UCR College of Engineering- Center for Environmental Research & Technology

2012 DOE Vehicle Technologies Program Review Presentation

Next Generation Environmentally-Friendly Driving Feedback Systems Research and Development

Matthew Barth

University of California Riverside

May 18, 2012

Project ID #
VSS086

Project Overview

- ***Timeline***
  - Start 10/1/2011
  - End 9/30/2014
  - 10% complete
- ***Budget***
  - Total project funding
    - DOE – $1,210,235
    - Contractor – $665,472
  - Funding received in FY11
    - $0
  - Funding for FY12
    - $556,267
- ***Barriers***
  - Barriers addressed
    - Public acceptance
    - Safety concern
- **Partners**
  - ESRI
  - NAVTEQ
  - Beat the Traffic
  - Earthrise Technology
  - Automatik
  - Riverside Transit Agency
  - Caltrans
  - U. of California Berkeley

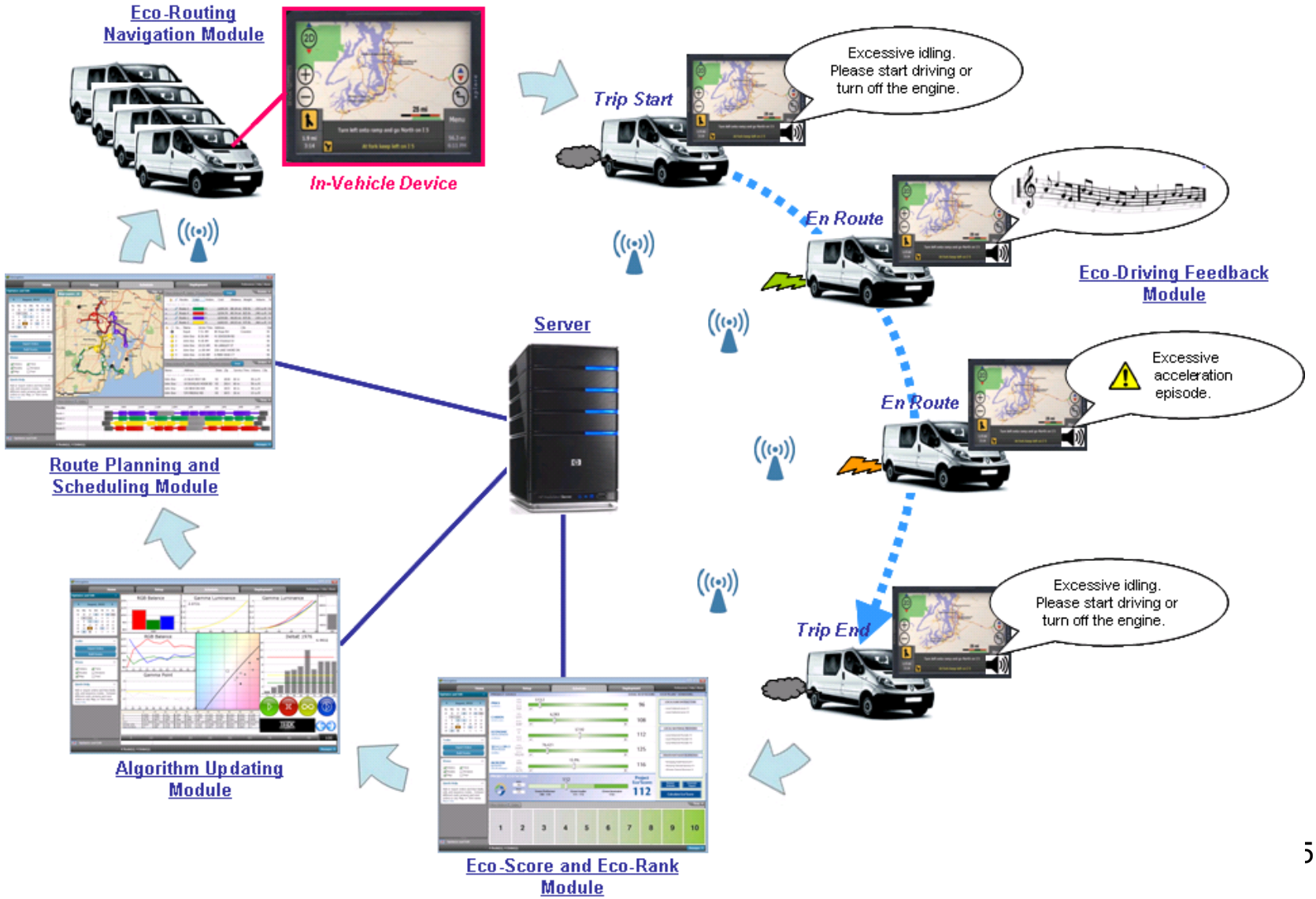
Project Objective

- To design, develop, and demonstrate a next-generation driving feedback system with four advanced modules:
  - Eco-Routing module
  - Eco-Driving Feedback module
