NREL
Transforming ENERGY

Advanced Transportation Hub Efficiency using Novel Analysis (ATHENA)

PI: Caleb Phillips
Presenter: Monte Lunacek
National Renewable Energy Laboratory (NREL)
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DOE Vehicle Technologies Program
2020 Annual Merit Review and Peer Evaluation Meeting

Project ID # ti094

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

Oak Ridge National Laboratory

DFW

NREL Transforming ENERGY

Project Lead: Caleb Phillips (NREL)

Budget

Total Project funding	**6,000,000**
DOE funding	5,000,000
Cost sharing	1,000,000

	Total DOE	NREL	ORNL
FY19 and FY20 YTD	$2.5M	$1.6M	$900K
Remaining	$2.5M	$1.4M	$1.1M

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
- *Reliability/resiliency*: strategies for demand growth and new mobility options.

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
  - Increasing systemwide affordability, emissions reduction, and improving convenience and efficiency at the connected regional transportation system
  - Adoption of future technologies
- Demonstrate a decoupling between population growth and energy use
- Process that is replicable to other regional hubs

Milestones

Q1 2019	Kickoff meeting for project with key team members and institutions	Done
Q2 2019	First quarterly meetings with advisory panel	Done
Q3 2019	Relevant operational data for DFW gathered, aligned, and stored for analysis	Done
Q4 2019	Initial description of technology scenarios and key model parameters for potential infrastructure changes for DFW	Done
Q1 2020	Results from airport-Specific *Mobility Energy Productivity* Analysis for DFW	Done
Q2 2020	Results from *Demand Prediction* and *Congestion Modeling*	Done

Q3 2020	Results from *Bus Electrification* and *Route Optimization*	In progress
Q4 2020	Preliminary results from *Infrastructure Expansion Modeling*	In progress
08-2020	**Go/No-go** based on 2020 Q1, Q2, and Q3	In progress

