Today's Mobile Source Data: an Overview

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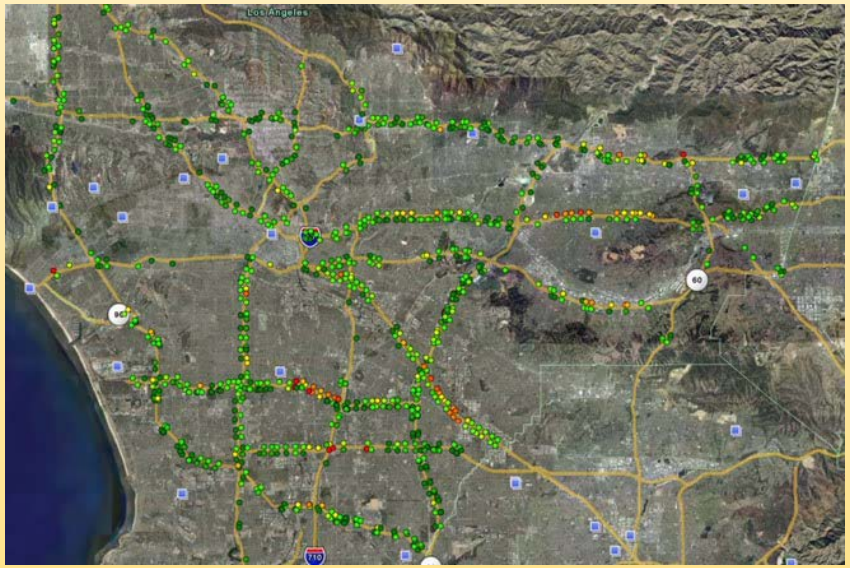
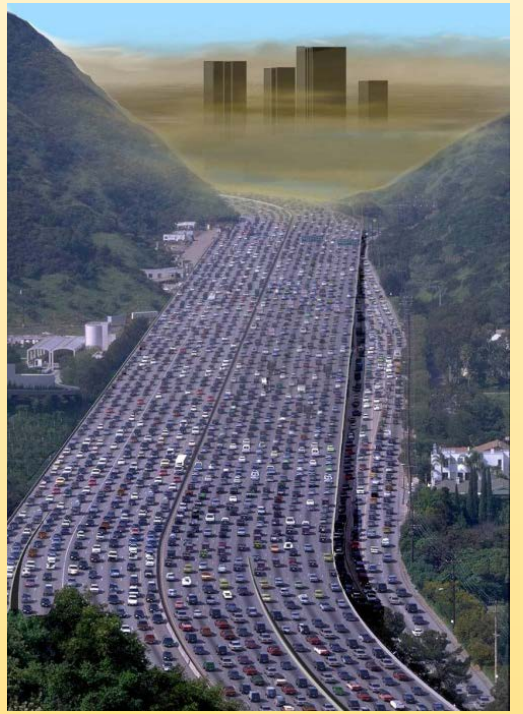
General Components of a Transportation-based Emissions/Energy Inventory:

- *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

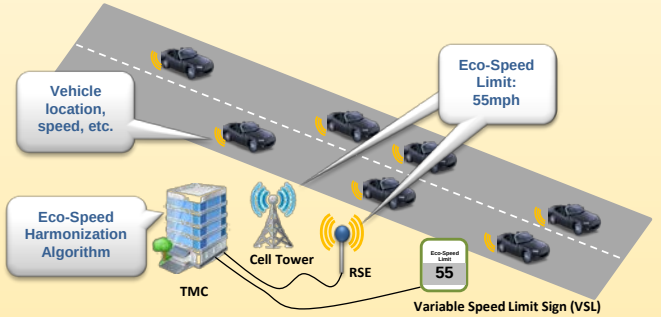
Data is Key in these Revolutions

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:

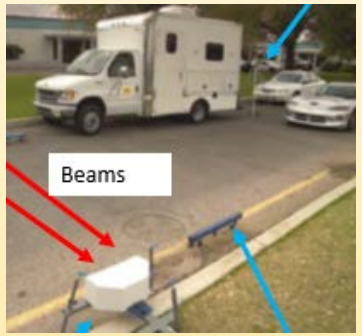
- Tremendous amount of vehicle sensor data are being collected (~1 TB every 5 minutes)
- Data are collected and shared for any crash

The Progression of Emissions/Energy Measurements

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

In Use Emissions Testing Product Continuum

Low cost/accuracy — Moderate cost/accuracy — High cost/accuracy



RSD

OBD reporting & integration

uPems (NTK)

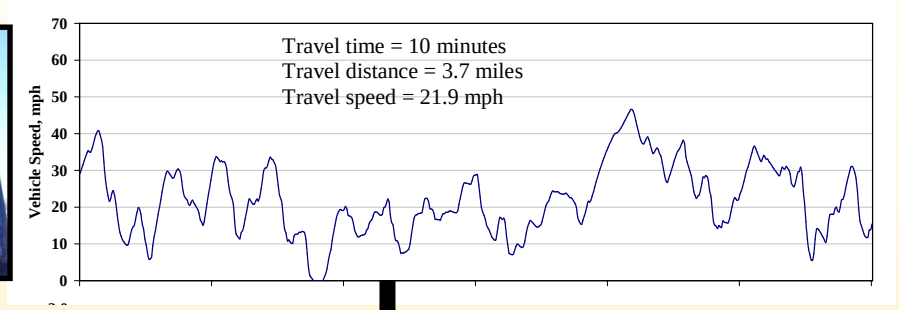
1065 Compliant System (AVL)

Dyno & Dyno in the loop

New Methods of Evaluation

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

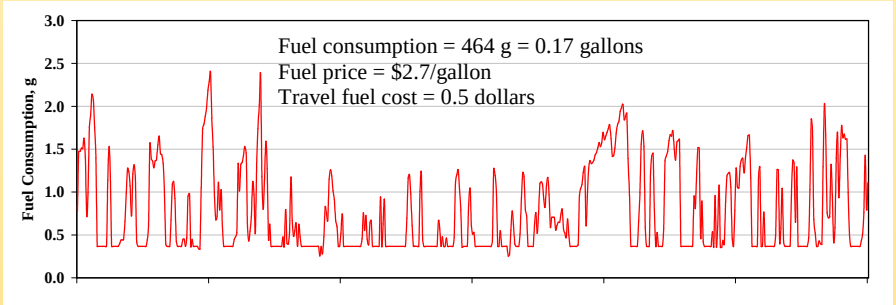
Emissions Modeling as a Source of Data



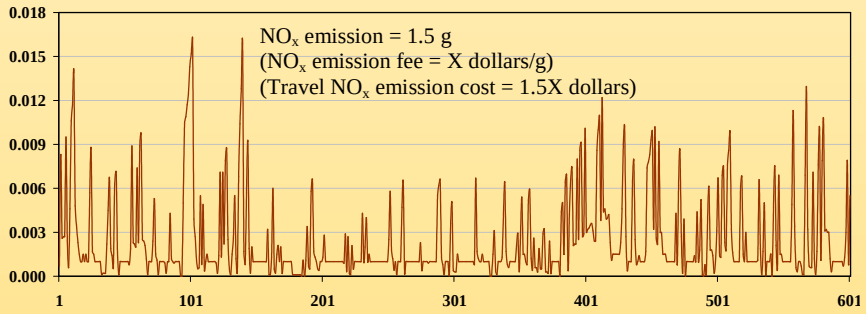
vehicle activity (velocity trajectory and grade if available)

