Clearly define the business problem you are addressing

This proposal addresses the challenge of lengthy travel times on the MBTA Commuter Rail, which negatively impacts ridership and overall system efficiency. To enhance commuter experience and meet growing time demands, there is an increasing need for optimized scheduling while maintaining service at key origin and destination stations.

This project proposes the introduction of express train lines that strategically eliminate low-demand stops, significantly reducing travel times for the majority of passengers while preserving access at the most critical stations.

The initiative aims to improve passenger convenience, enhance system efficiency, and position MBTA rail services as a competitive alternative to other modes of transportation.

State the goals of your modeling approach

Identify Key Variables and Operational Constraints
Analyze factors contributing to inefficient ridership patterns, including underutilized stops, peak vs. off-peak demand fluctuations, and service frequency. This exploration helps inform targeted improvements that align with rider behavior and service demand.

Optimize an Express Train Schedule
Develop an optimized express commuter rail schedule using linear programming that strategically removes low-demand stops while maintaining essential access points. The aim is to significantly reduce total travel time for the majority of riders and enhance overall system efficiency.

Simulate and Evaluate Impact on Ridership
Use census demographics and historical ridership data to simulate expected demand for the proposed express routes. This allows for the assessment of the model’s effectiveness in improving travel time, increasing ridership, and supporting equitable access across key population centers.

Describe the model(s) you used, including assumptions, methodology, and rationale

The objective of this modeling approach is to identify the optimal set of stops for an express commuter rail route that maximizes total passenger time savings, thereby improving system efficiency and commuter satisfaction.

We employed a **linear programming (LP) optimization model** designed to select which train stops should be included in the express route. The **objective function** calculates the total passenger-minutes saved by omitting specific stops—estimated as **two minutes per omitted stop**, multiplied by the **average number of passengers onboard** at that point in the journey.

Key Assumptions

- **Uniform time savings** of approximately two minutes per omitted stop.
- **Passenger volume at each station** is based on historical ridership data and census data to reflect true demand.
- **Omitting low-demand stops** will not significantly impact accessibility for the majority of riders.
- Clustering of travel times into **morning peak, afternoon off-peak, and evening peak periods** using timestamps to reflect demand variation throughout the day.

Methodology

- **Input Data**: Historical ridership data, census demographics by station location, and scheduled travel times.
- **Optimization Process**: The LP model evaluates different combinations of stops to determine which to retain or omit, aiming to **maximize total passenger time saved**.

Constraints

- **Preserve Service at Critical Endpoints**: Ensure that all express routes maintain service at key origin and destination stations to support full-route connectivity.
- **Restrict the Number of Omitted Stops**: Limit the total number of stops removed to maintain equitable access and avoid isolating lower-demand communities.
- **Retain High-Value Stations**: Prioritize keeping stops with high ridership volumes or strategic importance (e.g., transfer points, economic hubs) to maximize system utility and passenger benefit

Rationale

This approach ensures that decisions are **data-driven**, **scalable**, and focused on improving the **efficiency and competitiveness** of the MBTA Commuter Rail system. By simulating different service configurations and their effects on travel time and ridership, the model supports the development of a practical, commuter-friendly express service

<u>Include any relevant details that demonstrate the model's suitability for the problem</u>

- **Optimized Travel Time & Efficiency** – The linear programming model reduces travel time by eliminating low-demand stops while maintaining critical endpoints, improving system-wide efficiency and competitiveness.

- **Data-Driven & Scalable** – Uses census and ridership data to identify high-impact stops, with clustering techniques for peak and off-peak adjustments, ensuring adaptability across different routes.

- **Balanced Accessibility & Ridership Growth** – Constraints prevent excessive stop removals, maintaining accessibility while increasing ridership through faster, more reliable service.