UCR | College of Engineering- Center for Environmental Research & Technology

Next Generation Environmentally-Friendly Driving Feedback Systems Research and Development

sponsored by
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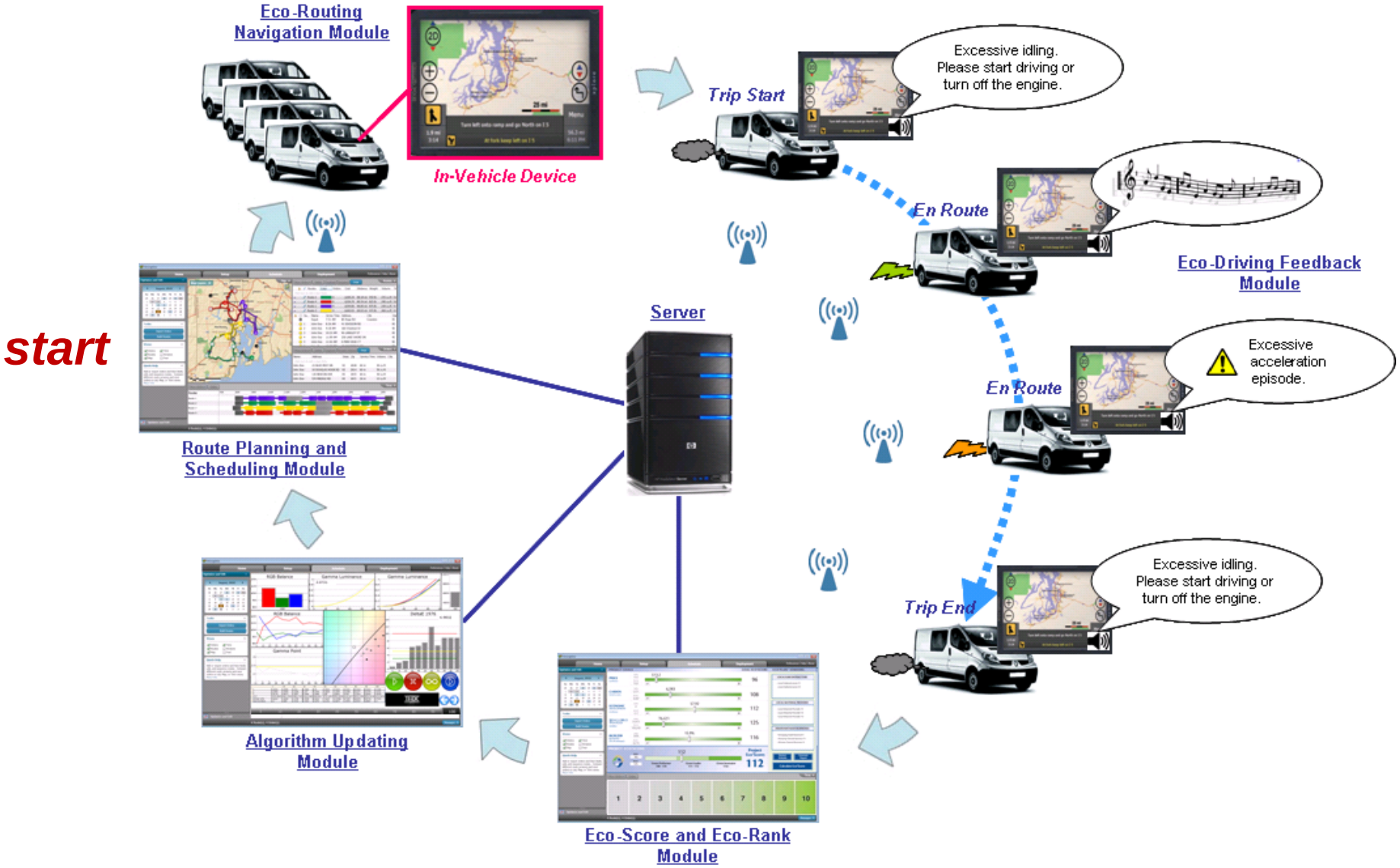
- **Overall project goal:**
  - To design, develop, and demonstrate a next-generation driving feedback system that will:
    - Improve fuel efficiency of the fleet of passenger cars and commercial vehicles by at least 2%,
    - Comply with federal safety and emissions regulations, and
    - Deployable 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.**

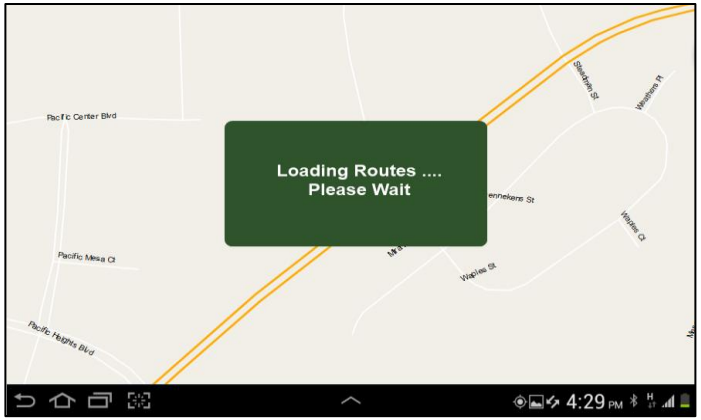
Research, Development, and Deployment Timeline