Emissions Modeling

vehicle calibration parameters and emissions factors



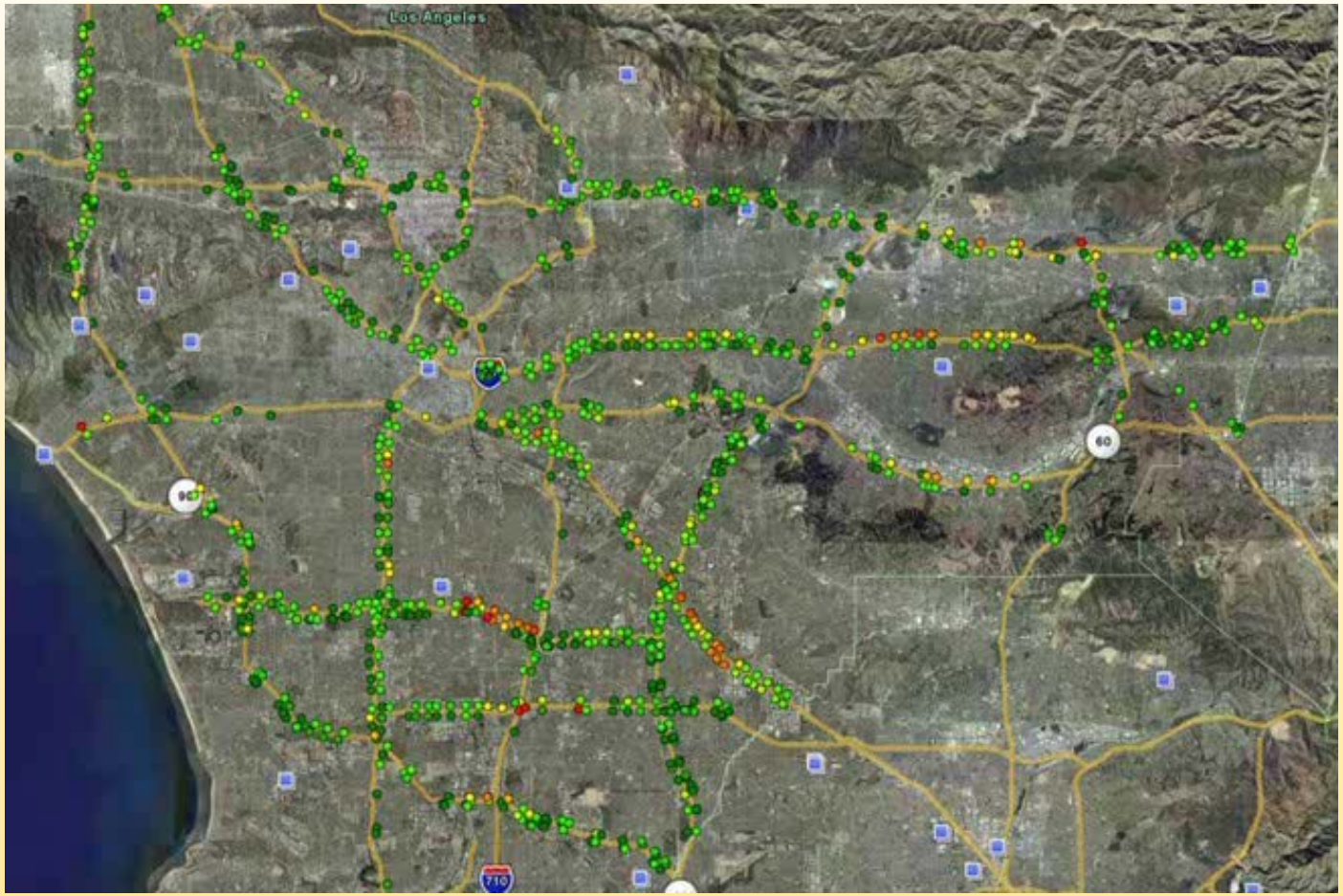
fuel consumption



emissions

Vehicle Activity Data has a Variety of Sources

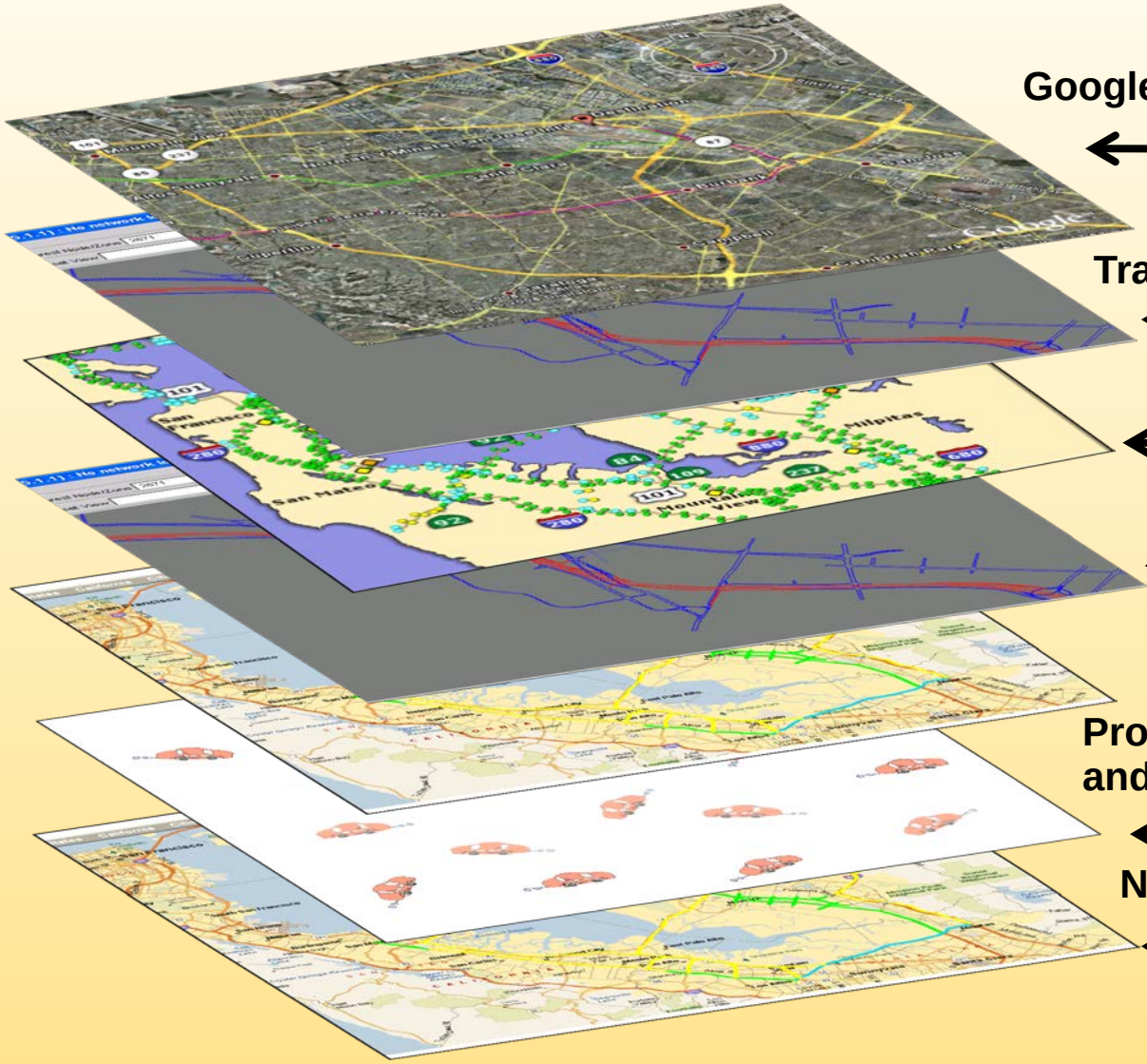
- real-time traffic density, speed, and flow are readily available
- Infrastructure sensors and crowd sourced
- Example: California PeMS, Inrix, Google, etc.
- Real-Time data are being used to measure congestion



- 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



Google Earth or Google Maps Interface

Traffic simulation result for arterials

PeMS data for freeways

Traffic signal/detector info

INRIX traffic data

Probe Vehicle network (arterials and freeways)

NAVTEQ underlying network data

Types of Data

Vehicle Activity Data:

- ICEs: On-board GPS, OBD data loggers (vehicle data, different methods of measuring fuel use)
- EVs: state-of-charge, electric current, voltage

Travel Survey Data:

- Daily travel modes and patterns
- Shared mobility choices
- Traveler demographics

Traffic Data:

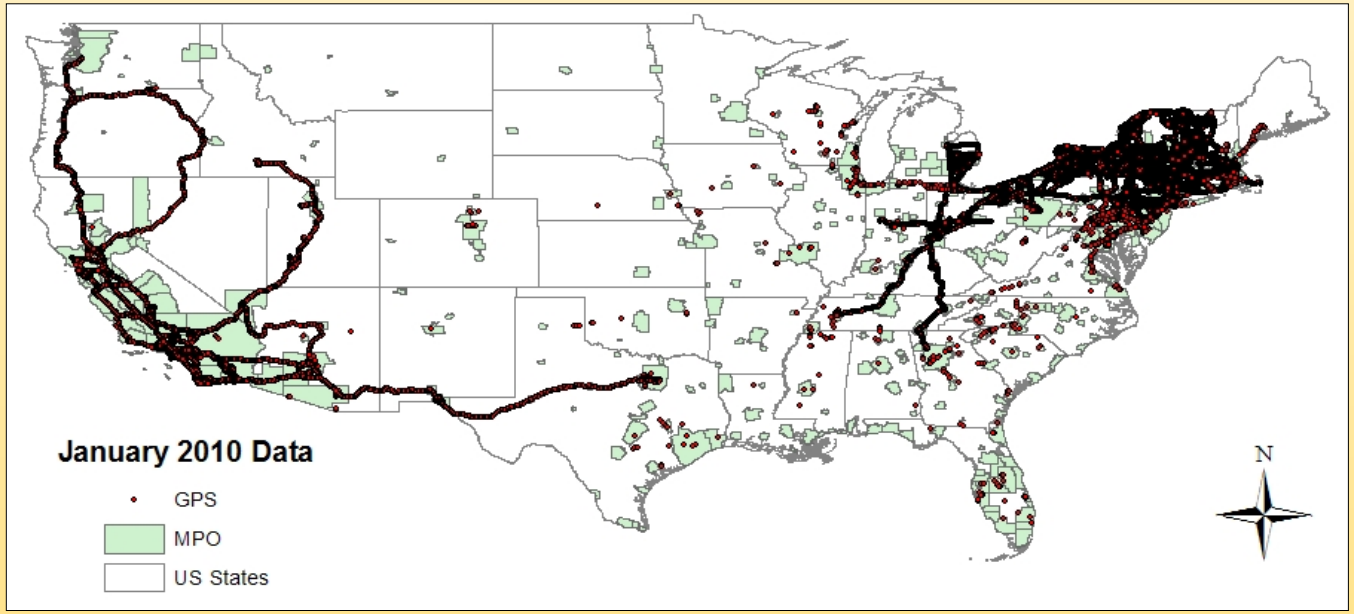
- Traffic volume, MOEs from infrastructure detectors
- Crowd sourced data: third-party sources (e.g., Inrix)

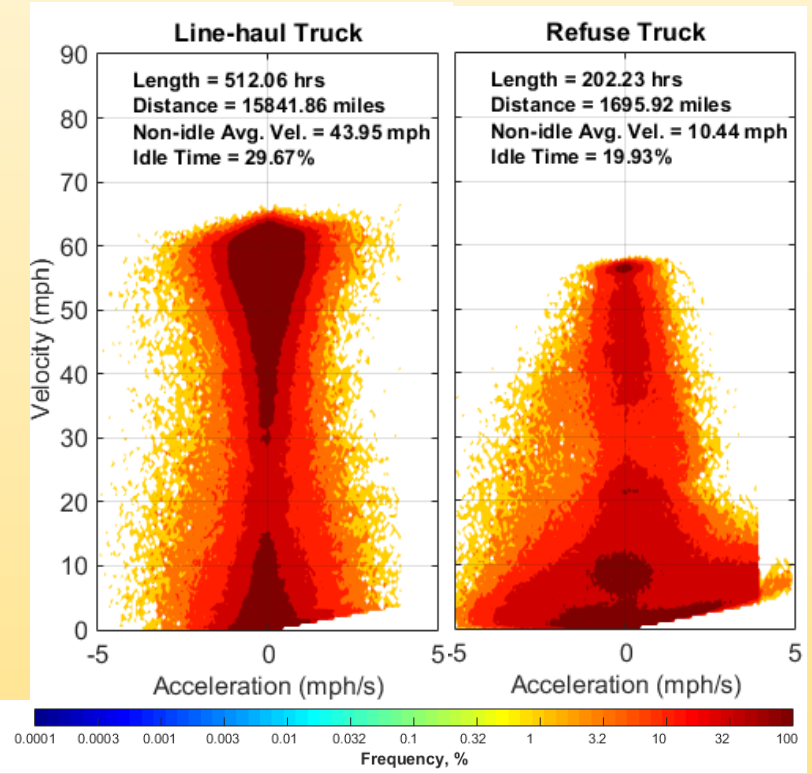
Microsimulation Data:

- Standard traffic data
- Specific APIs to determine CAV effectiveness
- Energy and emissions based on CE-CERT modeling suite

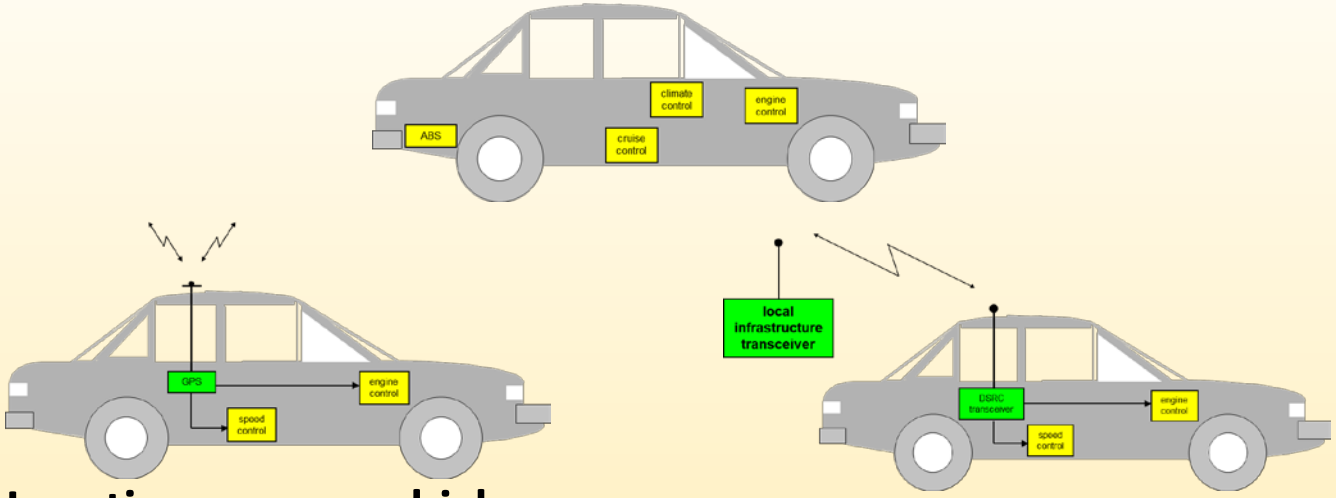
FREIGHT 'BIG" DATA

- Large-scale truck location (GPS) ***and engine operation (ECU)*** data
- Support various technical/policy analyses
  - Freight mobility and environmental performances
  - Trip and vehicle activity patterns
  - Fuel use and GHG & criteria pollutant emissions
  - Vehicle maintenance and compliance





