Bus Bridging Assessment Tool and Visualization Dashboard

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iCity–ORF Webinar, June 2020

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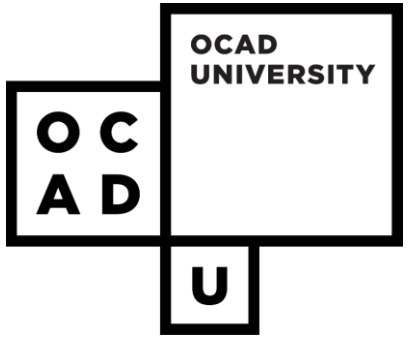
Outline

- Research Team
- DASh-Bus: A Decision Support Toolkit
  - Use Cases
    - Bus Bridging Assessment Scenario
    - Bus Bridging Optimization
- Visualization Dashboard

Research Team

- *DASh-Bus* Conceptualization and Development by University of Toronto
  - Alaa Itani
  - Dr. Aya Aboudina
  - Dr. Siva Srikukenthiran
  - Prof. Ehab Diab
  - Prof. Amer Shalaby

- Visualization Dashboard by OCADU
  - Olufunbi Disu-Sule
  - Dr. Greice Mariano
  - Prof. Jeremy Bowes



DASh-Bus: A Decision Support Toolkit

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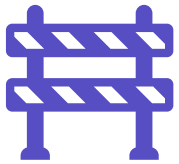
Background



144 unplanned subway closures in 2015

A Total of 6,500 buses were requested

70% of the requested buses were from operational bus routes

Economic cost of **m*ajor*** subway passengers' delay in New York City ~ $389 million annually

Background

Major unexpected rail disruptions occur frequently

Often, a simplistic approach is followed for selecting shuttle buses

Can lead to extensive delays for passengers and buildup at stations

Result in degraded service and potential loss of loyal passengers

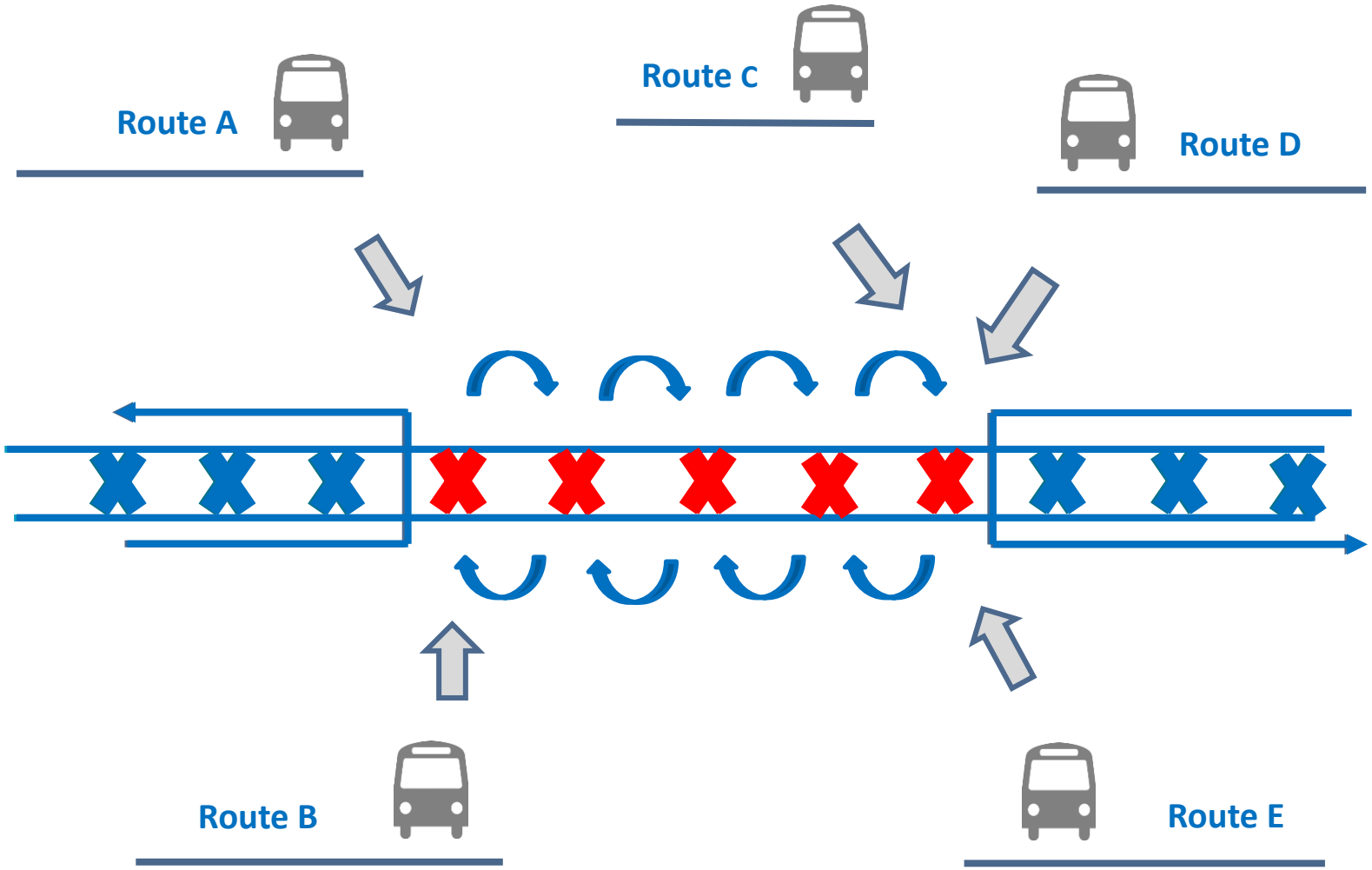
Objectives

Develop a tool to help agencies dispatch shuttle buses and evaluate different scenarios

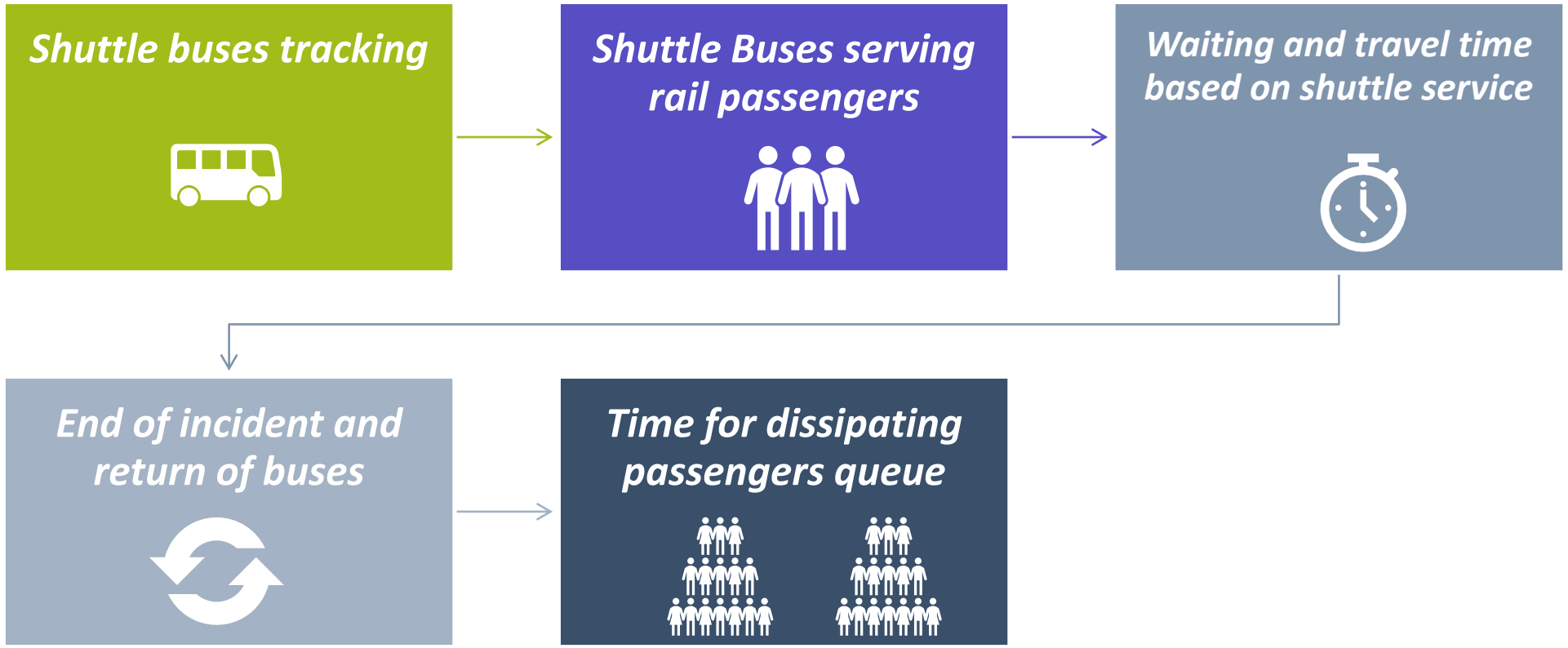
Provide measures of the impact on train and bus passengers

Provide measure of how well shuttle buses are used

Methodology Overview



Methodology Overview (Cont.)



