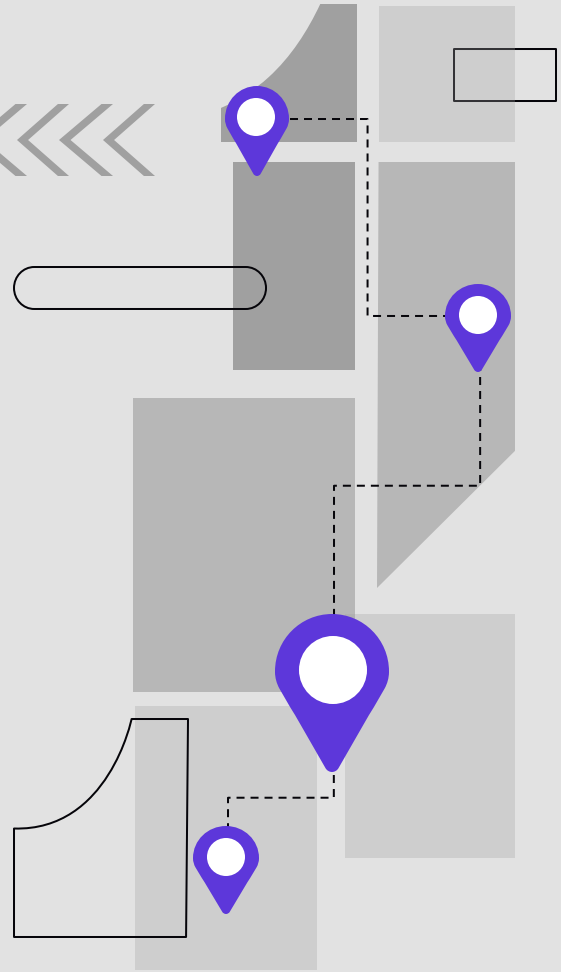
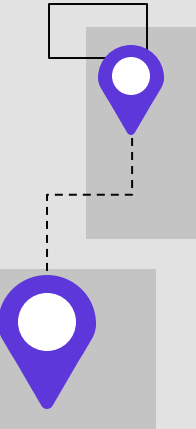
OPTIMIZING BUS ROUTES
BOSTON MBTA

Iris Brook and Luca-Andrei Manea



AGENDA

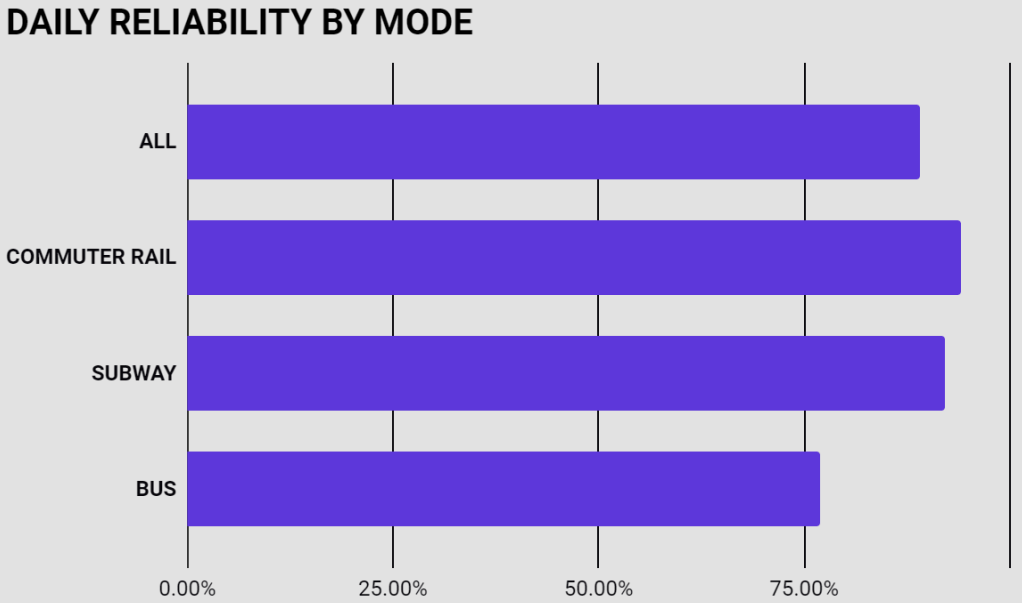
1. PROBLEM STATEMENT
2. DATASET OVERVIEW
3. MODELING
4. KEY FINDINGS
5. IMPACT



PROBLEM STATEMENT

OPTIMIZING BUS ROUTES

The *Massachusetts Bay Transportation Authority (MBTA)* operates an extensive network of bus routes, serving millions of passengers daily. However, buses are consistently the most unreliable mode of transportation for the MBTA.



