Artificial Intelligence for Future of Travel Demand Modeling

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Self Introduction

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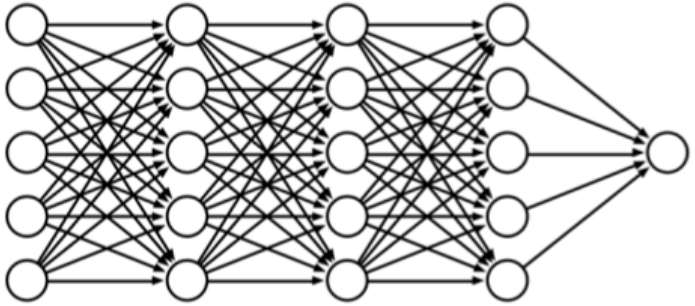
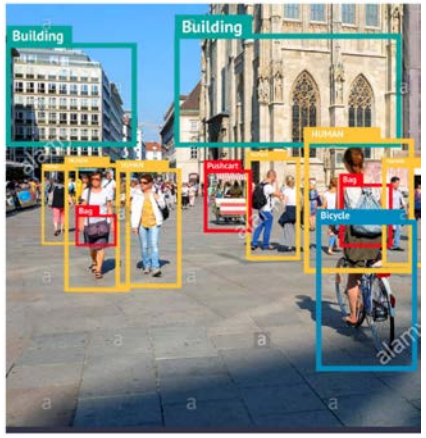
What is artificial intelligence?

Centered at the **Deep Learning** (Deep Neural Network Models)



Extremely broad applications



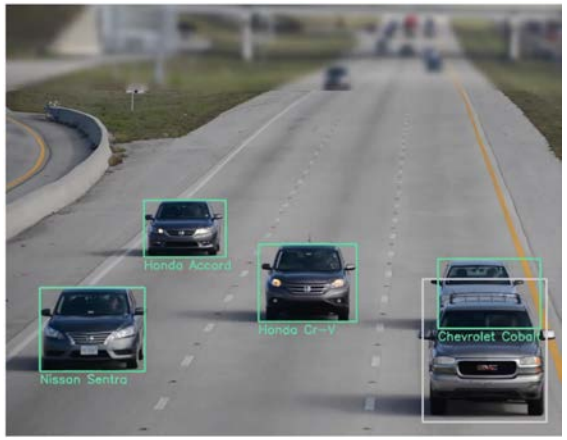


Figure 1: Training *AlphaZero* for 700,000 steps. Elo ratings were computed from evaluation games between different players when given one second per move. **a** Performance of *AlphaZero* in chess, compared to 2016 TCEC world-champion program *Stockfish*. **b** Performance of *AlphaZero* in shogi, compared to 2017 CSA world-champion program *Elmo*. **c** Performance of *AlphaZero* in Go, compared to *AlphaGo Lee* and *AlphaGo Zero* (20 block / 3 day) (29).

How to use AI to improve transportation?

Project: Transit-Centric Smart Mobility System (TSMS) for High-Growth Urban Activity Centers: Improving Energy Efficiency through Machine Learning

PIs: Jinhua Zhao (MIT), Haris Koutsopoulos (NEU), Shenhao Wang (UFL), Venu Garikapati (NERL)