Use Cases

✓Bus Bridging Scenario Assessment

➔ *DASh-Bus Planner*

✓Bus Bridging Optimization

➔ *DASh-Bus Optimizer*

Use Case #1: Bus Bridging Scenario Assessment

Data Input and Output

User Specified Input

- Incident location and time
- Expected duration of incident
- Dispatch time and Demand reduction
- Number & assignment of shuttle buses

Data Inputs

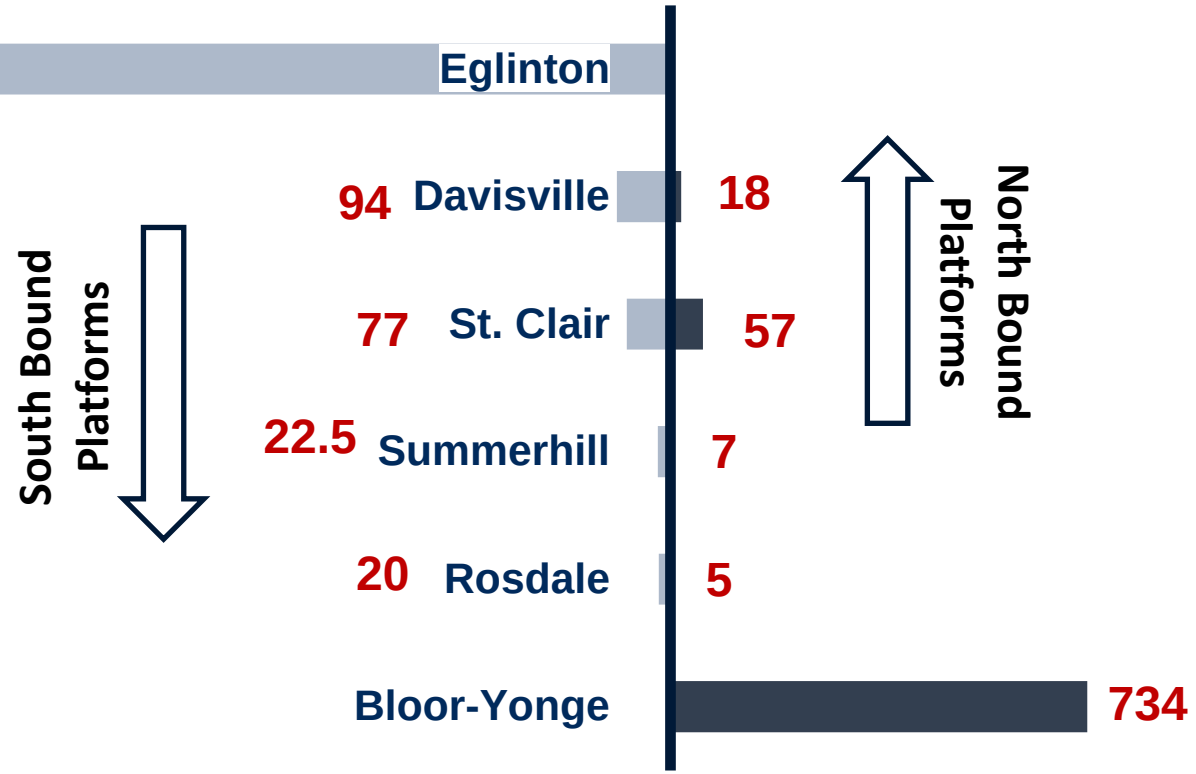
- Transit network characteristics
- Train and bus ridership
- Train and bus travel time

DASh-Bus Planner

- Subway Passengers' Delay
- Bus Riders' Delay
- Detailed measures at disrupted stations
- Longest queue at disrupted stations
- Detailed impact on each bus route
- Shuttle buses performance measures
- Degree of utilization of shuttle buses
- Deadhead time of shuttle buses

Case Study: Assessing an Existing Bus Bridging Plan

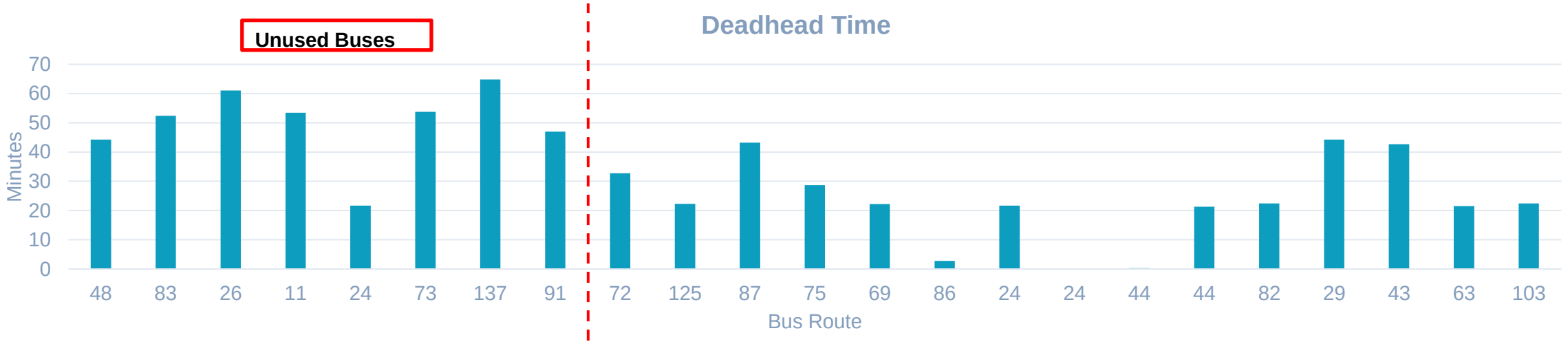
Disruption occurred during the **morning peak** period lasting for **31 min**
Closing **6 stations**, between **Bloor-Yonge** and **Eglinton**

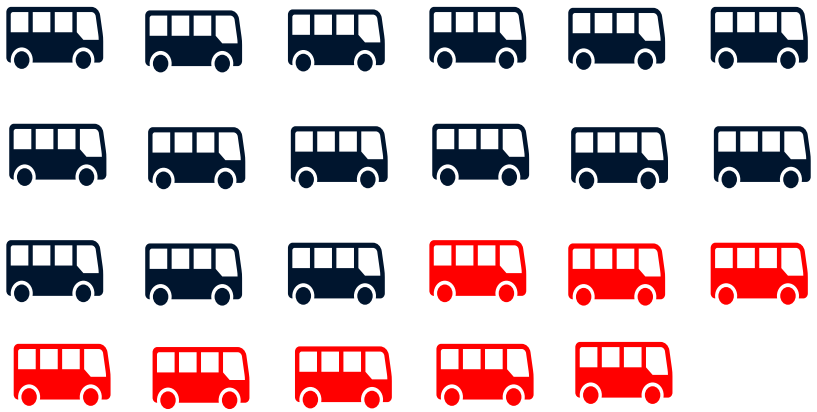


Delays at the Disrupted Subway Stations
(Passenger-hr.)