  - Eco-Score and Eco-Rank module
  - Algorithm Updating module
- Success criteria:
  - Improve fuel efficiency of the fleet of passenger cars and commercial vehicles by at least 2%
  - Comply with federal safety and emissions regulations
  - Deployable across existing vehicle fleets

Milestones for FY12

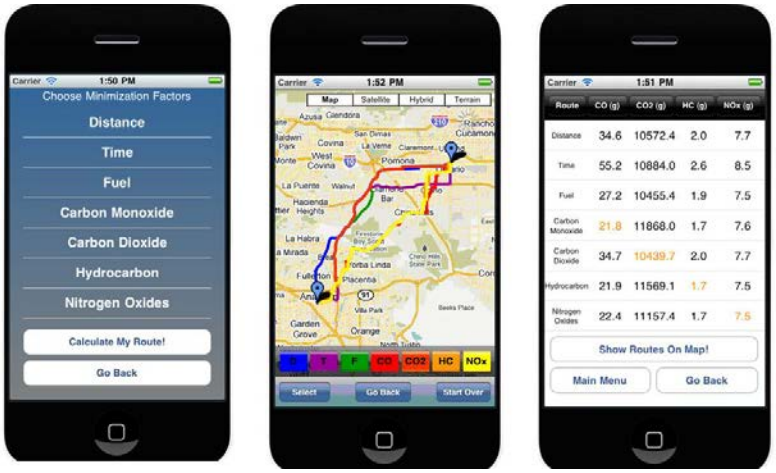
Month/Year	Milestone
Dec 2011	Complete an upgrade of Dynamic Roadway Network (DynaNet) database with 3D digital road map and real-time traffic data feed
Jul 2012	Complete the design of eco-driving feedback user interfaces and algorithms
Sep 2012	Complete Eco-Routing Navigation module that incorporates intersection delays in route calculations

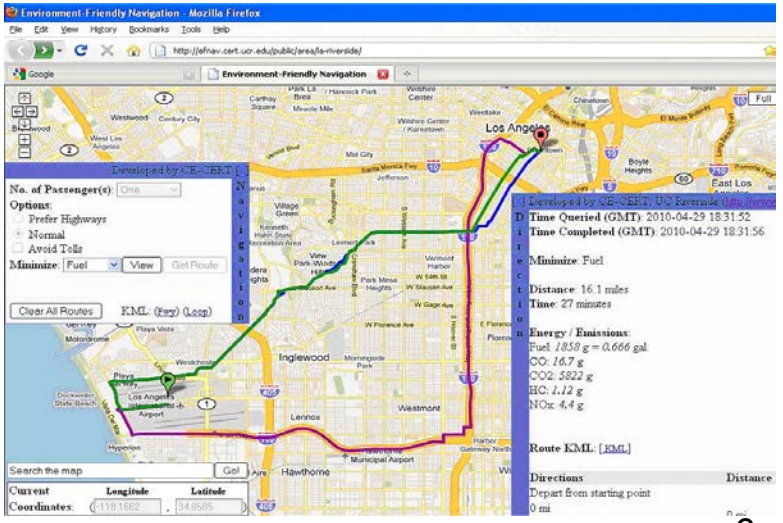
Approach – Vision



Approach – Eco-Routing

- Create routes and schedules for day-to-day fleet operation that are optimized for fleet average fuel consumption
- Use real-time traffic data in route calculations
- Account for intersection delays and road topology when finding optimal routes





