UCR College of Engineering- Center for Environmental Research & Technology

2014 DOE Vehicle Technologies Program Review Presentation

Next Generation Environmentally-Friendly Driving Feedback Systems Research and Development

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Project ID #
VSS086

This presentation does not contain any proprietary, confidential, or otherwise restricted information

Overview

- ***Timeline***
  - Start 10/1/2011
  - End 9/30/2014
  - 80% complete
- ***Budget***
  - Total project funding
    - DOE – $1,210,235
    - Contractor – $665,472
  - DOE funding in FY13
    - Received $376,301
    - Expended $333,166
  - DOE funding for FY14
    - Received $320,803
    - Expended $133,846*

*Through Feb 2014

- ***Barriers***
  - Public acceptance
  - Safety concern
  - Cost Effectiveness
- **Partners**
  - ESRI
  - NAVTEQ
  - Beat the Traffic
  - Earthrise Technology
  - Automatiks
  - U. of California Berkeley
  - Riverside Transit Agency (RTA)
  - California Department of Transportation (Caltrans)

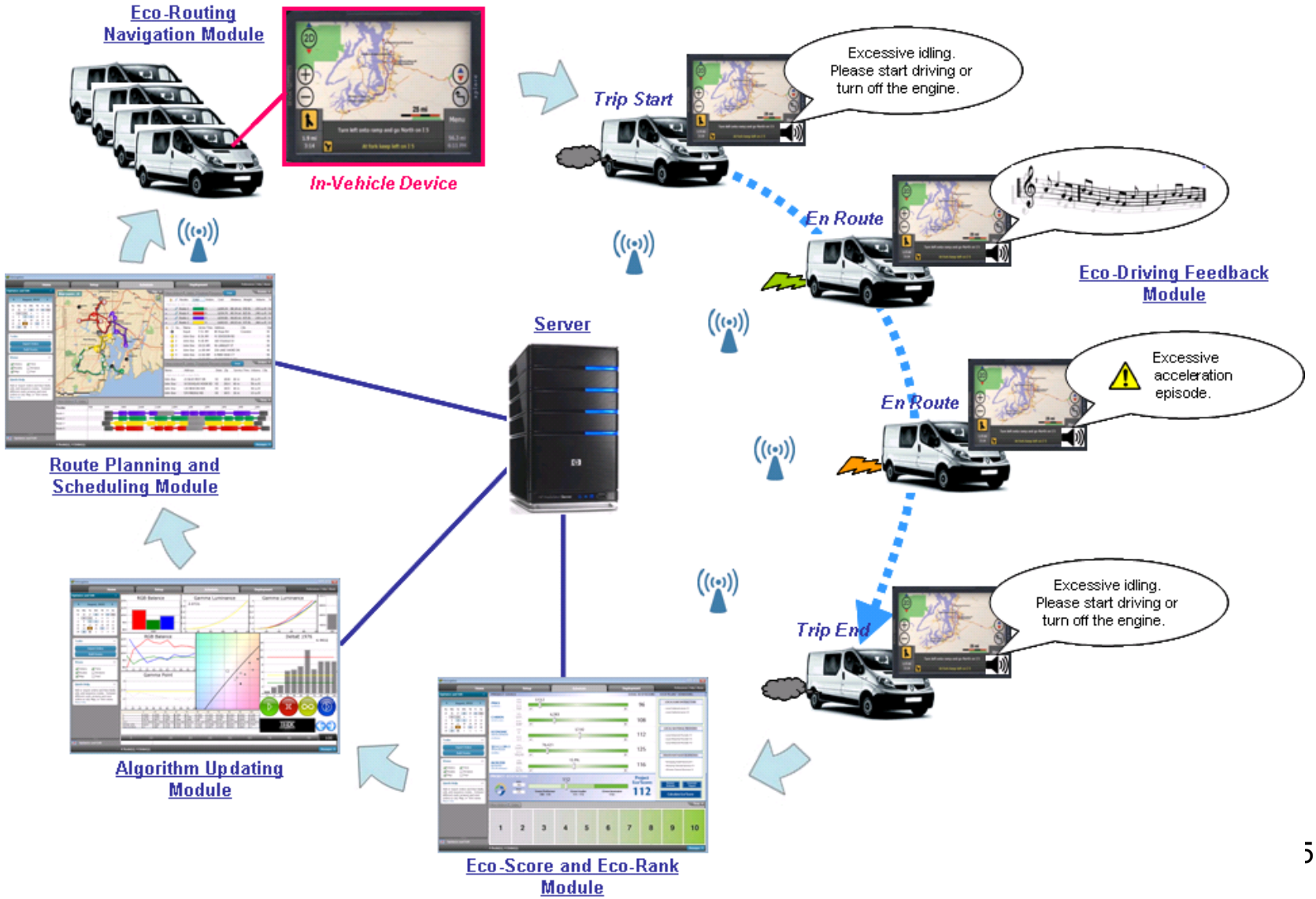
Relevance

- Overall project goal
  - To design, develop, and demonstrate a next-generation driving feedback system that will:
    - Improve fuel efficiency of the fleet of passenger cars and commercial vehicles by at least 2%,
    - Comply with federal safety and emissions regulations, and
    - Deployable across existing vehicle fleets.
- Project objectives over the past year (March 2013 – March 2014)
  - Complete the last module of the system
    - Eco-Score and Eco-Rank
  - Complete system integration
  - Perform system demonstration
  - Begin the field operation test

Approach (1)

- Offer and encourage fuel-efficient choices to drivers/fleet operators in multiple aspects of their vehicular travel:
  - Eco-Trip Scheduling module allows fleets to plan a sequence of stops (e.g., for delivery) that is most fuel efficient.
  - Eco-Routing Navigation module suggests the most fuel-efficient route from one stop to the next.
  - Eco-Driving Feedback module provides sensible information, recommendation, and warning for fuel-efficient vehicle operation.
  - Eco-Score and Eco-Rank module provides platform for driving performance tracking, self-evaluation, and peer comparison.
- Fuel savings from individual modules can add up.
- The modules make use of real-time information, high-performance computation, and advanced analytics.

Approach (2)


Eco-Routing Navigation Module
In-Vehicle Device
Trip Start
Excessive idling. Please start driving or turn off the engine.
En Route
Eco-Driving Feedback Module
Server
Excessive acceleration episode.
En Route
Route Planning and Scheduling Module
Trip End
Excessive idling. Please start driving or turn off the engine.
Algorithm Updating Module
Eco-Score and Eco-Rank Module

Approach (3)

- Years 1 & 2 for research and development.
- Year 3 for field operational test (FOT) and evaluation of system benefits.
- FOT on 45 vehicles from three fleets with different characteristics.
  - 15 paratransit shuttles of Riverside Transit Agency
    - 2012 Ford E-450
    - Operated 8-12 hours a day on weekdays

  - 15 pickup trucks of California Department of Transportation
    - 2008 Chevy Silverado C15
    - Assigned to individual employees for business use

  - 15 private vehicles of general public
    - Varied make, model, year
    - Varied usage patterns and driver demographics

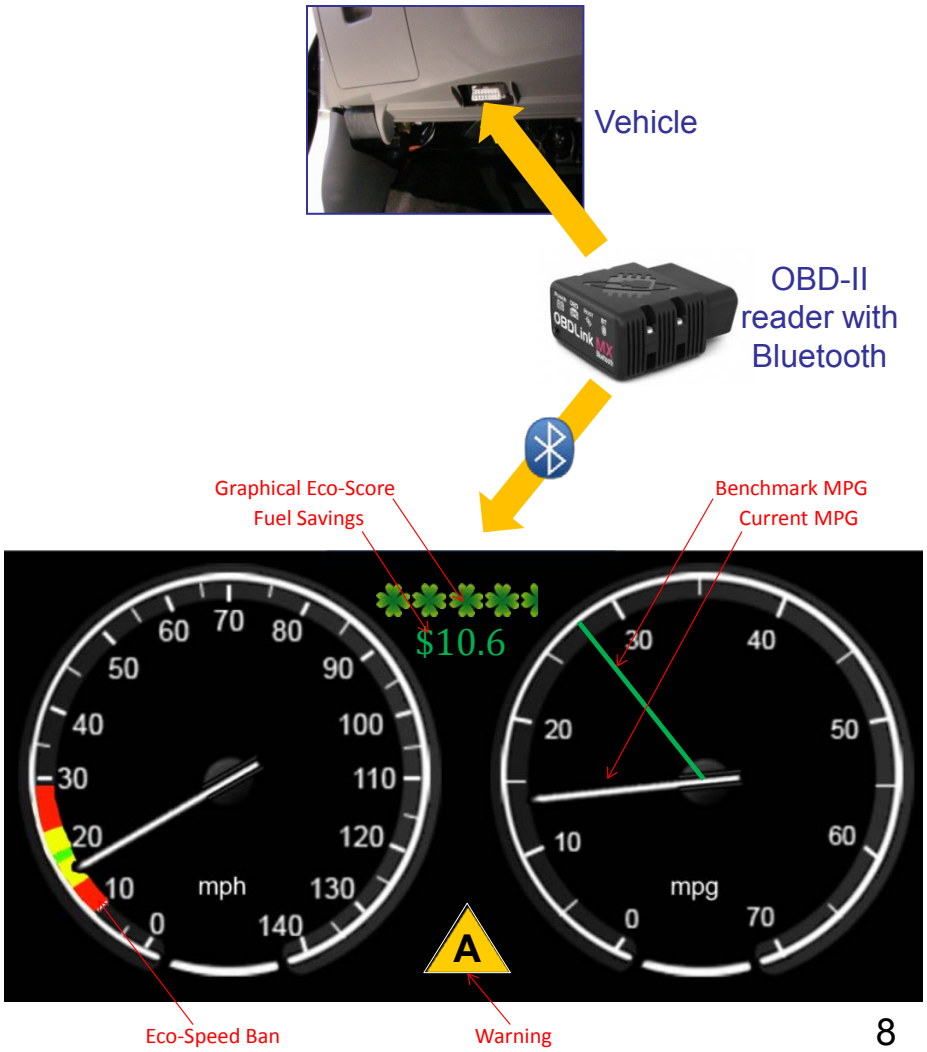
Approach (4)