Testing Other Response Plans

1 *Eliminate non-utilized buses*

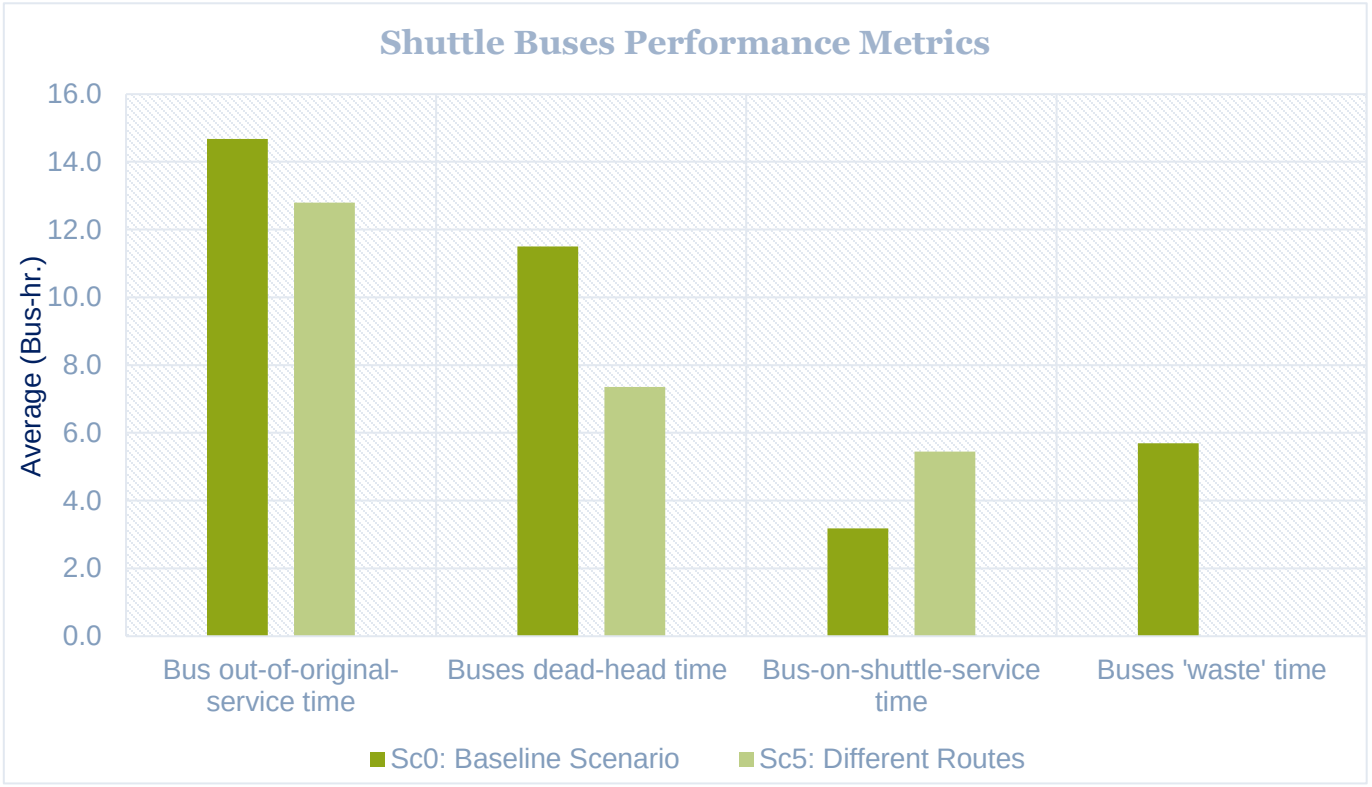


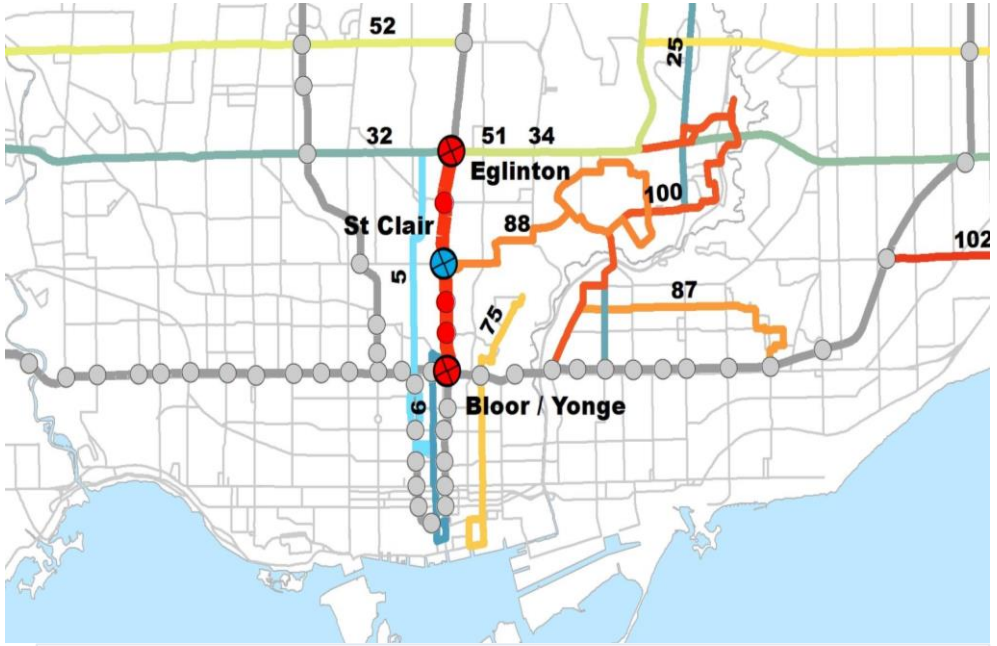


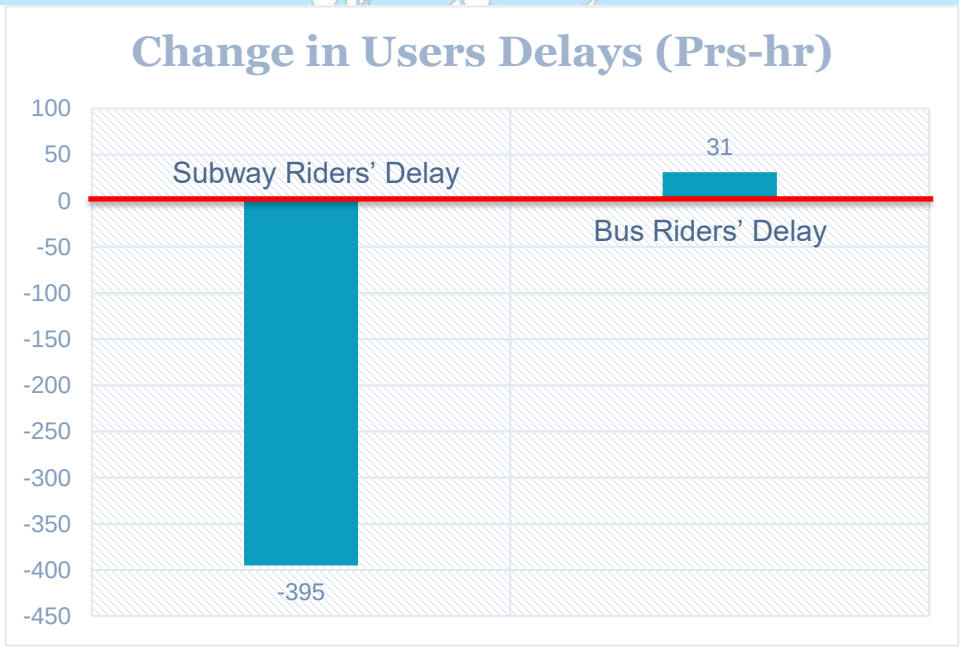
- **51%** reduction in bus users' delay
- Zero-min Wasted Time

Testing Other Response Plans (Cont.)