Approach – Eco-Driving Feedback

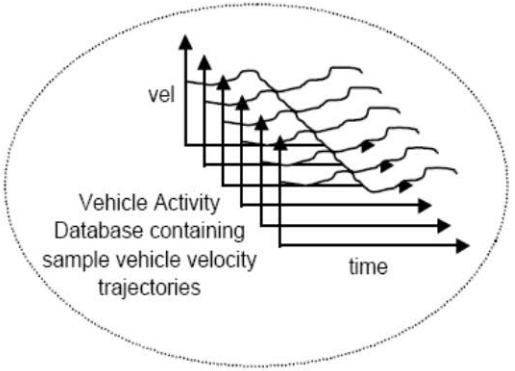
- Simple user interfaces
- Supplement visual feedback with auditory feedback to reduce distracted driving and improve effectiveness
- Convey monetary messages in addition to fuel economy messages

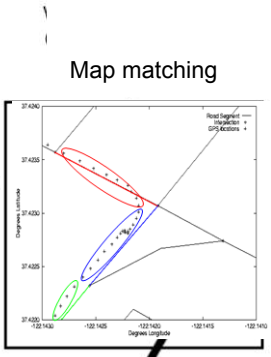
Approach – Eco-Score and Eco-Rank

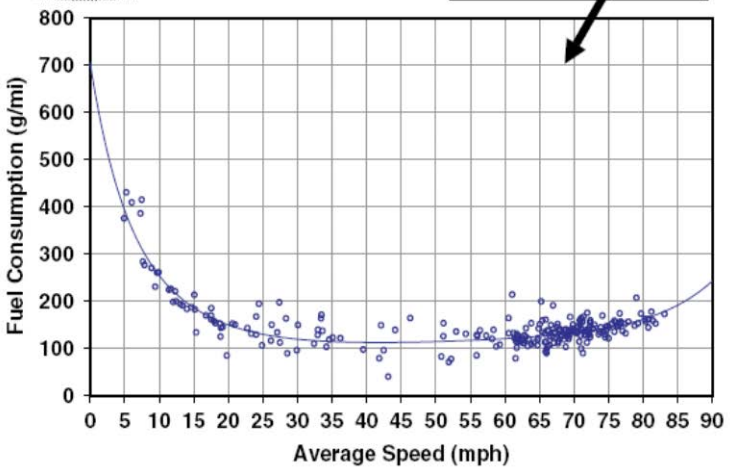
- Track vehicles and monitor driving behavior, vehicle performance, and fuel consumption in real-time
- Periodically assess driving behavior of drivers and provide recommendations for improvements
- Provide platform for performance comparison against oneself over time as well as against other drivers

Approach – Algorithm Updating

- Continuously update Eco-Routing algorithms based on real-world vehicle performance and fuel consumption





