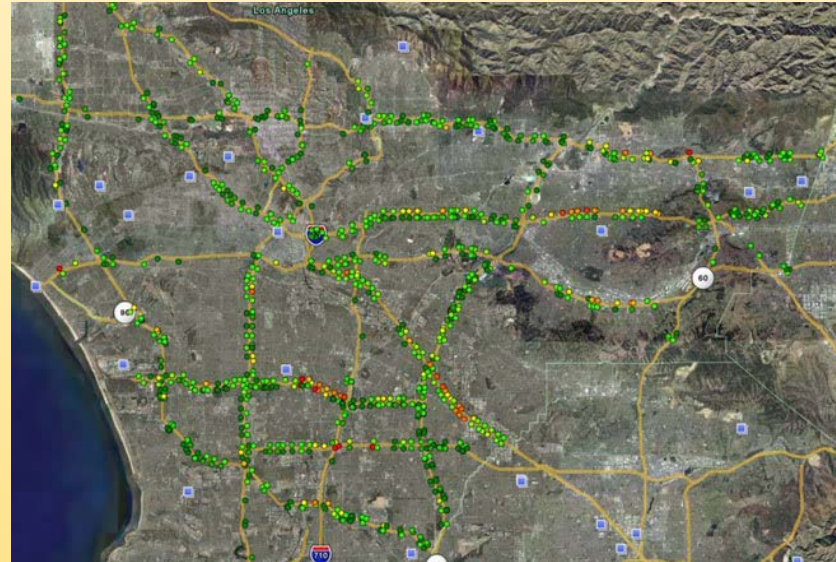
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General Components of a Transportation-based Emissions/Energy Inventory:

- *emissions/energy factors*
- *vehicle activity*
- *fleet composition*

environmental
inventory



TRANSPORTATION IS UNDERGOING FOUR MAJOR REVOLUTIONS

Shared Mobility:

- carsharing, ride hailing companies (e.g., Uber, Lyft), and advanced transit
- Drivers: Internet connectivity, convenience, and transportation costs



Electrification:

- electric drivetrains are becoming more common
- Drivers: advances in motors, controls, and batteries



Connectivity:

- Vehicles are increasingly “connected”
- Drivers: cellular communications, dedicated short range communications



Automation:

- Vehicle automation is emerging in many forms
- Automation comes with many social implications



DATA IS KEY IN THESE REVOLUTIONS

Shared Mobility:

- New travel patterns are emerging and are being carefully monitored to optimize shared-use vehicles systems



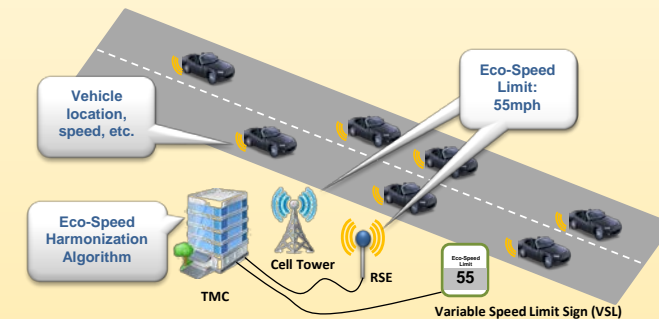
Electrification:

- Nearly every “electric” vehicle is connected
- Data are used to evaluate vehicle performance



Connectivity:

- Vehicles are increasingly **connected**: cellular communications, dedicated short range communications
- Data repositories already exist
- Data are used to evaluate safety, mobility, environment



Automation:

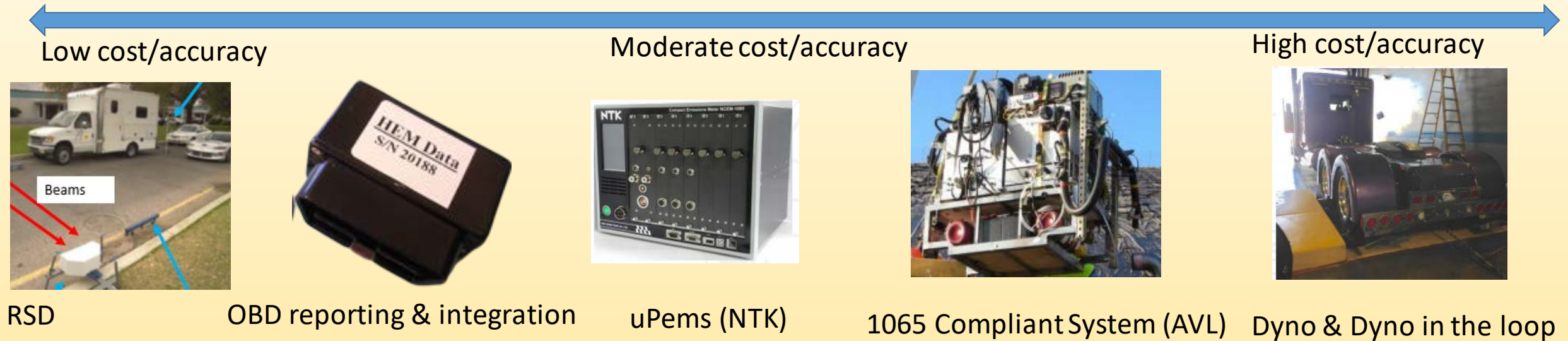
- Tremendous amount of vehicle sensor data are being collected (~1 TB every 5 minutes)
- Data are collected and shared for any crash