2 *Dispatch shuttle buses from nearby routes*

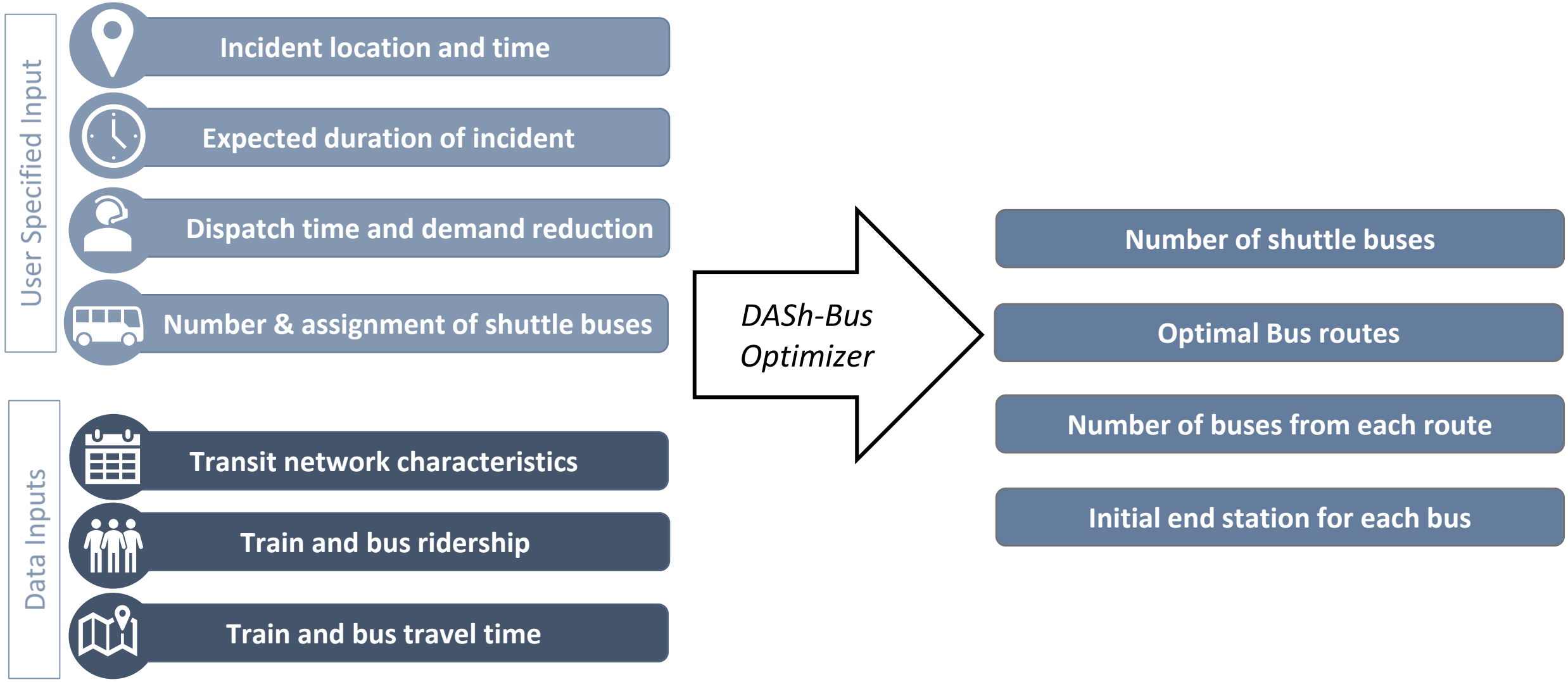




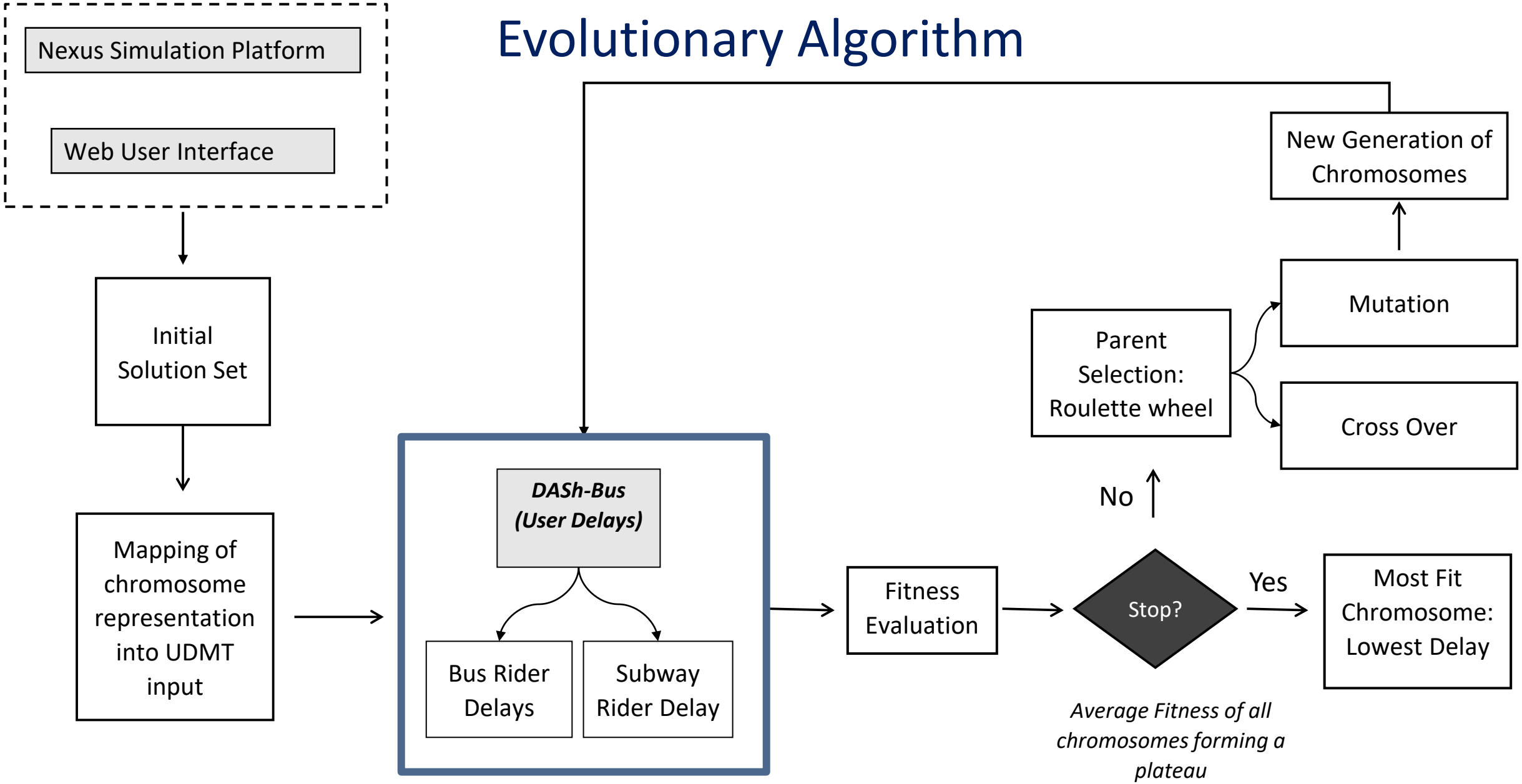


Use Case #2: Bus Bridging Optimization

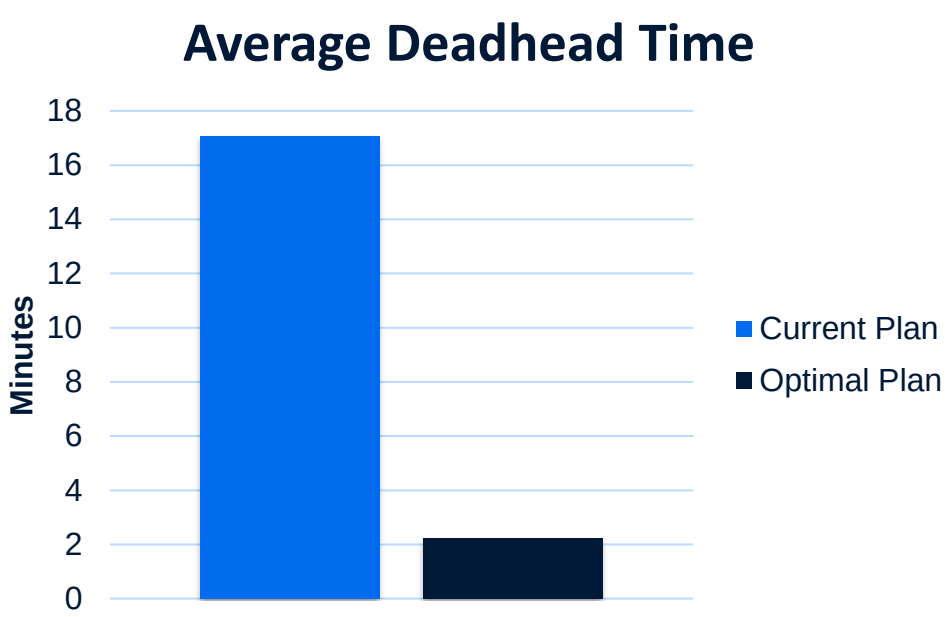
Data Input and Output

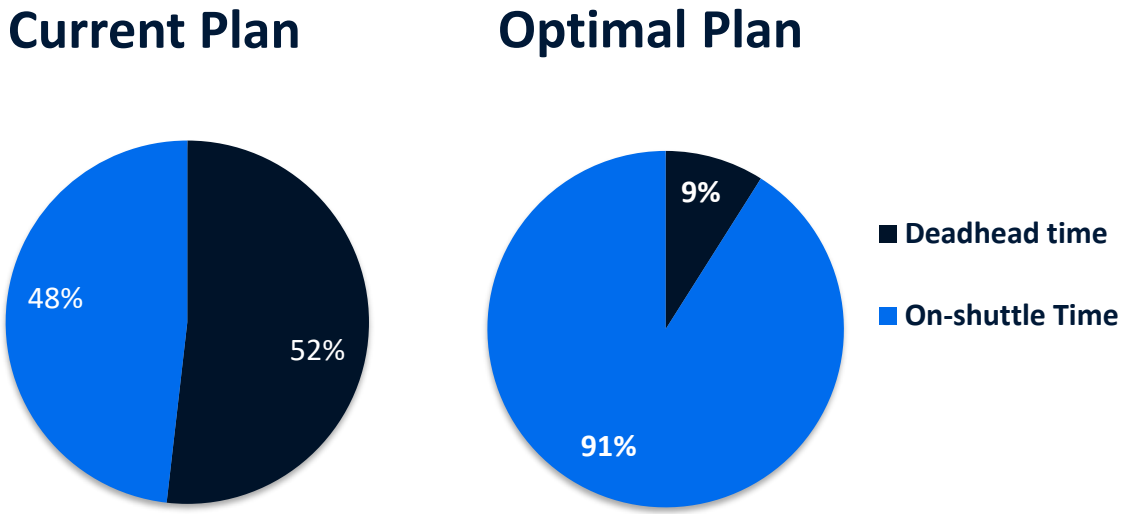


Evolutionary Algorithm



Comparison of Outcomes





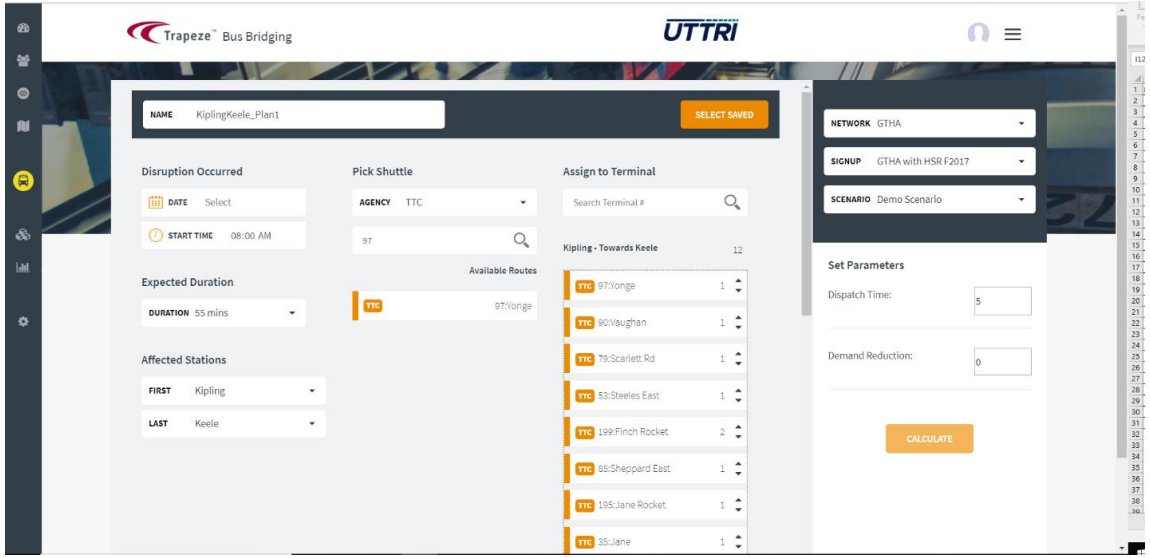
15 mins, on average, is saved in deadhead time of each shuttle bus

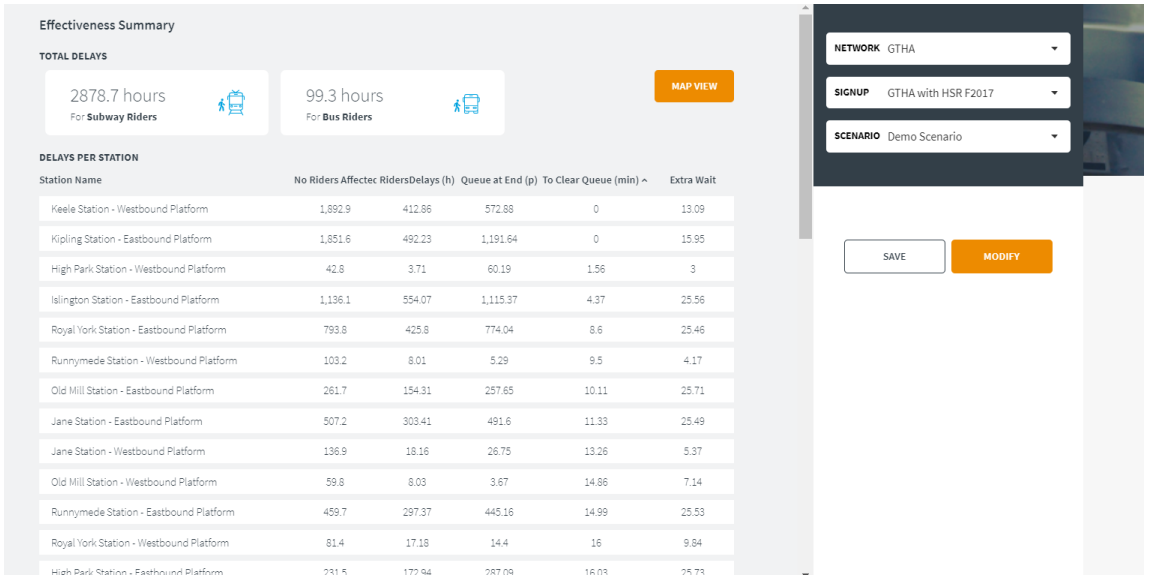
Optimal plan shows a better utilization of shuttle buses along the disrupted segment