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

Approach

We are here Go/No-Go

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

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

Q4 2019
Initial description of technology scenarios for infrastructure changes

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

Q2 2020
Passenger **digital twin**

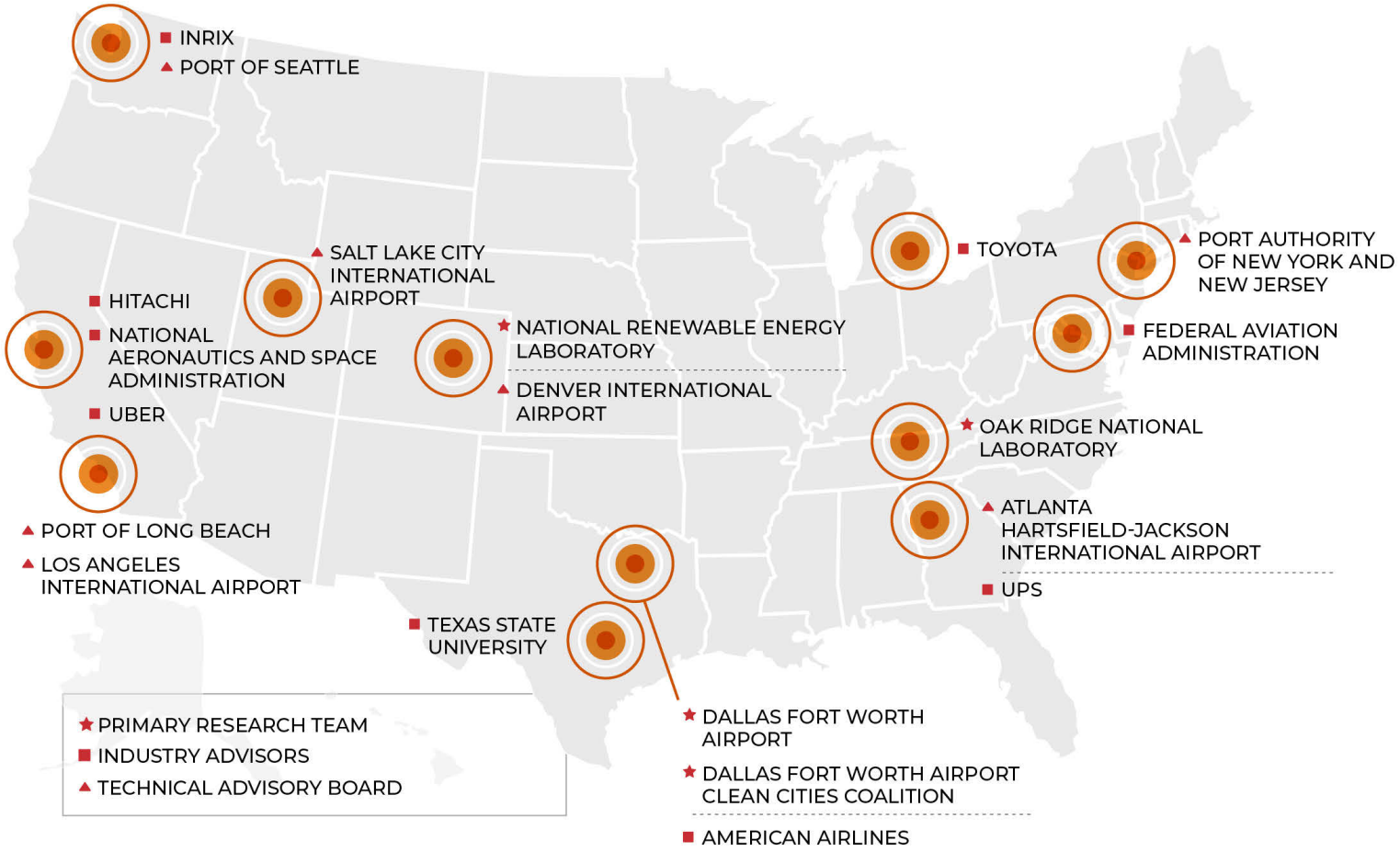
Q3 2020
Bus electrification and **route optimization**

Q4 2020
Preliminary infrastructure expansion modeling

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

Project Accomplishments and Progress

Collaboration



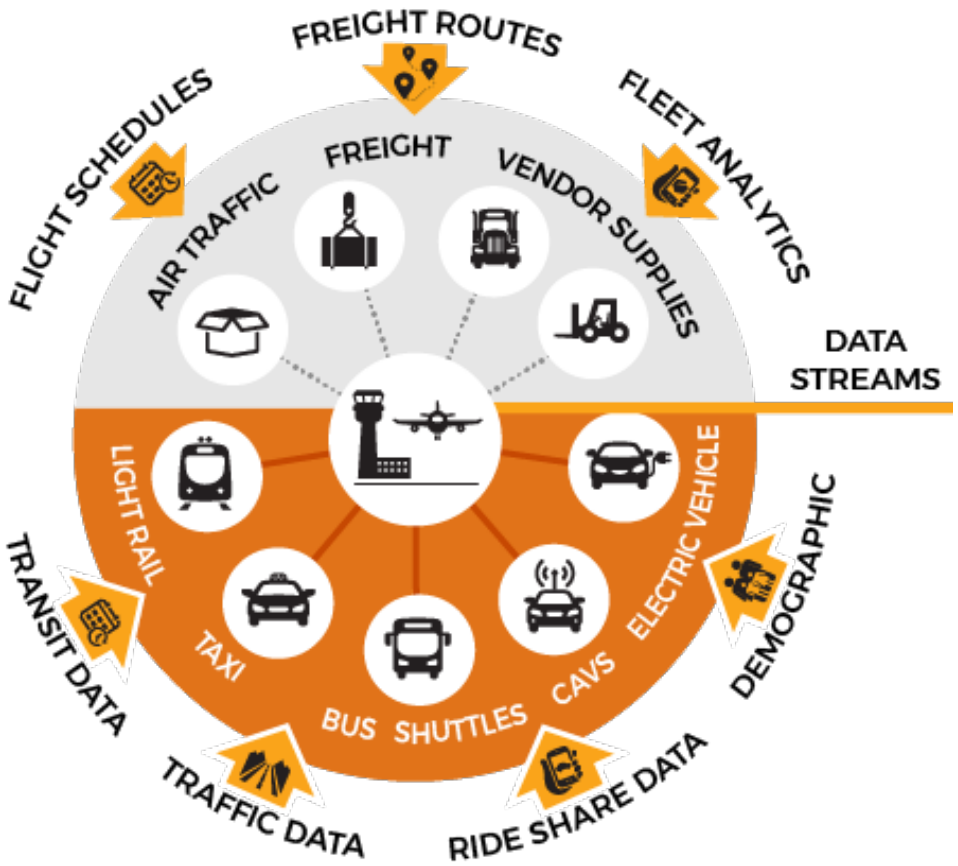
Over 20 different **Port Advisors** and **Industry Advisors** supporting ATHENA goals
and research objectives.