THE PROGRESSION OF EMISSIONS/ENERGY MEASUREMENTS

Transition from Laboratory to On-Road Measurements: SEMS/PEMS/PAMS

In Use Emissions Testing Product Continuum

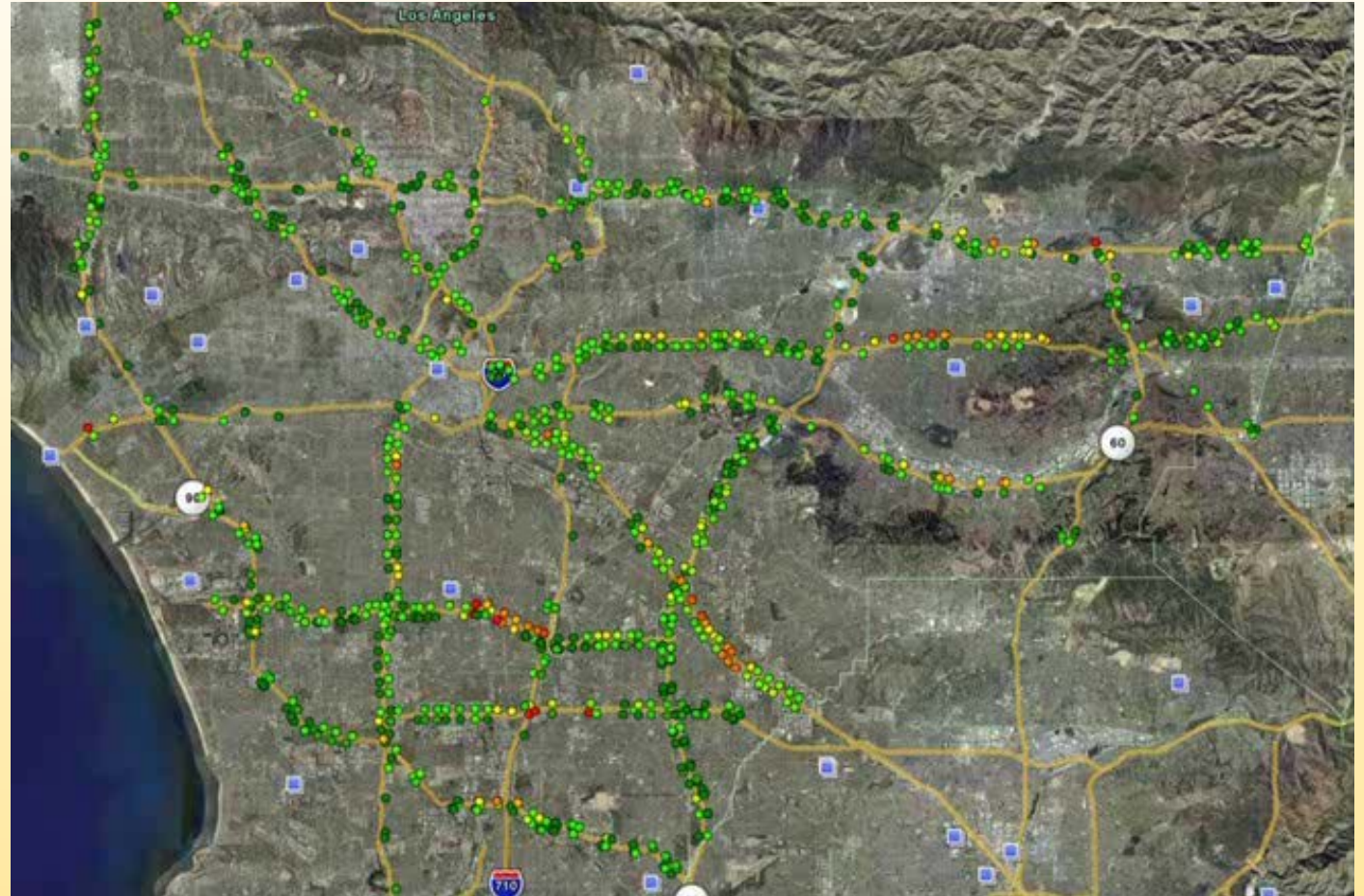


New Methods of Evaluation

- Take Advantage of Connected and Automated (Electric and Shared)
- Consider new Drivetrains: Battery Electric, Hybrid Electric, and Fuel Cell

VEHICLE ACTIVITY DATA HAS A VARIETY OF SOURCES

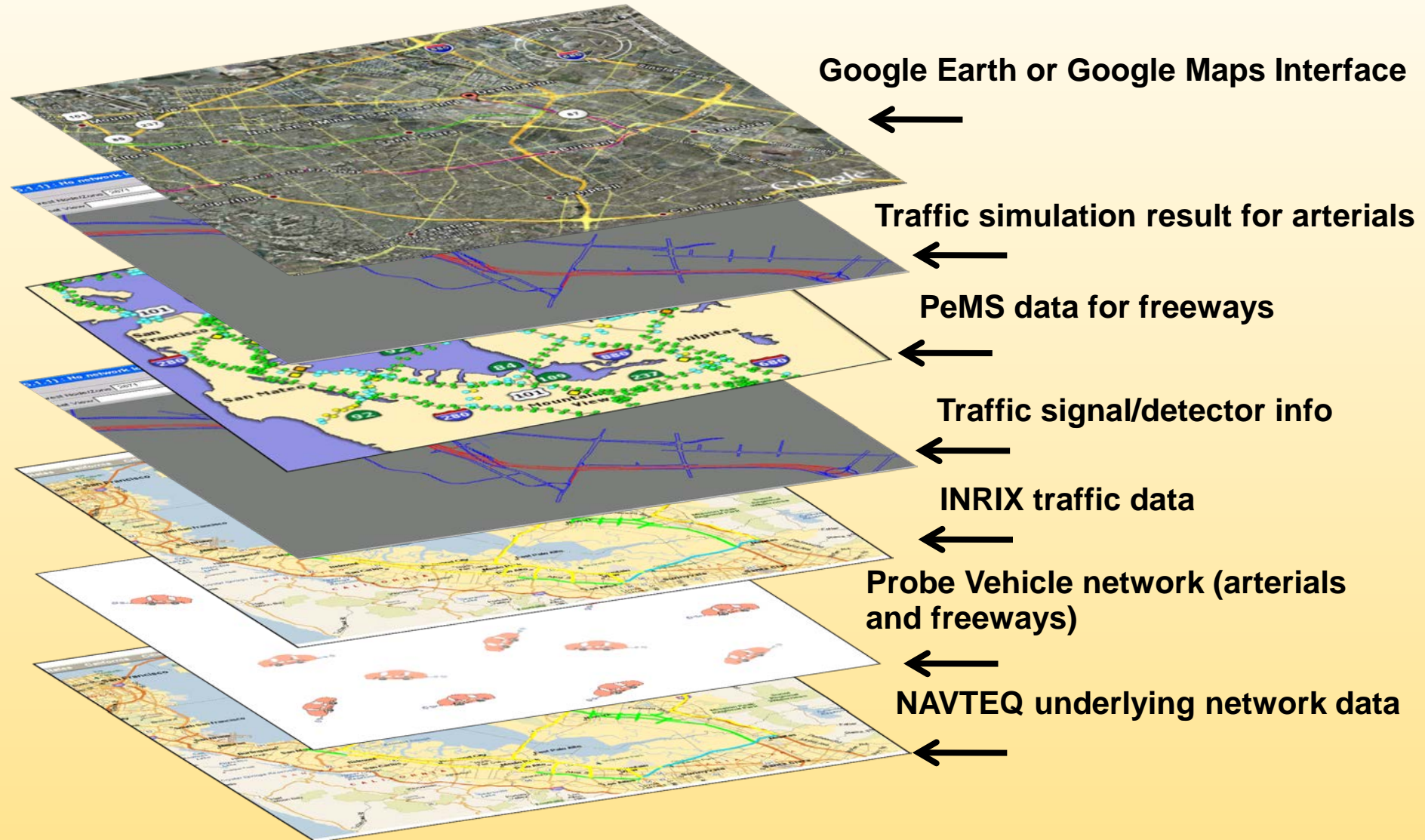
- real-time traffic density, speed, and flow are readily available
- Infrastructure sensors and crowd sourced
- Example: California PeMS, Inrix, Google, etc.
- Real-Time data are being used to measure congestion