Data from MBTA.com

Optimized bus routes can also introduce cost savings and environmental benefits.

DATASET OVERVIEW

All data was gathered from *mbta-massdot.opendata.arcgis.com* MBTA's Blue Book Open Data Portal

BUS STOPS

Details about individual bus stops within the network:

- Geographical Coordinates (*stop_lat, stop_lon*)
- Infrastructural Attributes (*sidewalk_width*, *condition*, and *material*)
- Administrative and locational details: municipality, neighborhood, and types of vehicles

FALL RIDERSHIP

Information about bus ridership patterns during the autumn season:

- *route_id*, *route_name*,
- *average_ons* (average number of passengers boarding)
- *average_offs* (average number of passengers alighting)
- *average_load* (average number of passengers on the bus

$$
\begin{aligned}
\min \quad & \sum_{r=1}^{R}\sum_{t=1}^{T} x_{rt} \\
\text{s.t.} \quad & C \cdot x_{rt} \geq L_{rt}^{mean} && \forall r = 1,\ldots,R,\ \forall t = 1,\ldots,T \\
& \sum_{r=1}^{R} x_{rt} \leq B && \forall t = 1,\ldots,T \\
& x_{rt} \geq 0,\ \text{integer} && \forall r = 1,\ldots,R,\ \forall t = 1,\ldots,T
\end{aligned}
$$

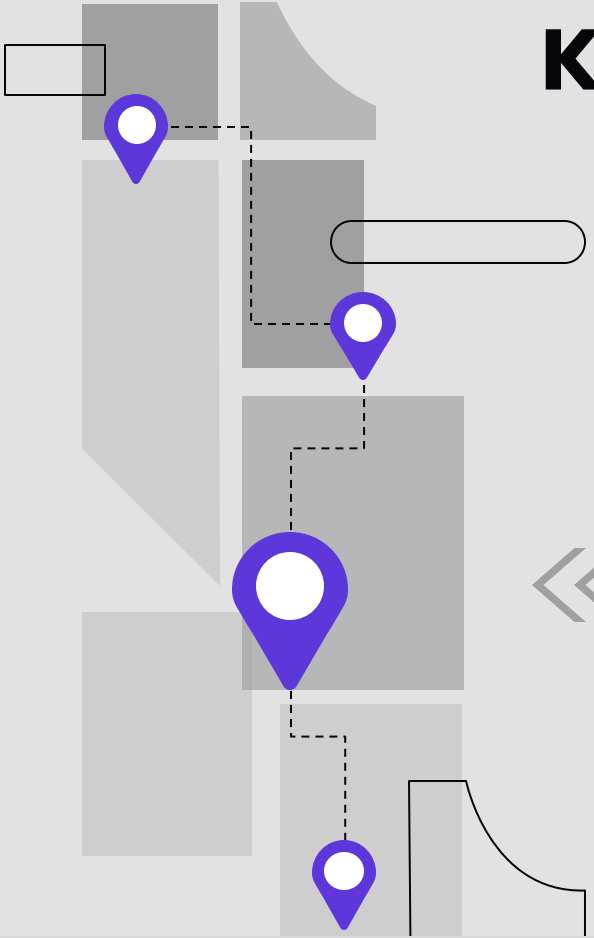
$$
\begin{aligned}
\max \quad & \sum_{r=1}^{R}\sum_{t=1}^{T} L_{rt}^{mean} \cdot y_{rt} \\
\text{s.t.} \quad & C \cdot x_{rt} \geq L_{rt}^{mean} \cdot y_{rt} && \forall r = 1,\ldots,R,\ \forall t = 1,\ldots,T \\
& \sum_{r=1}^{R} x_{rt} \leq B' && \forall t = 1,\ldots,T \\
& x_{rt} \geq 0,\ \text{integer} && \forall r = 1,\ldots,R,\ \forall t = 1,\ldots,T \\
& y_{rt} \in \{0,1\} && \forall r = 1,\ldots,R,\ \forall t = 1,\ldots,T
\end{aligned}
$$

$$
\begin{aligned}
\min \quad & \sum_{r=1}^{R}\sum_{t=1}^{T} x_{rt} \\
\text{s.t.} \quad & C \cdot x_{rt} \geq L_{rt}^{max} && \forall r = 1,\ldots,R,\ \forall t = 1,\ldots,T \\
& \sum_{r=1}^{R} x_{rt} \leq b && \forall t = 1,\ldots,T \\
& x_{rt} \geq 0,\ \text{integer} && \forall r = 1,\ldots,R,\ \forall t = 1,\ldots,T \\
& b \geq 0,\ \text{integer}
\end{aligned}
$$