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

DFW Operational Data



Locate, transfer, and organize **35 critical data sources.**

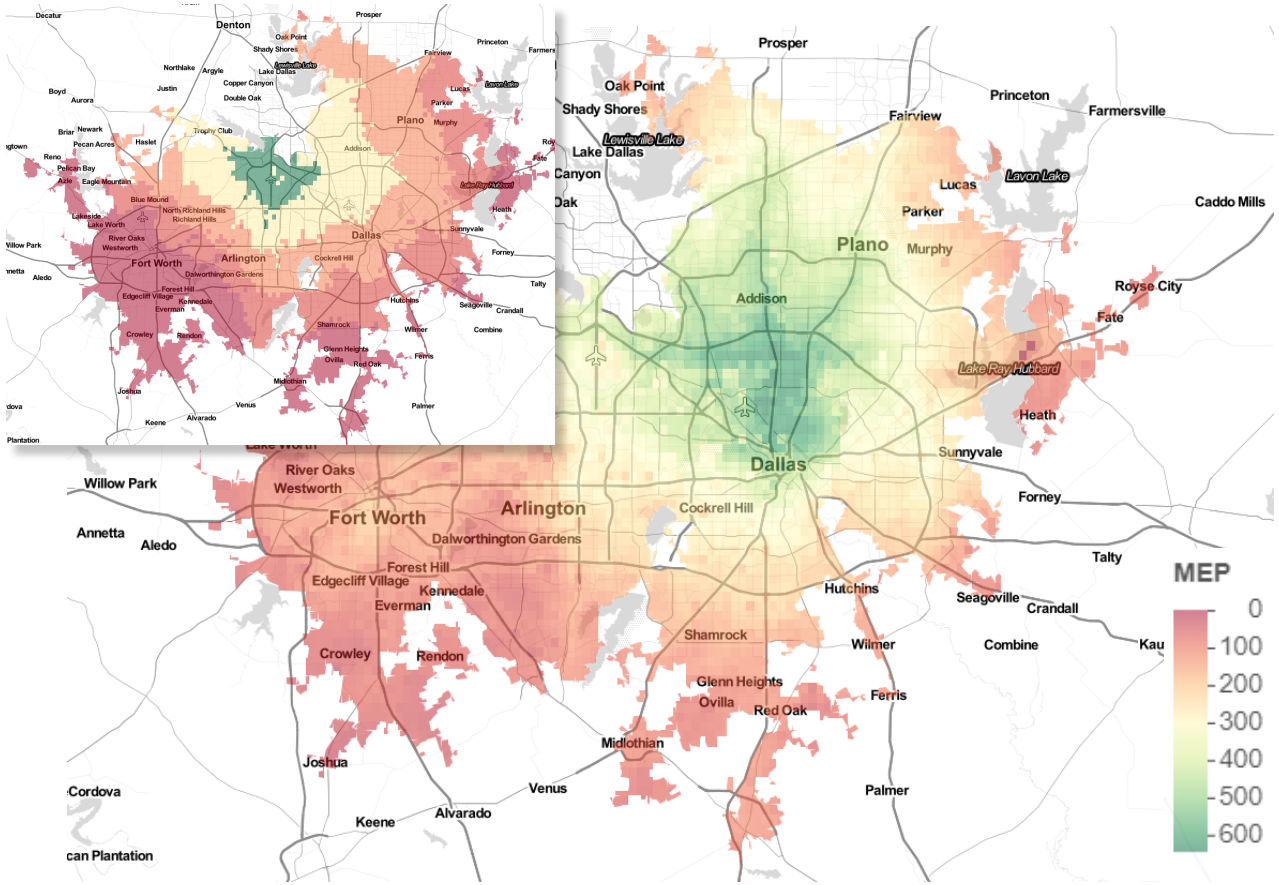
StreamSets ETL, Selenimum, Postgres DB, and Google drive