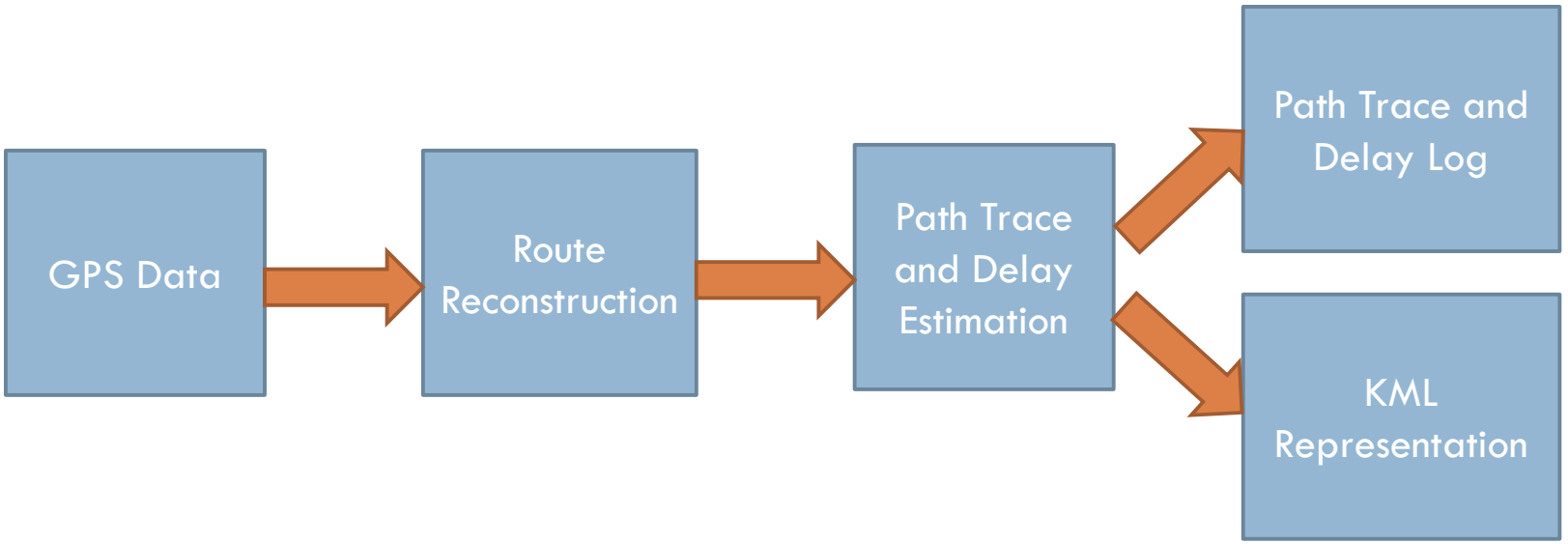


Approach – System Testing

- Test individual modules and the integrated system in testbed vehicle before field operational test in fleets

Technical Accomplishments

- Eco-Routing module
  - Upgraded DynaNet with 3D street map and new traffic data
  - Developing methods for estimating intersection delays from smartphone-based GPS data with 20-second interval



Estimating Intersection Delays

Direct path connecting 20-second GPS points

Reconstructed path along digital road network

vs.

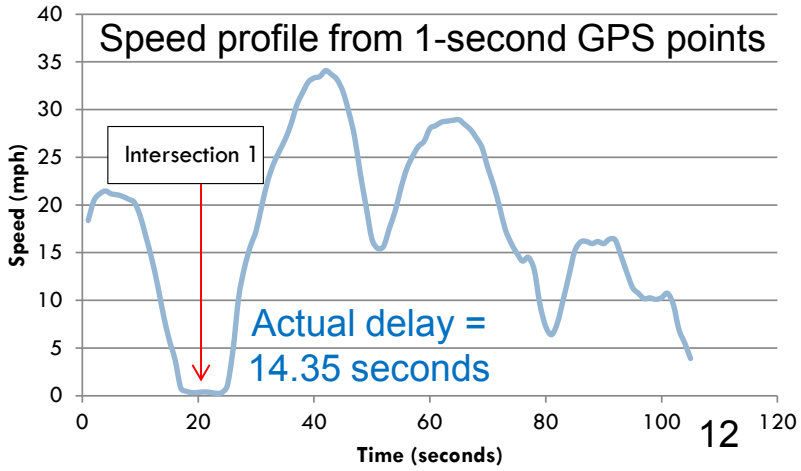
Actual path based on 1-second GPS points

Example log for path segment at intersection 1

To Node	Total distance Traveled (m)	Base Speed Limit (mph)	Expected Time (s)
1378569	152.50	20	17.06
1378570	17.61	20	1.97
End (mid link)	82.96	28	6.63

Estimated delay at intersection 1 = 14.30 seconds

vs.



Collaborations (1)

- University of California Riverside (university)
  - Prime contractor assuming leadership role
  - Conduct system research & development
  - Lead system testing & evaluation, reporting
- ESRI (industry)
  - Provide route planning & scheduling and GIS software packages
  - Provide technical support in the integration of its software products with other system components
- NAVTEQ (industry)
  - Provide 3D digital map and real-time & historical traffic data
  - Provide technical support in the integration of its products with other system components

Collaborations (2)

- Beat the Traffic (small-business enterprise)
  - Provide GPS data from its smartphones app users
  - Develop methods to detect and model intersection delays on arterial and local roads using these GPS data
- Earthrise Technology (small-business enterprise)
  - Provide vehicle on-board diagnostics and telematics devices
  - Provide software development and technical support services related to its devices
- Automatiks (small-business enterprise)
  - Provide system development, configuration, and installation of the in-vehicle device and its wireless connectivity with the system server

Collaborations (3)

- Riverside Transit Agency (local government)
  - Allow a subset of its paratransit fleet to be equipped with the system technology
  - Provide staff support during the field operation test of the system
- California Department of Transportation (state government)
  - Allow selected passenger cars from its extensive vehicle fleet to be equipped with the system
  - Provide staff support during the field operation test of the system
- University of California Berkeley (university)
  - Provide input into the design of the system through a series of expert interviews
  - Evaluate drivers' perception towards the system through before-and-after surveys

Proposed Future Work (FY12)