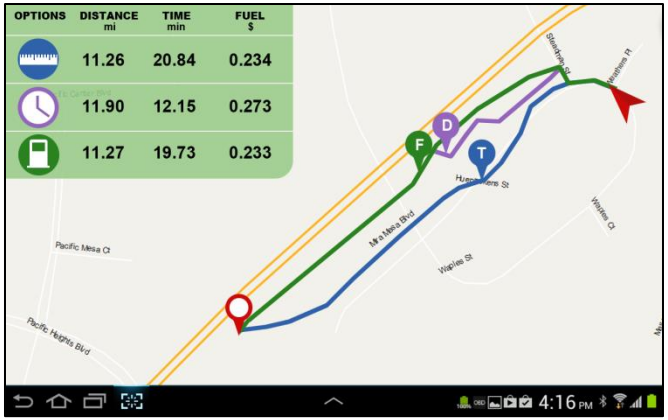
- Years 1 & 2 for research and development.
- Year 3 for field operational test (FOT) and evaluation of system benefits.
- FOT on 45 vehicles from three fleets with different characteristics.
  - 15 paratransit shuttles of Riverside Transit Agency
    - 2012 Ford E-450
    - Operated 8-12 hours a day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

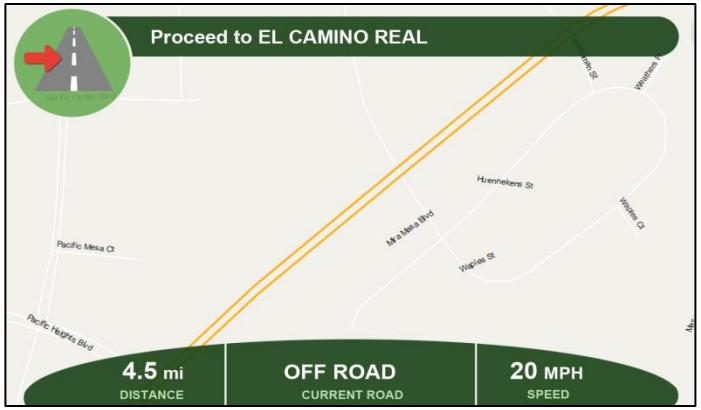
  - 15 pickup trucks of California Department of Transportation
    - 2008 Chevy Silverado C15
    - Assigned to individual employees for business use