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



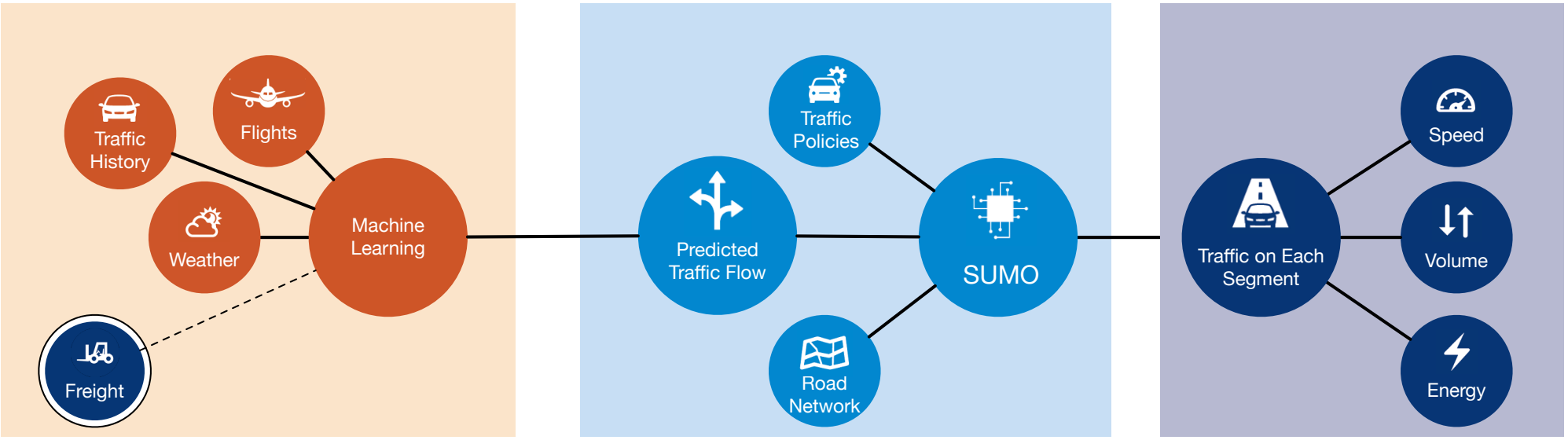
Quantifies the effectiveness of mobility in a region accounting for energy and affordability.

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.