Time period: 2020-2024

Industrial partner: Chicago Transit Authority

Pilot experiment: Chicago

Grant: $2.2M

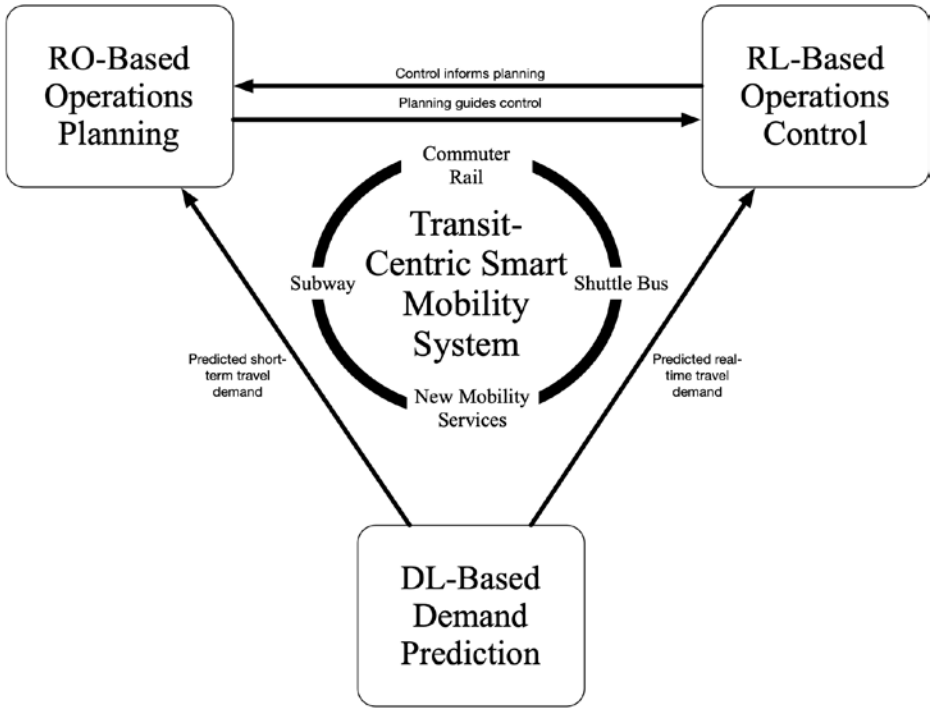
Sponsor: USDOE

Scope of the TSMS project

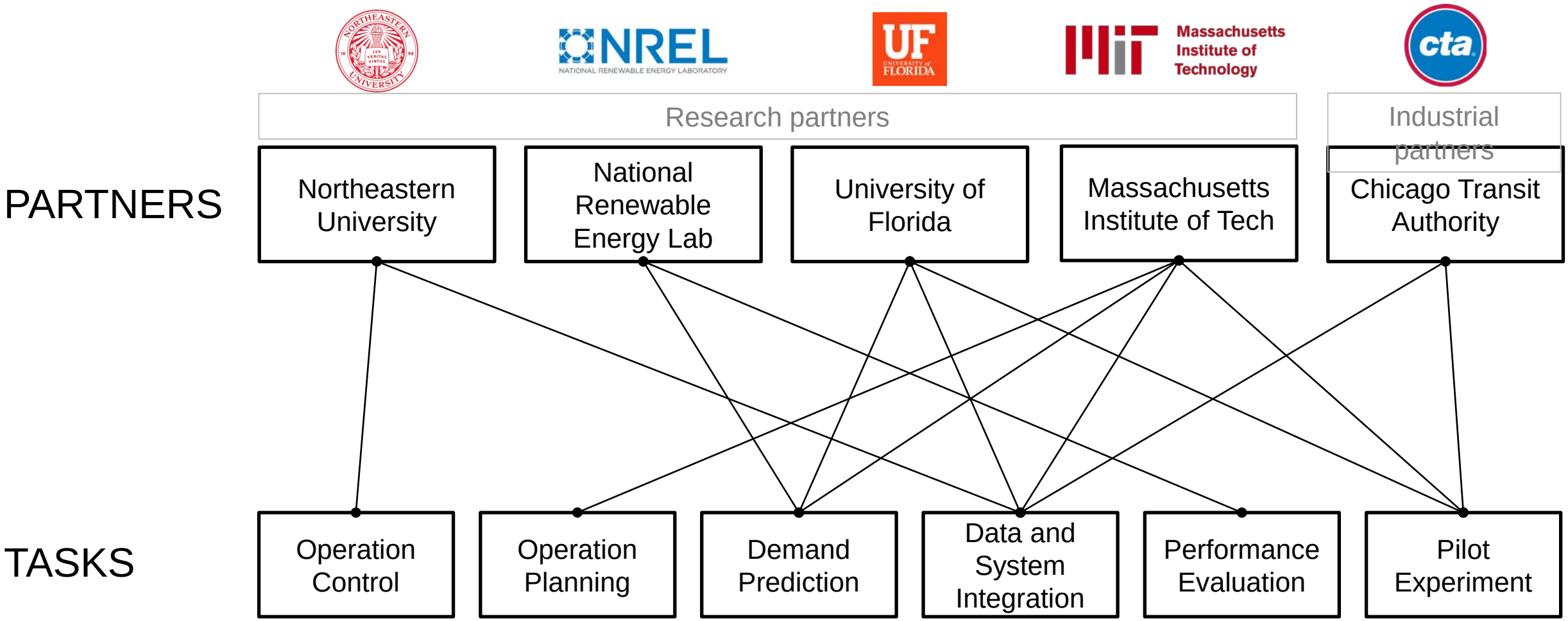
Goal: Using AI to improve the public transit.