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

Eco-Routing Navigation Module

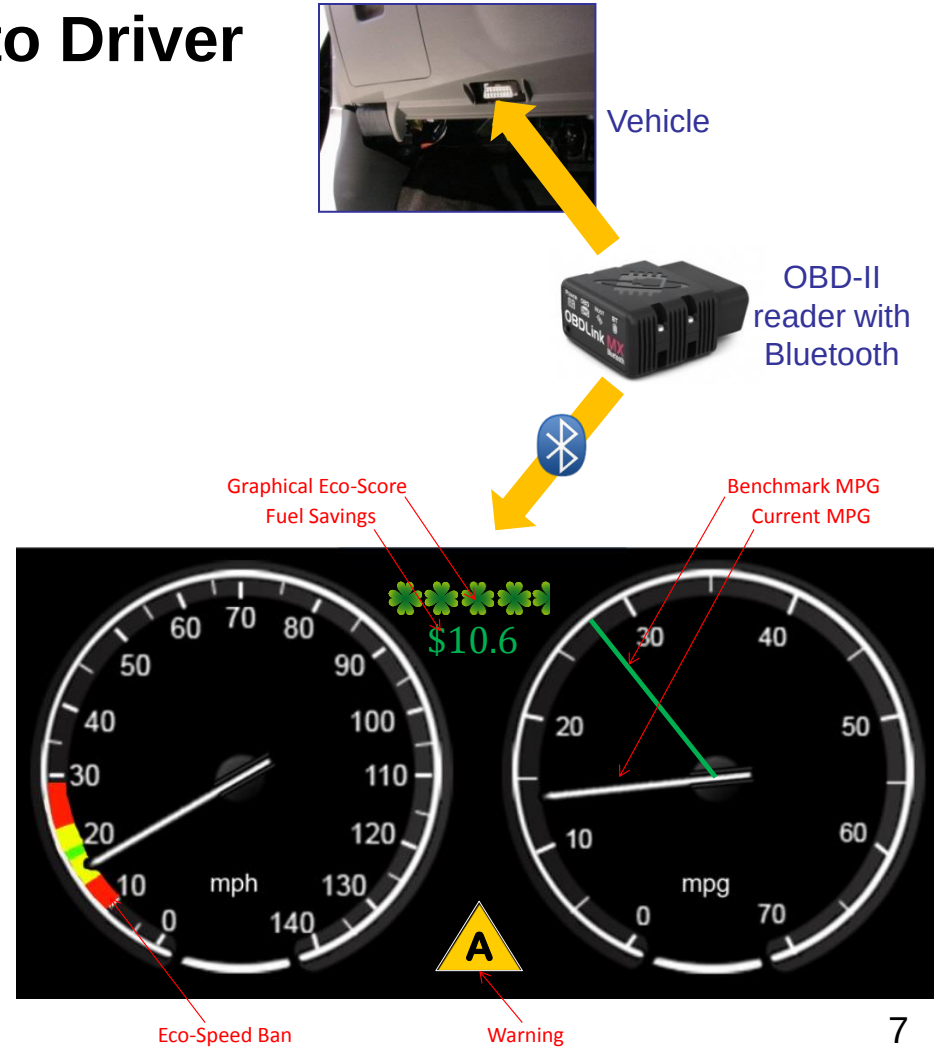






Eco-Driving Feedback Module

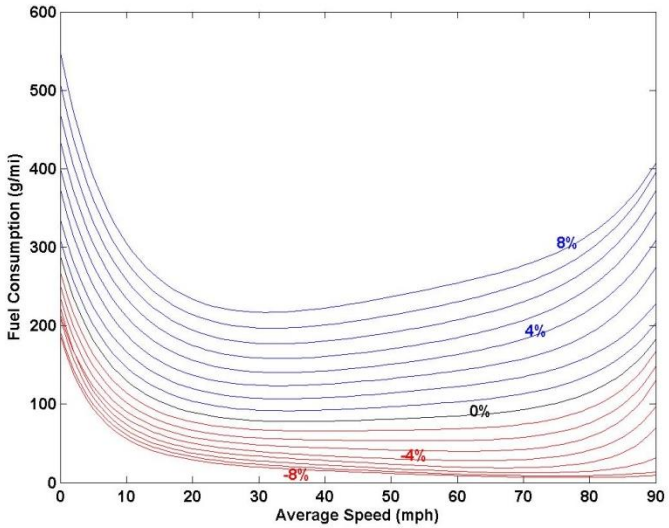
- **Eco-Driving Feedback to Driver**
  - Eco-speed band
  - Warnings
    - Aggressive acceleration
    - Hard braking
    - Excessive idling
  - Fuel efficiency
  - Cumulative fuel savings
- **Feedback based on:**
  - Actual fuel use
  - Driver's actions
  - Real-time traffic
  - Road slope