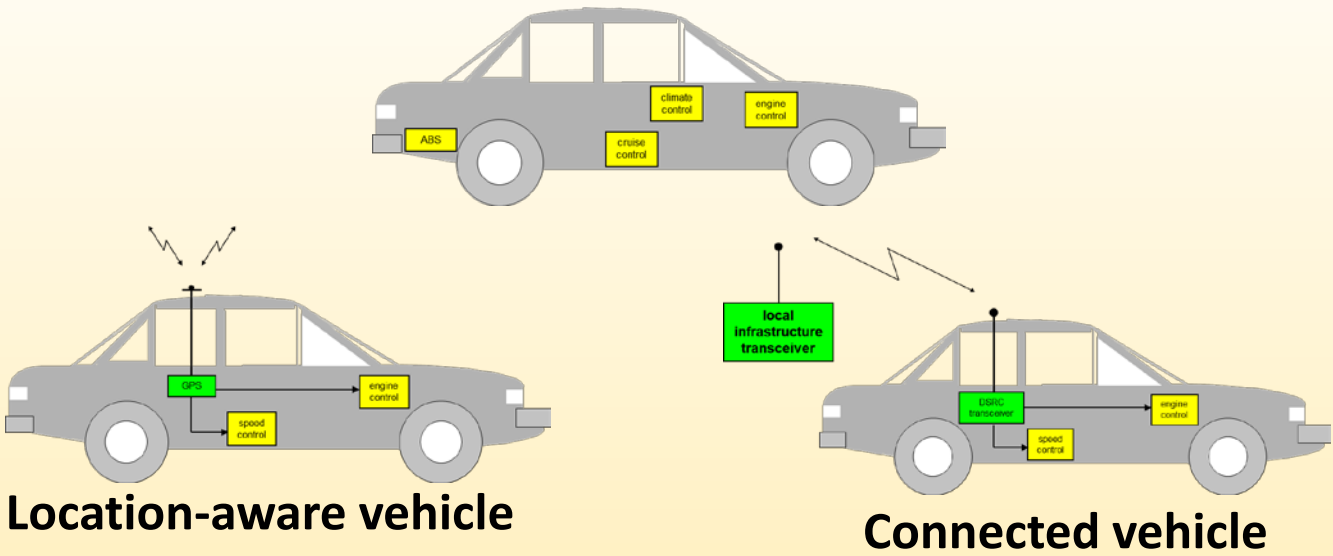
- National Data Center for Vehicle Activity: NREL's Transportation Data Secure Center (TSDC)

<https://www.nrel.gov/transportation/secure-transportation-data/>

Vehicle Activity Data: Data Integration



LOCATION-AWARE AND CONNECTED VEHICLES

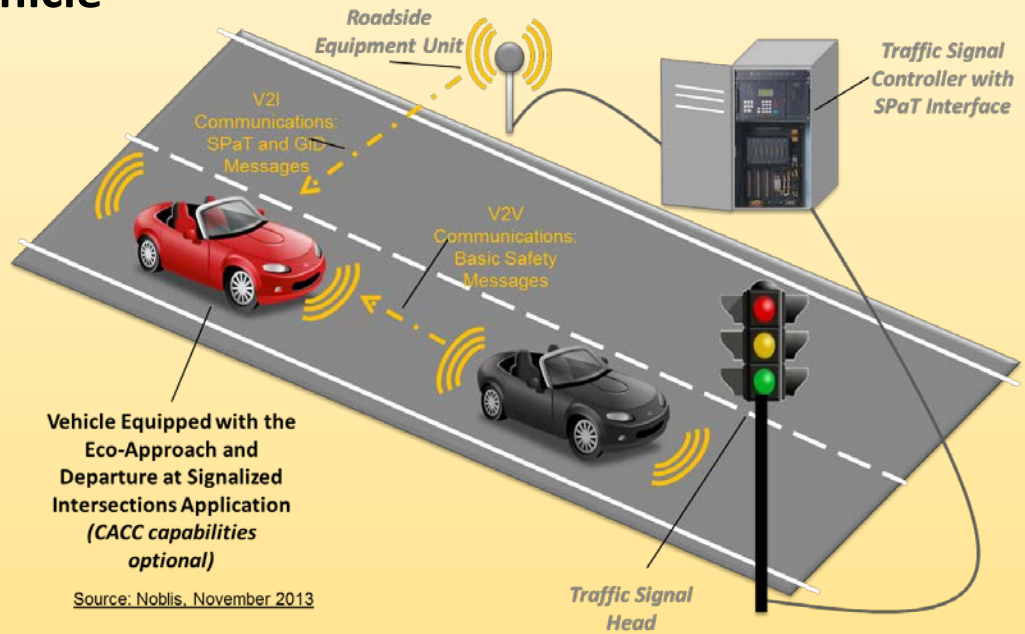


Platooning



Source: U.S. DOT

Connected Environment



Vehicle Equipped with the Eco-Approach and Departure at Signalized Intersections Application (CACC capabilities optional)

Source: Noblis, November 2013

USDOT's Connected Vehicle Program

CV Technology Pilot Programs

- Safety: Connected vehicle safety pilot
- Mobility: Dynamic mobility applications (DMA)
- Environment: Applications for the environment – real-time information synthesis (AERIS)
- Road Weather: Road Weather Connected Vehicle Applications

CV Pilot Deployment Program (Wave 1)

- I-80 in Wyoming (truck safety and efficiency)
- New York City (vehicle and pedestrian)
- Tampa, Florida (traffic around reversible freeway lanes)

US DOT Research Data Exchange (RDE)

<http://www.its-rde.net/>



Connected Vehicle Applications:

V2I Safety	Environment	Mobility
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)	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	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
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	Road Weather	Smart Roadside
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	Motorist Advisories and Warnings (MAW) Enhanced MDSS Vehicle Data Translator (VDT) Weather Response Traffic Information (WxTINFO)	Wireless Inspection Smart Truck Parking