Digital Twin Operation Model



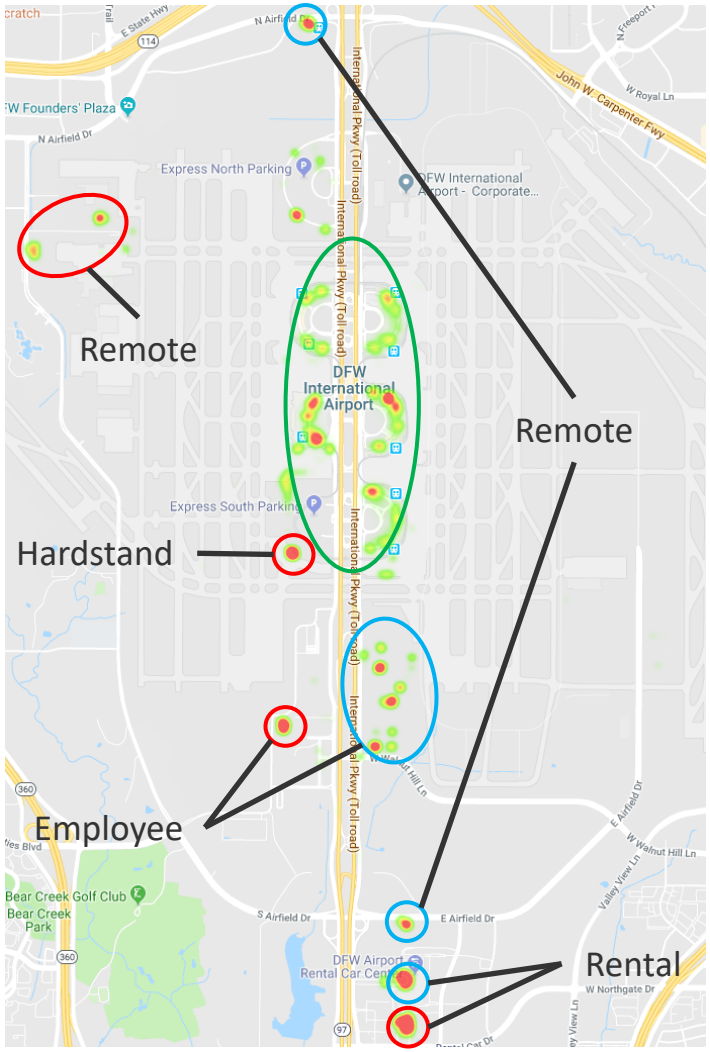
Machine-Learning models effectively predict traffic flow from historic data streams with, trained and tuned on NREL's **HPC.**

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.