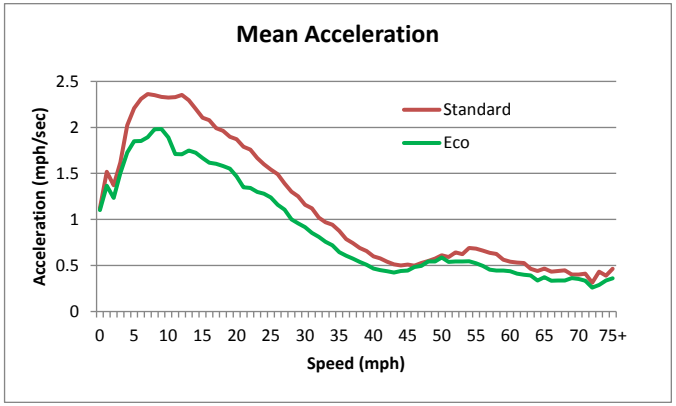


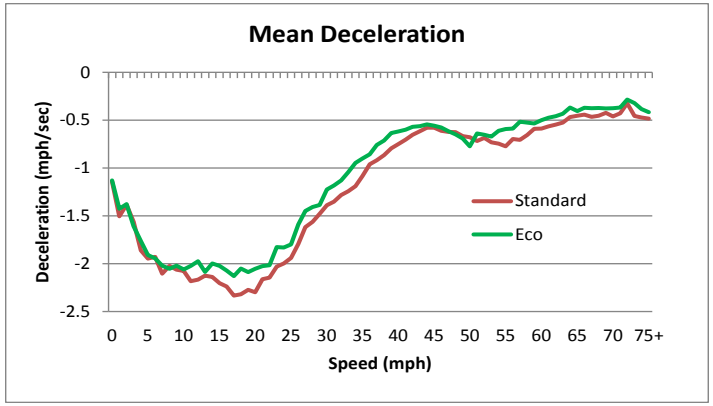
Feedback System on RTA Bus

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

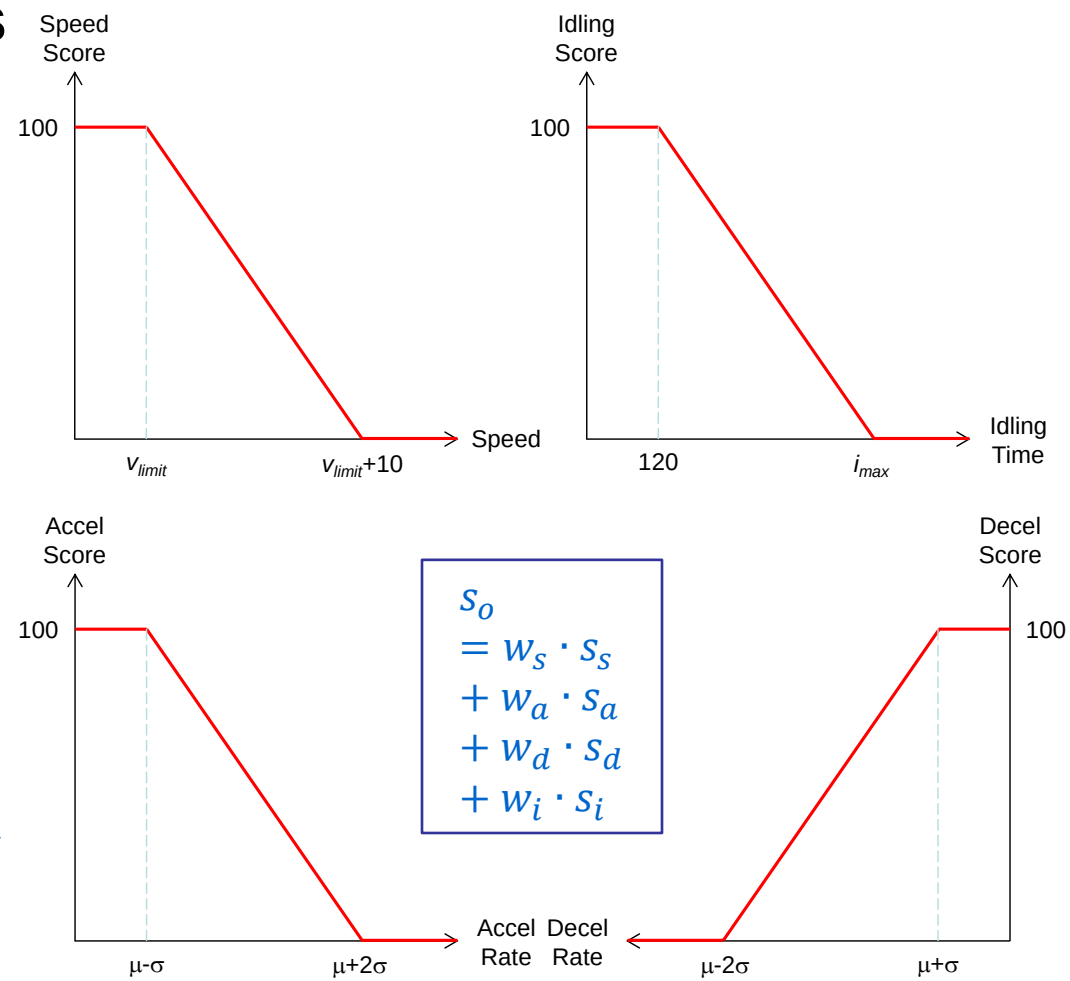






Eco-Score Module (2)

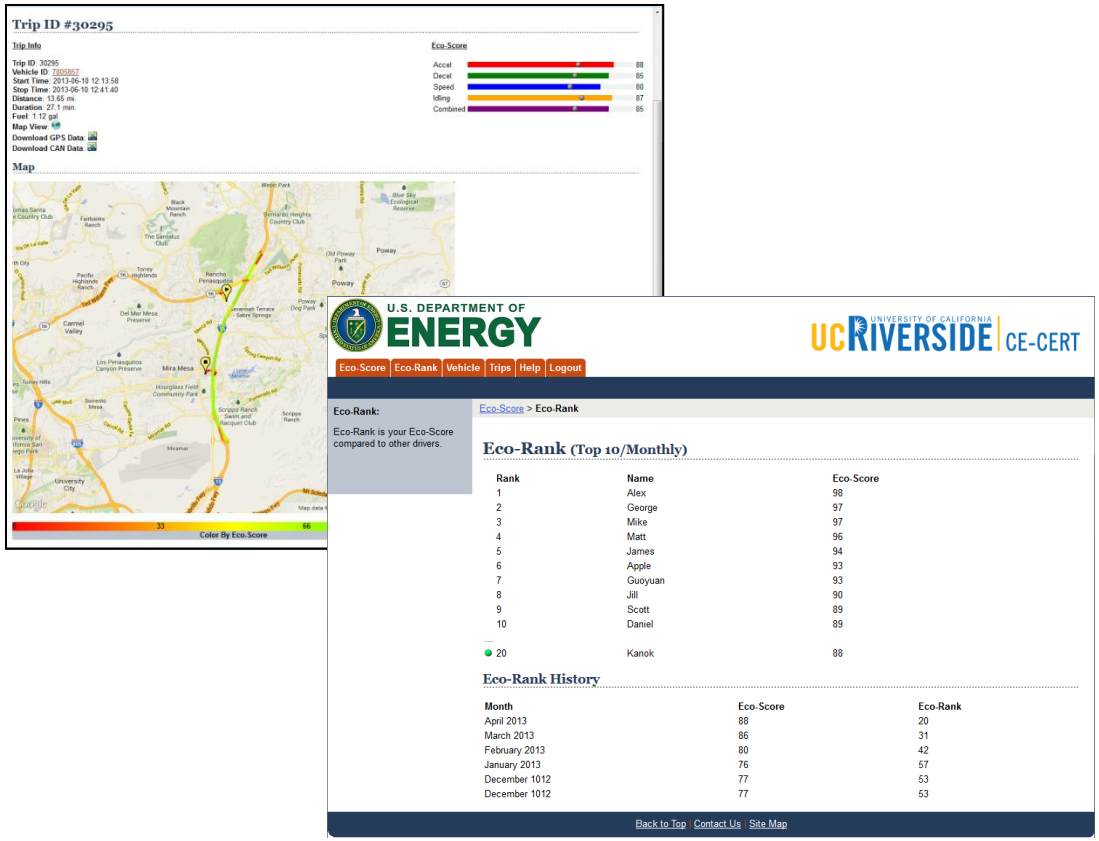
- **Eco-Score algorithms**
  - Speed score (s_s)
  - Idling score (s_i)
  - Acceleration score (s_a)
  - Deceleration score (s_d)
  - Overall score (s_o)
- **Score aggregation**
  - Individual scores calculated second-by-second
  - Second-by-second scores averaged for any time periods (trip, day, week,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