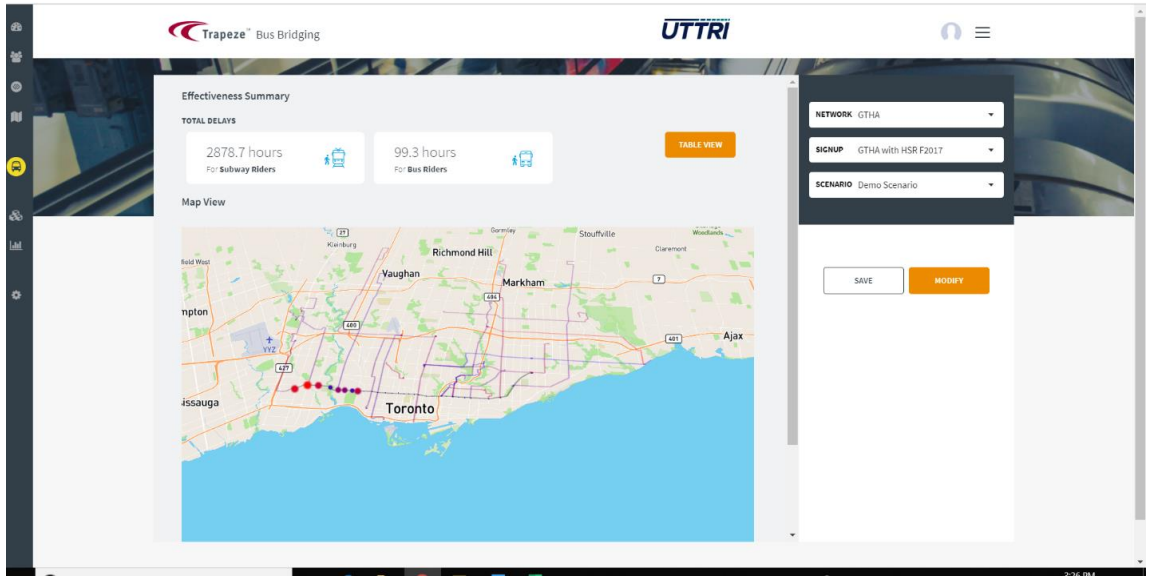
Publications

- Aboudina, A., Itani, A., Diab, E., Srikukenthiran, S., and Shalaby, A. (in press). Evaluation of bus bridging scenarios for railway service disruption management: a users delay modelling tool. *Public Transport*. DOI: 10.1007/s12469-020-00238-w.
- Itani, A., S. Srikukenthiran and A. Shalaby, 2020. "*Capacity-Constrained Bus Bridging Optimization Framework*", Transportation Research Record.
- Itani, I., A. Aboudina, E. Diab, S. Srikukenthiran and A. Shalaby, 2019. "*Managing Unplanned Rail Disruptions: Policy Implications and Guidelines towards an Effective Bus Bridging Strategy*", Transportation Research Record, Vol. 2673(4), pp. 473-489.
- Diab, E., G. Feng and A. Shalaby, 2018. "*Breaking into Emergency Shuttle Service: Aspects and Impacts of Retracting Buses from Existing Scheduled Bus Services*", Canadian Journal of Civil Engineering, Vol. 45(8), pp. 647-658.

Initial Visualization Dashboard







Visualization Dashboard

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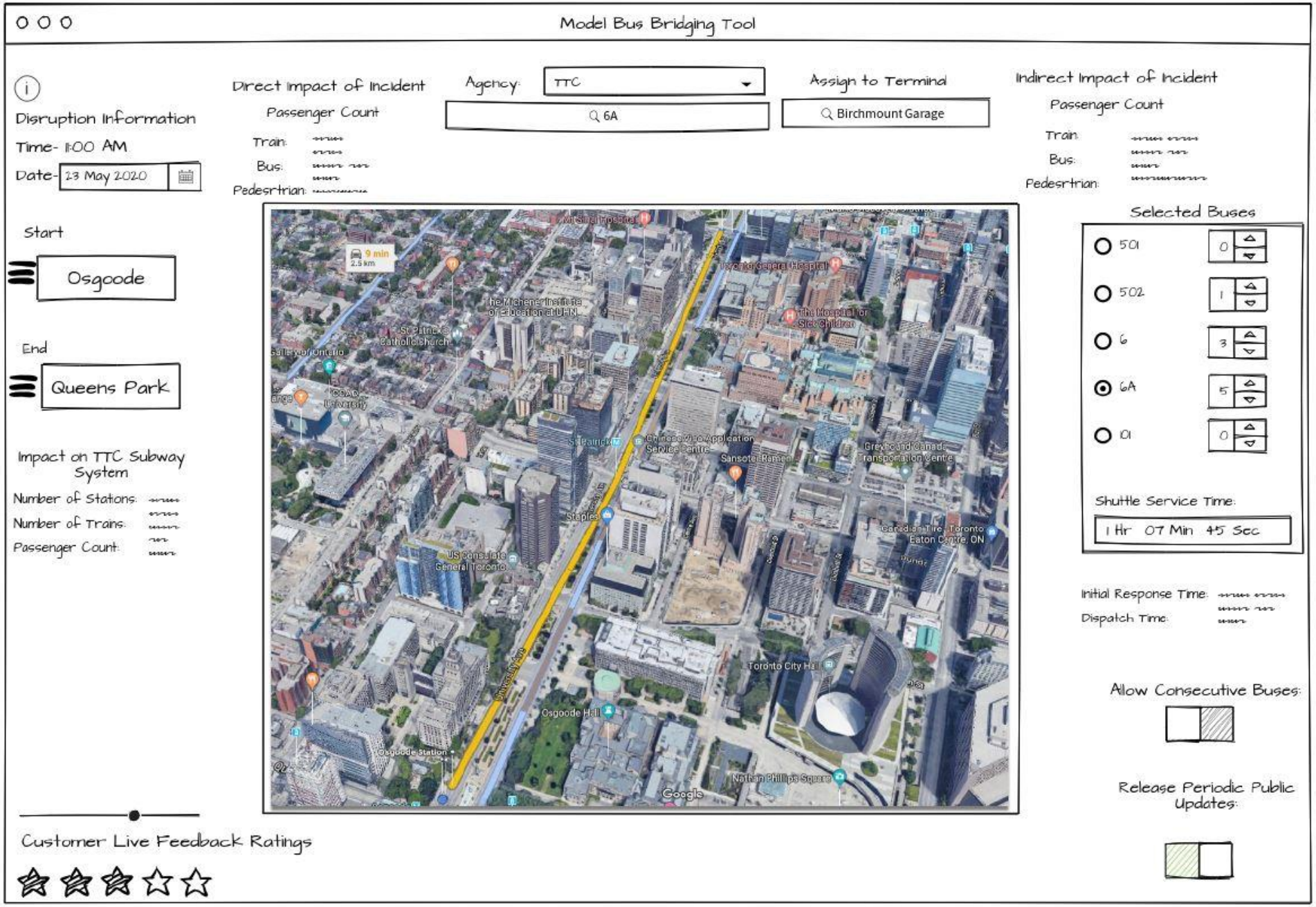
What was missing from the initial dashboard prototype?

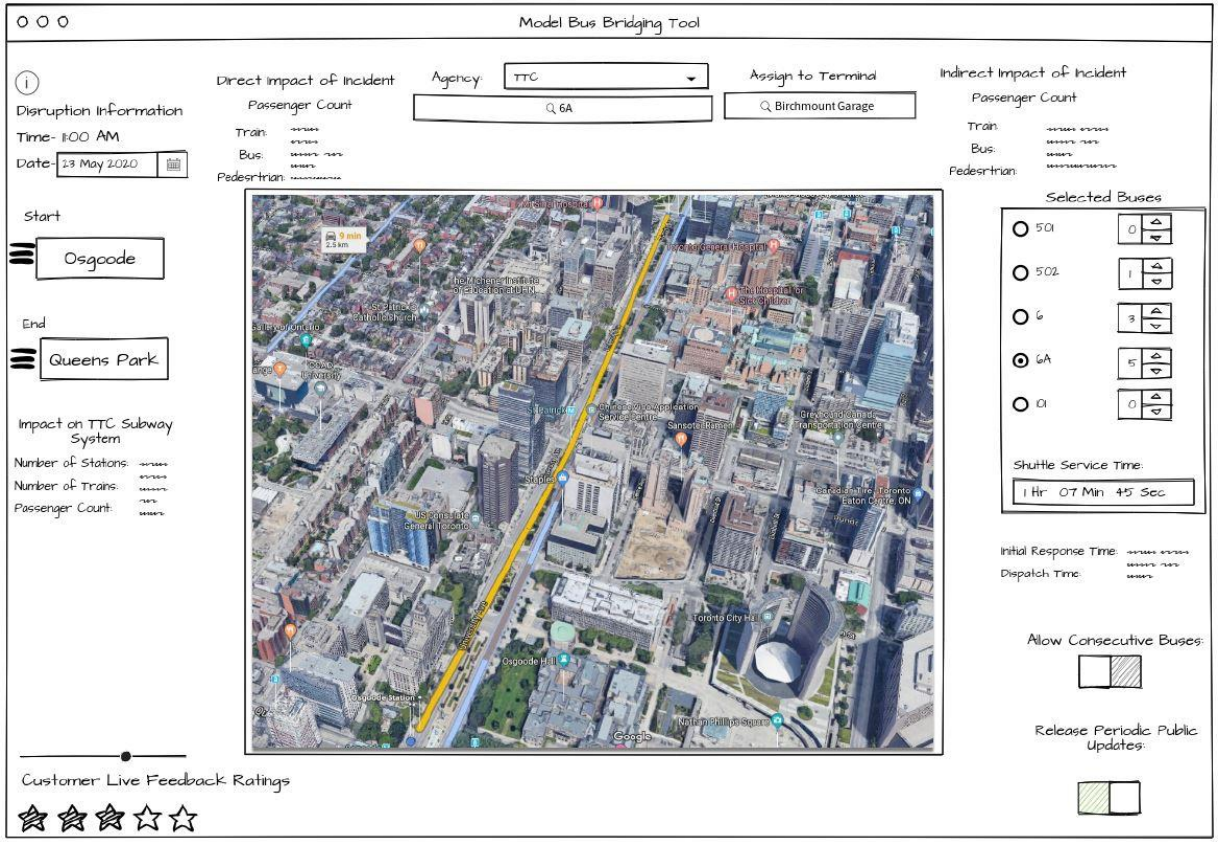
- Visualizations of several scenarios simultaneously
- Graphically scaled passenger counts
- Side by side comparison of data and map
- Delay time for arriving passengers at affected stations
- Complete overview of system
- Interactive data visualizations
- Distinct visualizations of unique trends and data sets
- No potential for real time vehicle tracking