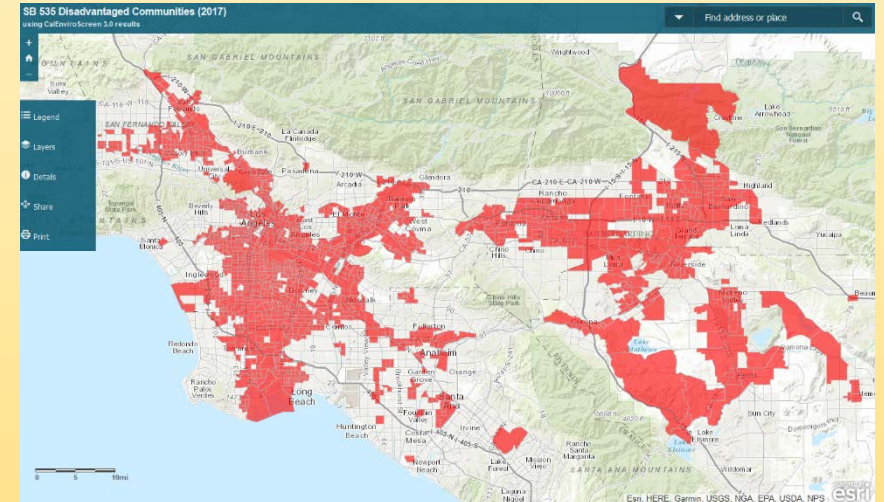
Low Cost Air Quality Monitoring Equipment

Low Cost Air Quality Monitoring Sensors

- Huge Advances in recent years
- Role of Citizen Scientists
- SCAQMD AQ-SPEC: <http://www.aqmd.gov/aq-spec>

California AB-617

- Requires community monitoring throughout the state



Data Recommendations

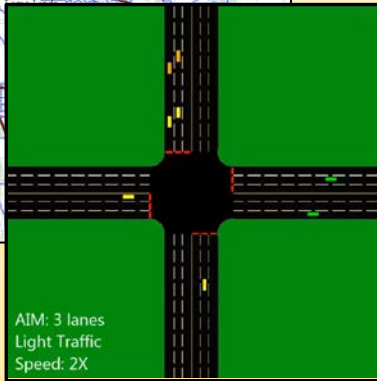
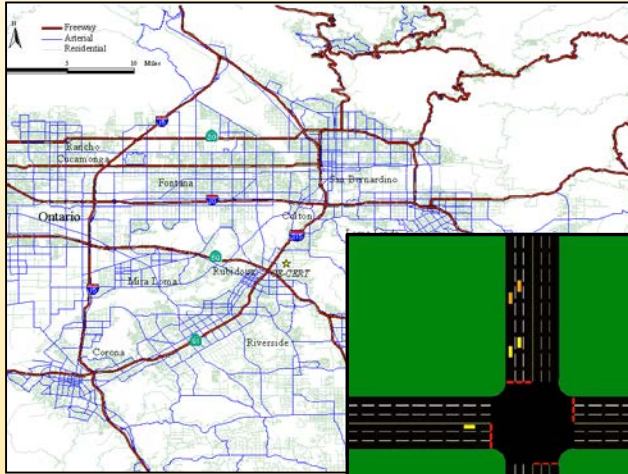
- **Vehicle Activity Data: subscribe to congestion-based vehicle activity datasets**
 - State systems, Inrix, etc.
 - Add features that are relevant to energy and emissions modeling (e.g., time resolution)
- **Support NREL NREL's Transportation Data Secure Center**
 - <https://www.nrel.gov/transportation/secure-transportation-data/>
 - Public and secure portals exist
 - Add features that are relevant to energy and emissions modeling (e.g., time resolution), emissions data
 - Validation comes naturally when a lot of people use this
- **Consider a Research Data Exchange System for Emissions Data**
 - USDOT Example: <http://www.its-rde.net/>
 - Hire consulting firms to maintain and validate data sets

