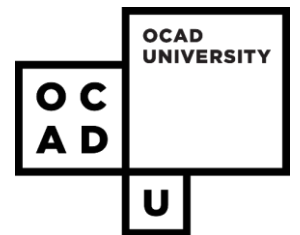


Bus Bridging Assessment Tool and Visualization Dashboard

Alaa Itani, MAsc.

Olufunbi Disu-Sule

iCity–ORF Webinar, June 2020



Outline

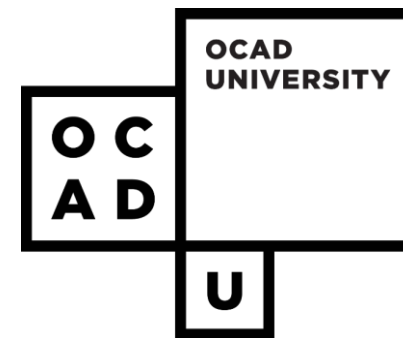
- Research Team
- DASH-Bus: A Decision Support Toolkit
 - Use Cases
 - Bus Bridging Assessment Scenario
 - Bus Bridging Optimization
- Visualization Dashboard

Research Team

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

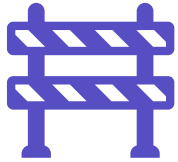


- Visualization Dashboard by OCADU
 - Olufunbi Disu-Sule
 - Dr. Greice Mariano
 - Prof. Jeremy Bowes



DASh-Bus: A Decision Support Toolkit

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 **major** 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