First Iteration

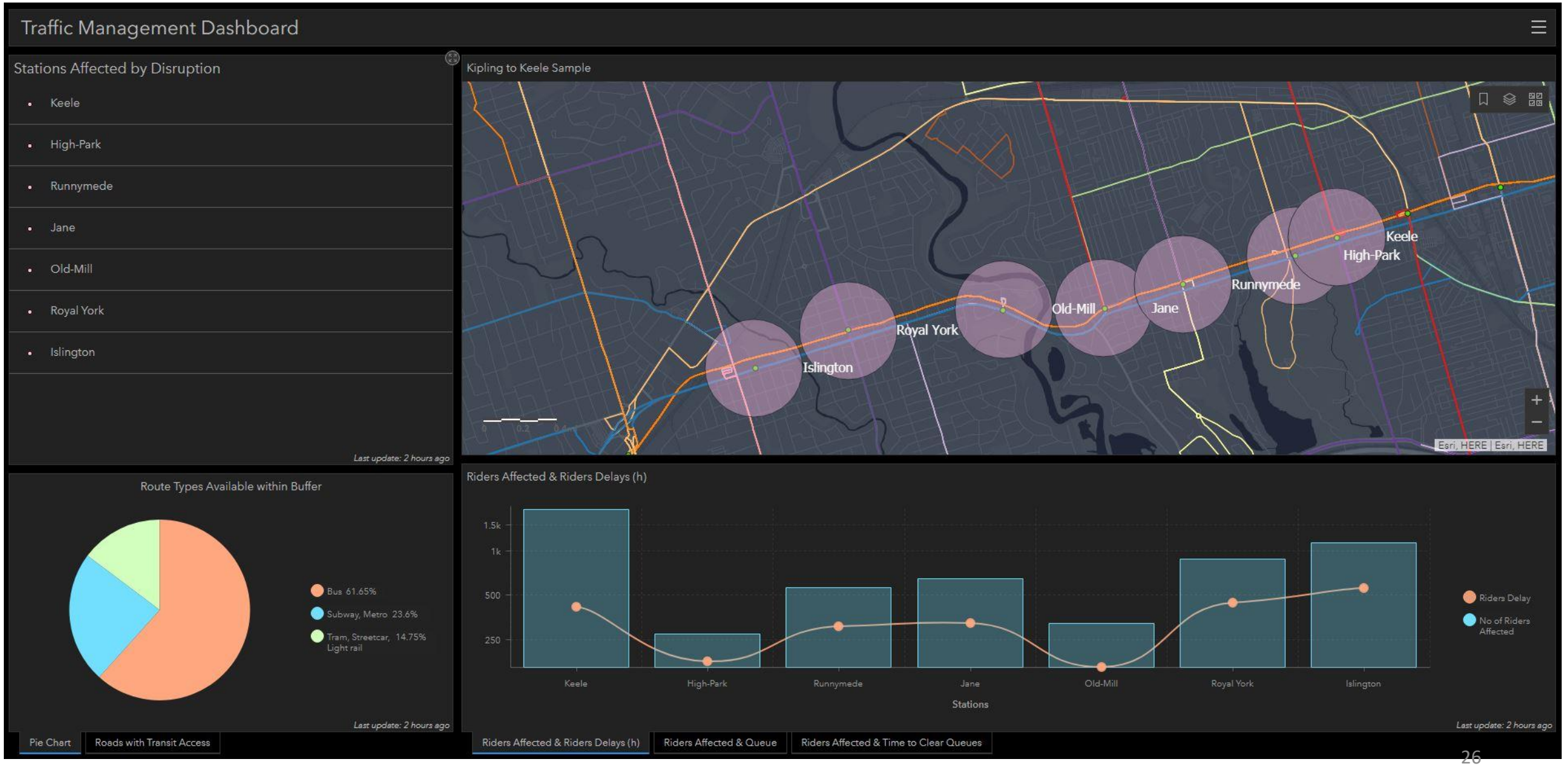


Assessment

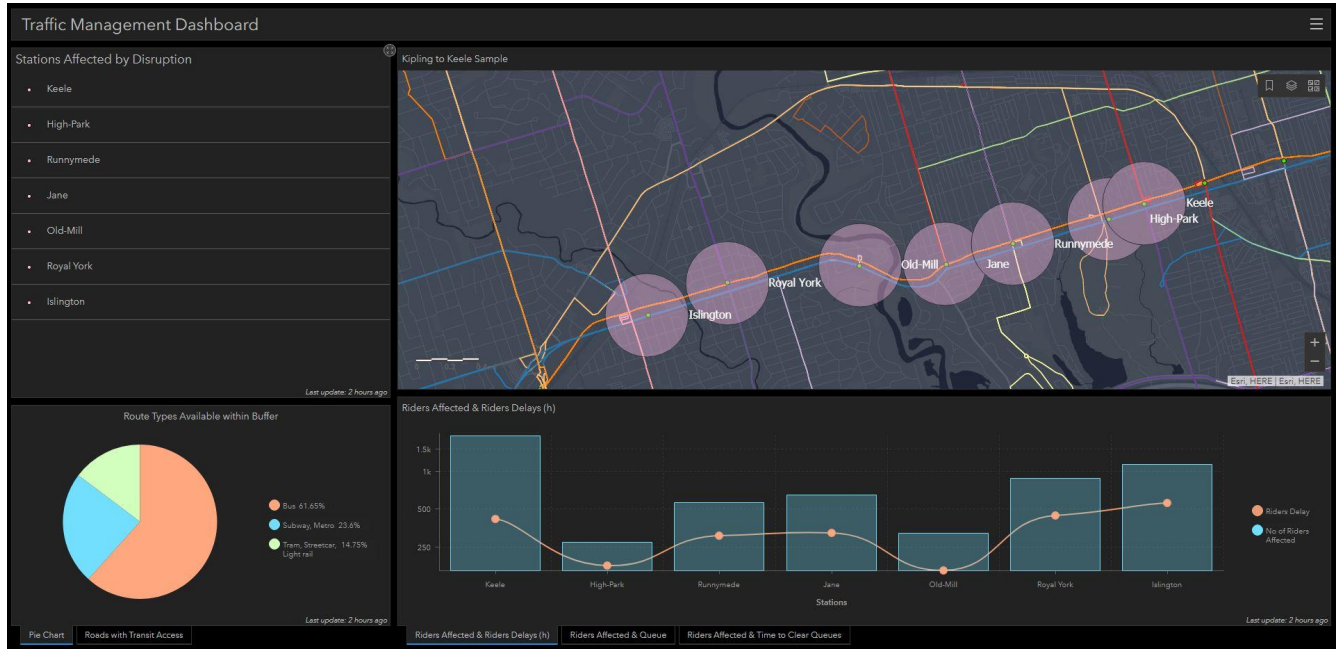
- Display delay using unique graphics
- Lacking in any comparative statistical data
- Compare two different scenarios
- Display surrounding bus lines
- Increase levels of interactivity
- Support decision making
- Improve map readability