$$s_o = w_s \cdot s_s + w_a \cdot s_a + w_d \cdot s_d + w_i \cdot s_i$$

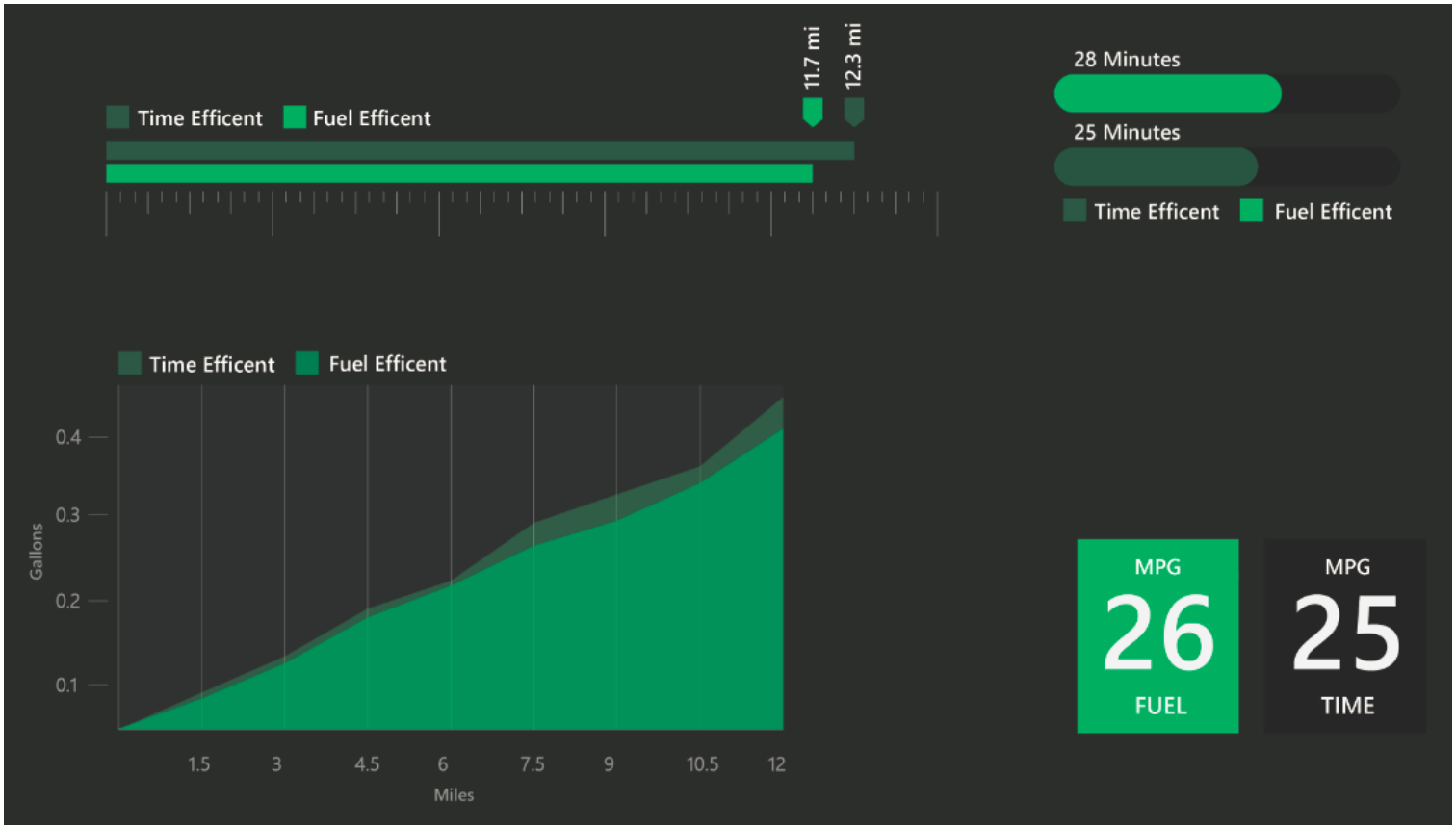
Web-Applications

- 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.