- Milestones for FY13 and FY14

Month/Year	Milestones	Status
Dec 2012	Complete Eco-Driving Feedback Module	Completed
Feb 2013	Complete Eco-Routing Navigation Module	Completed
Mar 2013	Complete Eco-Score and Eco-Rank Module	Completed
May 2013	Complete system integration design	Completed
Jul 2013	Complete system integration with testbed vehicle	Completed
Sep 2013	Demonstrate the system	Completed
Dec 2013	Complete system installation in vehicles participating in field operational test	Completed

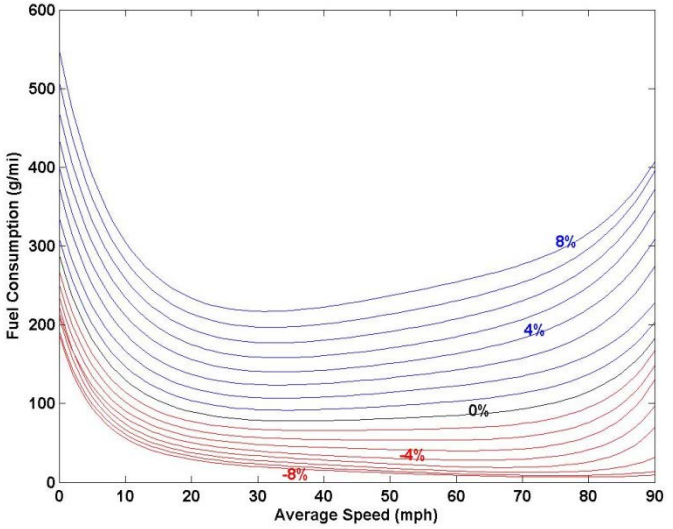
Technical Accomplishments (1)

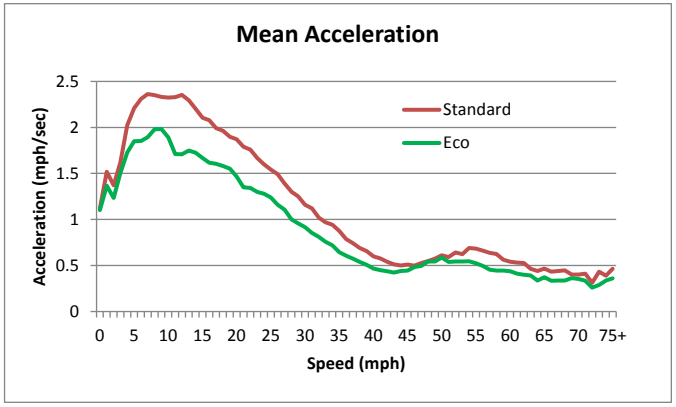
- Eco-Driving Feedback
  - Eco-speed band
  - Warnings
    - Aggressive acceleration
    - Hard braking
    - Excessive idling
  - Fuel efficiency
  - Cumulative fuel savings
- Feedback based on:
  - Actual fuel use
  - Driver's actions
  - Real-time traffic
  - Road slope