Second Iteration



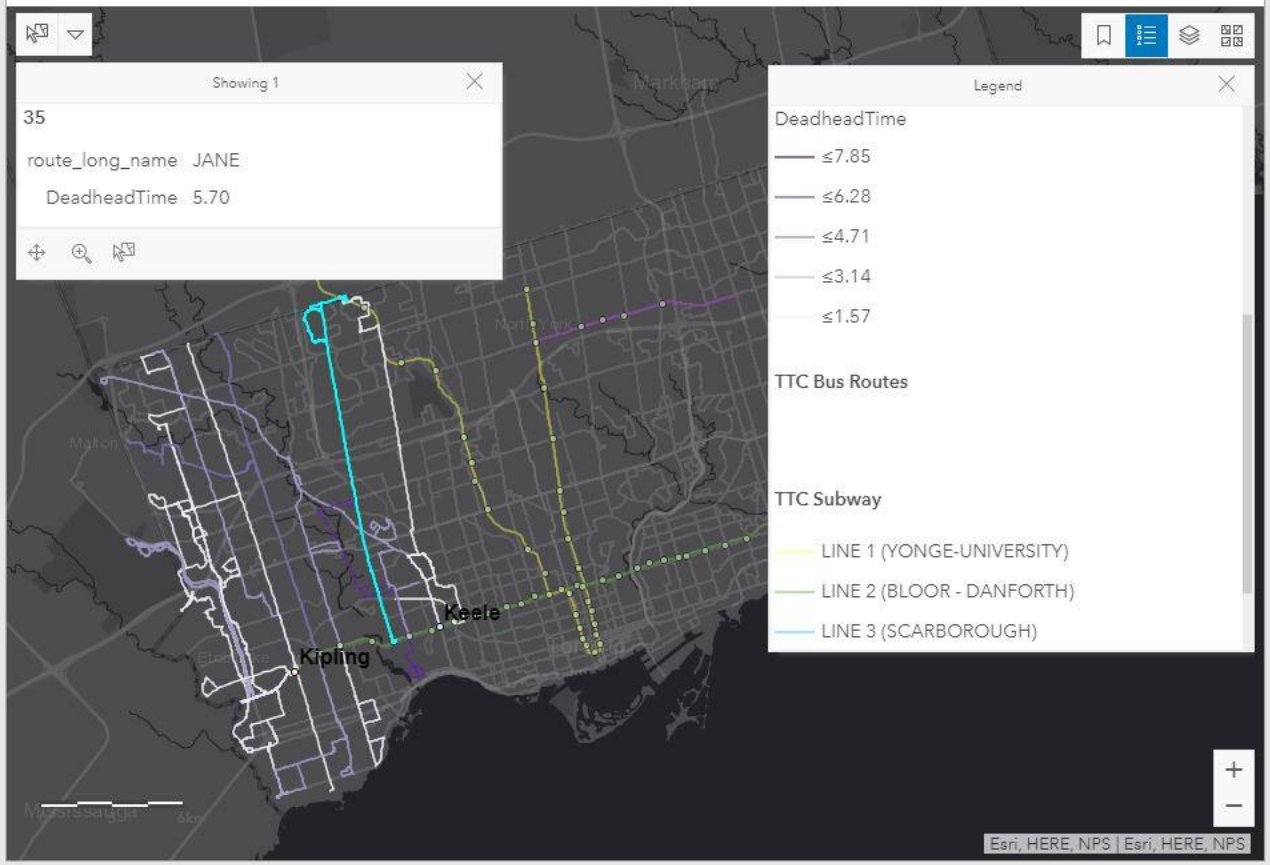
Assessment



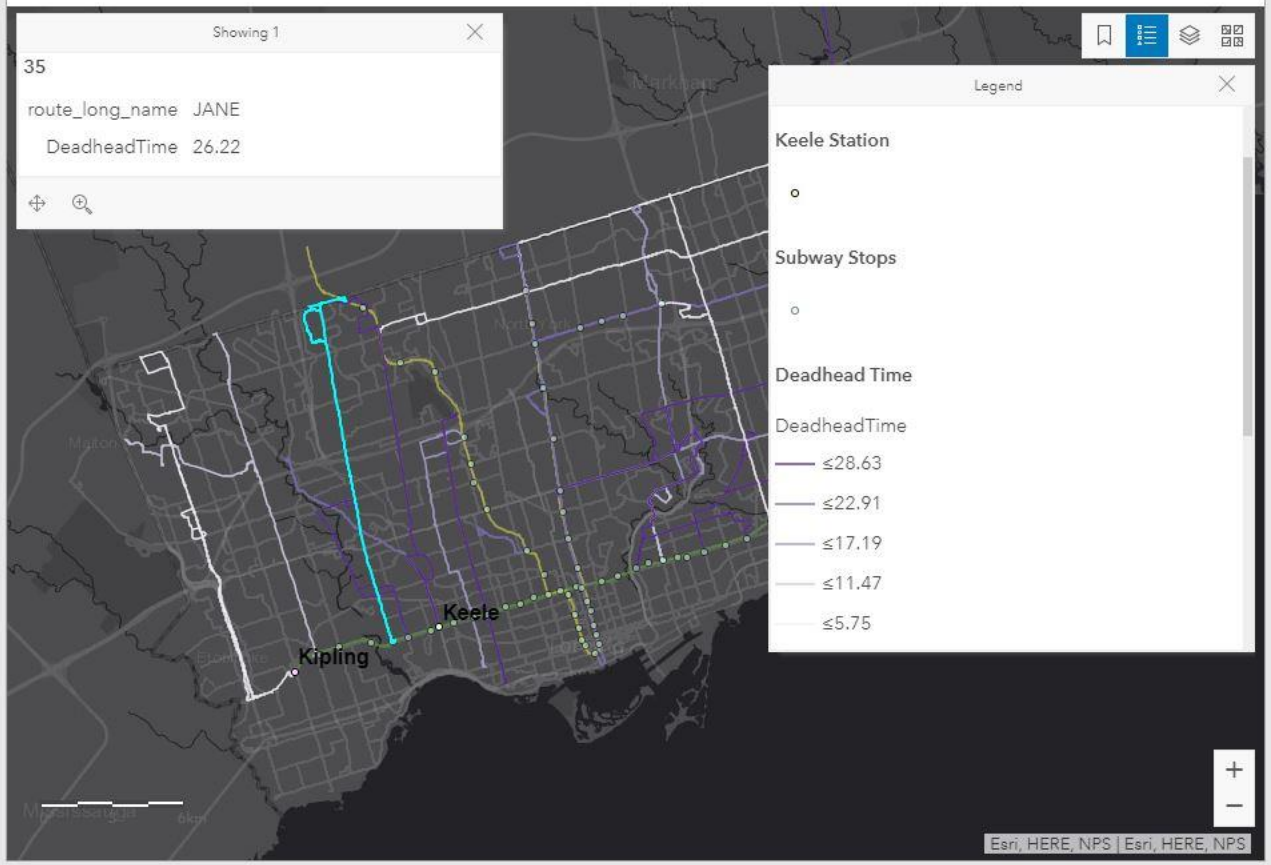
- Provide overview of entire scenario
- Display total user delay for each scenario
- Increase meaningful data displayed
- Further increase the interactivity of the dashboard
- Necessary for a display of 2 scenarios simultaneously
- Map elements should have tooltips and dialogue boxes when selected/hovered.

Third Iteration

Scenario 1

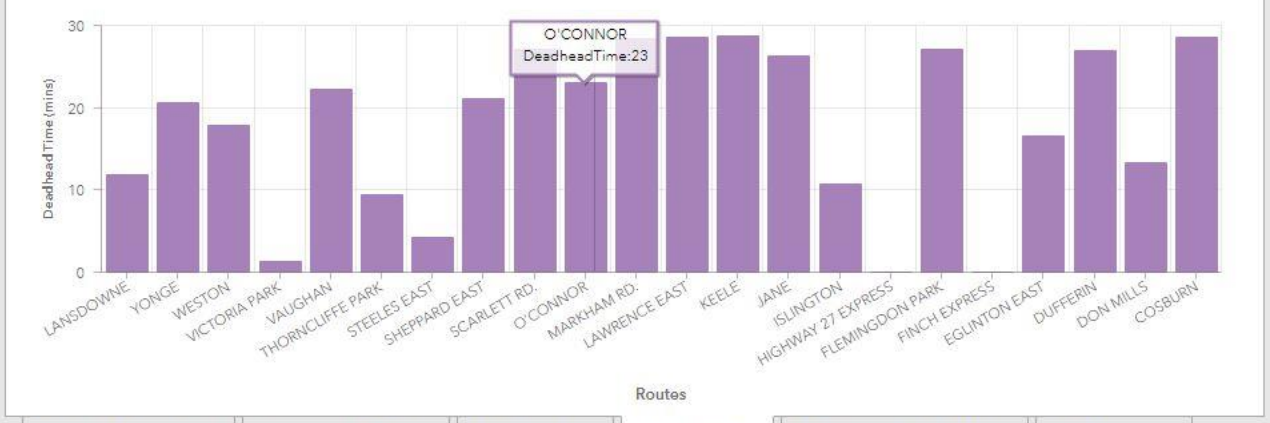


Scenario 2



Deadhead Time

Deadhead Time



Number of Buses Pulled | Out of Service Duration | Bus Riders Delay | Deadhead Time | Out of Serv/Bus Riders Delay | Bus Riders Delay

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Scenario 1

Total Bus Riders Delay

4.738k

Sum of all values in scenario

Number of Buses Pulled | Out of Service Duration | Bus Riders Delay | Deadhead Time | Out of Serv/Bus Riders Delay | Bus Riders Delay

