Reducing Cost and Emissions with Eco-Driving for Transit Vehicles

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A National Center for Sustainable Transportation Webinar

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Georgia Tech College of Engineering
School of Civil & Environmental Engineering

TRANSFORMING THE TRANSPORTATION SYSTEM

- **RESEARCH** – *Producing "state of knowledge" white papers and interdisciplinary research projects*
- **EDUCATION** – *Developing model curricula for graduate programs and advanced training programs*
- **ENGAGEMENT** – *Informing the policy-making process at the local, state, and federal level*

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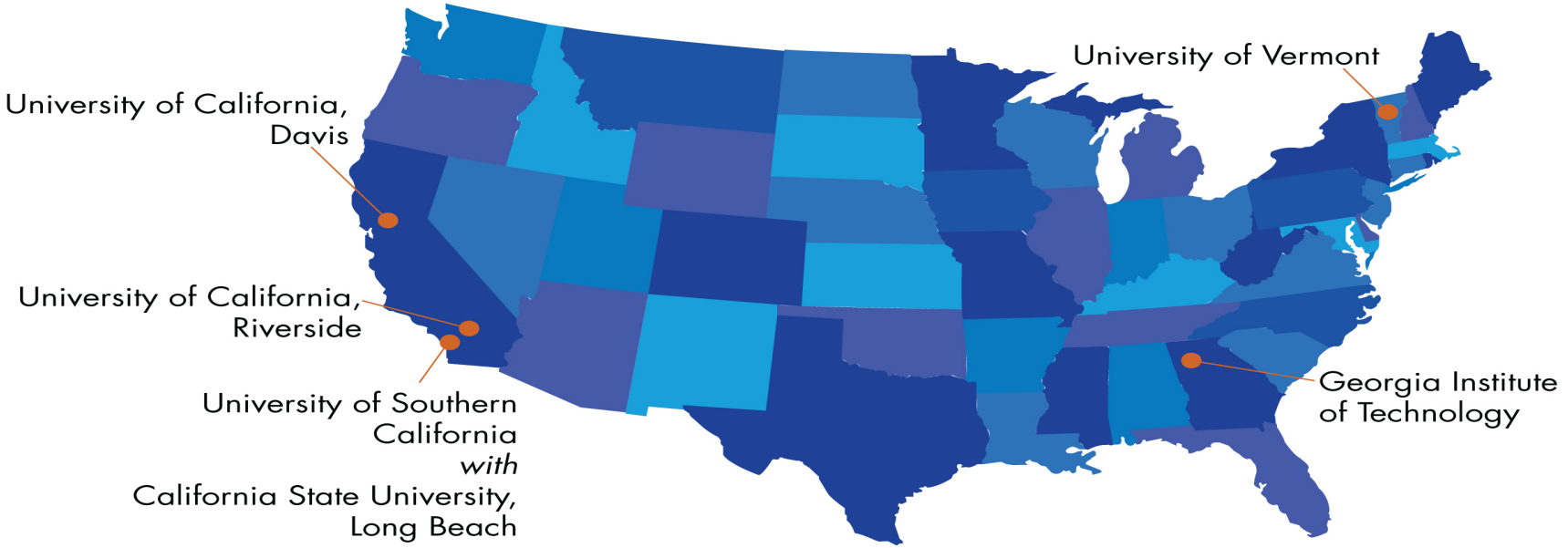

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Outline

- Introduction
- Eco-driving algorithm
- Case study
  - Data
  - Method
  - Scenarios
  - Results
- Conclusions
- Ongoing and future efforts

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Introduction

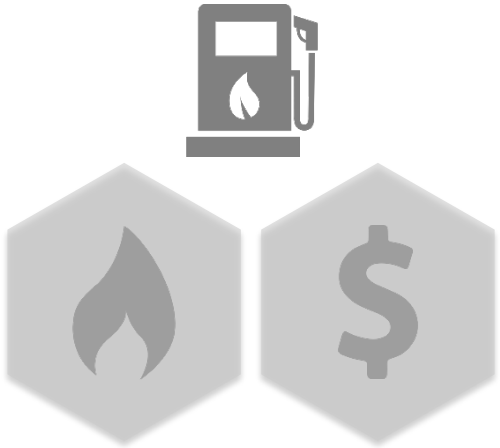
- Transit agencies are always seeking opportunities to conserve fuel to lower operating costs
  - Operating improvement
  - Alternative fuel buses
- Two transit agencies' fuel and emissions saving results from eco-driving are presented
  - Fuel savings
  - Emission reduction (Greenhouse gases, NOx, $PM_{2.5}$)

Key Findings

Key Findings

Conserves Fuel

Eco-driving can reduce fuel consumption by 5% in local transit service, and 7% in express bus service



Key Findings

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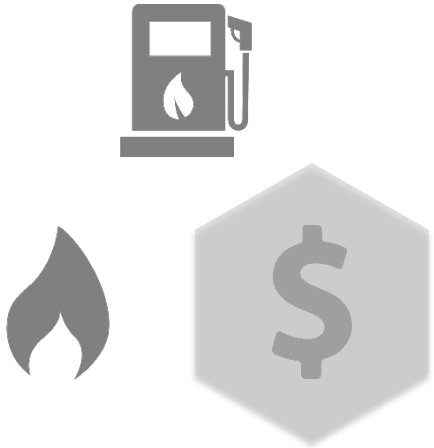
Works for CNG

