Advanced Transportation Hub Efficiency using Novel Analysis (ATHENA)

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National Renewable Energy Laboratory (NREL)
June 2, 2020

DOE Vehicle Technologies Program
2020 Annual Merit Review and Peer Evaluation Meeting

Project ID # ti094

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

Timeline

Project start date 10/01/2018
Project end date 09/30/2021
Percent complete 50%

Barriers

• Airport passenger volumes are expected to double in the next 20 years with similar growth in air cargo volumes
• The DFW region is one of the nation’s fastest growing metropolitan regions currently in non-attainment for Ozone and NOx
• New disruptive transportation technologies (electric, connectivity, automation) and new transportation business models (TNCs) being introduced
• Resiliency in the face of disruptions due to weather, system failures, and unforeseen events

Primary Partners

DOE funding 5,000,000
Cost sharing 1,000,000

Budget

Total Project funding 6,000,000

Remaining

FY19 and FY20 YTD $2.5M $1.6M $900K
Remaining $2.5M $1.4M $1.1M

Project Lead: Caleb Phillips (NREL)
Project Objectives

Objectives
- Utilize the DOE’s world-class high-performance computing (HPC) resources
- Expertise in optimization, modeling, data sciences, and transportation systems

1. To drive effective decision-making around advanced mobility technologies
2. Identify insights that will enable long-term gains in efficiency and productivity
3. Develop common metrics and methodology for DFW that can be applied to other ports.

VTO Technology Integration Goals
- National security: transportation energy diversity
- Economic growth: ports are major economic drivers in their regions
- Affordability for business and consumers: electrification and efficient mobility advancements
Project Objectives: Impact

• The application of operational models to support near-term needs in planning for shuttle fleet electrification and curb-front terminal congestion
• Enable DFW to demonstrate a 50% reduction in ground transportation energy use for the airport and its connected transportation infrastructure by 2045
  o Increasing systemwide affordability, emissions reduction, and improving convenience and efficiency at the connected regional transportation system
  o Adoption of future technologies
• Demonstrate a decoupling between population growth and energy use
• Process that is replicable to other regional hubs
## Milestones

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Milestone Description</th>
<th>Status</th>
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<tbody>
<tr>
<td>Q1 2019</td>
<td>Kickoff meeting for project with key team members and institutions</td>
<td>Done</td>
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<tr>
<td>Q2 2019</td>
<td>First quarterly meetings with advisory panel</td>
<td>Done</td>
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<tr>
<td>Q3 2019</td>
<td>Relevant operational data for DFW gathered, aligned, and stored for analysis</td>
<td>Done</td>
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<tr>
<td>Q4 2019</td>
<td>Initial description of technology scenarios and key model parameters for potential infrastructure changes for DFW</td>
<td>Done</td>
</tr>
<tr>
<td>Q1 2020</td>
<td>Results from airport-Specific <em>Mobility Energy Productivity</em> Analysis for DFW</td>
<td>Done</td>
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<tr>
<td>Q2 2020</td>
<td>Results from <em>Demand Prediction</em> and <em>Congestion Modeling</em></td>
<td>Done</td>
</tr>
<tr>
<td>Q3 2020</td>
<td>Results from <em>Bus Electrification</em> and <em>Route Optimization</em></td>
<td>In progress</td>
</tr>
<tr>
<td>Q4 2020</td>
<td>Preliminary results from <em>Infrastructure Expansion Modeling</em></td>
<td>In progress</td>
</tr>
<tr>
<td>08-2020</td>
<td><strong>Go/No-go</strong> based on 2020 Q1, Q2, and Q3</td>
<td>In progress</td>
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</tbody>
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Any proposed future work is subject to change based on funding levels.
Approach

We are here  Go/No-Go

Identify **collaboration** partners and meetings
Q1, Q2 2019

Initial description of technology scenarios for infrastructure changes
Q4 2019

Passenger **digital twin**
Q2 2020

Preliminary infrastructure expansion modeling
Q4 2020

Q3 2019
Collecting, processing, and aligning **data**

Q1 2020
Mobility Energy Productivity (**MEP**)

Q3 2020
**Bus electrification** and route optimization

Any proposed future work is subject to change based on funding levels.
Project Accomplishments and Progress
Collaboration

Over 20 different Port Advisors and Industry Advisors supporting ATHENA goals and research objectives.