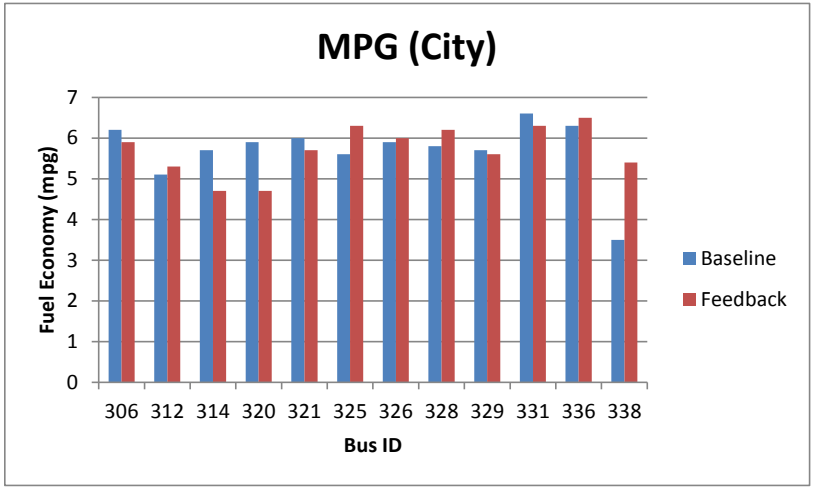


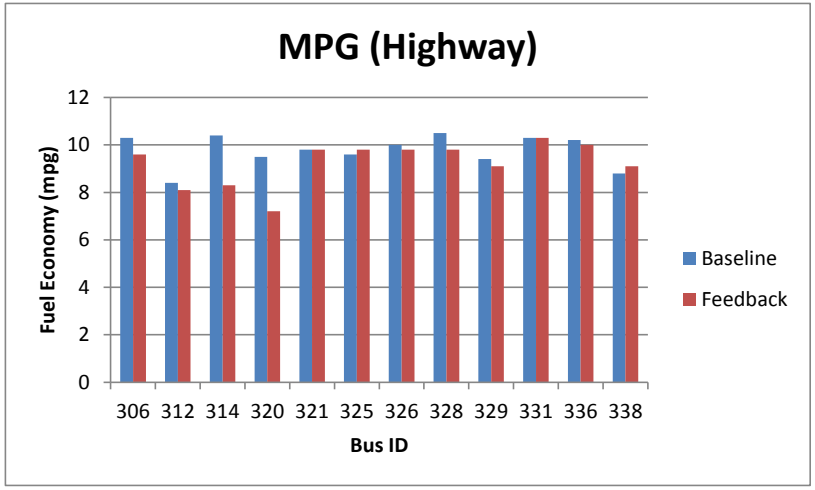
Technical Accomplishments (videos)

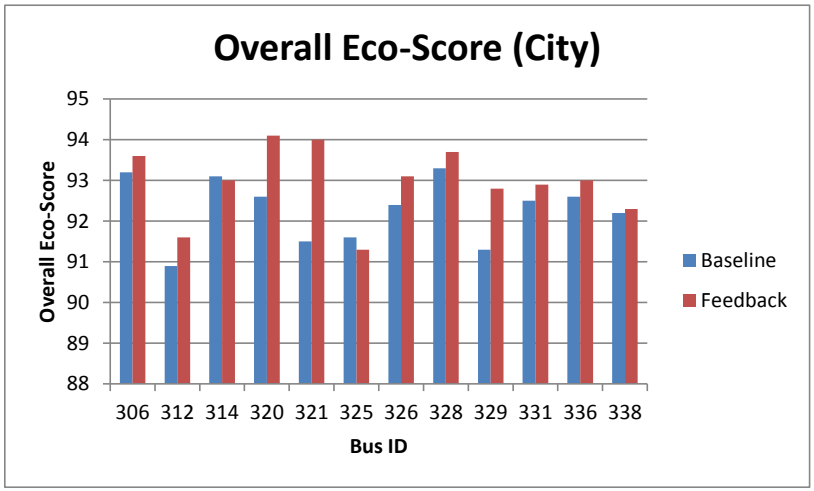
- System integration
- System demonstration