Three technical pillars for three transit functions

- **Deep learning (DL)** for transit demand prediction
- **Reinforcement learning (RL)** for transit operation control
- **Robust optimization (RO)** for transit operation planning



Collaboration network

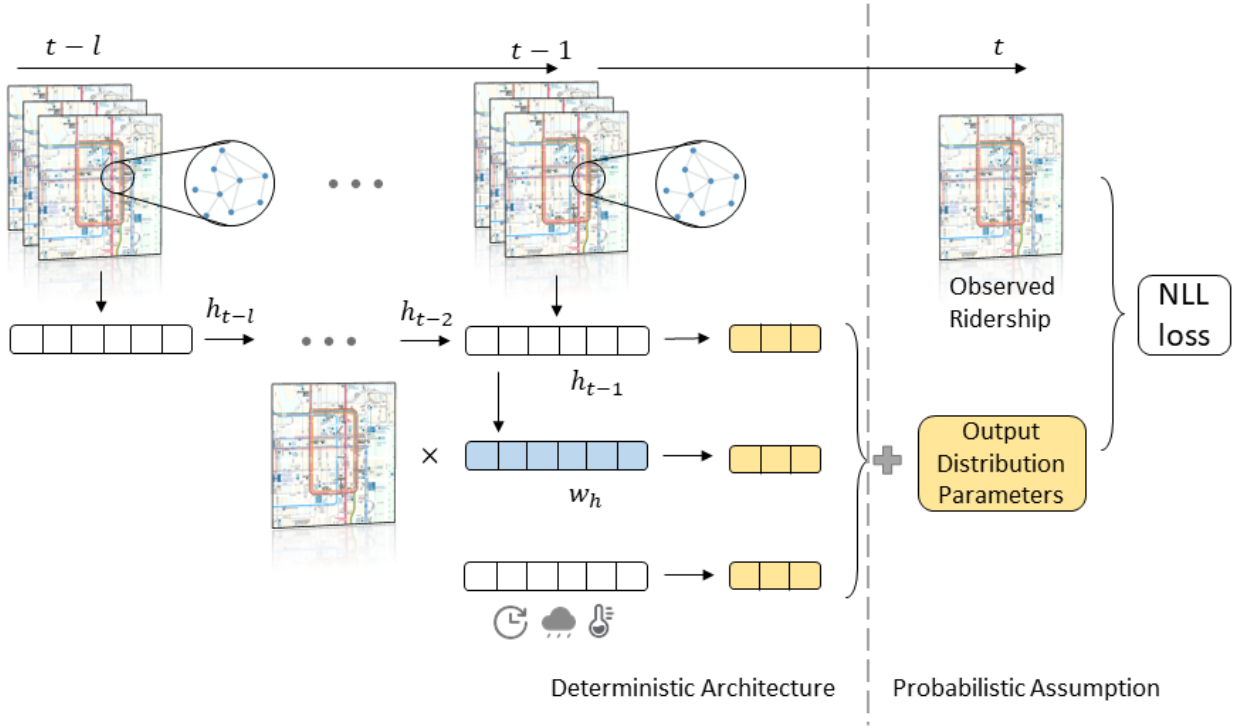


Technical achievement 1. Designing probabilistic graph neural networks (GCNs) to predict spatiotemporal transit demand