Eco-driving would reduce fuel consumption by 5% for a hypothetical all-CNG local fleet, and 10% for an assumed all-CNG express fleet



Key Findings

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Saves Cost

Savings amount to $1,000/bus/year
No significant capital investment
Many ancillary benefits

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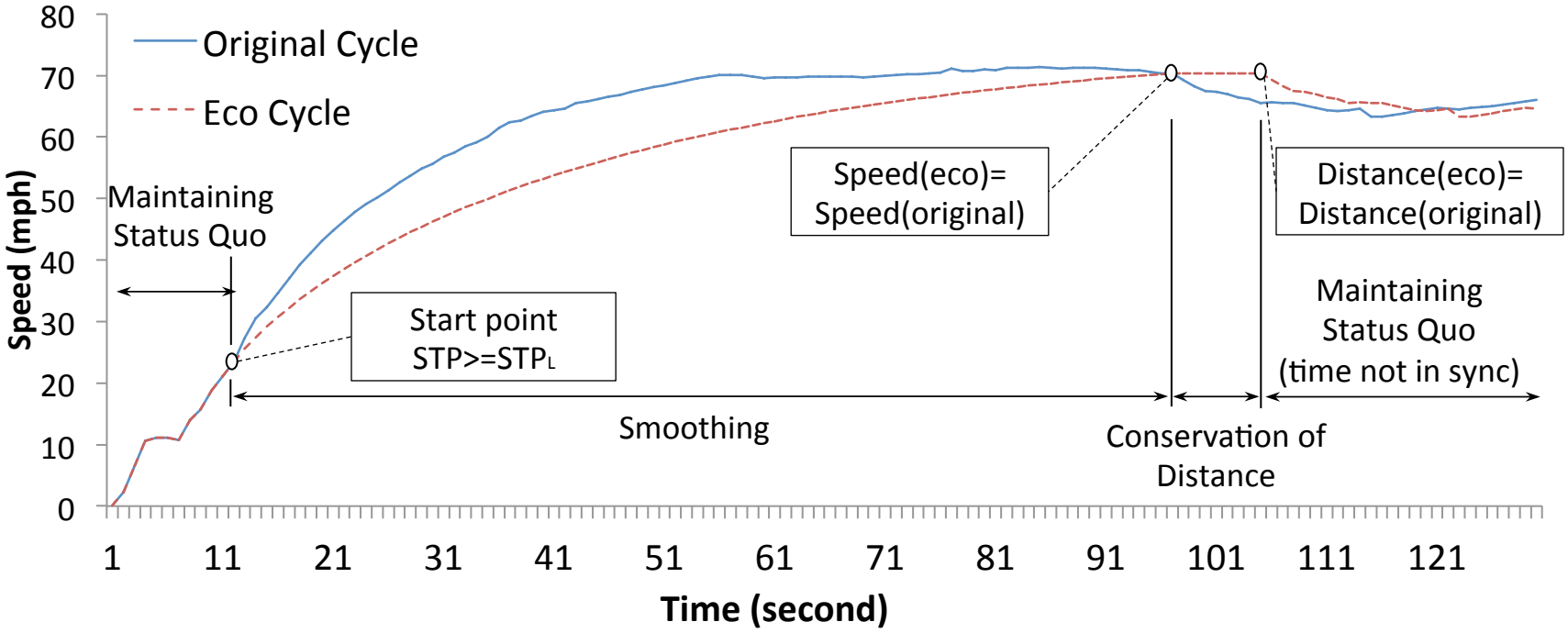
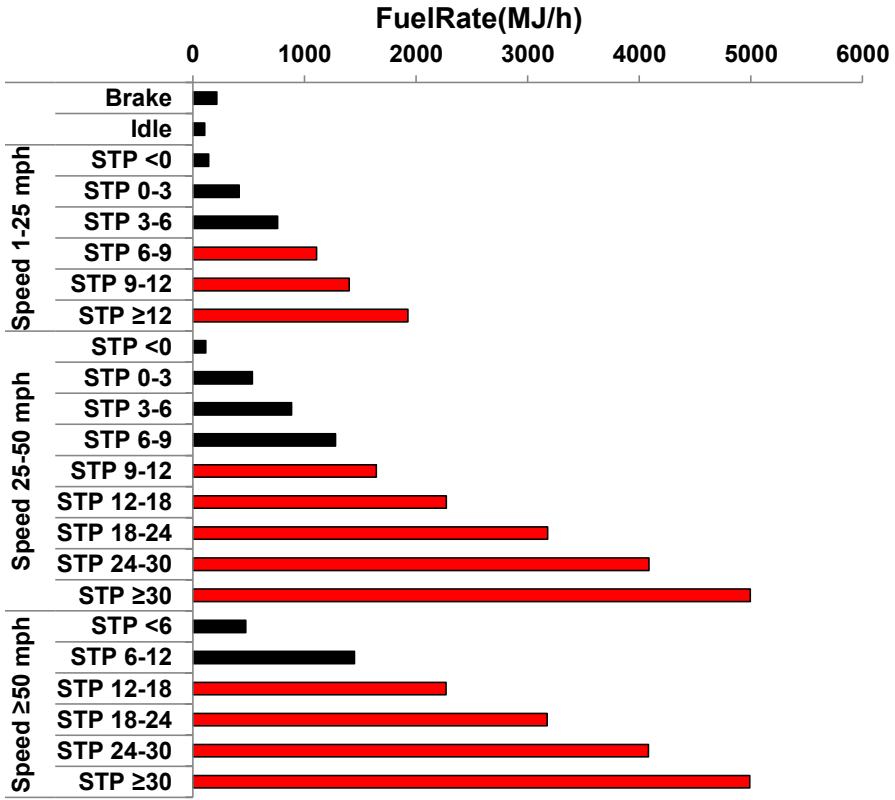
Eco-Driving Algorithm