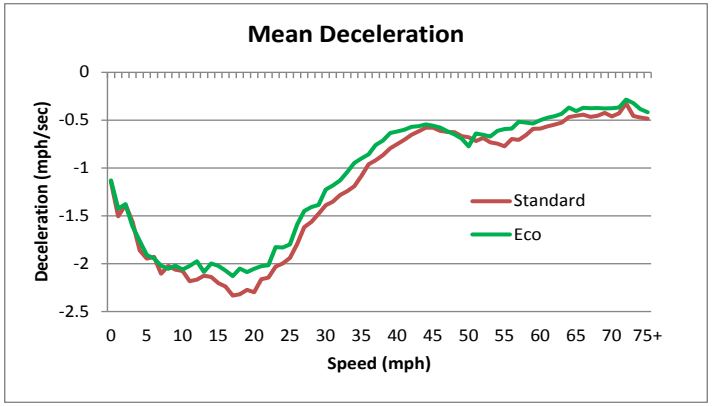


Technical Accomplishments (2)

- Eco-Score logics
  - Not penalize drivers for stuck in traffic congestion
  - Not penalize drivers for non-discretionary idling (e.g., at red lights
  - Encourage milder acceleration and braking

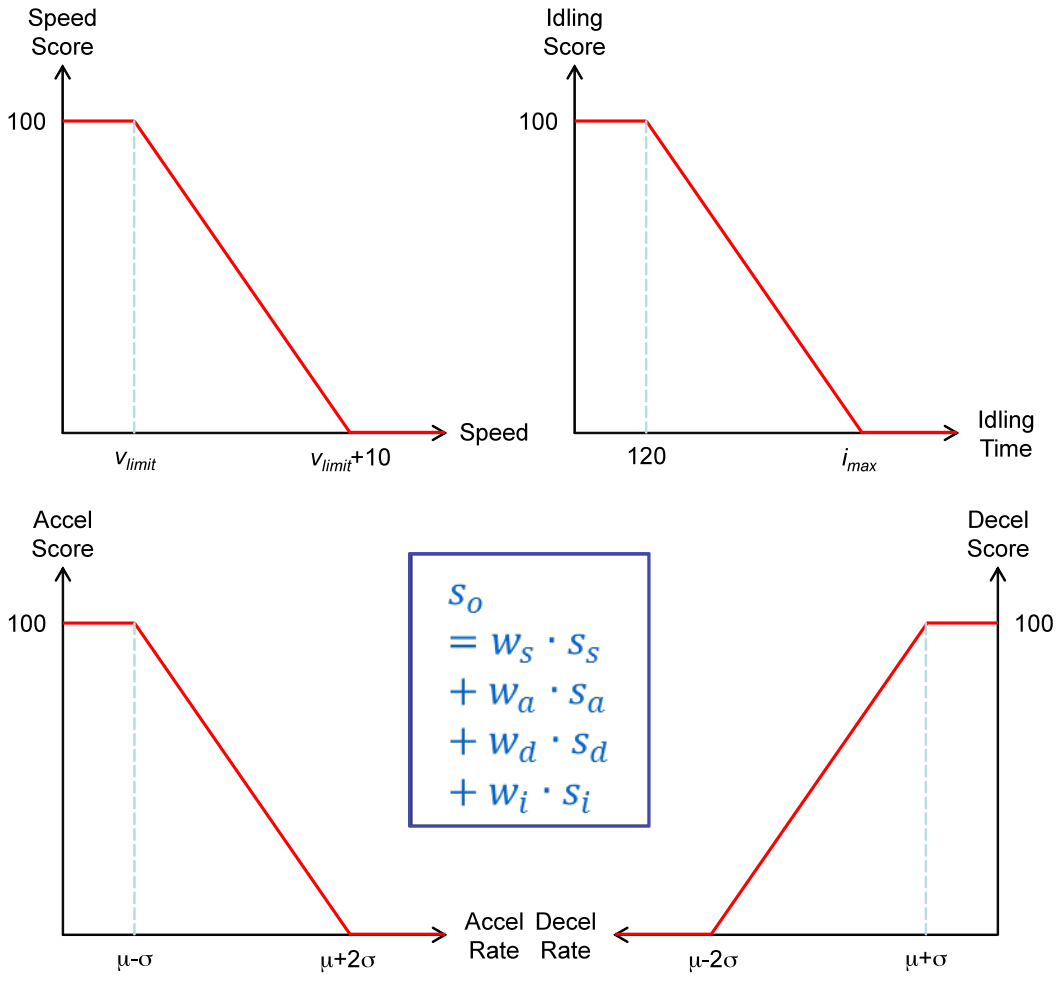






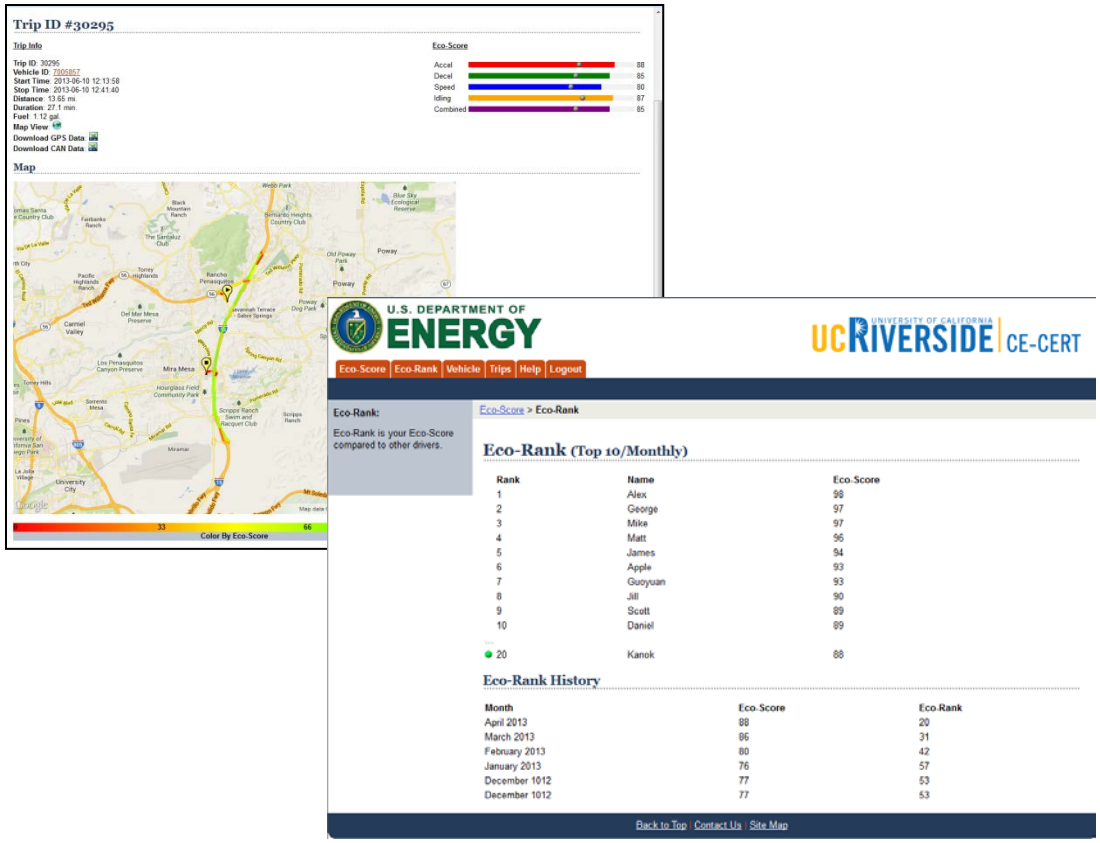
Technical Accomplishments (3)

- Eco-Score algorithms
  - Speed score (s_s)
  - Idling score (s_i)
  - Acceleration score (s_a)
  - Deceleration score (s_d)
  - Overall score (s_o)
- Score aggregation
  - Individual scores calculated second-by-second
  - Second-by-second scores averaged for any time periods (trip, day, week, lifetime, etc.)