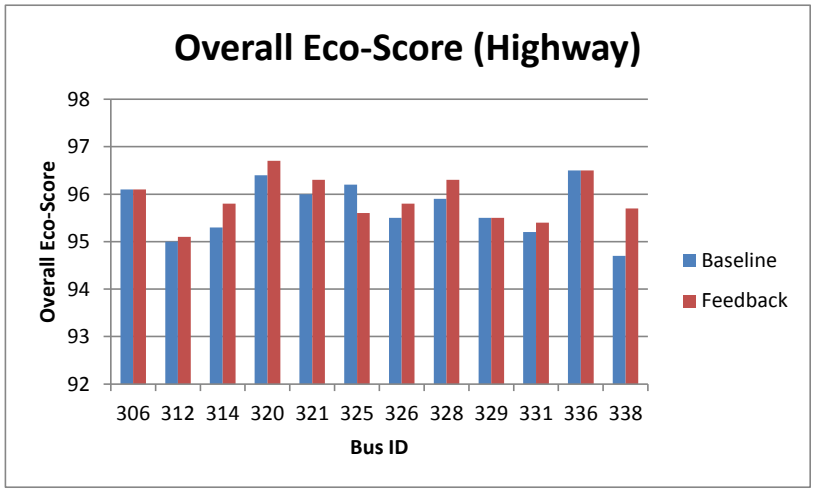


Preliminary Results

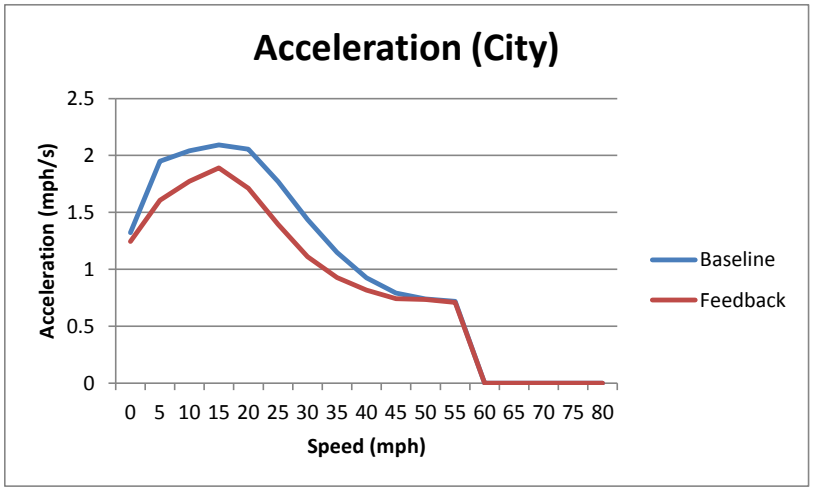


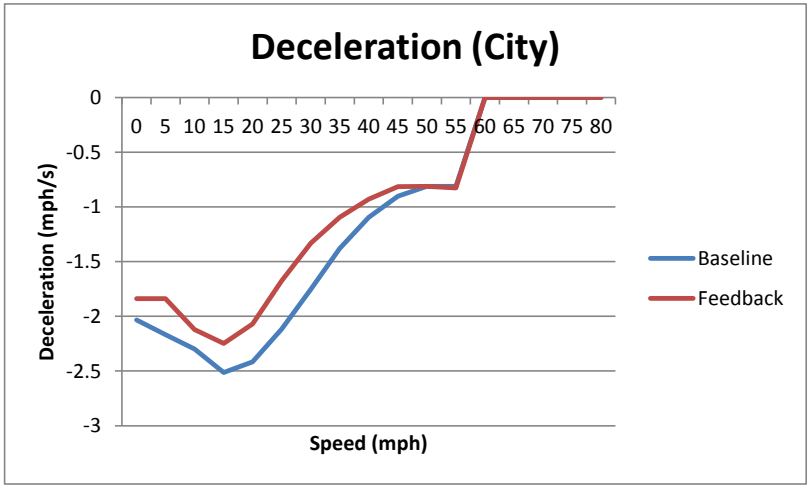


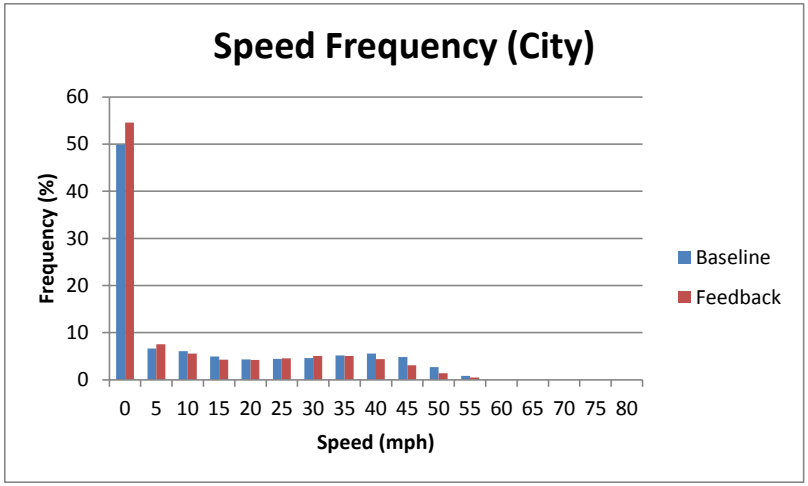


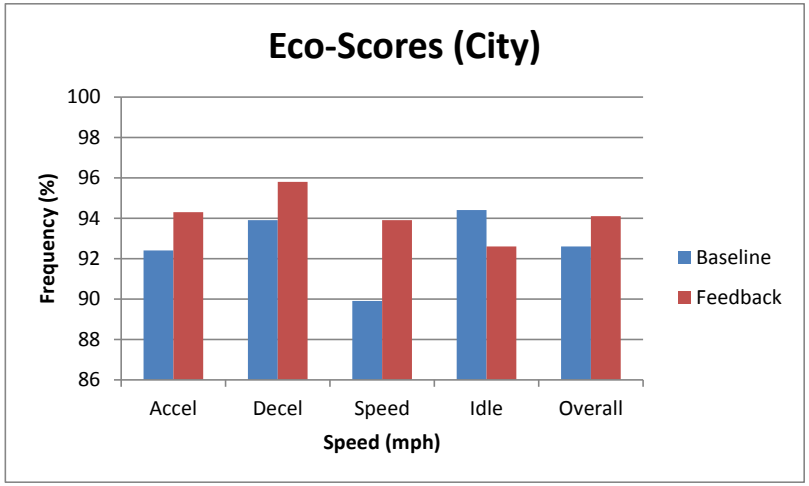


Bus 320 Comparison Results (City)