- **Eco-driving training**: a feasible strategy to reduce fuel consumption and emissions of all kinds of vehicle types
- **Eco-driving techniques**
  - Anticipate the traffic
  - **Maintain a steady speed**
  - **Limit engine loads**
  - Limit idling
  - **Limit high speed**
  - **Avoid hard accelerations**
  - Shift to the highest possible gear with low rpm
  - Check tire pressure regularly

Eco-driving Cycle Modification



Avoid High Power Operations



- High power operations
- Large speed and aggressive accelerations involved
- High energy consumption and high emissions involved

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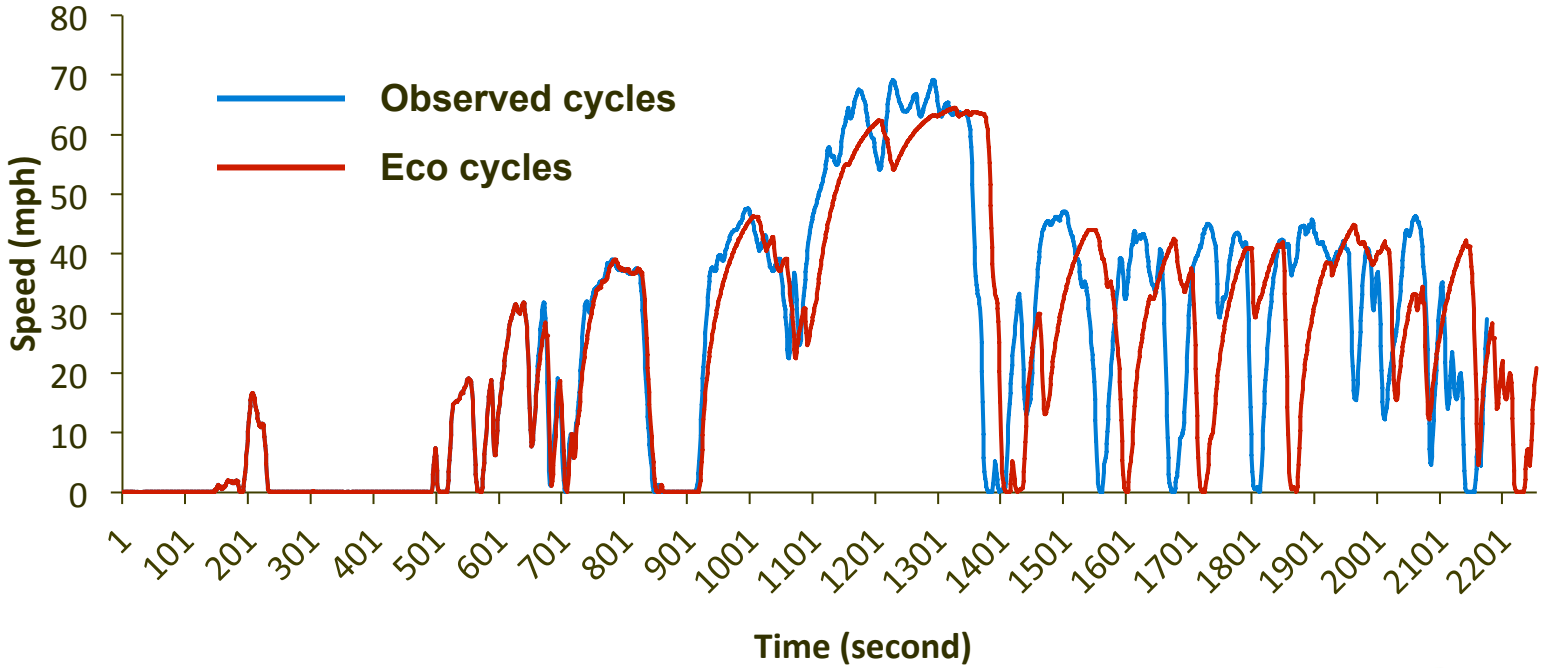
Example of Observed and Eco Cycles



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Data

Second-by-second transit operating data

- Local transit: Metropolitan Atlanta Rapid Transit Authority (MARTA)
- Express bus: Georgia Regional Transportation Authority (GRTA)