Scenario 2

Total Bus Riders Delay

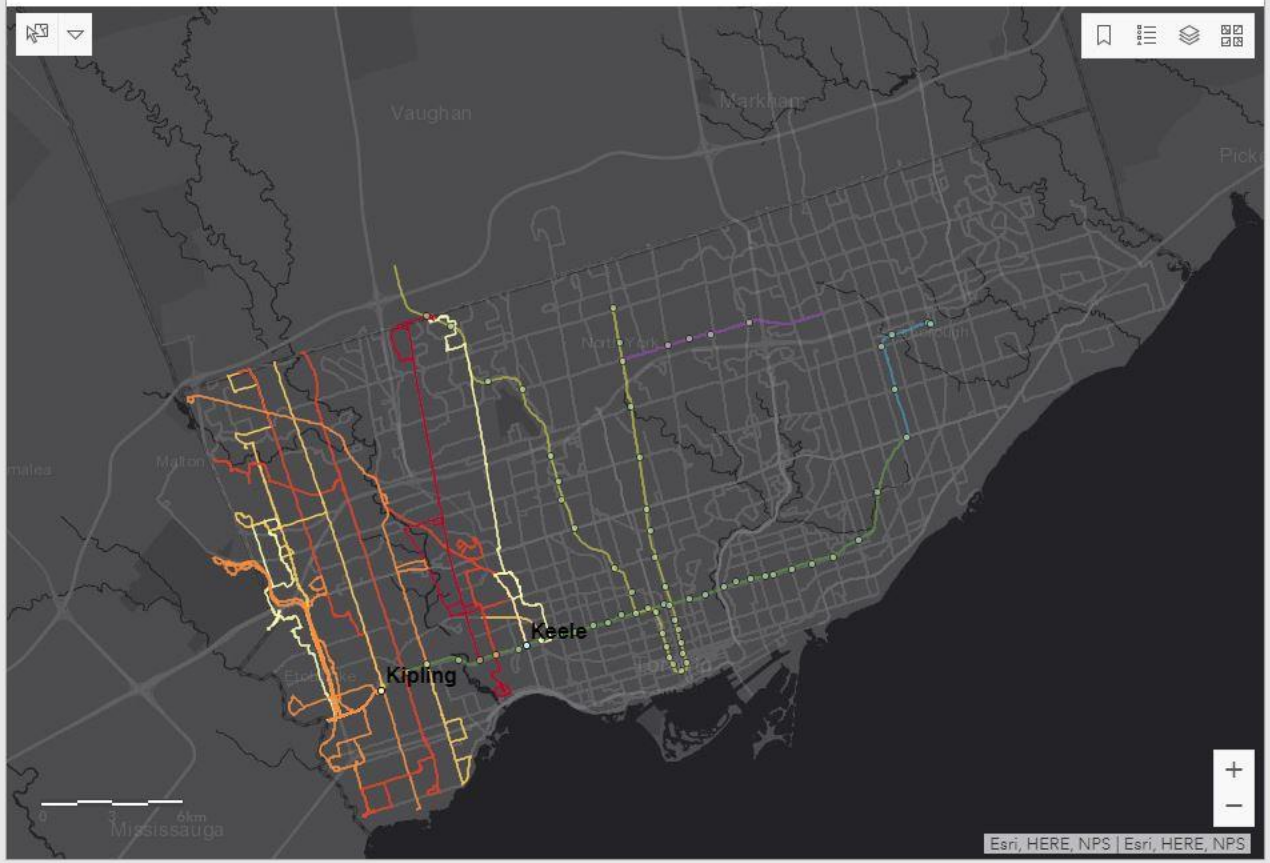
4.772k

Sum of all Values in Scenario

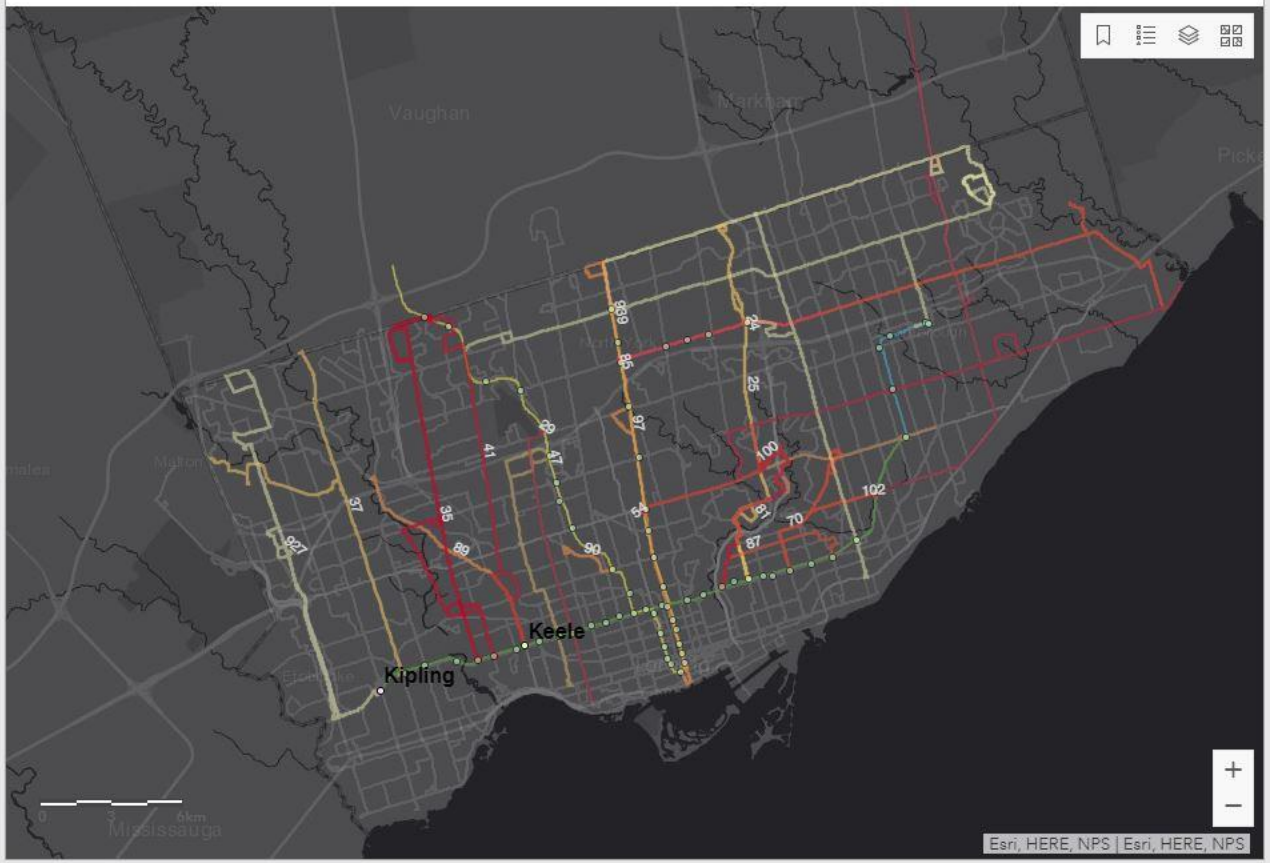
Last update: 3 minutes ago

Number of Buses Pulled | Out of Service Duration | Bus Riders Delay | Deadhead Time | Out of Serv/Bus Riders Delay | Bus Riders Delay

Scenario 1

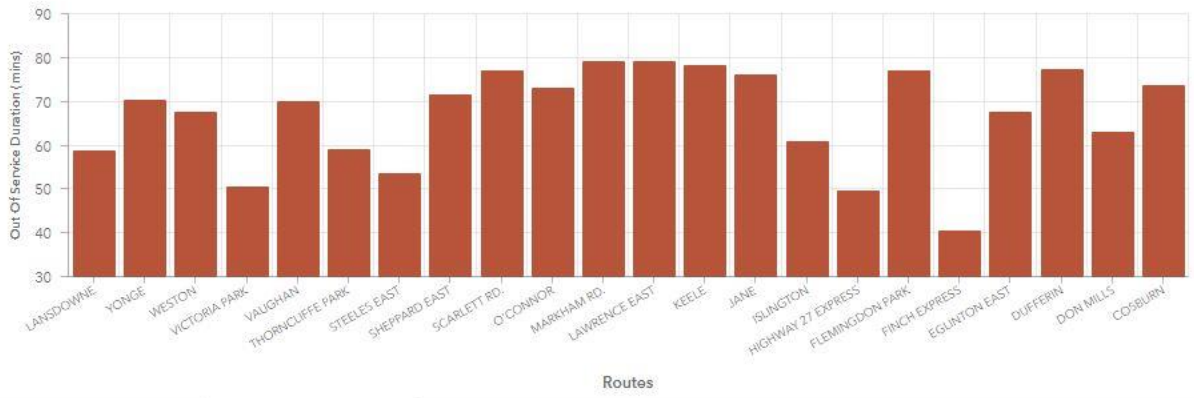


Scenario 2



Out of Service Duration

Out Of Service Duration



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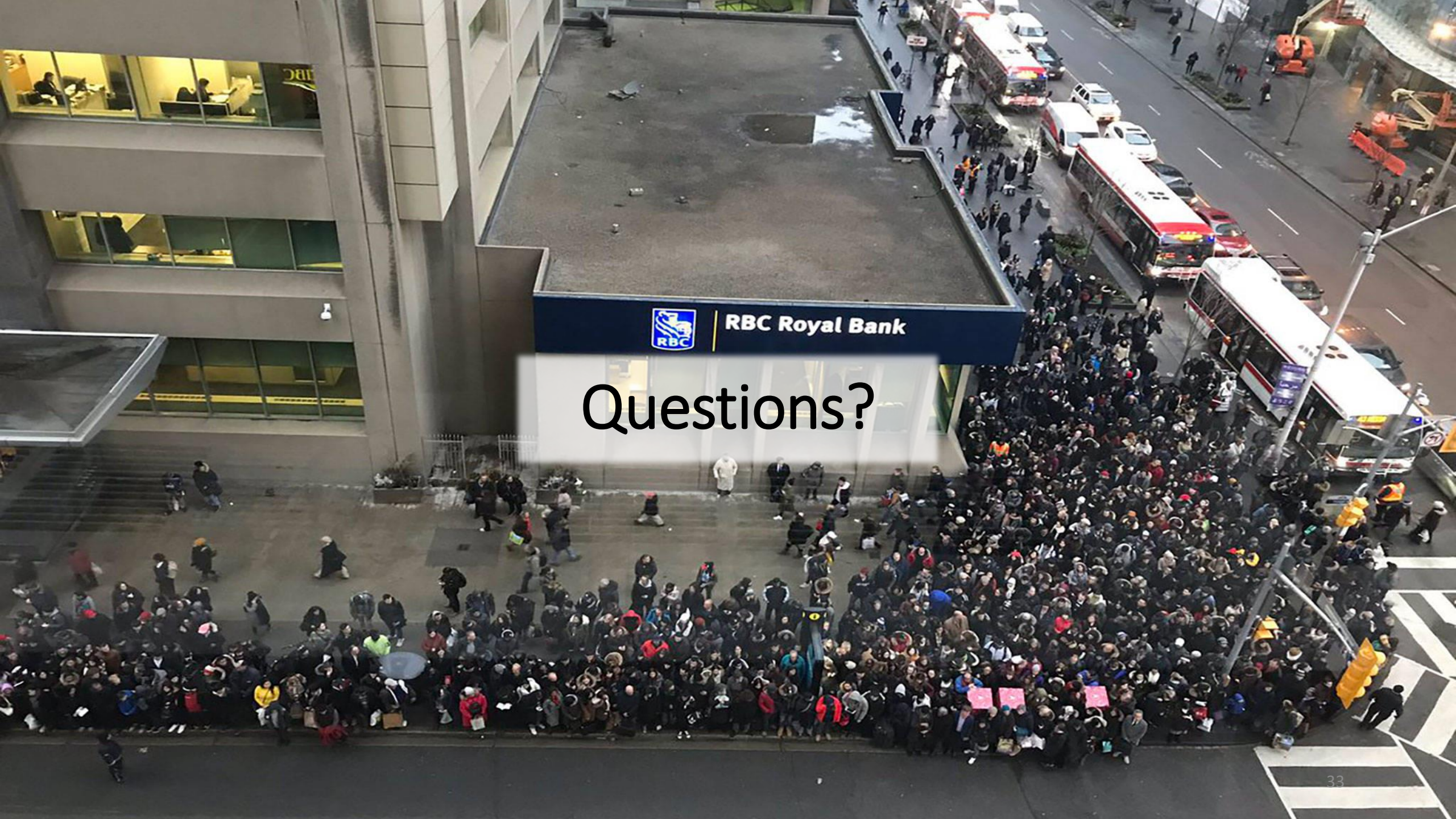
Acknowledgments

- ORF
- Trapeze Inc
- NSERC
- OCE
- SOSCIP



Questions?

Potential Use Cases

- Key challenges that face transit agencies post-COVID
  - "*Improving the management of flows to avoid crowds/excessive concentration of travelers in a given place at a given time*" ~ Sylvain Haon, Senior Director Strategy at UITP
- Relief of overcrowding using shuttle buses
  - "*Imposing physical distancing in public transport vehicles means operating them using only 20 per cent of their capacity*"
- Managing rail disruptions post-COVID
  - "*It's equivalent of only 8 to 10 passengers in standard bus…*"

Source: Intelligent Transport. "Looking Ahead to Public Transport Post-Pandemic." Accessed June 5, 2020. https://www.intelligenttransport.com/transport-articles/100389/looking-ahead-to-public-transport-post-pandemic/.