Technology innovation

1. Propose probabilistic GCNs, as opposed to deterministic GCNs
2. Apply the framework to quantify demand uncertainty
3. Predict spatiotemporal demand uncertainty with >25% higher performance than benchmarks

Combining probabilistic and deterministic assumptions

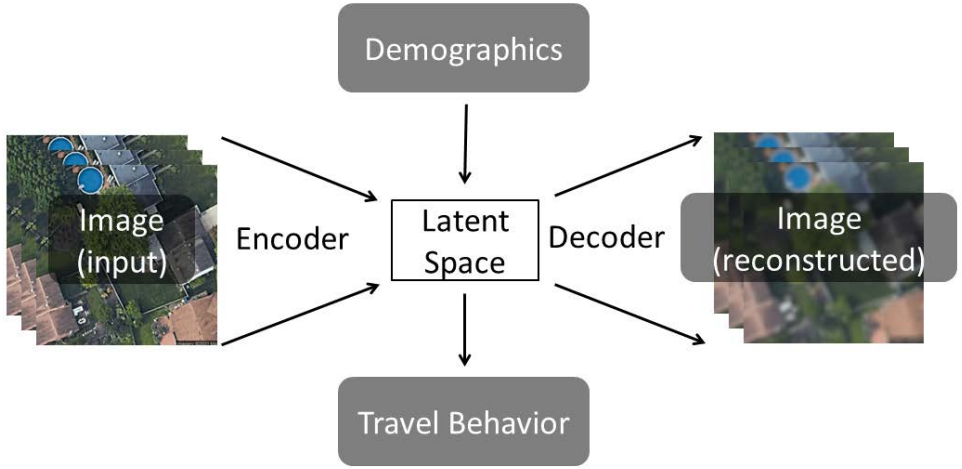


Technical achievement 2: Using urban imagery to enhance travel demand prediction with >5% improvement

Technology innovation

1. Create a deep hybrid model (DHM) for transit demand prediction with urban imagery
2. It improves accuracy by >5% in demand prediction

Deep hybrid models combining data (numbers + imagery), and models (classical demand models + computer vision)



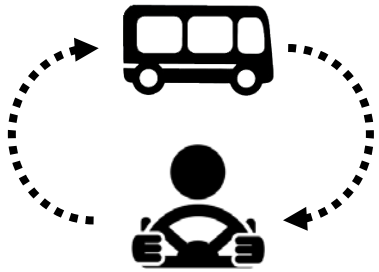
Technical achievement 3: Designing a reinforcement learning (RL) framework for real-time bus controls

Bus as a reinforcement learner

Technology innovation – RL formulation

1. Agent: bus
2. State: local and neighboring buses
3. Action: holding and stop-skipping
4. Reward: waiting and riding time

Empirically, the RL approach reduces the waiting time by **4~8%.**



Human & Machine Interactions

An Important Question for the TSMS project

How are the technical achievements translated into practice?

Using the technologies to conduct a bus control pilot experiment in Route-81, Chicago (2022 Fall)

Collaborative work with Chicago Transit Authority (CTA)

Motivation of the pilot

Transit workforce shortage in 2022: 84% of US agencies impacted

In **CTA**: Only **84%** services were delivered.

The status-quo control system is:

- Non-digitized
- Non-integrated
- Not effective

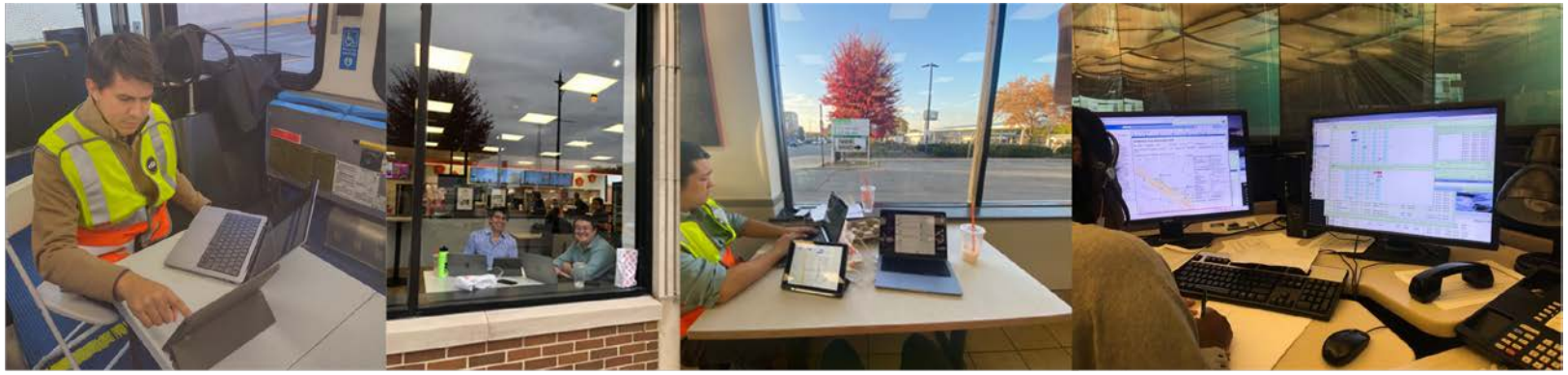
We demonstrate how AI can address the transit operation challenges in a pilot.

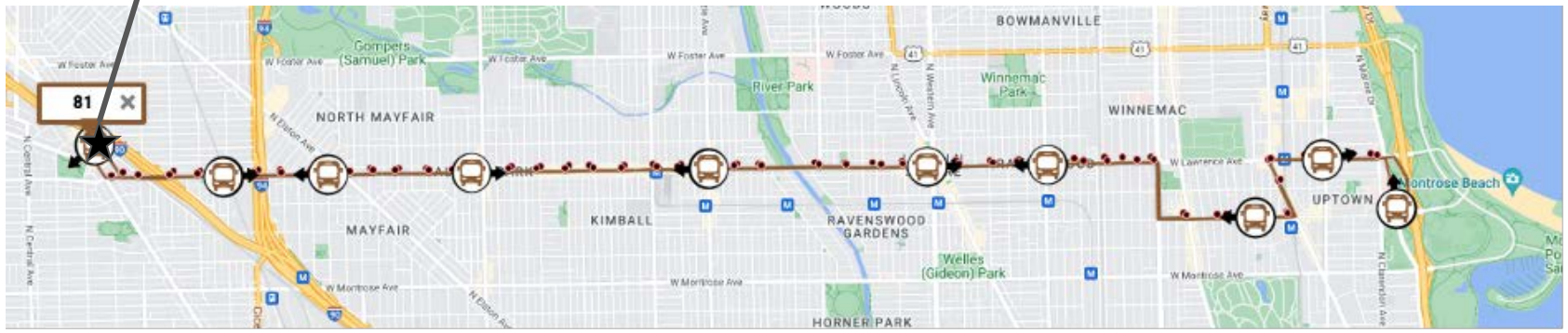
Achievements in the pilot

1. Built a real-time control dashboard to streamline the information.
2. Implemented an AI-empowered recommendation engine to control bus dispatching.