GIS files

- Road network
- Transit stops

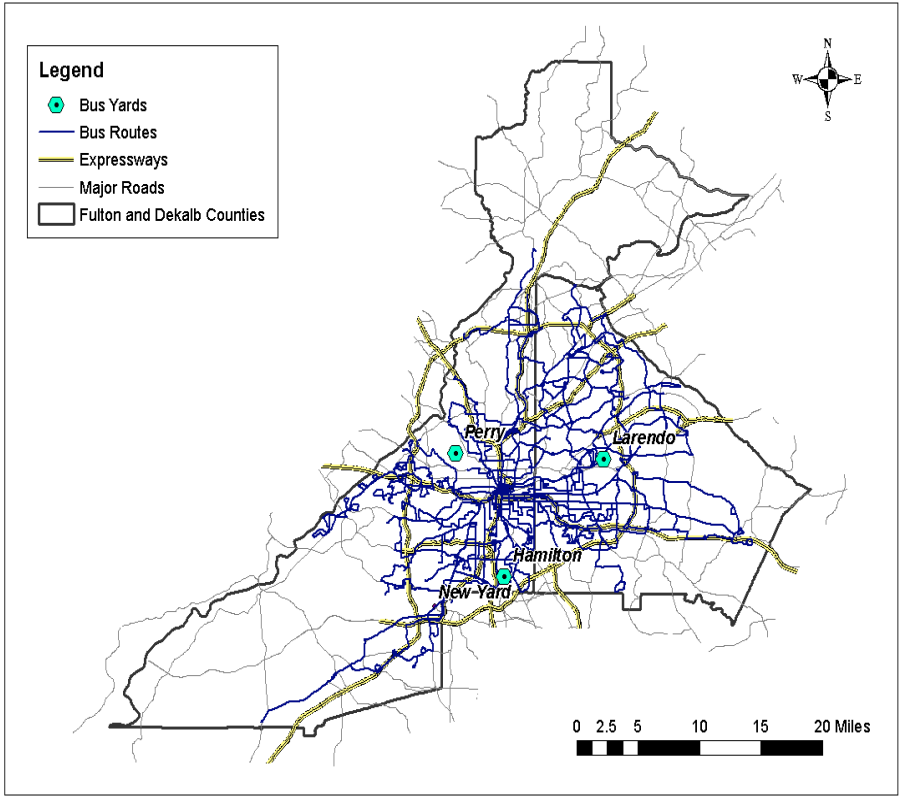
Fleet composition

- National Transit Database (NTD)

Operating schedules

- General Transit Feed Specification (GTFS)

MARTA Operating Data



- **Fleet Composition**
  - 158 diesel
  - 350 CNG buses
- **GPS Loggers**
  - 15
- **Revenue Routes**
  - 224
- **Identified Service Runs**
  - 5,734
- **Operating Distance**
  - 65,600 miles
- **Operating Duration**
  - 6,062 hours

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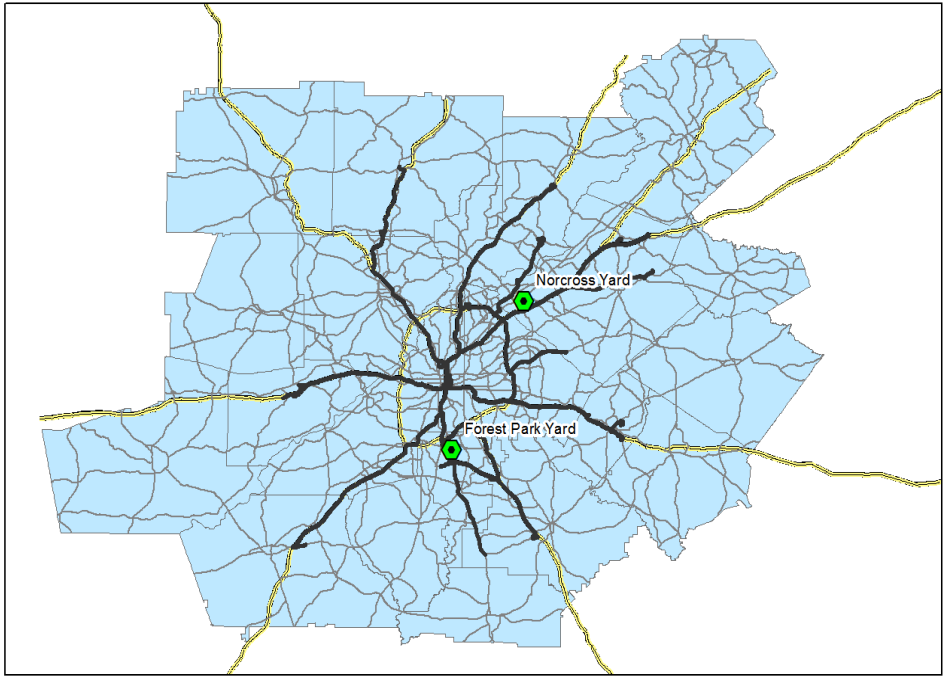
GRTA Operating Data



- **Fleet Composition**
  - 166 diesel
- **GPS Loggers**
  - 14
- **Revenue Routes**
  - 14
- **Identified Service Runs**
  - 51
- **Operating Distance**
  - 5,917 miles
- **Operating Duration**
  - 104 hours