2000's: Location-Aware and Connected Vehicles

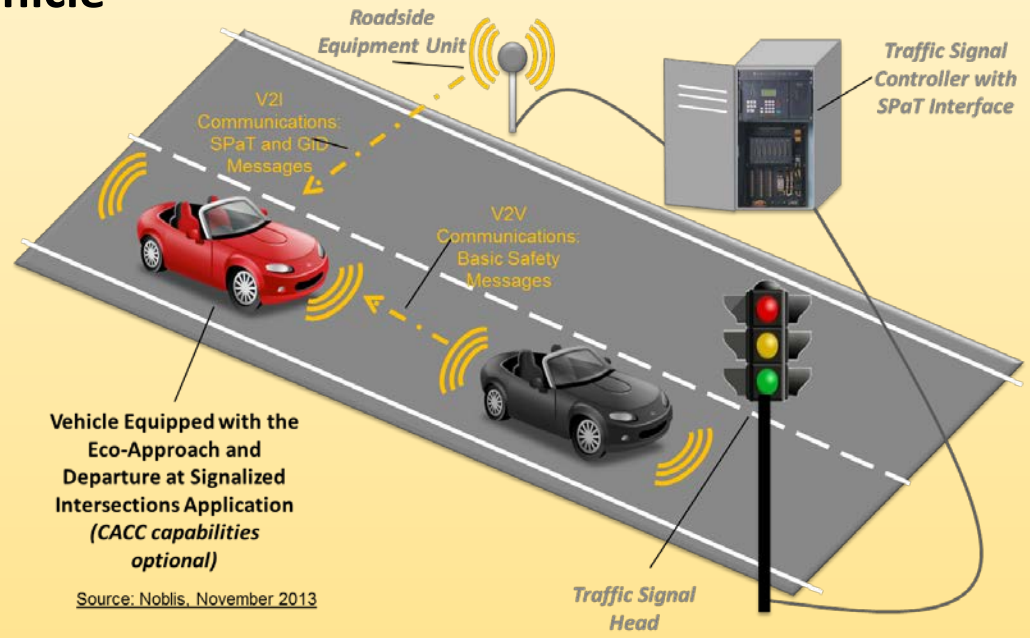


Location-aware vehicle

Connected vehicle

Platooning

Connected Environment



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

- 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

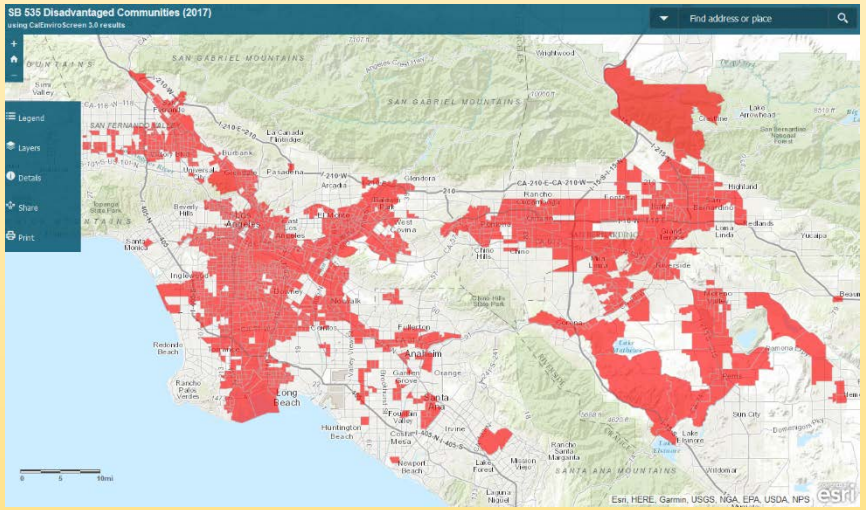
Low Cost Air Quality Monitoring Equipment

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 in disadvantaged communities

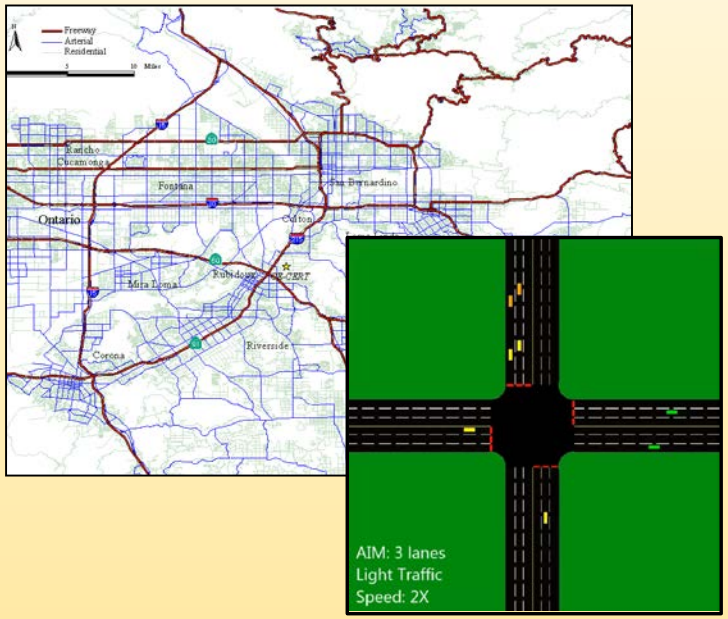


Emerging Transportation Applications that Leverage Data to Minimize Energy and Emissions

DATA IS THE KEY ENABLER CONNECTING SYSTEMS

Dynamometer-in-the-Loop Control System

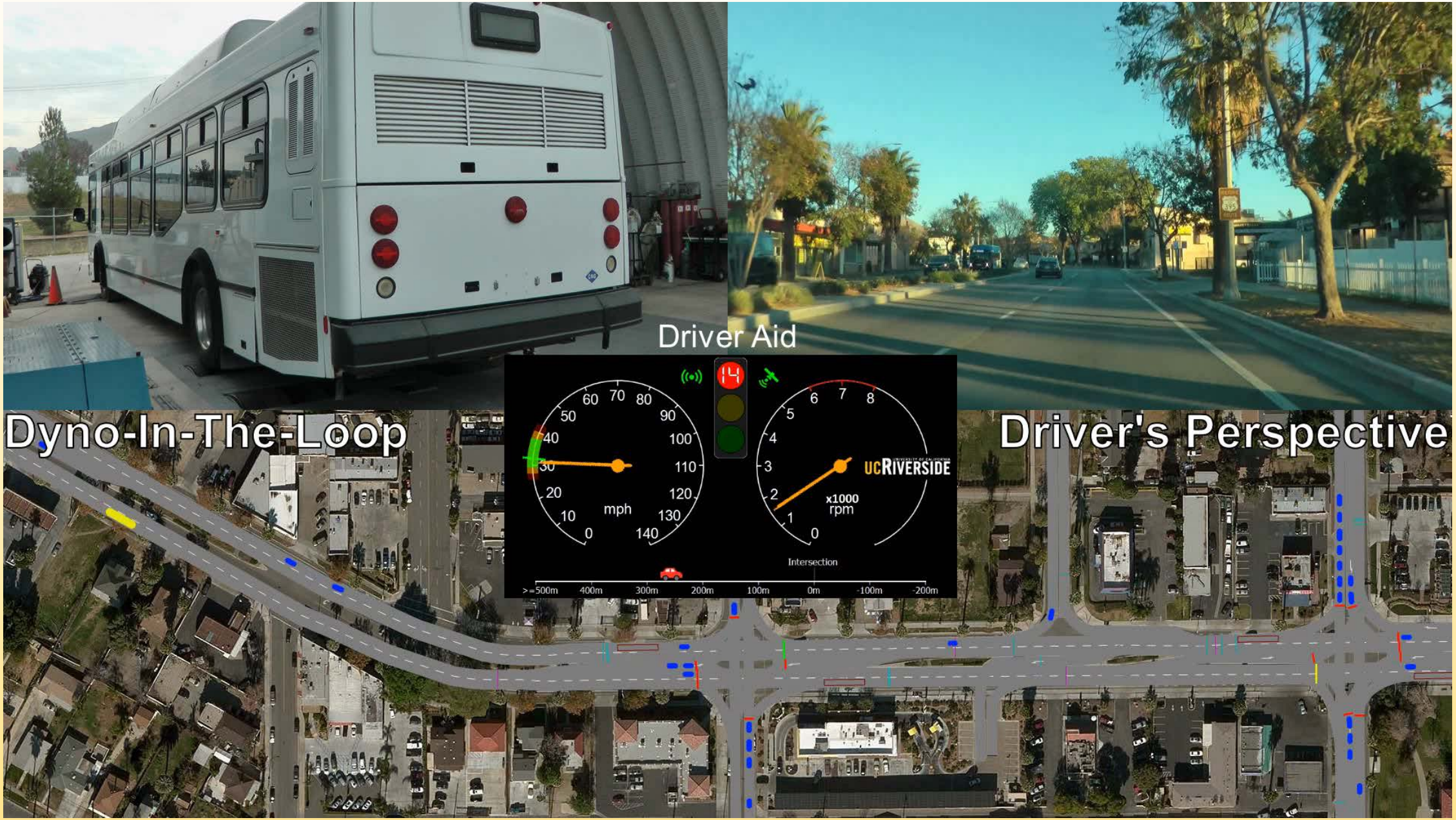
Transportation Systems Research Microscopic Traffic Modeling