Accomplishments

- October 2018: ATHENA technical kickoff meeting
- November 2018: Partner meeting
- November 2019: Year 2 kickoff meeting
- June 2019: Stakeholder meeting
- January 2020: Stakeholder meeting

CRITICAL: Advisors help ensure broad applicability and generalization of ATHENA outcomes
Locate, transfer, and organize **35 critical data sources**.

StreamSets ETL, Selenium, Postgres DB, and Google drive

**Gap analysis** identified 5 missing data sets

Data-sharing partnerships and investments in digital and sensing infrastructure could result in more **complete and accurate models** of current airport operations

*Data sets and gap analysis, along with our current research, identify the most critical data needed to build operational models at airports.*
Mobility Energy Productivity (MEP) Metric

Quantifies the effectiveness of mobility in a region accounting for energy and affordability.

Higher MEP score (green) represents greater access to a variety of opportunities using a larger set of modes in a time-, cost-, and energy-efficient manner.

An airport-specific MEP quantifies the ease of accessing DFW airport from various locations in the DFW region.

MEP Metric provides a foundation for comparing improvements in transportation infrastructure that lead to increased ease of access of the DFW airport or other locations around the DFW region.
Machine-Learning models effectively predict traffic flow from historic data streams with, trained and tuned on NREL’s HPC.

Traffic simulation with a road network and a set of policies. Simulations on NREL’s HPC.

Detailed output of various characteristics

Using this model, DFW can forecast near-term traffic impacts of the Central Terminal Area (CTA) in real time, as well as simulate novel scenarios to explore potential policy and infrastructure changes.
Data acquisition and duty cycle analysis
- 173K miles, 1 Hz GPS and CAN data
- Rental car, employee and remote parking and hard-stand terminal shuttles
- Detailed duty cycle characterization
- Data used in bus route optimization

EV powertrain simulations – estimate of energy storage for DFW shuttle applications

Dwell-time Hotspot Analysis - visualization of frequent stop locations to identify potential locations for EV chargers.

50% - 100% of Rental Car shuttles could be electrified with current battery and charger technologies.
Bus Route Optimization

**Objective**
Reduce energy consumption subject to:
- Reducing passenger wait times
- Minimizing unused bus capacity.

Optimization performed on NREL’s HPC and final solutions are validated in parallel by a discrete event simulator.

Headway and maximum ride time are directly related to energy use and emissions.

A 30% efficiency gain is available with some customer impacts; 60% possible overall.*

*preliminary results
Collaboration and Coordination,
Overall Market Impact,
and Summary
Collaboration and Coordination

**Primary collaborators**
Project partners, data sharing, weekly or bimonthly meetings

**Data partners**
Data sharing and ad hoc support

DFW, American Airlines, UPS, INRIX, North Central Texas Council of Governments (NCTCOG)

**Advisors**
Quarterly meetings on progress

**Ports:** Seattle, Long Beach, Port Authority of New York New Jersey (PANYNJ)
**Airports:** LAX, Salt Lake, Denver, Atlanta, DFW

**Industry Advisors:** Uber, Hitachi, Texas State University, American Airlines, UPS, FAA, Toyota, INRIX, National Aeronautics and Space Administration.
Overall Market Impact

Achievements

• Created a consortium around mobility at ports
• Gathered and identified key data sets for operational models
• Created a metric, MEP, for understanding mobility and energy
• Operational model of the DFW airport on NREL’s HPC
• Evaluated bus electrification
• Bus route optimization using NREL’s HPC

Upcoming

• Explore congestion policies at the Central Terminal Area (CTA)
• Mode-choice and Agent-Based Model (ABM) for future demand
• Optimization for planning for infrastructure expansion

Any proposed future work is subject to change based on funding levels.
### Summary

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Use world-class HPC and cutting-edge data science to optimize energy productivity at major transportation hubs</th>
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</thead>
<tbody>
<tr>
<td>Approach</td>
<td>Build a consortium around mobility</td>
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<td>Gather necessary data and identify gaps</td>
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<td>Build an operational model, evaluate electrification and route optimization, create mobility metrics, long-term planning</td>
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<tr>
<td>Collaborators</td>
<td>Partners, advisors, and data providers</td>
</tr>
<tr>
<td>Accomplishments</td>
<td>20 advisors and 3 partners on the project</td>
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<tr>
<td></td>
<td>Data collected and gaps identified</td>
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<tr>
<td></td>
<td>Mobility Energy Productivity (MEP)</td>
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<td></td>
<td>Operational data-driven model</td>
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<td></td>
<td>Bus electrification and route optimization</td>
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Thank You

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NREL/PR-2C00-76679

This work was authored in part by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Vehicle Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.