2014 DOE Vehicle Technologies
Program Review Presentation

Next Generation Environmentally-Friendly Driving Feedback Systems Research and Development

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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*

• **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)

*Through Feb 2014
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 (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

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<tr>
<th>Month/Year</th>
<th>Milestones</th>
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<td>Dec 2012</td>
<td>Complete Eco-Driving Feedback Module</td>
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<tr>
<td>Feb 2013</td>
<td>Complete Eco-Routing Navigation Module</td>
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<td>Mar 2013</td>
<td>Complete Eco-Score and Eco-Rank Module</td>
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<tr>
<td>May 2013</td>
<td>Complete system integration design</td>
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<td>Jul 2013</td>
<td>Complete system integration with testbed vehicle</td>
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<td>Sep 2013</td>
<td>Demonstrate the system</td>
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<tr>
<td>Dec 2013</td>
<td>Complete system installation in vehicles participating in field operational test</td>
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Technical Accomplishments (1)

• Eco-Driver 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

![Graph showing efficiency comparison between time and fuel consumption](image)
Technical Accomplishments (6)

- Baseline data – 3 weeks data for Caltrans vehicles

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Technical Accomplishments (7)

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