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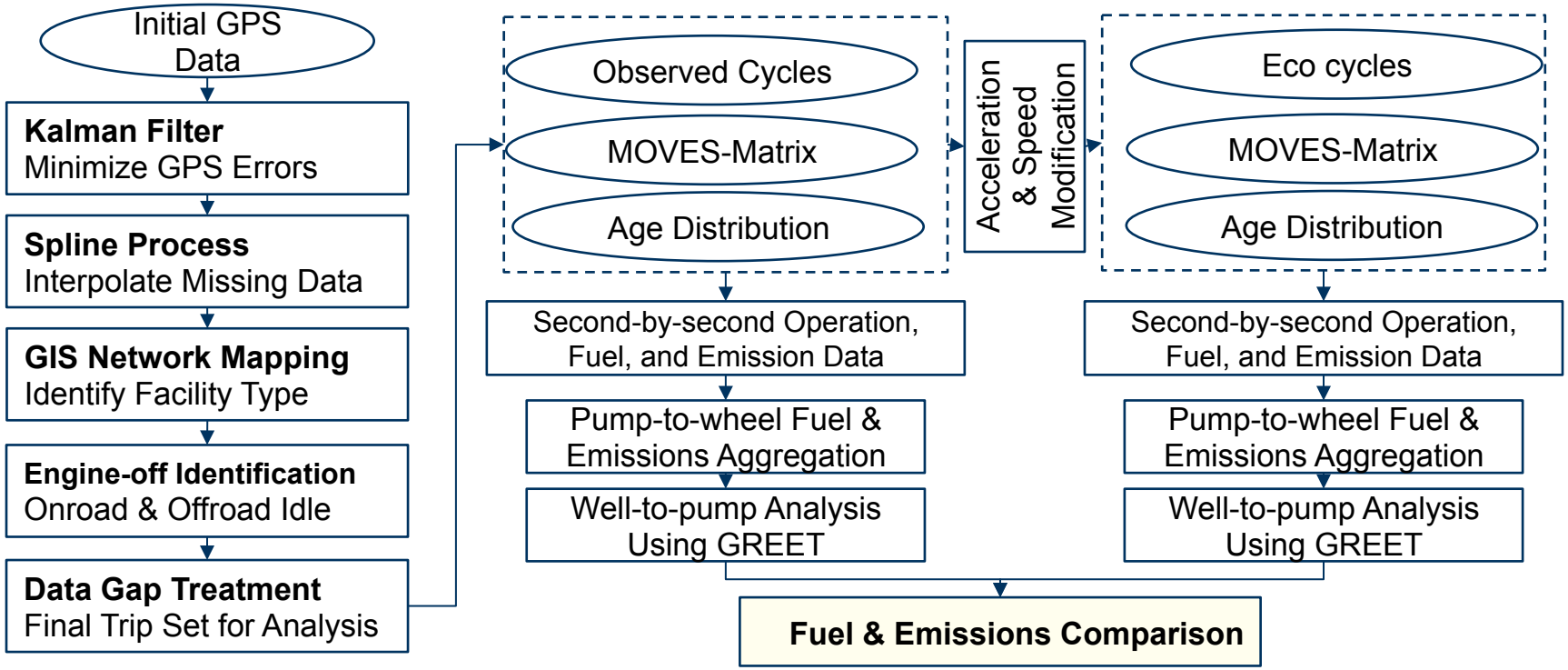
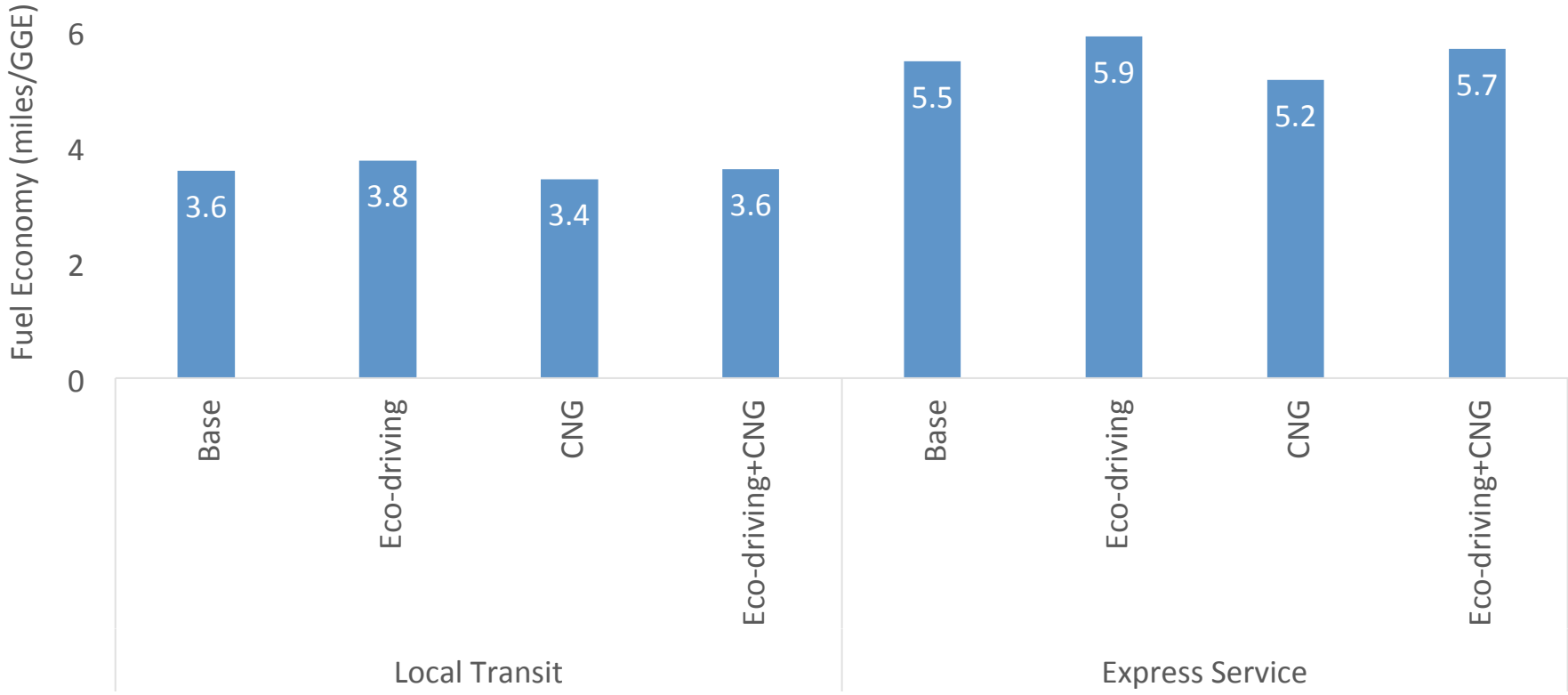
Method