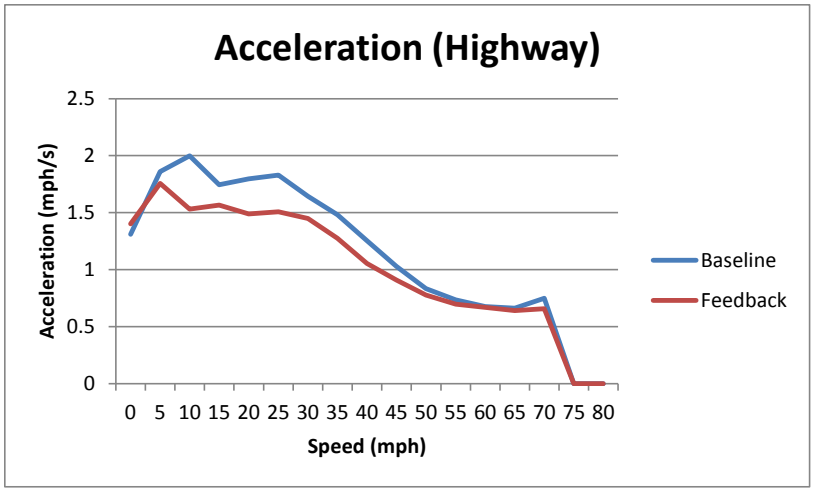


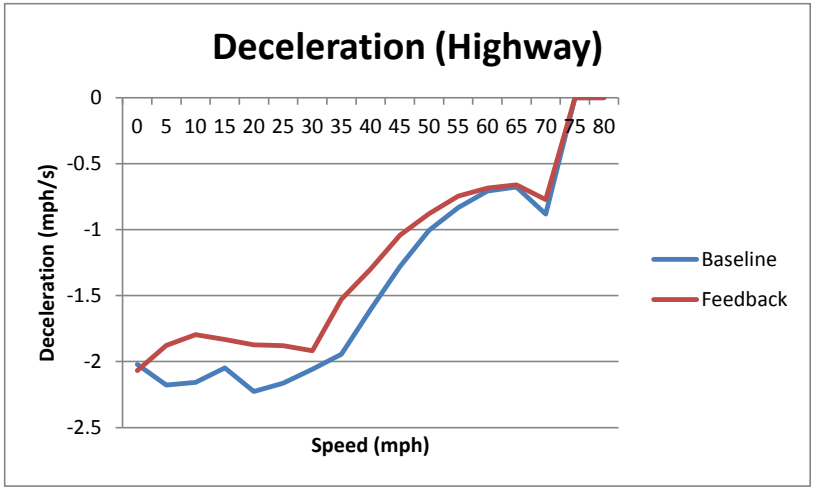


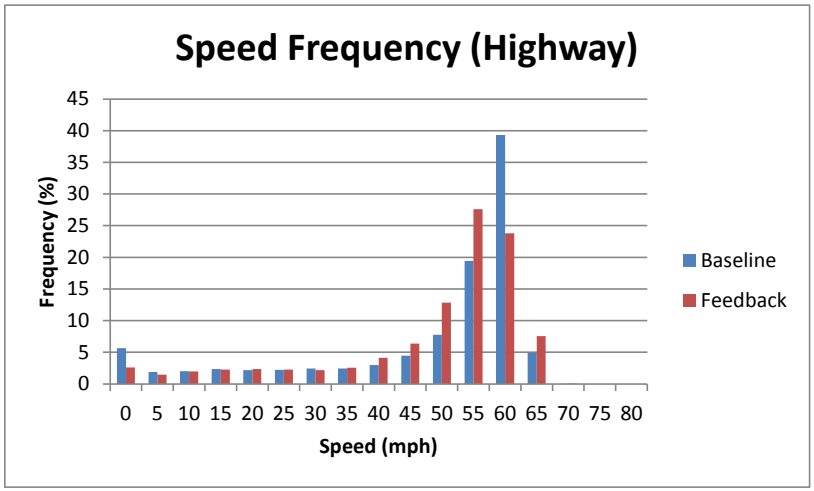


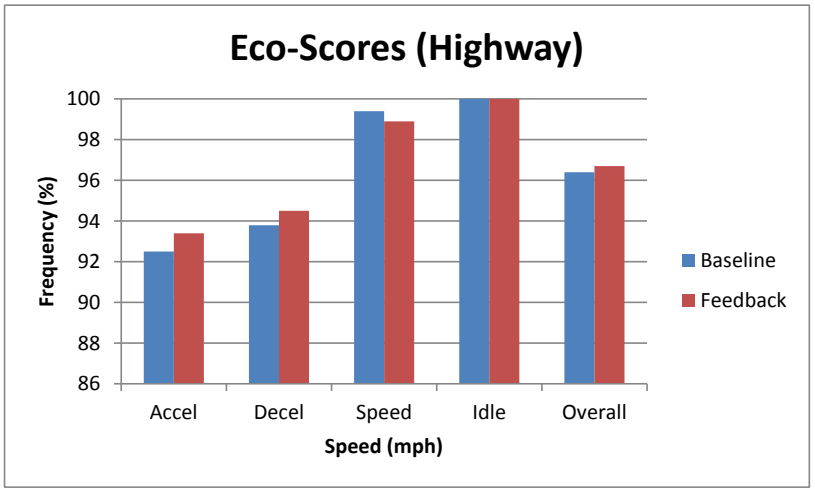


Bus 320 Comparison Results (Highway)









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