Bus electrification

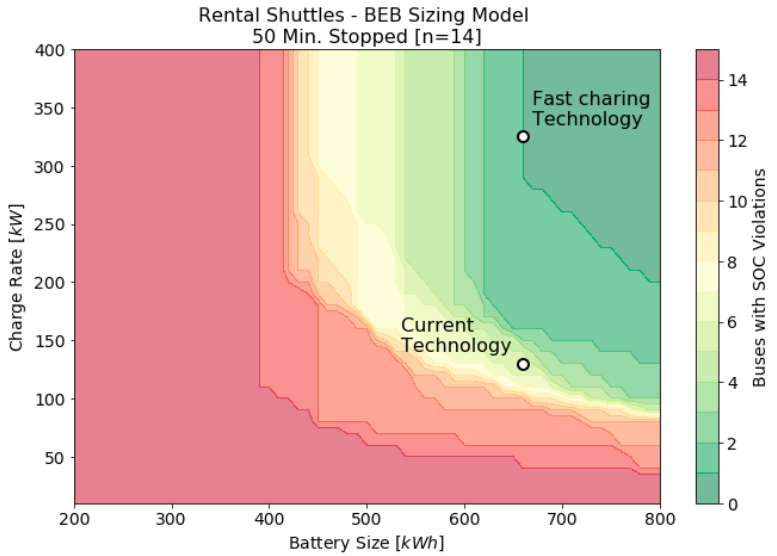


Data acquisition and duty cycle analysis

- 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

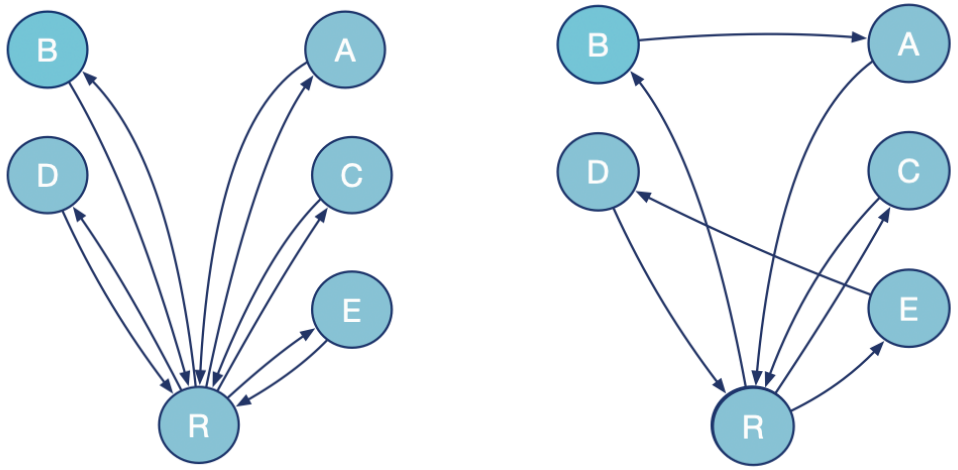
Objective
Reduce **energy consumption** subject to:

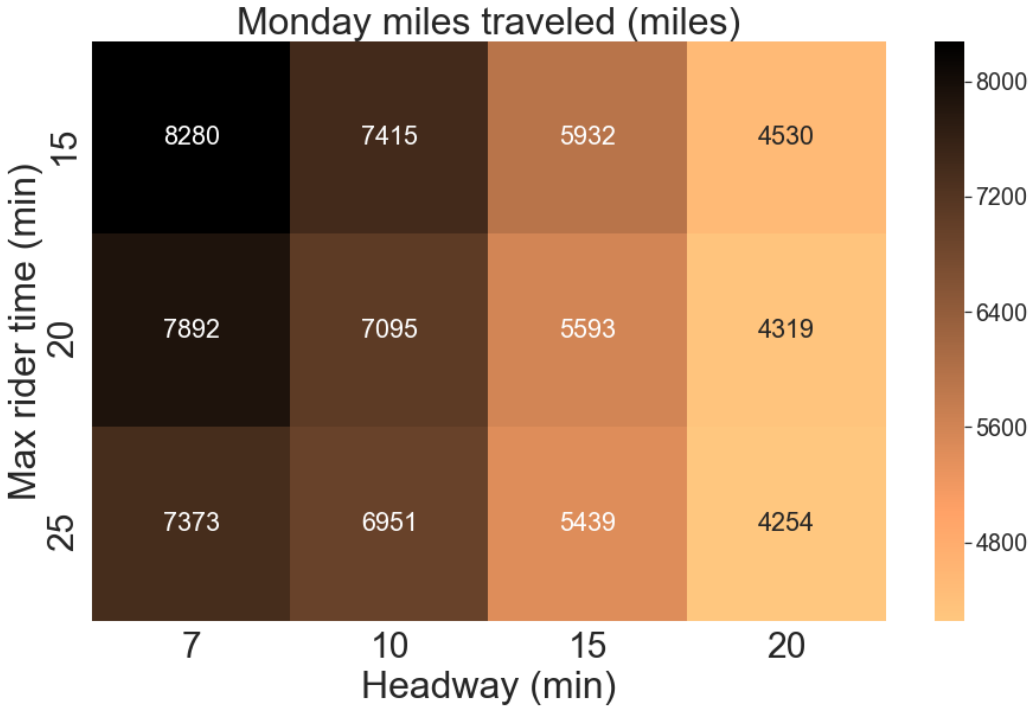
- Reducing passenger **wait times**
- Minimizing unused bus **capacity.**

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

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

Thank You

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