Dynamometer Operation

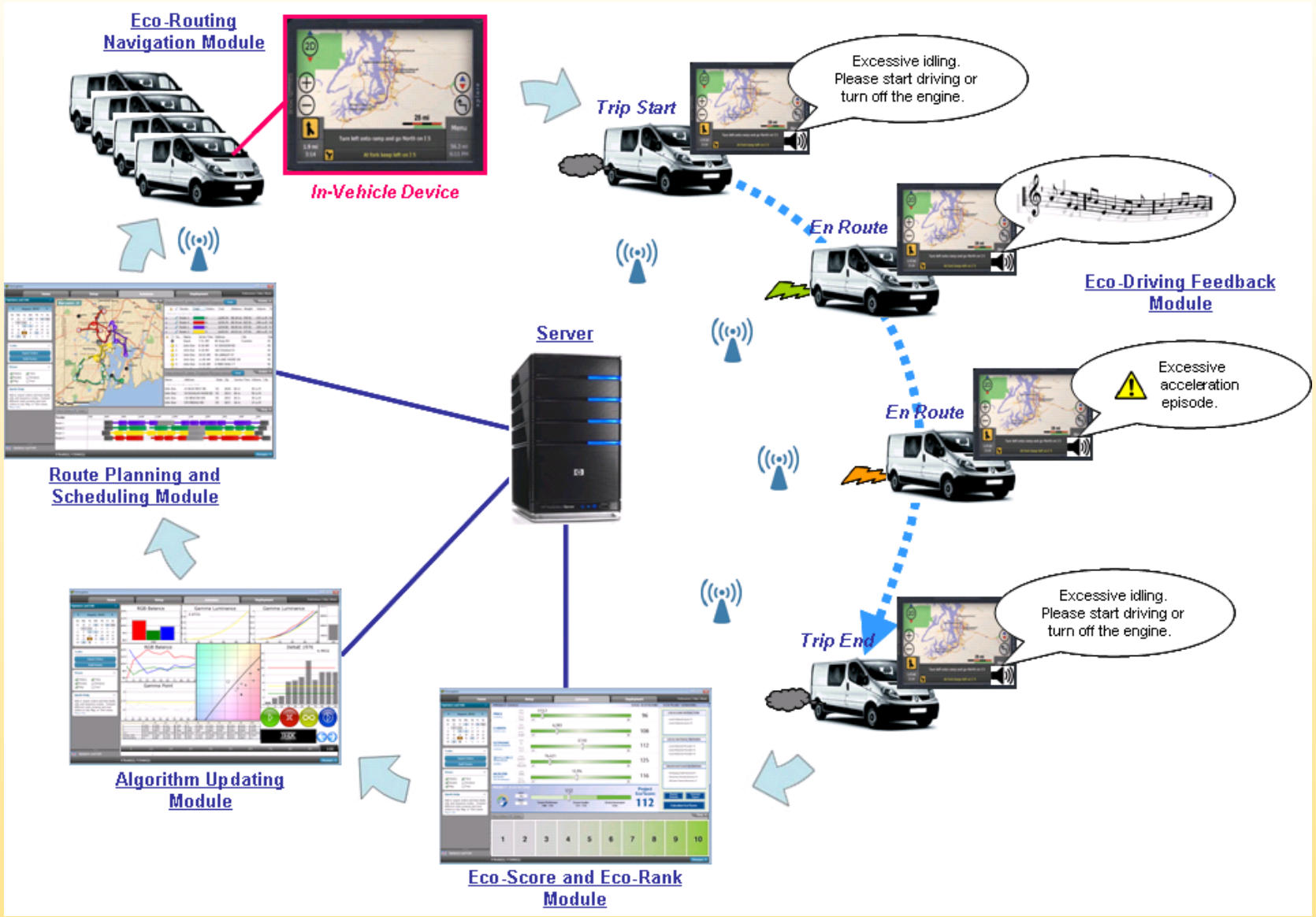
Real-Time Vehicle Trajectory Data

Integrated Virtual Environments with Real-World Testing



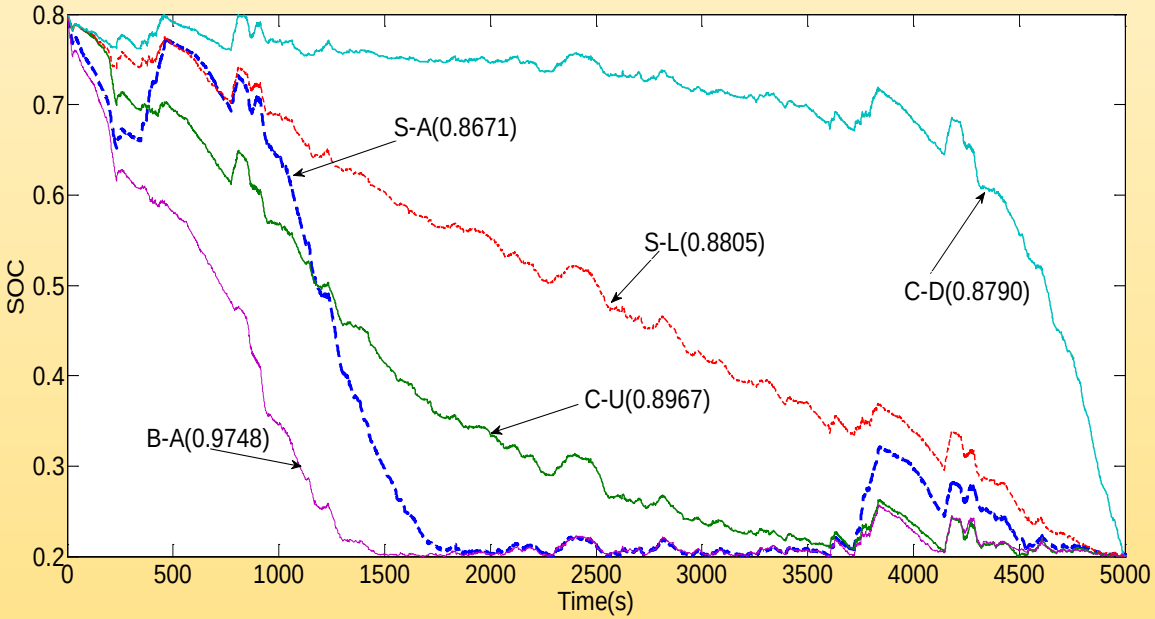
NEXT GEN ECO-DRIVING FEEDBACK SYSTEM

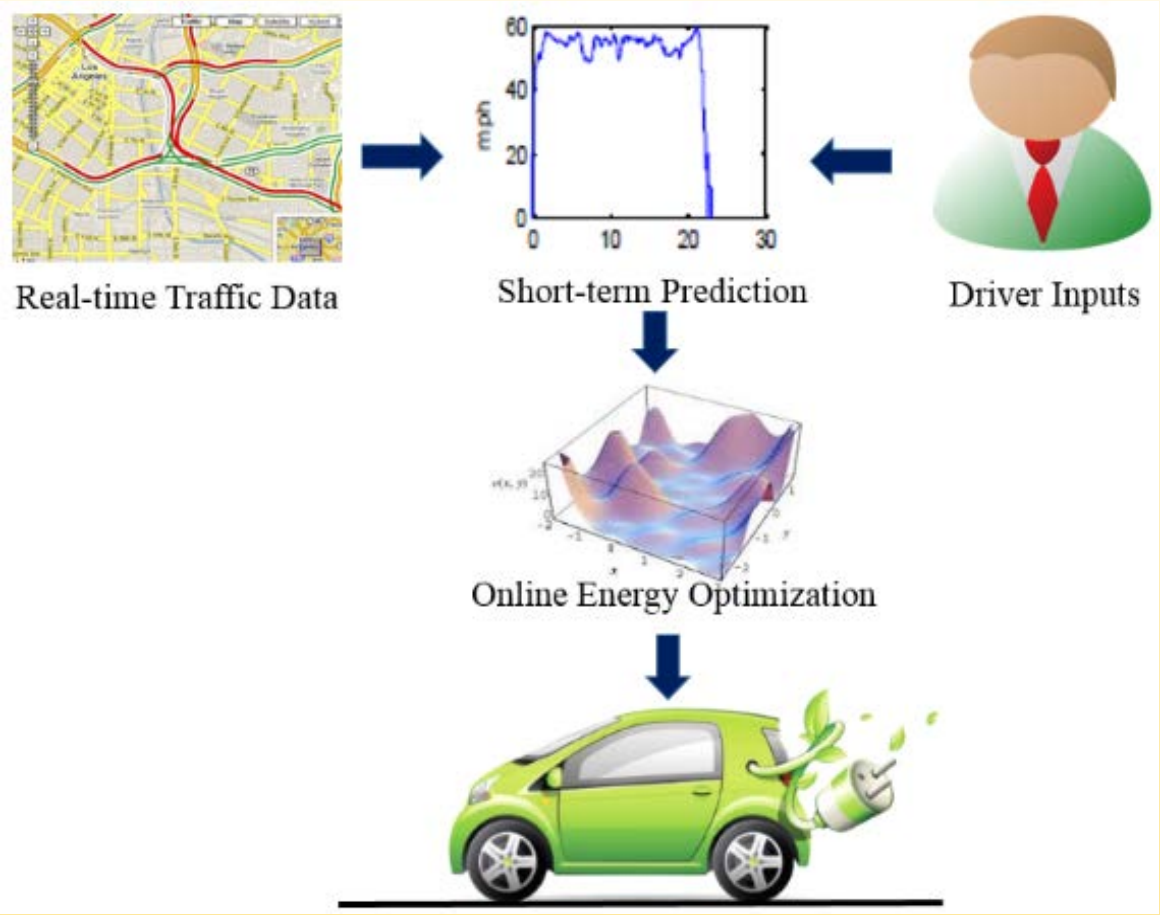
- Developed driving feedback technologies that encourage drivers and fleets to make fuel-efficient choices in all aspects of vehicular travel
- *2-9% fuel savings from field operational tests*