***Develop or Support Applications that Leverage Data
to Minimize Energy and Emissions***

DATA IS THE KEY ENABLER CONNECTING SYSTEMS

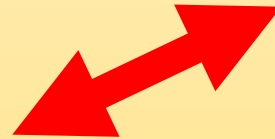
Dynamometer-in-the-Loop Control System

Transportation Systems
Research Microscopic
Traffic Modeling



Real-Time Vehicle
Trajectory Data

Dynamometer
Operation



Integrated Virtual Environments with Real-World Testing



Driver Aid

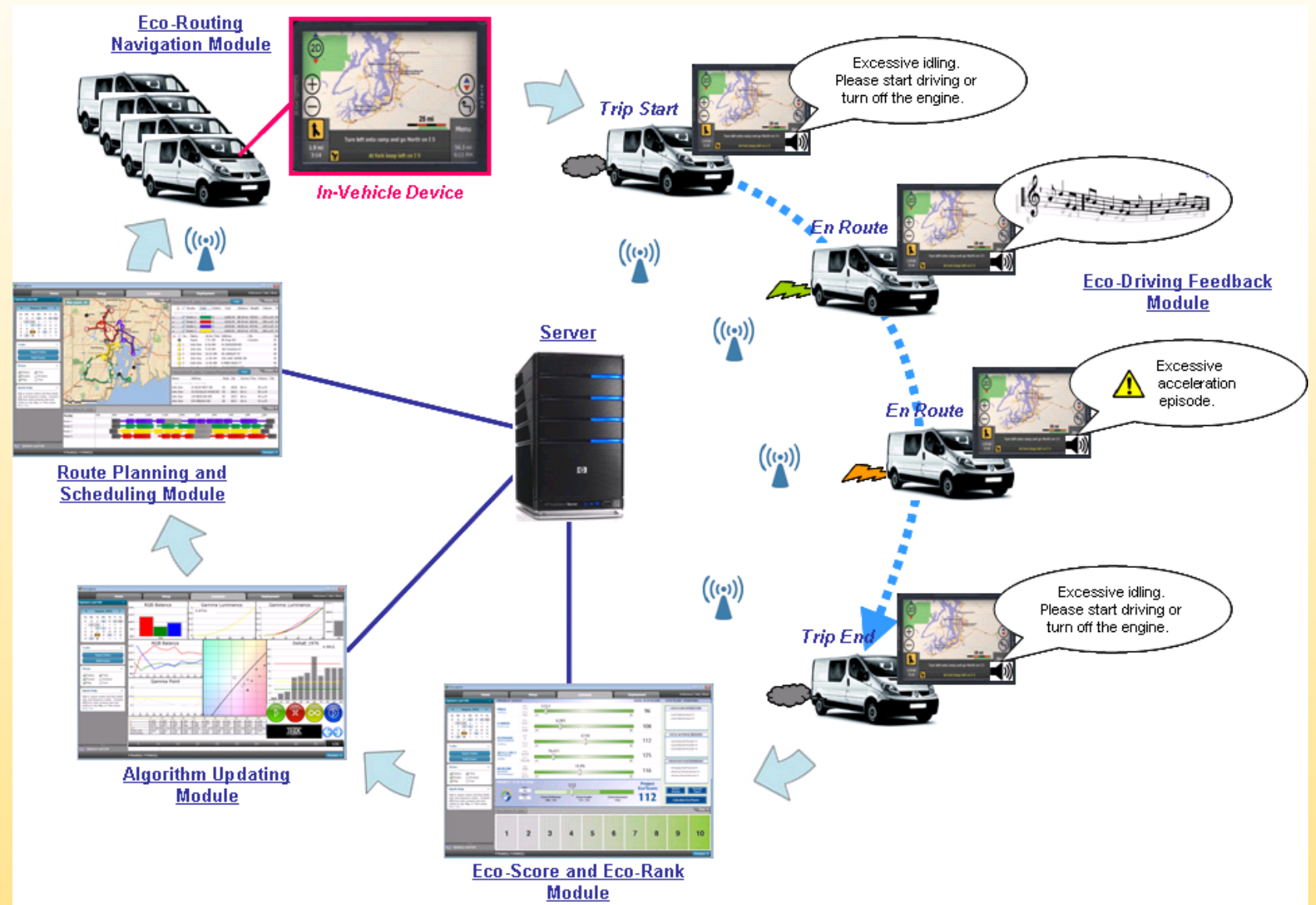
Dyno-In-The-Loop



Driver's Perspective

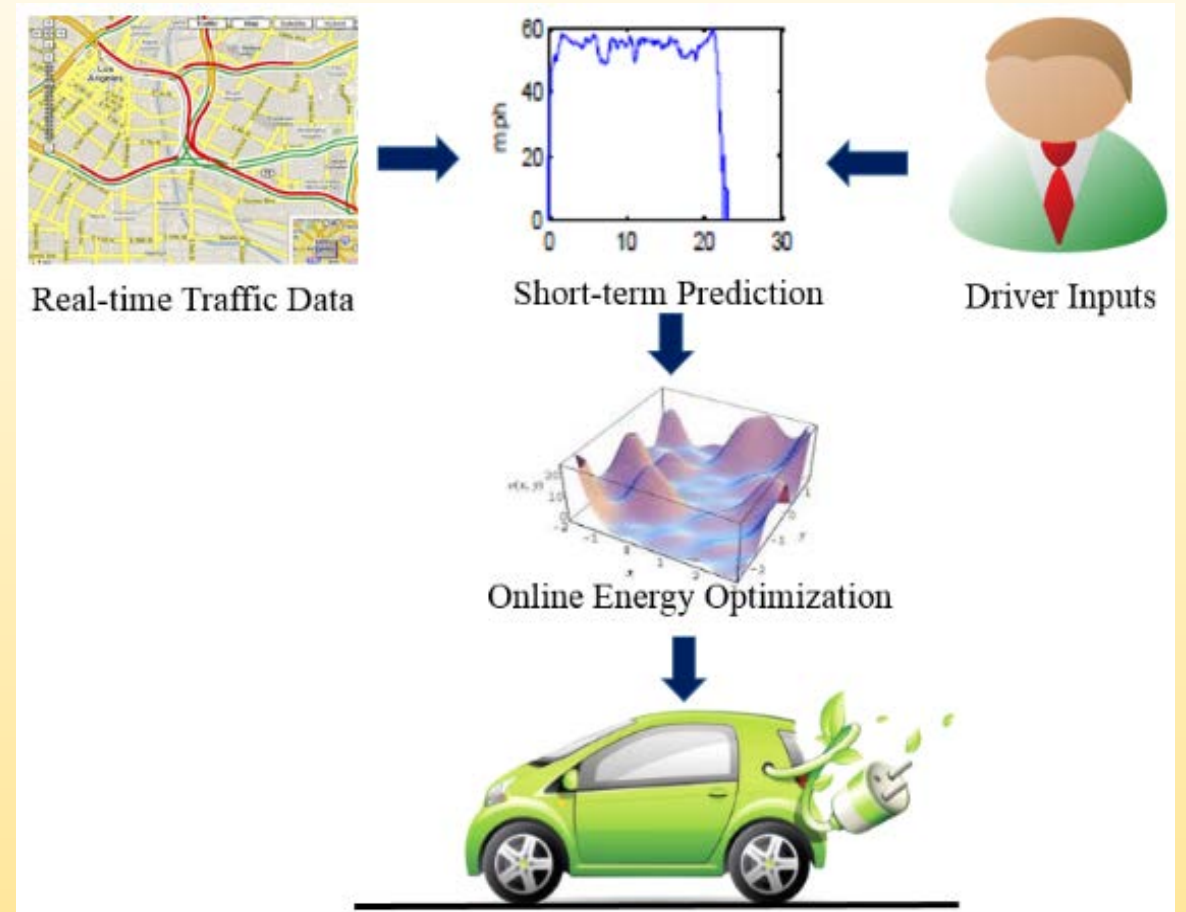
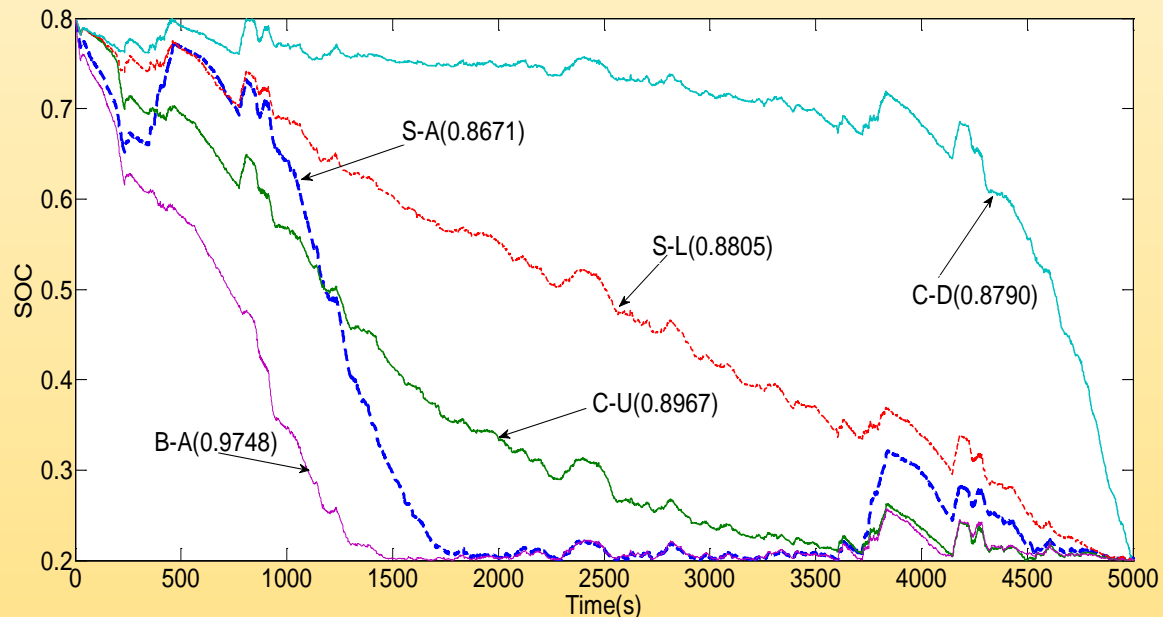
NEXT GEN ECO-DRIVING FEEDBACK SYSTEM