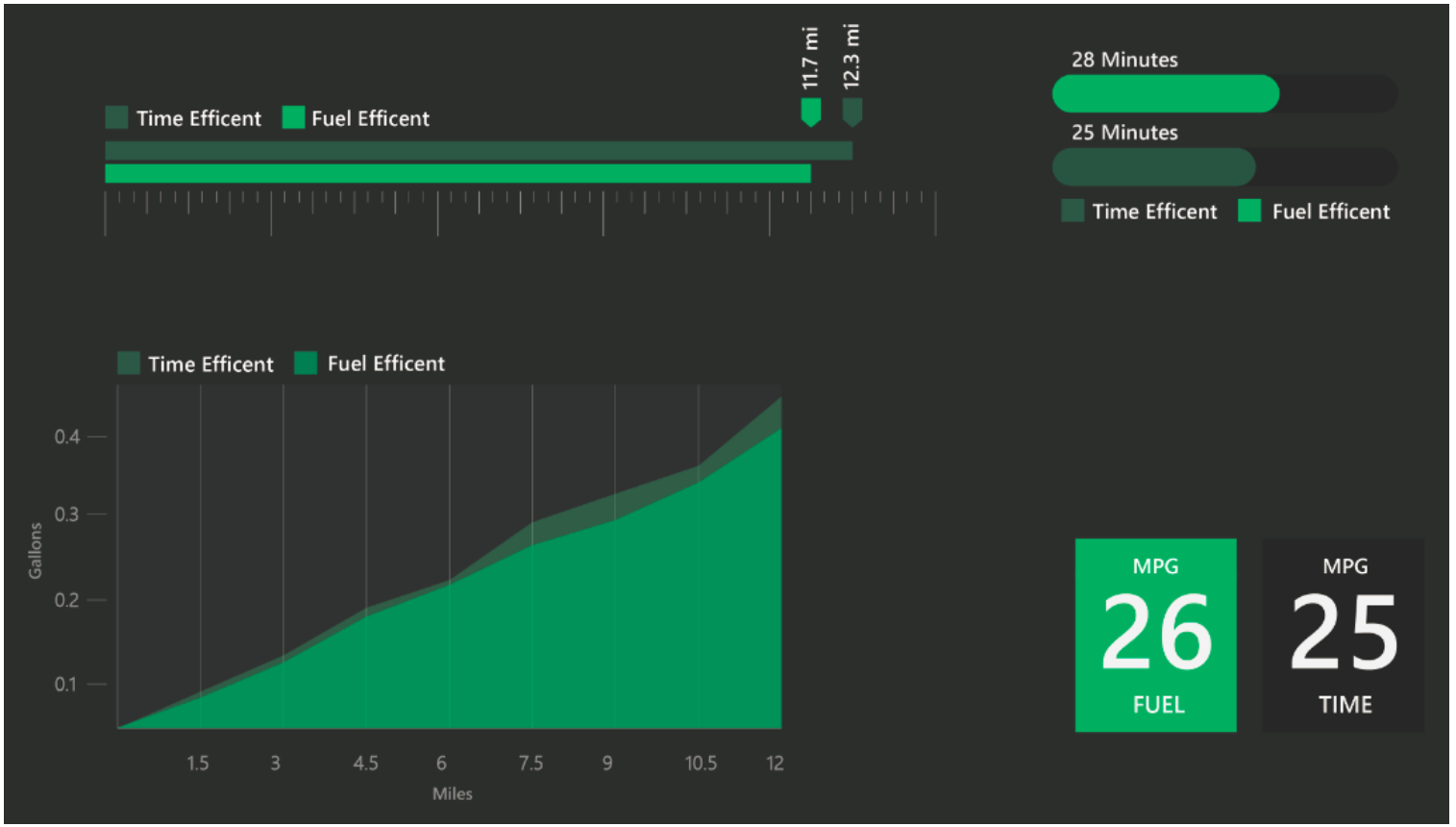
Technical Accomplishments (4)

- Eco-Score & Eco-Rank web application
- Ranking based on the overall Eco-Score
- Ranking period
  - Monthly
  - Annually
  - Etc.
- Comparing drivers
  - Same fleets
  - Same units in a fleet
  - Same vehicles
  - Private leagues
  - Etc.



Technical Accomplishments (5)

- System integration
- System demonstration



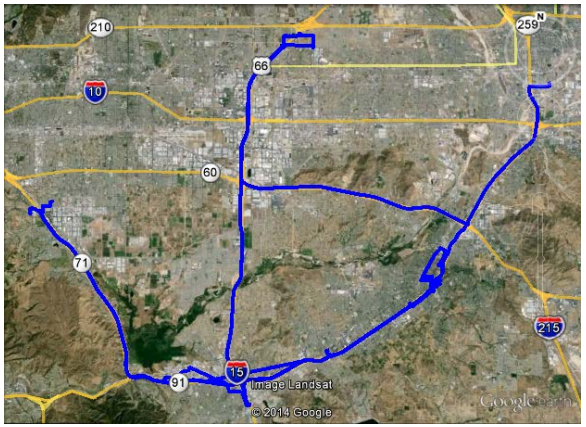
Technical Accomplishments (6)