PHEVs: New Energy Management System

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

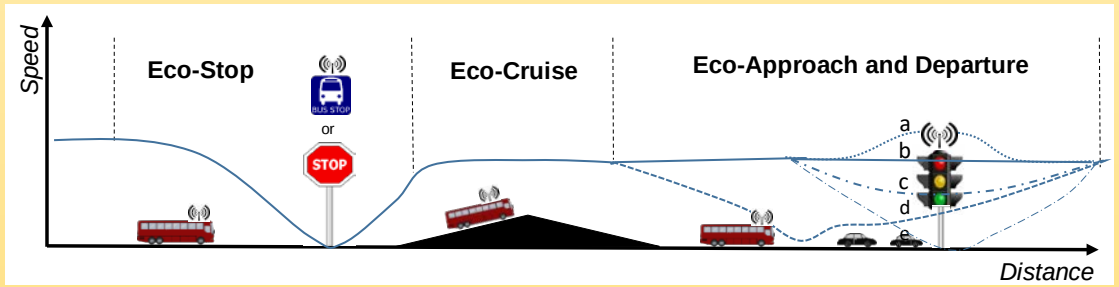




ARPA-E NextCar Research Program
Integrated Powertrain and Vehicle Dynamic Controls

UCR Connected ECO-BUS:

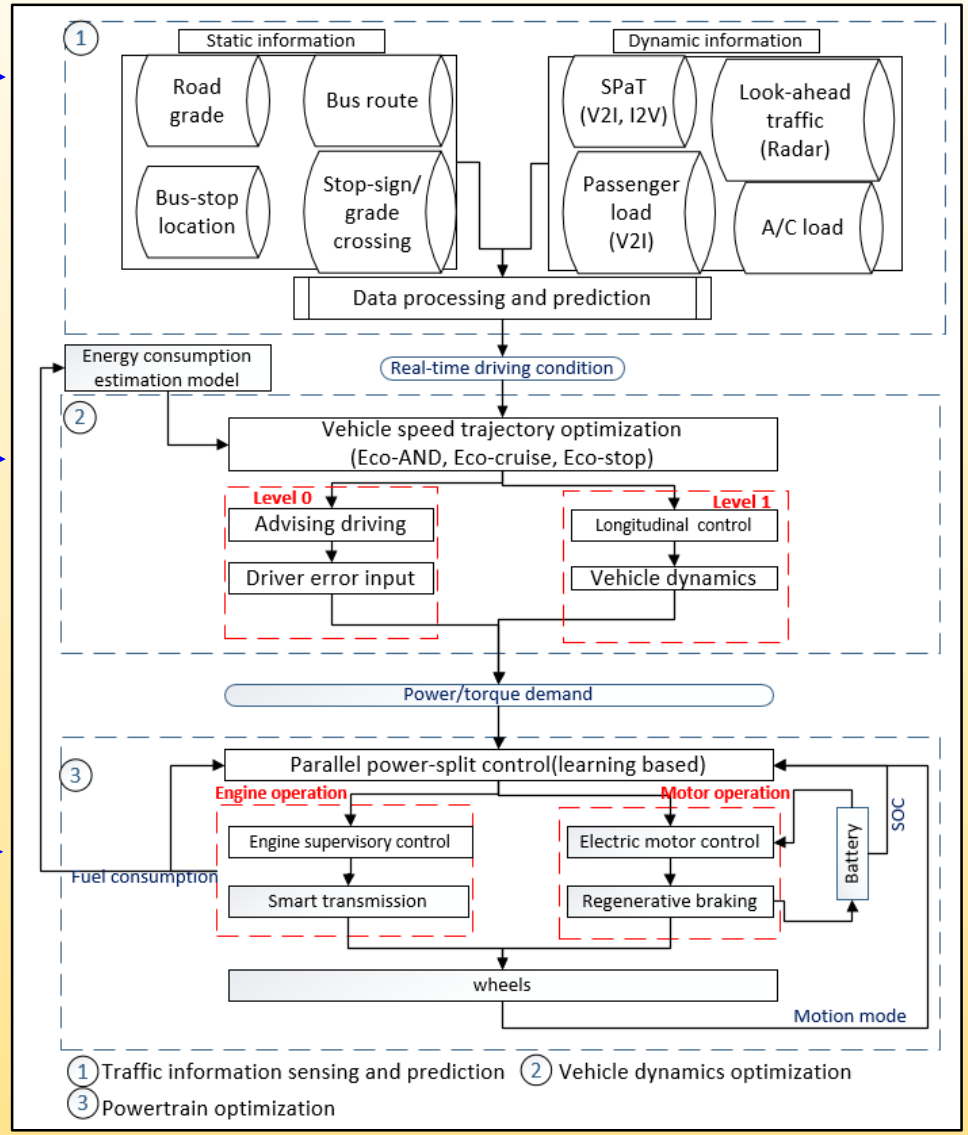
- ARPA-E NextCar program
- > 20% fuel & emission savings
- dynamic parameter selection
- potential level-2 automation



Traffic and Road Grade Info:

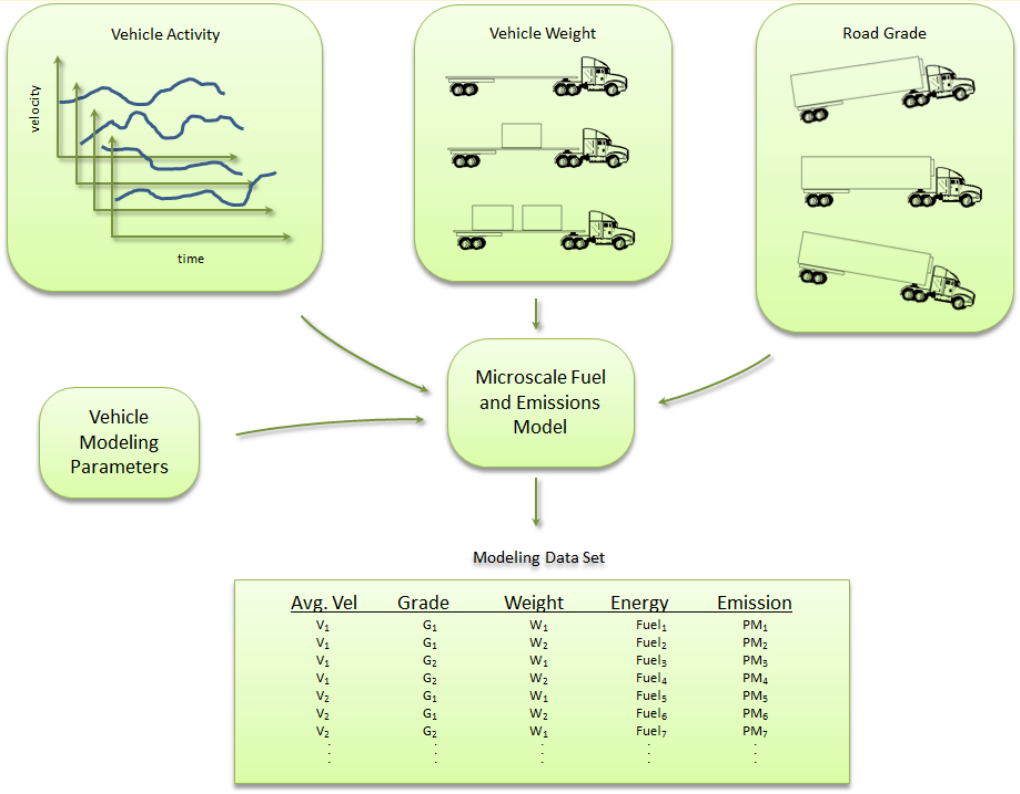
Vehicle Dynamics controls:

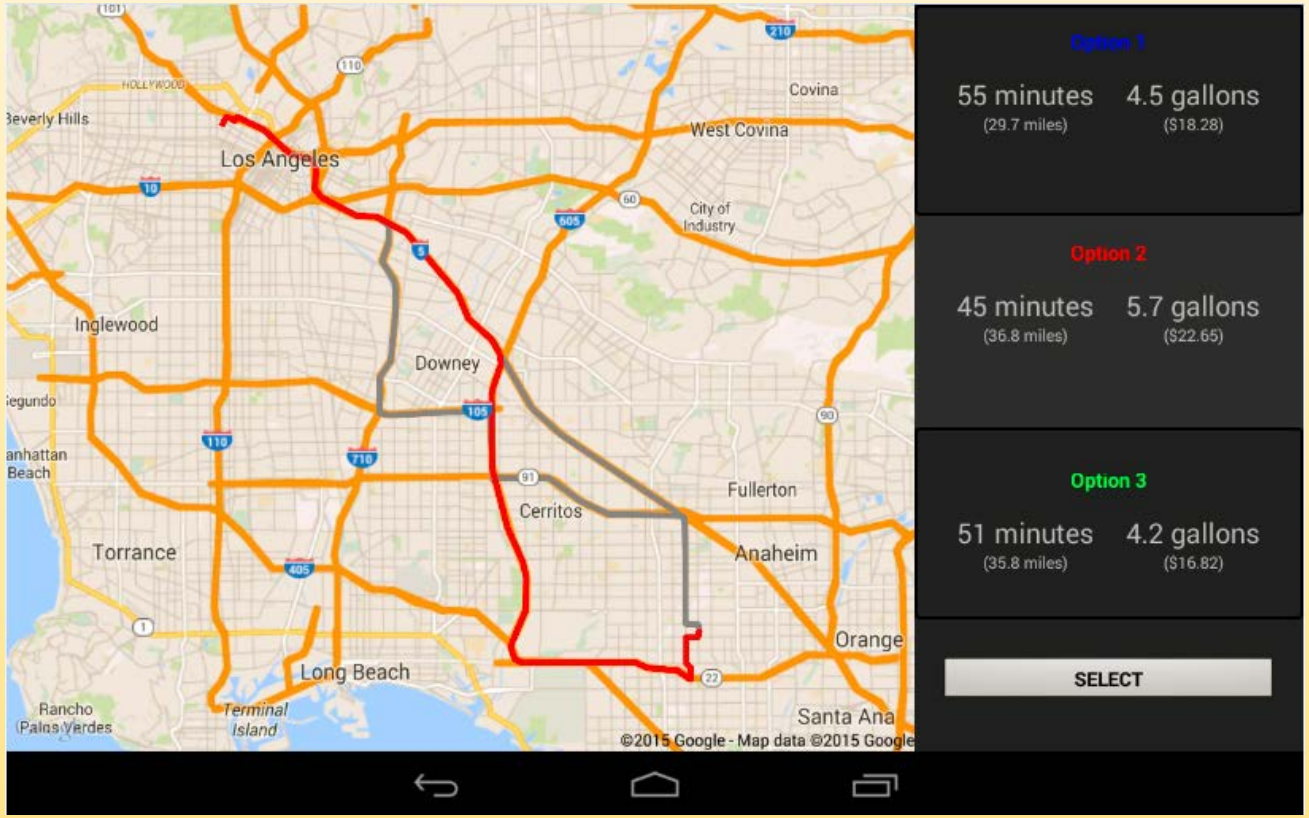
Powertrain controls:



TRUCK ECO-ROUTING

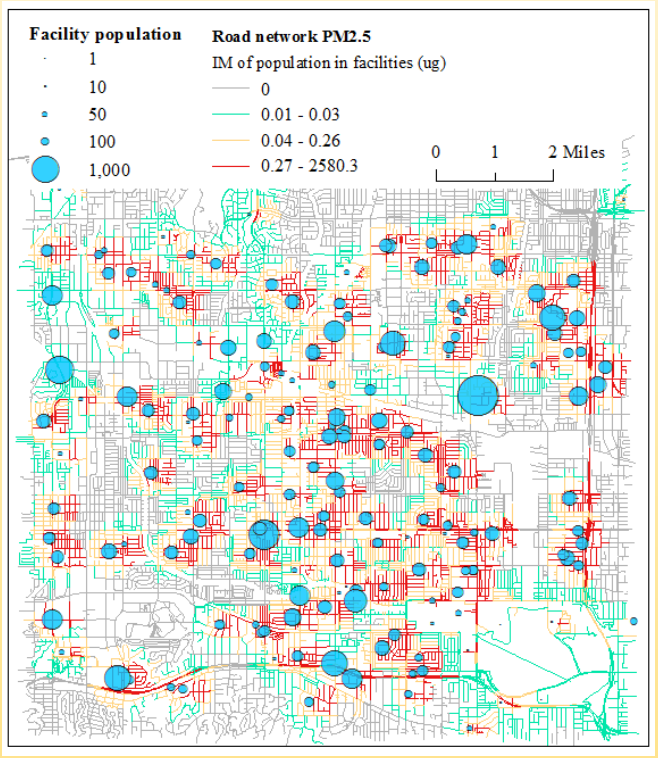
- Calculate route that minimize fuel consumption or a specific emission.
- Account for real-time traffic, road grade, and combined vehicle weight.
- Simulation shows tradeoff between fuel consumption and travel time.
  - 9%-18% fuel savings with 16%-36% travel time penalty.

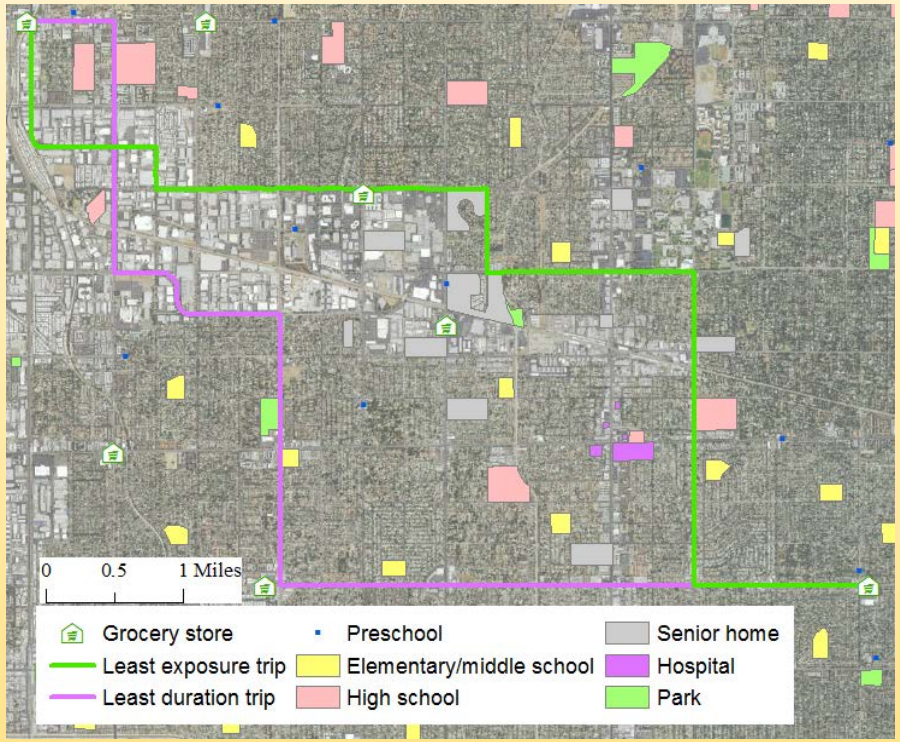




Low Human Exposure Truck Routing

- 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.