- Developed driving feedback technologies that encourage drivers and fleets to make fuel-efficient choices in all aspects of vehicular travel
- *2-9% fuel savings from field operational tests*



PHEVs: NEW ENERGY MANAGEMENT SYSTEM

- For PHEVs and HEVs
- Optimize energy flow between ICE and motors using predictive analytics based on machine learning algorithms



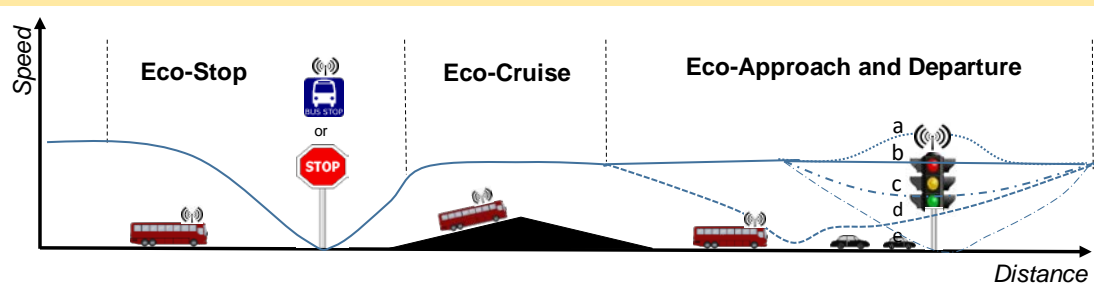
ARPA-E NEXTCAR RESEARCH PROGRAM

INTEGRATED POWERTRAIN AND VEHICLE DYNAMIC CONTROLS



UCR Connected ECO-BUS:

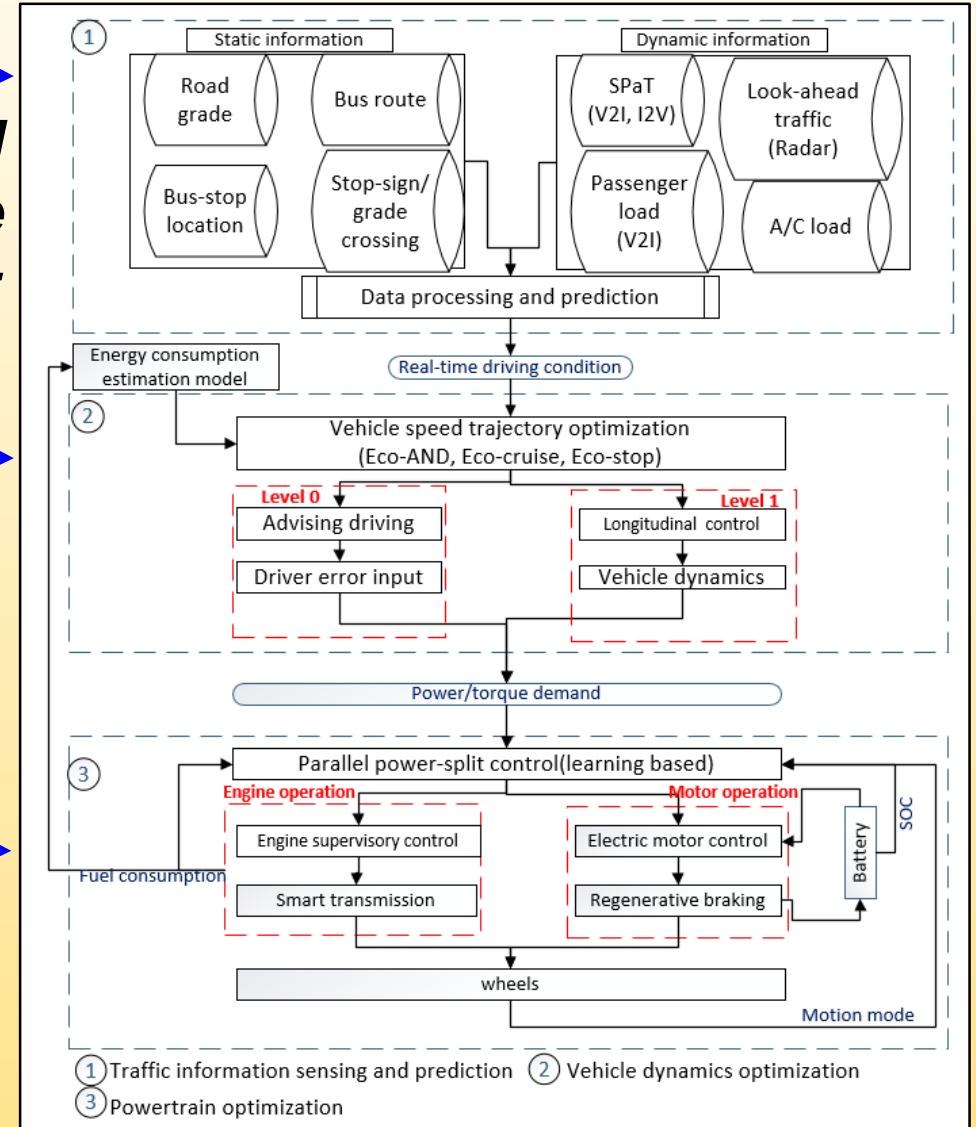
- ARPA-E NextCar program
- > 20% fuel & emission savings
- dynamic parameter selection
- potential level-2 automation



➔
Traffic and Road Grade Info:

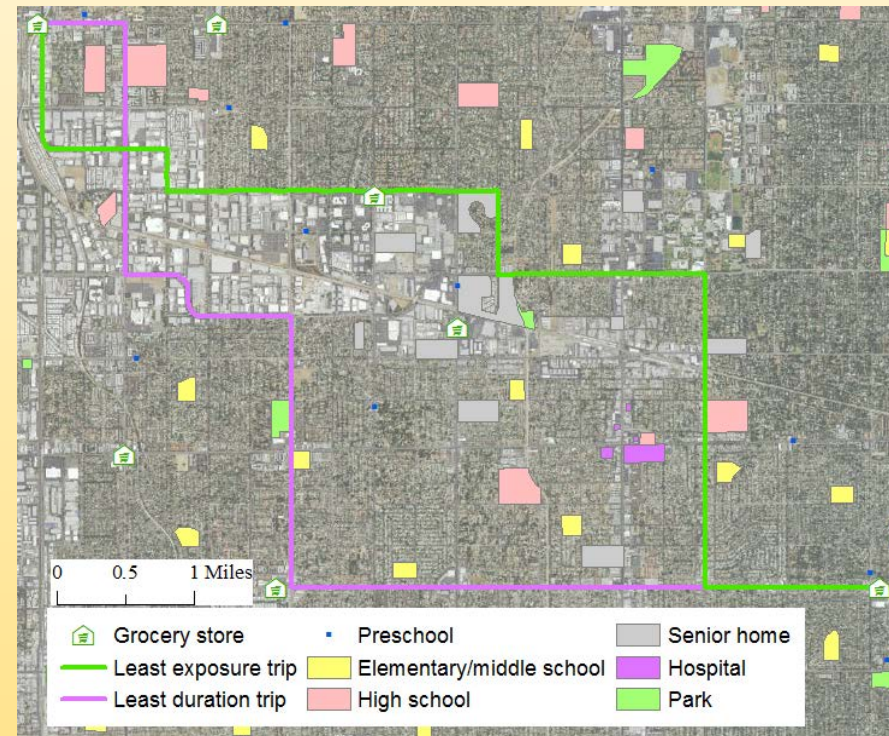
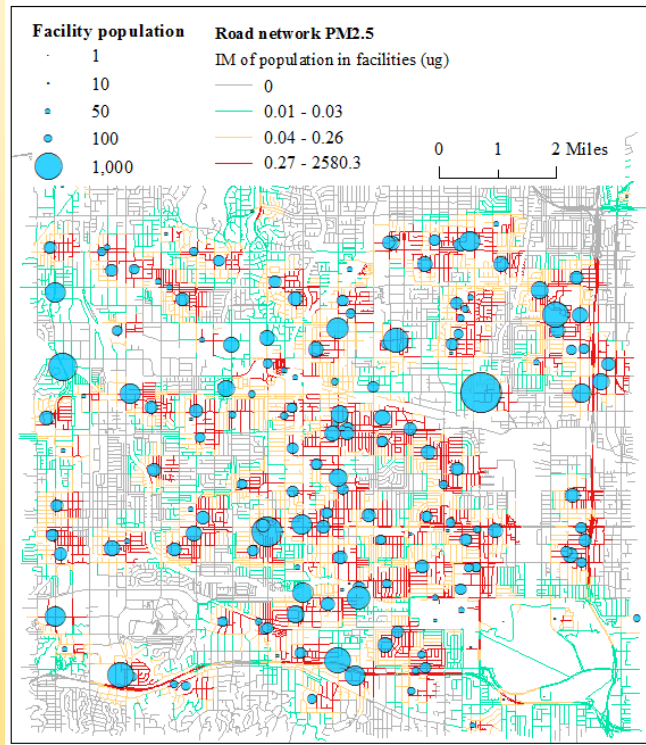
➔
Vehicle Dynamics controls:

➔
Powertrain controls:



LOW HUMAN EXPOSURE TRUCK ROUTING

- Route HDDTs in such a way that lowers impact of their emissions on local air quality and population exposure.
- Consider how emissions disperse into the nearby communities and inhaled by residents, especially sensitive population groups.