- Baseline data – 3 weeks data for Caltrans vehicles

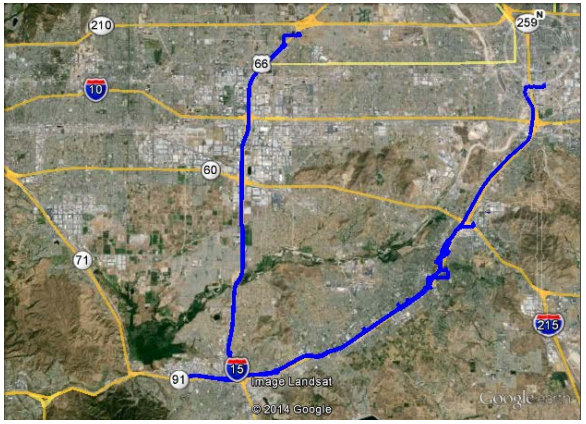
Summary Statistics

Vehicle ID	No. of Trips	Distance (miles)	Duration (minutes)	Fuel Use (gallons)	Average Speed (mph)	MPG
7004942t05	28	701	895	30	47	23
7004955t06	111	606	1889	40	19	15
7004959t10	31	683	1627	51	25	13
7004957t07	69	1492	2376	73	37	20
7004951t04	4	30	43	2	43	15
7004956t08	65	1034	1377	39	45	27
7004948t02	56	120	467	8	15	15
7004949t01	91	659	2291	45	17	15
7004945t03	19	700	772	31	54	23
7004922t09	41	803	1181	31	40	26
7004962t11	16	118	220	5	32	24
7004958t13	18	73	130	3	34	24

Trip Patterns - 7004955t06



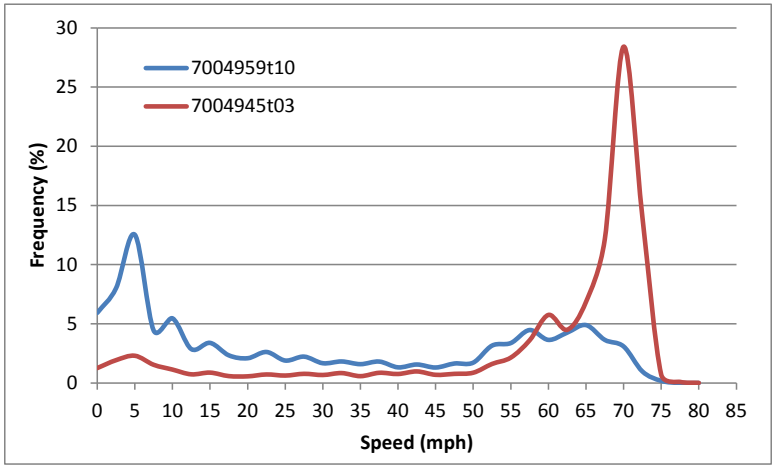
Trip Patterns - 7004949t01



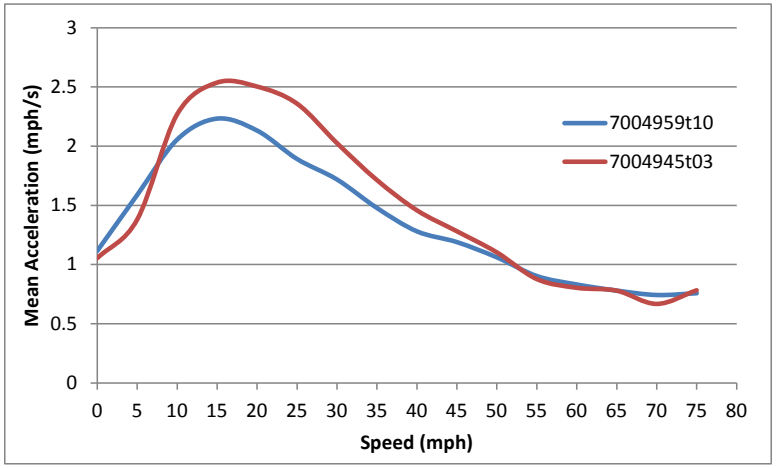
Technical Accomplishments (7)

- Baseline data – 3 weeks data for Caltrans vehicles
  - Same vehicle make, model, year
  - Different drivers
  - Different trip patterns
  - Different driving behaviors