Terminal: Jefferson Park

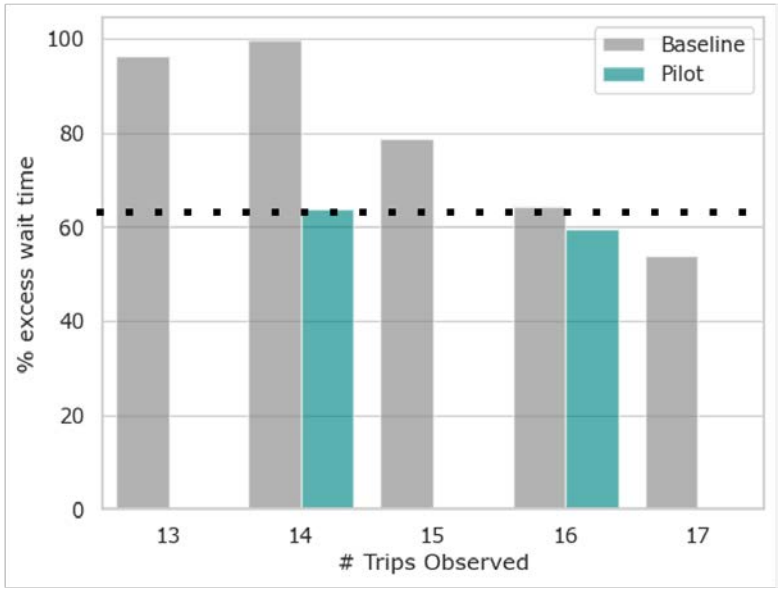
Students on the site



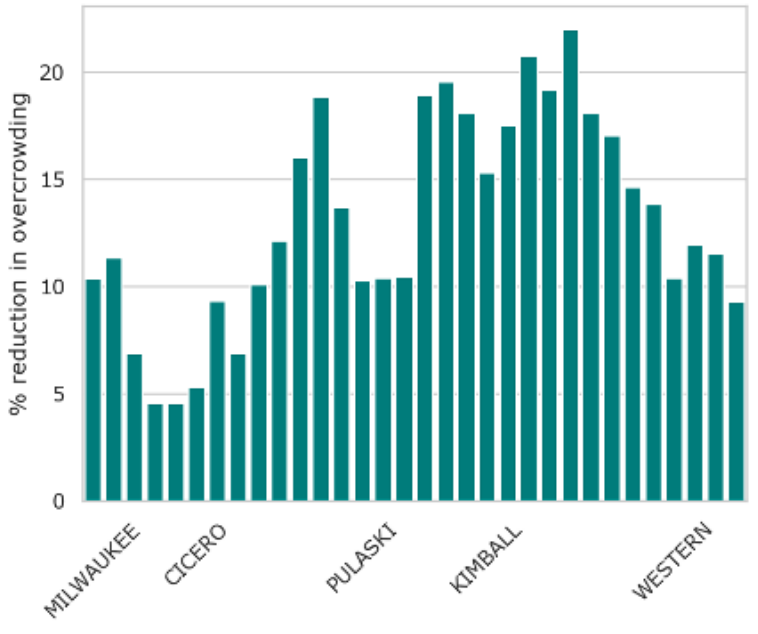


Achievements in the pilot

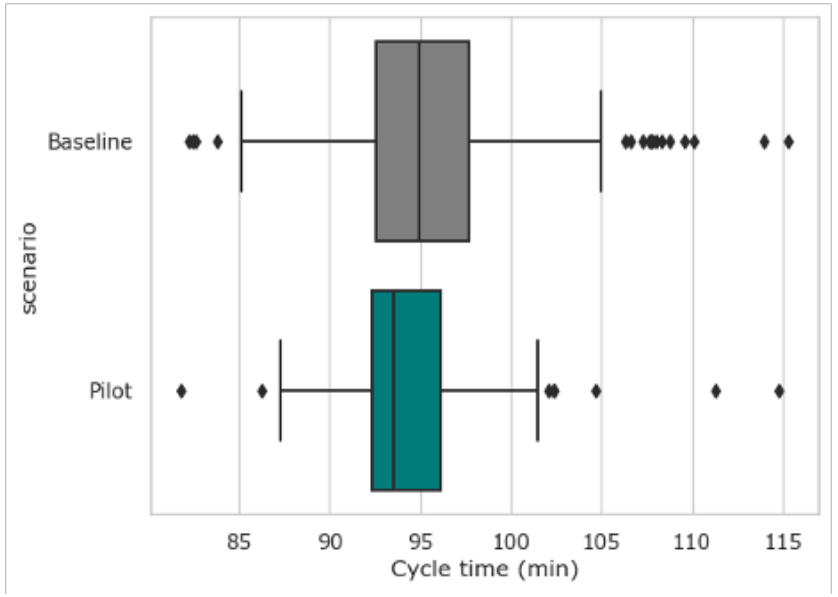
Excess wait time by # of bus trips
37% reduction



Overcrowding by stop
5-20% reduction



90th Cycle times
2.4% reduction



Thank You

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