MODELING

1. **Model (1):** *Minimize Total Buses*
    a. Objective: Minimize fleet size while covering all routes.
    b. Outcome: Optimal fleet of 1,054 buses satisfies all routes; weekends require significant resources.
2. **Model (2):** *Maximize Passengers with Limited Fleet*
    a. Scenario: MBTA has only 800 buses.
    b. Outcome: 92.31% service coverage achieved; time periods 10 and 11 (weekends) identified as critical points.
3. **Model (3):** *Worst-Case Scenario Planning*
    a. Objective: Minimize buses for peak passenger demand.
    b. Outcome: 1,136 buses needed for worst-case scenarios; weekday demand significantly lower than weekend.

KEY FINDINGS



92.31 %

Of passenger demand met with
30% less buses (800)

516 buses

Needed to satisfy worst-case
maximum passenger load on weekdays*

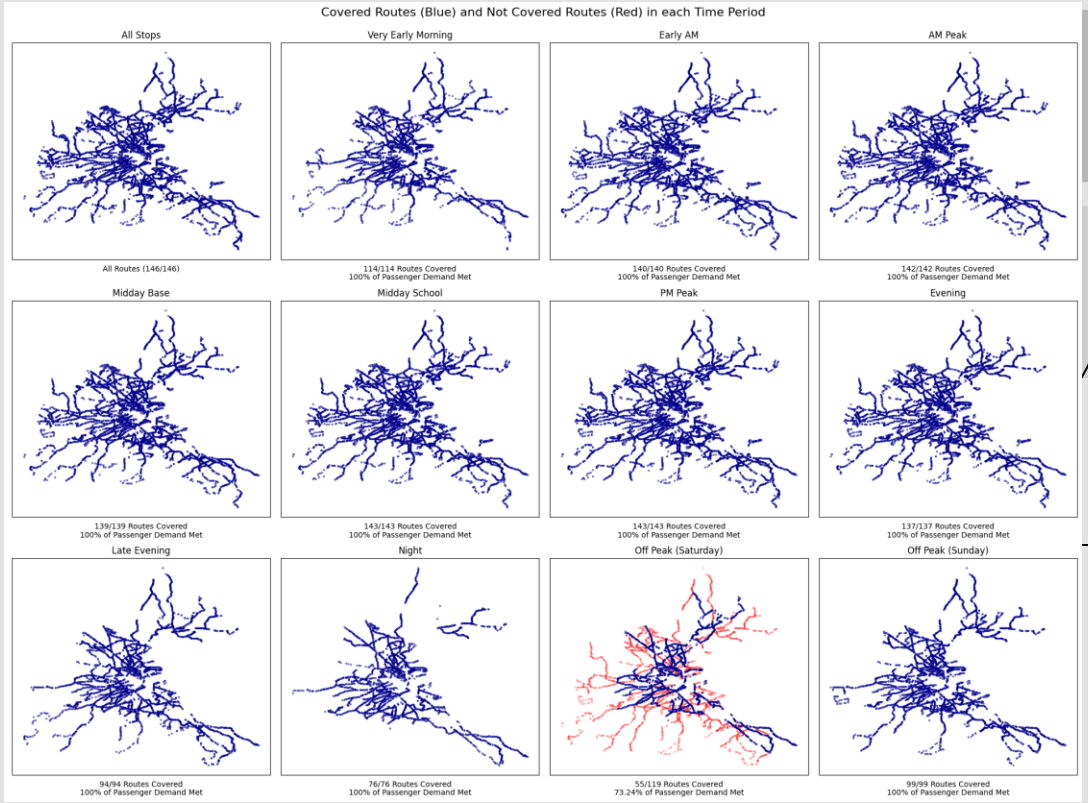
1054 buses

Needed to satisfy mean maximum
passenger load for all time periods

* We recommend the MBTA also focuses on optimizing other modes of transportation on weekends as there is a much higher passenger demand then for buses

POSSIBLE IMPACT

- **Performance:** Improved on-time performance and travel times for bus network
- **Efficiency:** Reduced fleet leads to less fuel consumption and operational costs
- **Sustainability:** Lower emissions from optimized routes enhance environmental goals
- **Service Quality:** More reliable bus service increases passenger satisfaction



THANK YOU

Any questions?

Iris Brook
MBAn '24
irisb211@mit.edu

Luca-Andrei Manea
MBAn '24
lucman@mit.edu