Next Generation Environmentally-Friendly Driving Feedback Systems Research and Development

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• **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.

• **Partners:**
  – ESRI
  – NAVTEQ
  – Beat the Traffic
  – Earthrise Technology
  – Automatiks
  – U. of California Berkeley
  – Riverside Transit Agency (RTA)
  – California Department of Transportation (Caltrans)
Approach: *integrated feedback system*
Approach: integrated feedback system

- 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.
**Research, Development, and Deployment Timeline**

- 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
Eco-Routing Navigation Module
Eco-Driving Feedback Module

- Eco-Driving Feedback to Driver
  - 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
Feedback System on RTA Bus
Eco-Score Module (1)

- **Eco-Score logic**
  - 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
Eco-Score Module (2)

- **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.)
Web-Applications

- 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 (videos)

• System integration
• System demonstration
Preliminary Results

**MPG (City)**

- Fuel Economy (mpg) vs. Bus ID
- Baseline and Feedback

**MPG (Highway)**

- Fuel Economy (mpg) vs. Bus ID
- Baseline and Feedback

**Overall Eco-Score (City)**

- Overall Eco-Score vs. Bus ID
- Baseline and Feedback

**Overall Eco-Score (Highway)**

- Overall Eco-Score vs. Bus ID
- Baseline and Feedback
Bus 320 Comparison Results (City)

**Acceleration (City)**

- Baseline
- Feedback

**Deceleration (City)**

- Baseline
- Feedback

**Speed Frequency (City)**

- Baseline
- Feedback

**Eco-Scores (City)**

- Baseline
- Feedback
Bus 320 Comparison Results (Highway)

**Acceleration (Highway)**

- Baseline
- Feedback

**Deceleration (Highway)**

- Baseline
- Feedback

**Speed Frequency (Highway)**

- Baseline
- Feedback

**Eco-Scores (Highway)**

- Baseline
- Feedback
Discussion

• Eco-scores and detailed driving profiles suggest that the feedback system seems to have the desired effect on driving behaviors of the participating bus drivers.
  – Fuel savings due to driving behavior changes to be quantified

• Current MPG numbers are affected by a number of factors such as loaded (passenger) weight, usage of air conditioning (especially in summer), etc.
  – Need to be adjusted for these factors using a methodology that has already been developed

• Remaining work
  – FOT to be completed end of October
  – Data processing and analysis to be completed end of year
  – Final report to be completed by mid of next year
Summary

• Relevance
  – Technology targeted at improving fuel efficiency of the existing fleet by at least 2% (and potentially much higher) preliminary results show ~10%-15% improvements

• 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
  – complete field operational test and system evaluation