NC STATE UNIVERSITY

EDWARD P. FITTS DEPARTMENT OF INDUSTRIAL AND SYSTEMS ENGINEERING

BOSTON Public Schools Focus on Children

sas

Analyzing and Optimizing Shuttle Bus Allocation for Boston Public Schools on behalf of SAS

Savannah Abel, Benjamin Craver, Philip Greco, Annie Lin, Michael Rosenberg

Introduction

Scope:

- 1.2 Billion USD school system, that
- Serves 56,000 students annually
- 15,000 students participate in the system's School Choice program

Purpose:

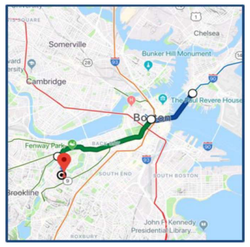
- Enables students to choose the school that best fits their needs

Problem:

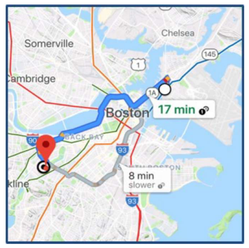
- Creates a system-wide transportation challenge
  - 15,000 students are not served by traditional school bus routes

Question:

- How can BPS serve students with fair and efficient alternative transportation?



Option 1: Take the MBTA (40 Minutes)



Option 2: Allocate a shuttle bus (17 min)

Data Collection

Model Formulation

Decision Variables

$Assign - Student_{i,r}$ 1 if student i is assigned to stop r; 0 otherwise.
$Assign - Route_{r,q}$ q if a route from stop r to school q is created; 0 otherwise.

Objective Function

$$z = \min \sum_{i \in I} \sum_{r \in R} \sum_{q \in Q} ((timetostop + timetoschool_{q,r}) * AssignStudent_{i,r} + tpasstime_i * (1 - AssignStudent_{i,r}))$$

Constraints

$s.t.$

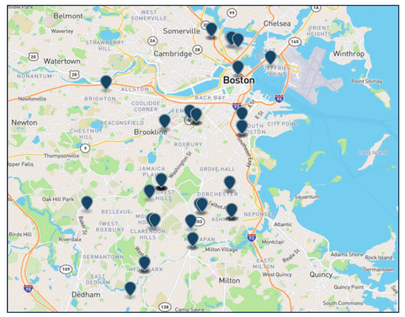
$$\sum_{r \in R} \sum_{q \in Q} Assign - Route_{r,q} = total - fleet$$

$$Assign - Student_{i,r} = Assign - Route_{r,q_i} \quad \forall i, r$$

$$\sum_{r \in R} Assign - Student_{i,r} \leq 1 \quad \forall i$$

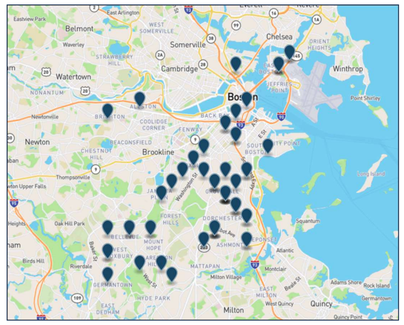
Results

Old Shuttle Allocation

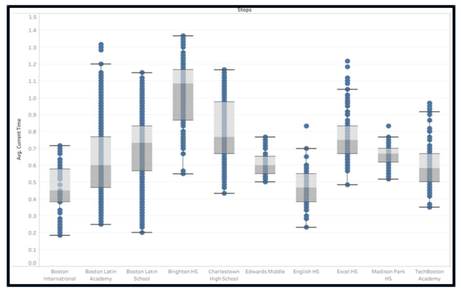


59 routes servicing 2,224 students

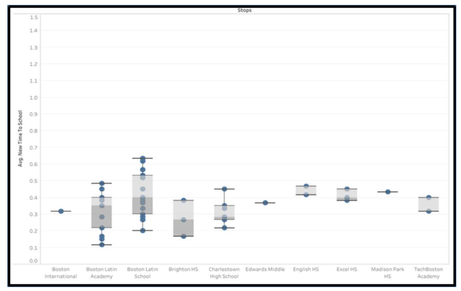
New Shuttle Allocation



59 routes servicing 4,334 students



Confidence intervals for students traveling to school on the old shuttle allocation. Average time is 0.696 hours.



Confidence interval for students traveling to school on the new shuttle routes. Average time is 0.56366 hours.

Continuous Control

- ✓ NCSU: Candidate Bus Stop Locations — 2,500 Generated Data Points
- ✓ NCSU: Drive times from every stop to every school. — 25,000 Generated Data Points
- ✓ NCSU: TPass Times For Each Student — 15,000 Generated Data Points
- ✓ NCSU: Walk times to every shuttle stop for each student. — 2,500 Generated Data Points
- ✓ NCSU: Running Model Implemented in SAS OR with easy to update input data. — Optimized to run online (BPS does not need software)
- ✓ NCSU: Model results in the same format BPS currently uses to allocate students. — New shuttle routes and student allocation output data.
- ➤ BPS: Implement new Shuttle Routes and Student Allocation — No student time is longer and cost is the same.
- ➤ BPS: Update the model every year for new students. — Only requires routine updates to student addresses.

19% ⬇

Acknowledgements

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