Initial GPS Data
Kalman Filter
Minimize GPS Errors
Spline Process
Interpolate Missing Data
GIS Network Mapping
Identify Facility Type
Engine-off Identification
Onroad & Offroad Idle
Data Gap Treatment
Final Trip Set for Analysis
Observed Cycles
MOVES-Matrix
Age Distribution
Acceleration & Speed Modification
Eco cycles
MOVES-Matrix
Age Distribution
Second-by-second Operation, Fuel, and Emission Data
Second-by-second Operation, Fuel, and Emission Data
Pump-to-wheel Fuel & Emissions Aggregation
Pump-to-wheel Fuel & Emissions Aggregation
Well-to-pump Analysis Using GREET
Well-to-pump Analysis Using GREET
Fuel & Emissions Comparison

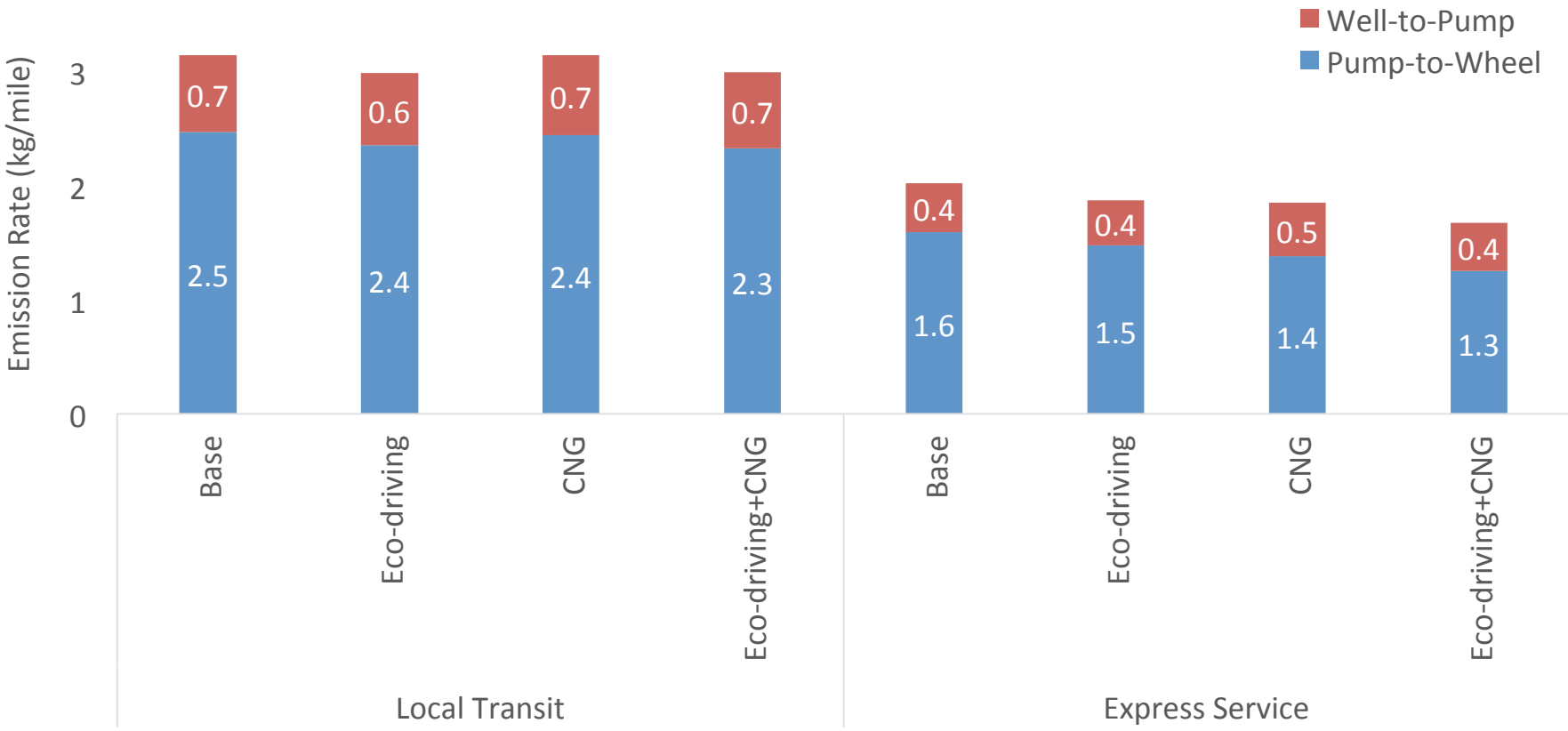
Scenarios

	1. Eco-driving	2. CNG	3. Eco-driving + CNG
Operations	Eco cycles	Observed cycles	Eco cycles
Fleet	Existing fleet	Existing diesel buses ↓ New CNG buses	Existing diesel buses ↓ New CNG buses