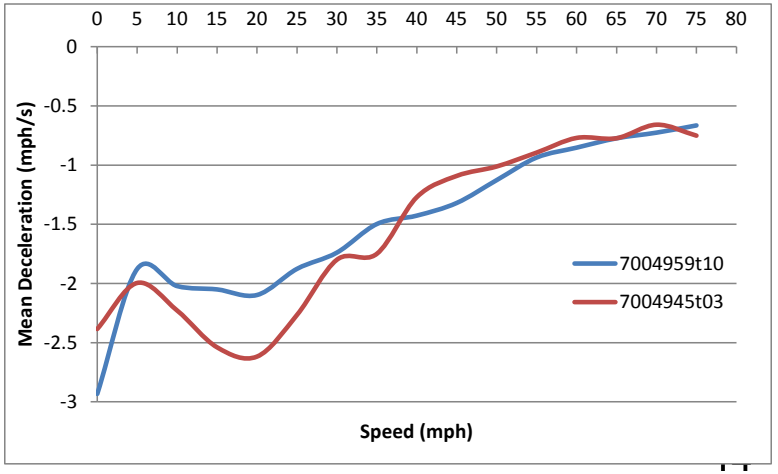
Speed Distribution



Mean Acceleration Profile



Mean Deceleration Profile



Responses to Previous Year Reviewers' Key Comments (1)

- "It was not clear how many drivers would be involved, how they would be selected, and what controls would be established."
  - At the time, the fleet and driver selection was in flux. Slide #6 of this presentation now describes the number of drivers from each of the three fleets.
- "…also unclear if individual drivers in a fleet were being tracked."
  - Individual drivers are tracked for both fleet and consumer vehicles.
- "…the project did not seem to control variables such as miles driven, route, duty cycle, terrain, routing, climate, traffic conditions, and weight of load carried, …the last variable has a tremendous effect on fuel consumption …"
  - It is correct that fuel efficiency can be affected by all these variables. The system includes Eco-Score as a measure of fuel-efficient "driving behaviors". Eco-Score is independent of the variables mentioned above.
  - For the paratransit fleet, the project team has access to trip scheduling database, i.e., knowing the number of passengers in the vehicles at any point in time.

Collaborations & Coordination (1)

- Collaborations within the project
  - U. of California Riverside (university; prime contractor)
    - Conduct system R&D, lead system testing & evaluation
  - Esri (industry)
    - Provide trip scheduling & GIS software and technical support
  - NAVTEQ (industry)
    - Provide 3D digital map and real-time & historical traffic data
  - Beat the Traffic (small-business enterprise)
    - Model intersection delays using smartphone-based GPS data
  - Earthrise Technology (small-business enterprise)
    - Develop OBD-II interface software and provide technical support
  - Automatiks (small-business enterprise)
    - Configure connectivity between in-vehicle device and system server

Collaborations & Coordination (2)

- Collaborations within the project (continued)
  - Riverside Transit Agency (local government)
    - Provide fleet and staff support for system field operational test
  - California Department of Transportation (state government)
    - Provide fleet and staff support for system field operational test
  - University of California Berkeley (university)
    - Conduct expert interviews and drivers' perception surveys
- Coordination with other research programs
  - Eco-Driving research of the U. of California's Multi-campus Research Program and Initiative (MRPI)
  - Applications for the Environment: Real-Time Information Synthesis (AERIS) research of the Federal Highway Administration

Collaborations & Coordination (3)

- Collaborations outside the project
  - Worked with Nissan to develop method for quantifying fuel saving/GHG reduction benefits of eco-driving technologies
  - Interviewed 11 experts to obtain inputs for system design
    - California Department of Transportation [fleet management]
    - Daimler Trucks [R&D]
    - Environmental Protection Agency (2 experts) [policy]
    - Environmental systems Research Institute [R&D]
    - General Motors [R&D]
    - National Renewable Energy Laboratory [R&D]
    - Riverside Transit Agency [fleet management]
    - Westat [consulting]
    - University of Minnesota, HumanFIRST Program [R&D]
    - U.S. Department of Transportation [policy]

Proposed Future Work

- Field operational test
  - Complete the 2-month collection “baseline” driving data without feedback system
  - Install the driving feedback system
  - Collect driving data with feedback system for 2 months
  - Conduct driver opinion surveys
- System evaluation
  - Establish evaluation metrics
  - Analyze collected data without and with feedback system
    - Determine system performance, fuel savings, and cost effectiveness
  - Analyze driver opinion surveys
    - Determine driver acceptance
  - Identify strengths and areas for future improvement

Summary

- Relevance
  - Technology targeted at improving fuel efficiency of the existing fleet by at least 2% (and potentially much higher)
- Approach
  - Cost-effective system that encourages fuel-efficient choices in trip scheduling, route selection, and vehicle operation
- Technical Accomplishments
  - Completed research & development
  - Completed system integration and demonstration
- Collaborations
  - Wide range of collaborators both inside and outside the project
- Future Work
  - To complete field operational test and system evaluation