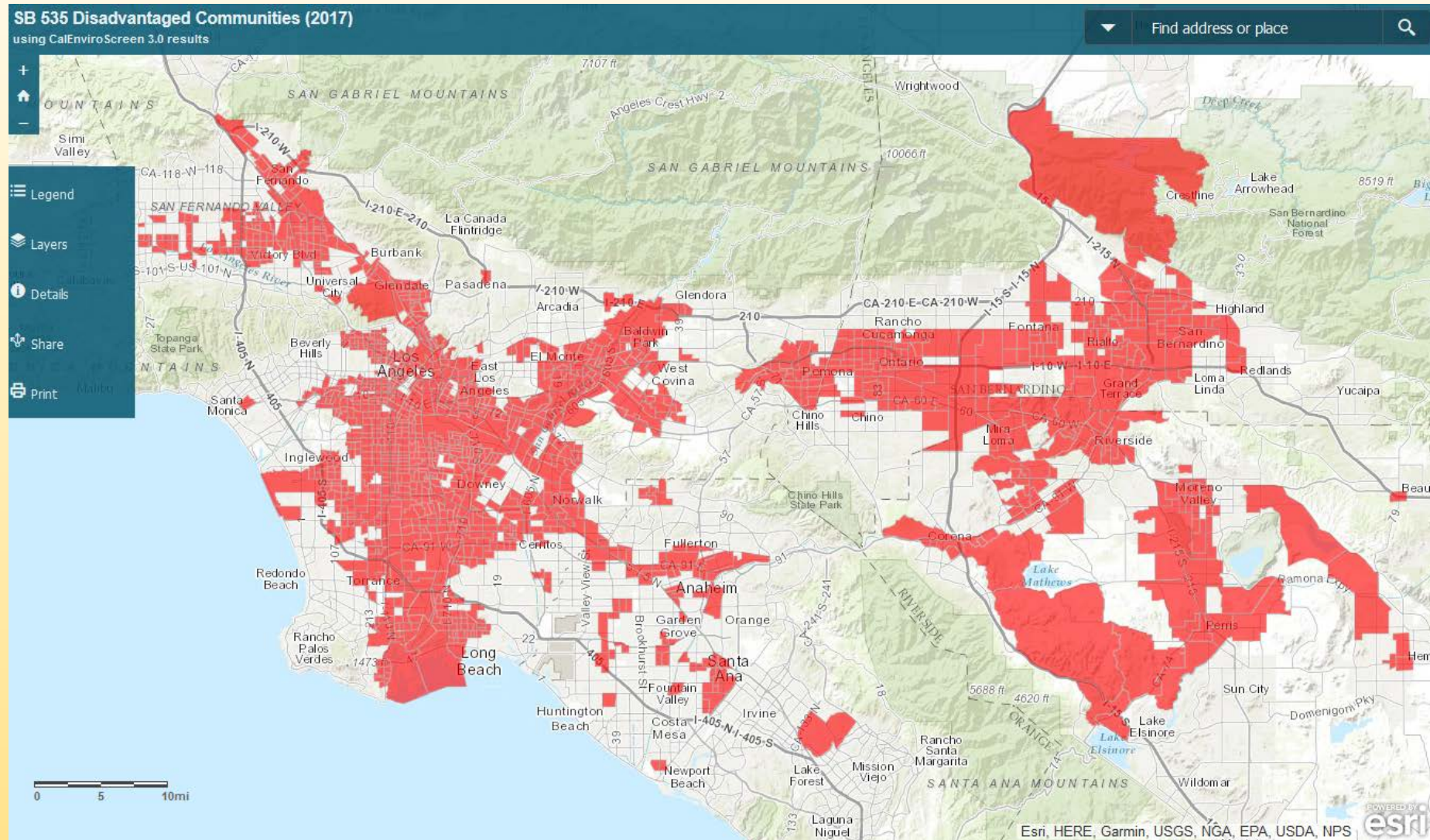


CONSIDER NEW METHODS OF CERTIFICATION AND VERIFICATION: **DYNAMIC ENERGY AND EMISSIONS MANAGEMENT (DEEM)**

- *Managing Energy Consumption and Emissions in Real-Time*
- **Dynamic** in terms of both **spatially** and **temporally**
- Management from both industry and regulatory perspectives
- Can be coupled with real-time reporting
- Can be applied to many types of **emissions**:
 - greenhouse gases
 - criterial pollutants
 - air toxics

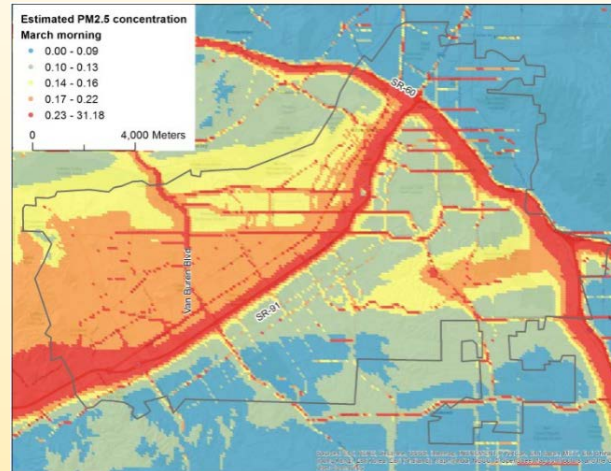
DEEM - SPATIAL APPLICATION (AKA, GEOFENCING)

- Consider focusing on disadvantaged communities...

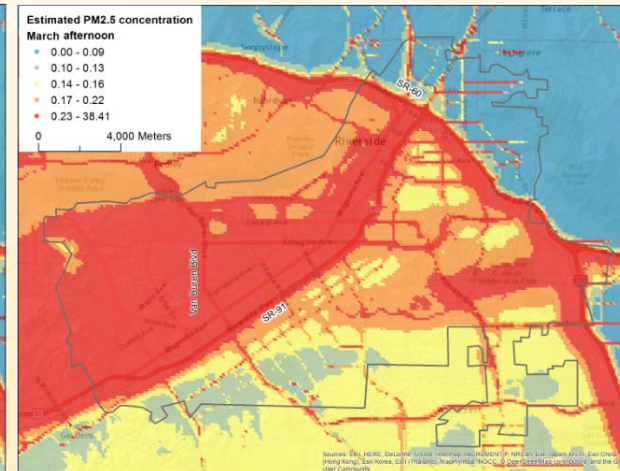


DEEM - TEMPORAL APPLICATION

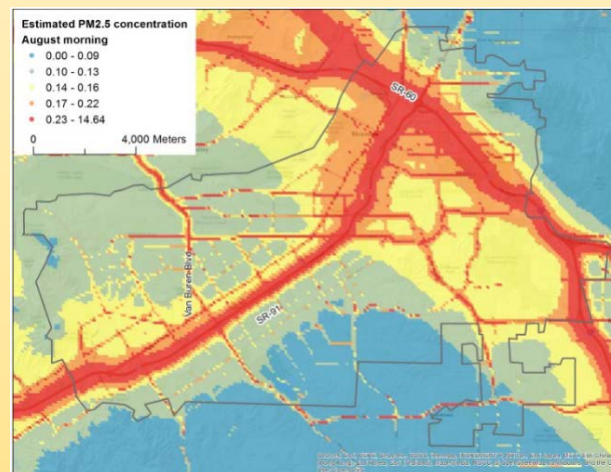
- Based on real-time or historical air quality patterns.
- Figures show modeled fine particle concentration from on-road mobile sources in Riverside, California



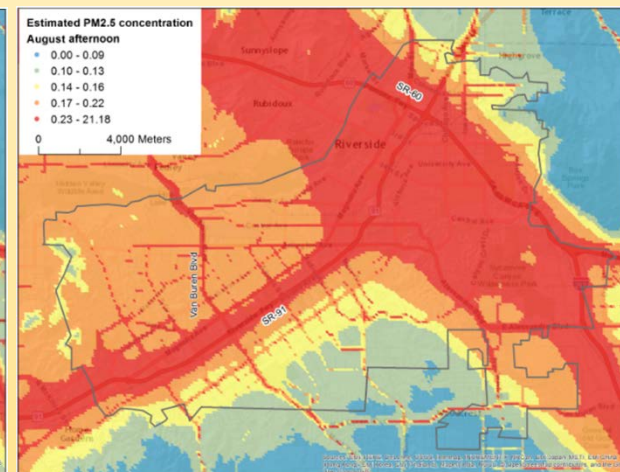
(a) March 2012, AM period



(b) March 2012, PM period



(c) August 2012, AM period



(d) August 2012, PM period

DEEM STRATEGIES CAN HAPPEN AT MANY LEVELS

- ***Engine/Powertrain Level:***

- Energy management for HEVs and PHEVs
- Engine tuning
- Aftertreatment tuning

- ***Vehicle/Driver Level:***

- Eco-driving
- Environmentally Friendly Intelligent Transportation Systems (ITS)

- ***Transportation System Level:***

- Routing and navigation
- Lower speed limits (*aka*, intelligent speed adaptation or speed harmonization)