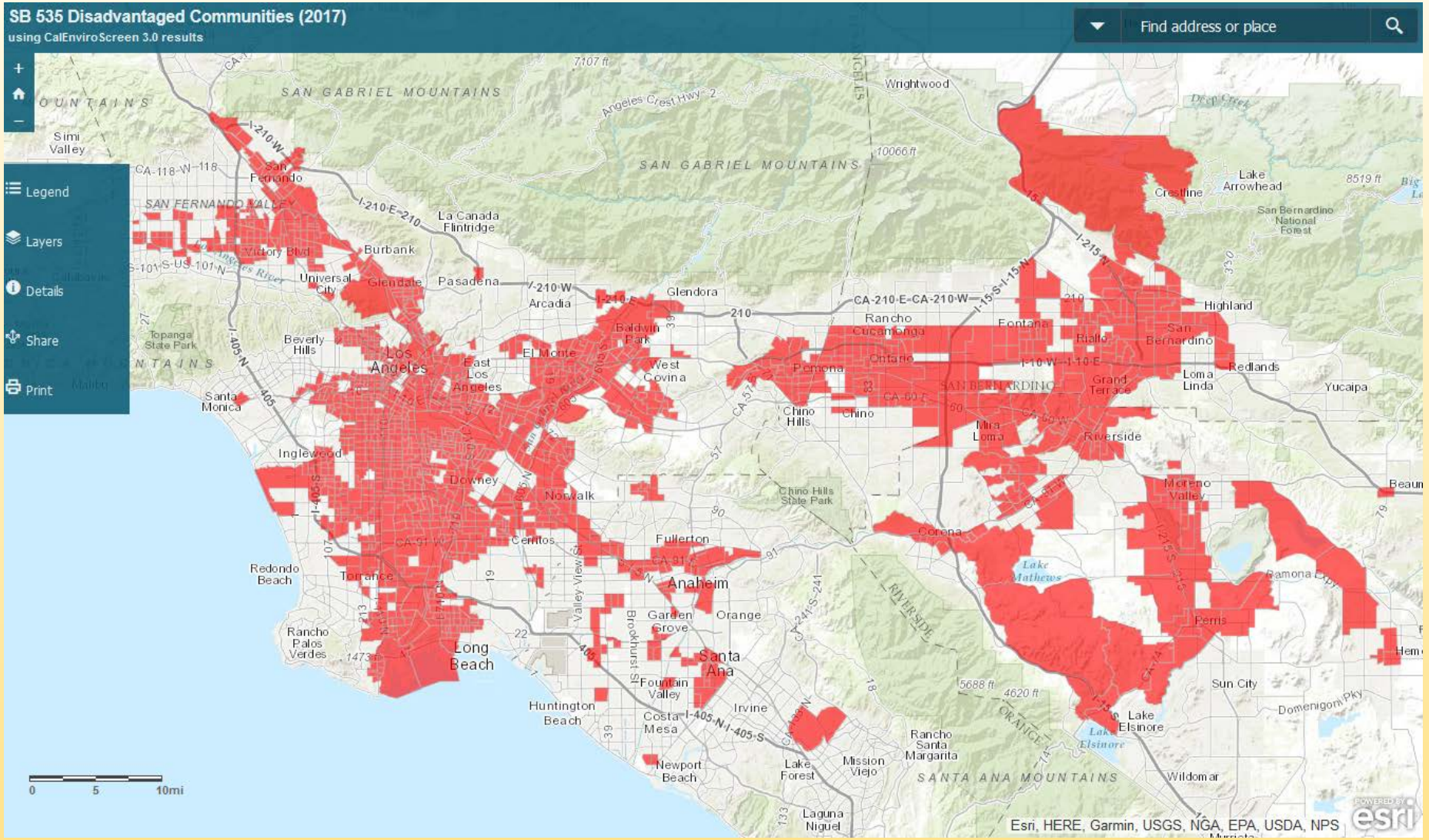


DYNAMIC ENERGY AND EMISSIONS MANAGEMENT (DEEM)

- *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

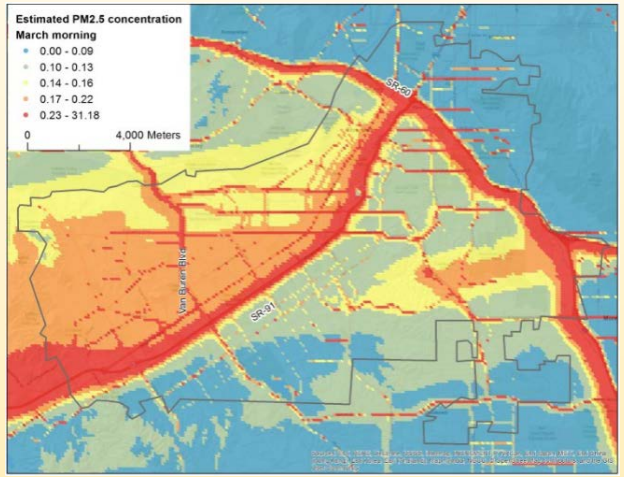
DEEM - SPATIAL APPLICATION (AKA, GEOFENCING)

- For California, focus on disadvantaged communities.

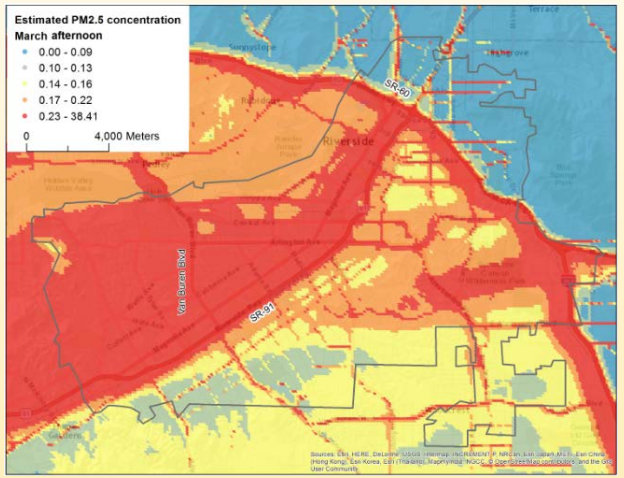


DEEM - Temporal Application

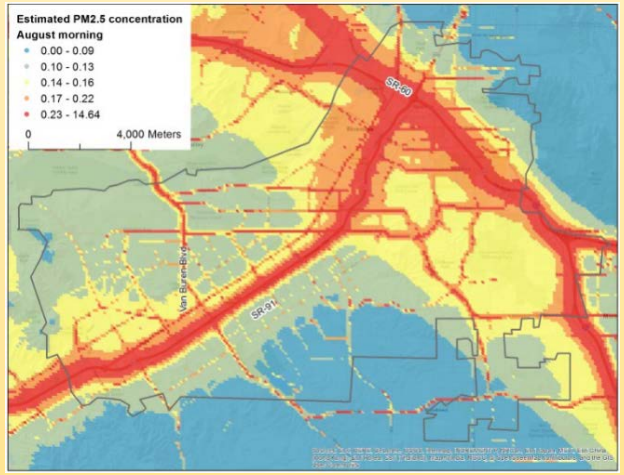
- Based on real-time or historical air quality patterns.
- Figures show modeled fine particle concentration from on-road mobile sources in Riverside, California



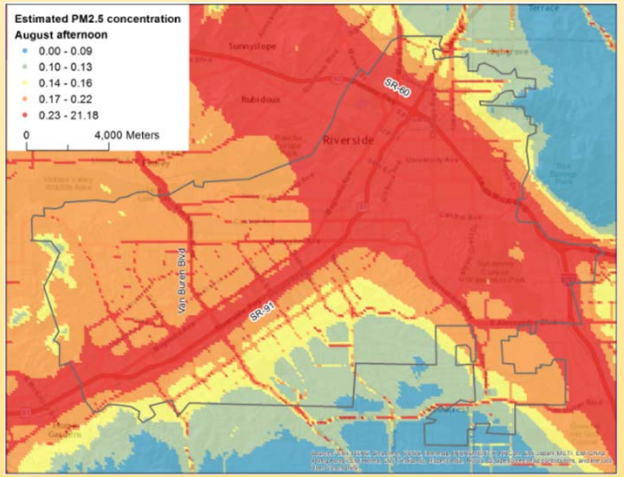
(a) March 2012, AM period



(b) March 2012, PM period



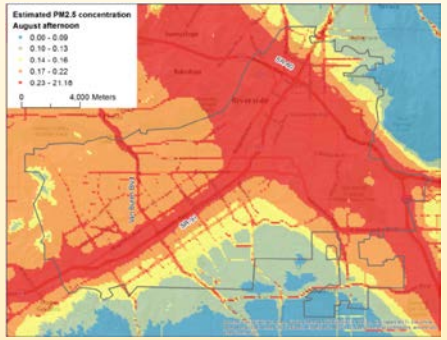
(c) August 2012, AM period



(d) August 2012, PM period

Decision Flow Chart in a Vehicle Equipped with DEEM

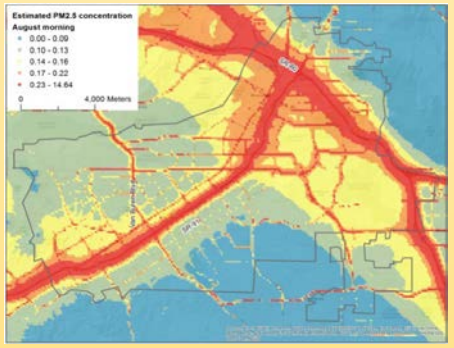
Where am I? (Is this area highly populated and highly polluted?)*

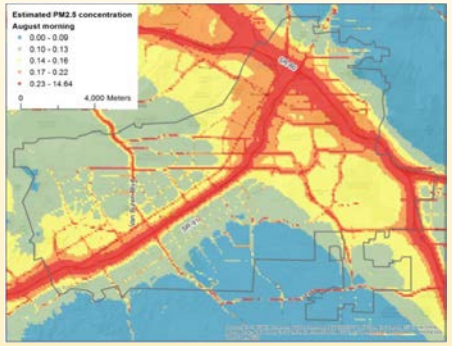


Yes, highly polluted area

Vehicle operates with near zero or zero criteria and toxic emissions

Exposure to harmful pollutants in areas of poor air quality is immediately reduced





No, no local health risks

Vehicle operates to maximize fuel and GHG reductions

Vehicle emissions do not result in increased exposure

Tradeoffs are optimized: Fuel Use, Compliance Cost, GHG Emissions, & Air pollution

Transparency in Real-time: Vehicle automatically reports to regulators about compliant operations

*Red represents high PM, Ozone or Toxic concentrations

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)**

THANK YOU!