- Eco-Routing Module
  - Calibrate Energy Operational Parameter Set (EOPS) for vehicles in the test fleets
  - Integrate EOPS with route planning/scheduling software
  - Perform system module testing
- Eco-Driving Feedback Module
  - Design types, properties, and media of feedback
  - Design feedback algorithms
  - Implement Eco-Driving feedback software
  - Integrate the software with OBD firmware
  - Perform system module testing

Proposed Future Work (FY13)

- Eco-Score and Eco-Rank Module
  - Design Eco-Score and Eco-Rank calculation algorithms
  - Design module's user interfaces
  - Implement Eco-Score and Eco-Rank module software
  - Perform system module testing
- Algorithm Updating Module
  - Design algorithm updating methodologies
  - Design module's user interfaces
  - Implement algorithm updating module software
  - Perform system module testing
- System Integration
  - Set up system server and communication links
  - Perform full system testing

Summary

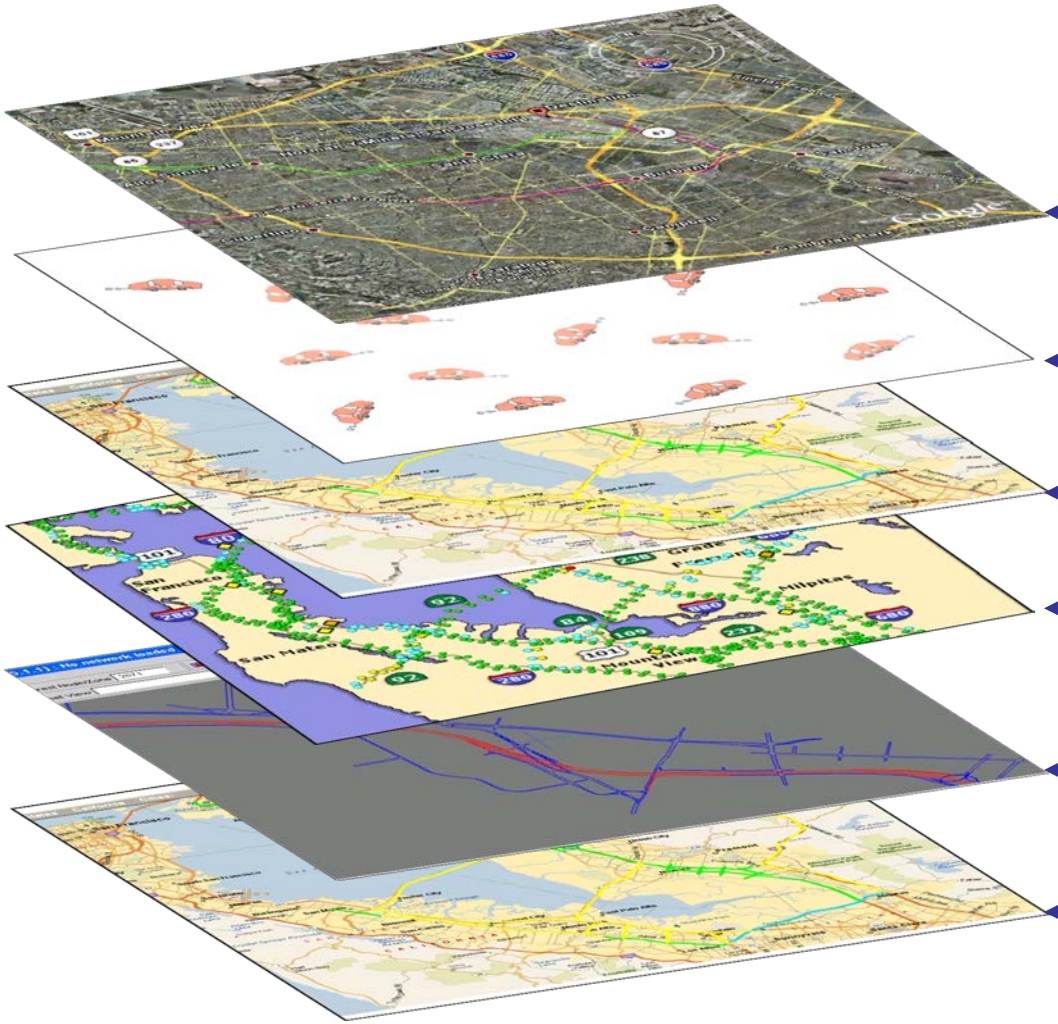
- The proposed driver feedback system are designed to improve fuel efficiency of vehicles in multiple processes of trip-making, from planning to routing to driving.