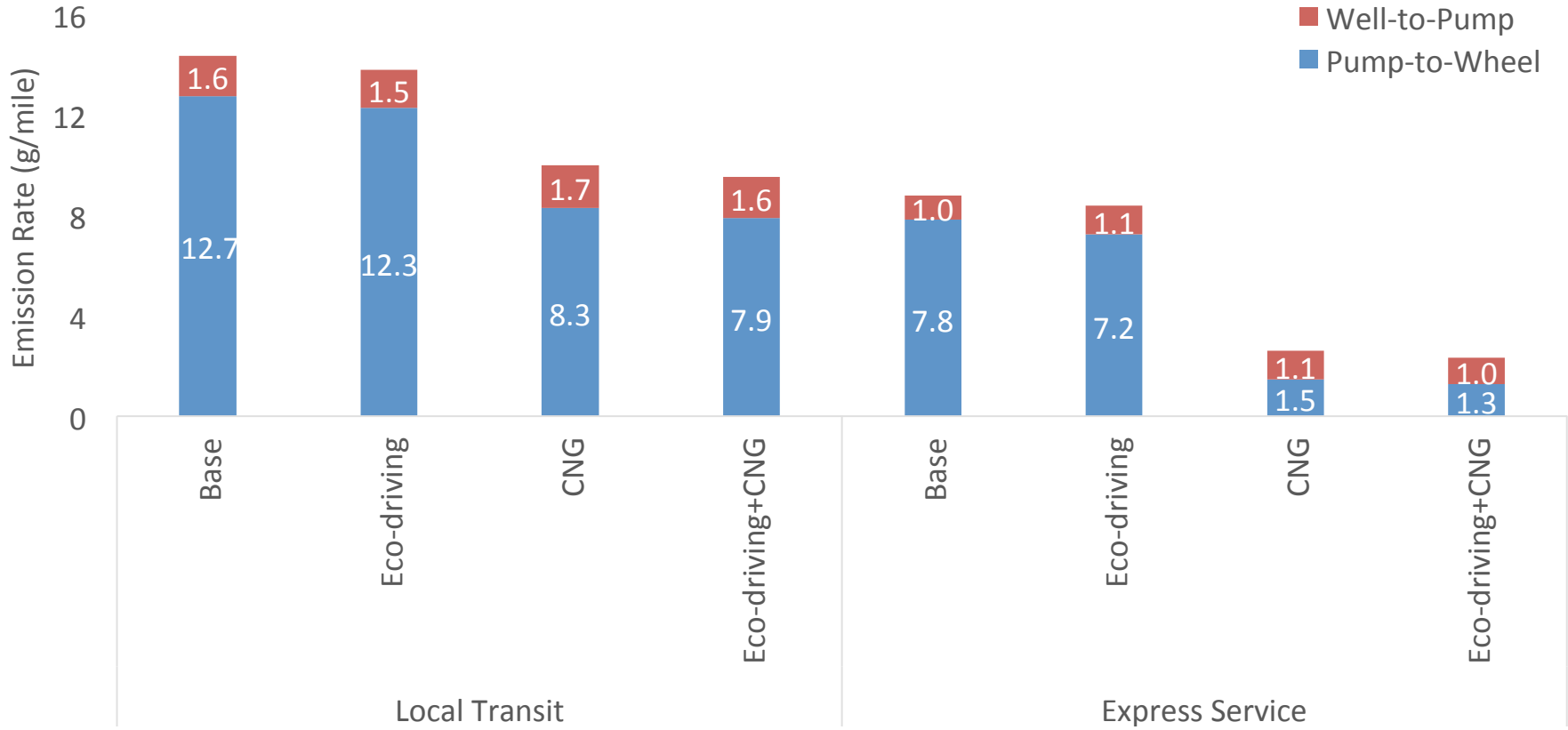
Fuel Consumption Results



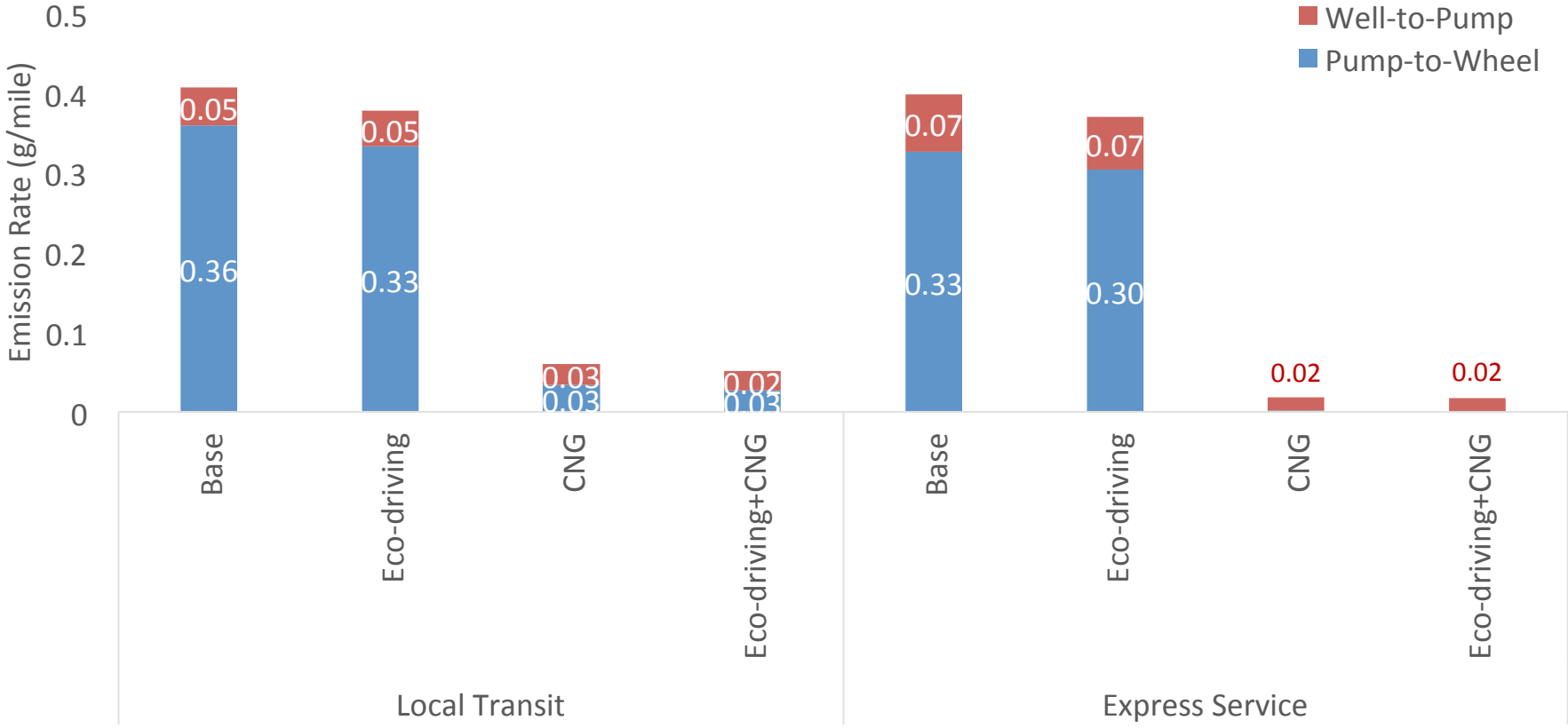
Life-Cycle GHG Results



NOx Emission Rate Results



$PM_{2.5}$ Emission Rate Results



Cost Savings

Local service MARTA, 508 buses	• **Fuel consumption reduction: 5%** • **300,000 gallons of diesel fuel equivalent per year** • **$720,000 in annual fuel savings, or $1,000/bus/year**
Express service GRTA, 166 buses	• **Fuel consumption reduction: 7%** • **55,000 gallons of diesel per year** • **$132,000 in annual fuel savings, or $800/bus/year**
Implementation cost $650/bus/year	• **Includes equipment, real-time communications, driver incentives, and data analysis**

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Without significant capital investment, eco-driving

- Can reduce fuel consumption & emissions
- Will provide net cost savings
- Is also effective for CNG fleets

And ancillary benefits if coupled with bus monitoring



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Asset Management

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Asset Management

On-time Performance

Without significant capital investment, eco-driving

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Asset Management

On-time Performance

Driver Safety

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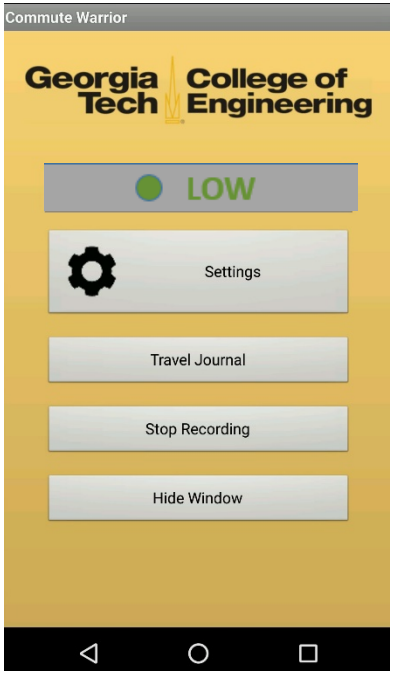
Implementing Eco-Driving for Transit

- Upcoming demo project with MARTA
- Commute Warrior Live Fuel and Emissions
  - The current operating mode is indicated through a dot varying in color
    - Green for low fuel and emissions
    - Yellow for medium fuel and emissions
    - Red for high fuel and emissions



Thank you!

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This presentation is based on the NCST white paper “Eco-driving for Transit”
http://ncst.ucdavis.edu/white-paper/gt-dot-wp1-3c/