- The research team possesses strong collaborations between academic institutions, corporations, small-business enterprises, and state and local governments.

- The research team is well positioned for work planned next year.

Technical Back-Up Slides

Dynamic Roadway Network (DynaNet)



Google Earth or Google Maps interfaces

Real-time probe vehicle data (for freeways and surface streets)

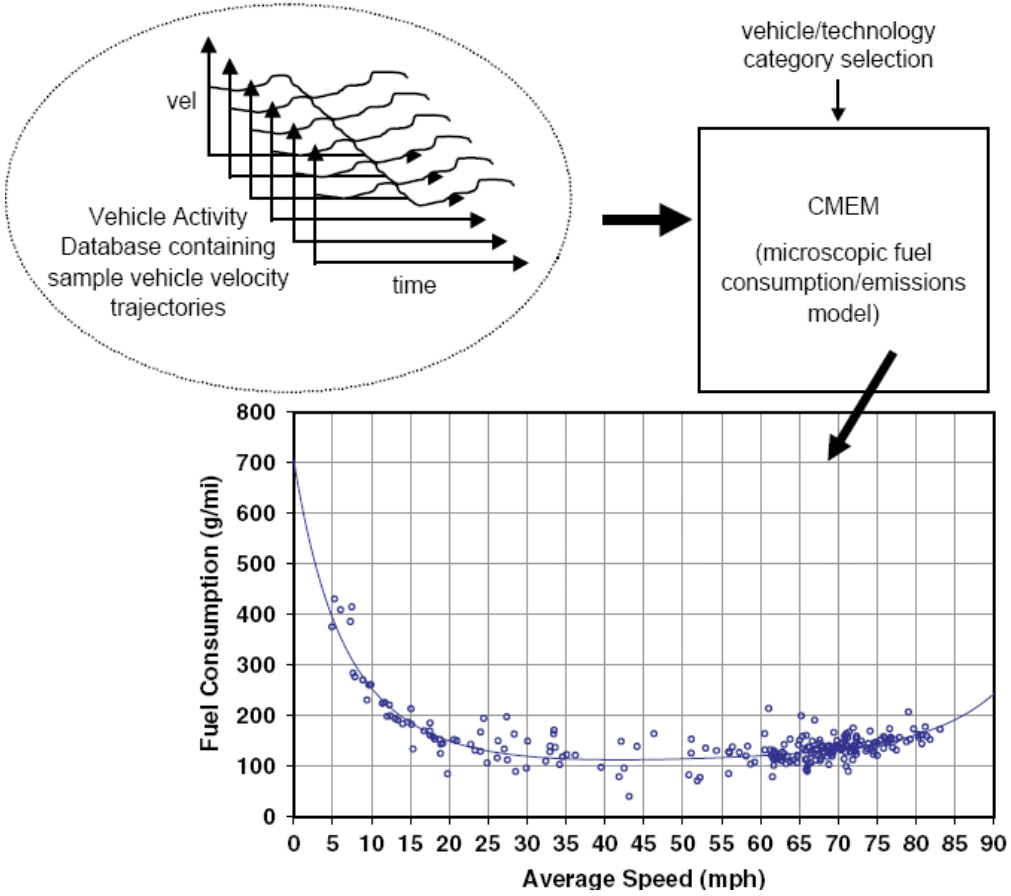
Real-time data from other sources

Real-time PeMS data (for freeways)

Historical data from travel demand or traffic simulation models

Underlying digital roadway network with speed limit info

Energy Operational Parameter Set (EOPS)



$$\ln(f_k) = \beta_0 + \beta_1 v_k + \beta_2 v_k^2 + \beta_3 v_k^3 + \beta_4 v_k^4 + \beta_5 g_k$$

	Coefficient	Standard Error	*t* Stat	*p*-value
β_0	6.804318E+00	5.32E-02	128.0	0
β_1	-1.402186E-01	7.32E-03	-19.2	2.07E-78
β_2	3.921384E-03	3.14E-04	12.5	3.42E-35
β_3	-5.197728E-05	5.15E-06	-10.1	1.15E-23
β_4	2.573800E-07	2.85E-08	9.0	2.74E-19
β_5	1.372520E-01	8.65E-04	158.7	0