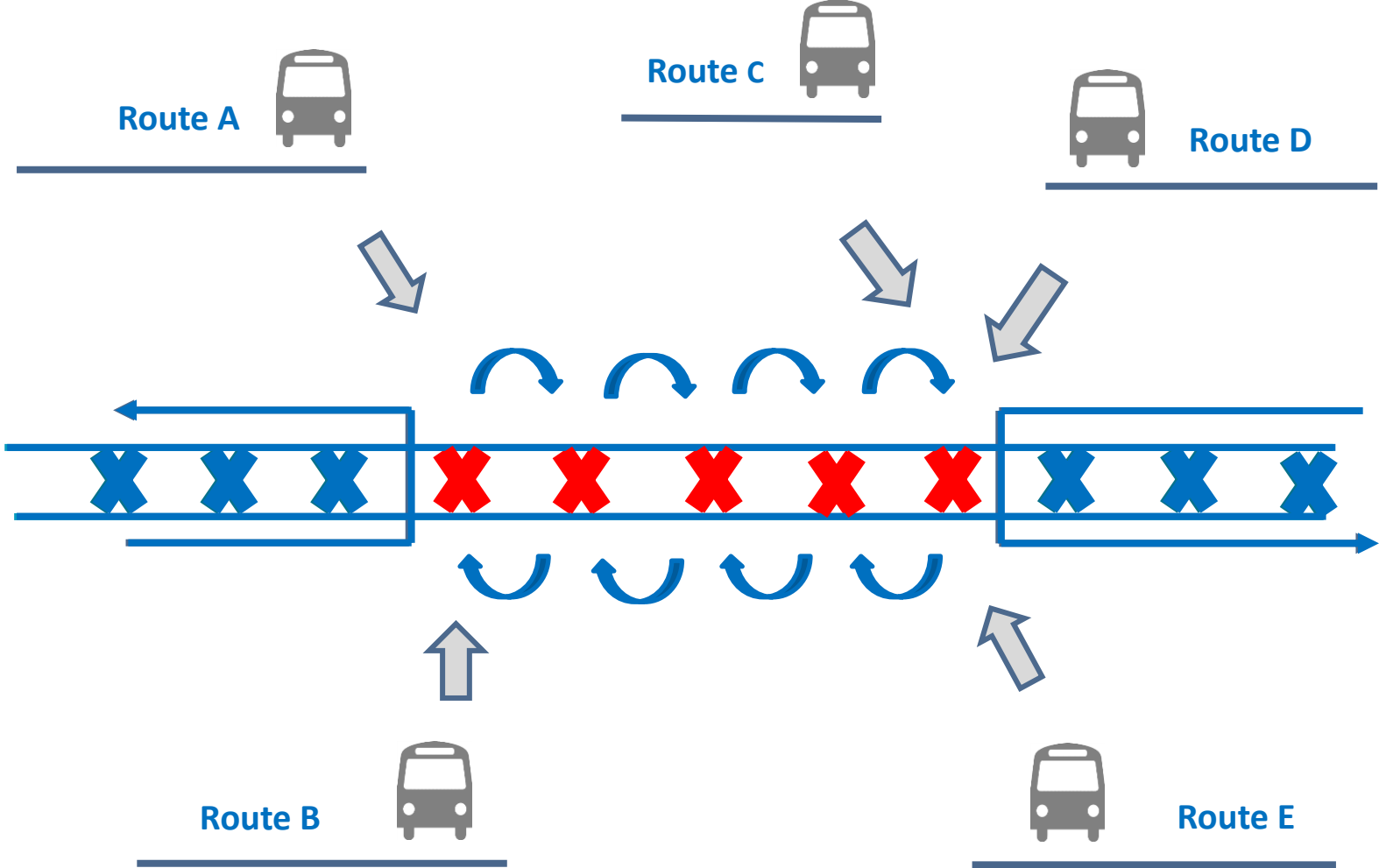


Provide measures of the impact on train and bus passengers

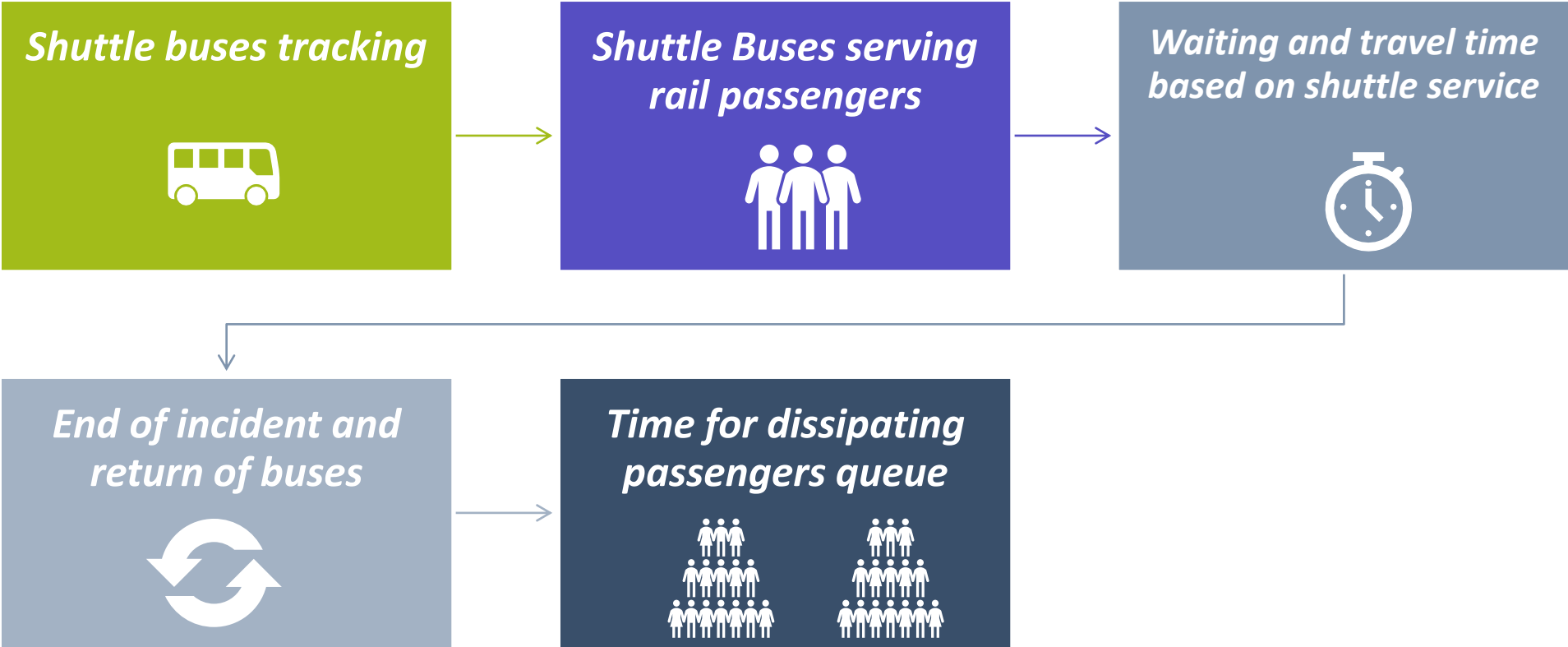


Provide measure of how well shuttle buses are used

Methodology Overview



Methodology Overview (Cont.)



Use Cases

✓ Bus Bridging Scenario Assessment

➔ *DASh-Bus Planner*

✓ Bus Bridging Optimization

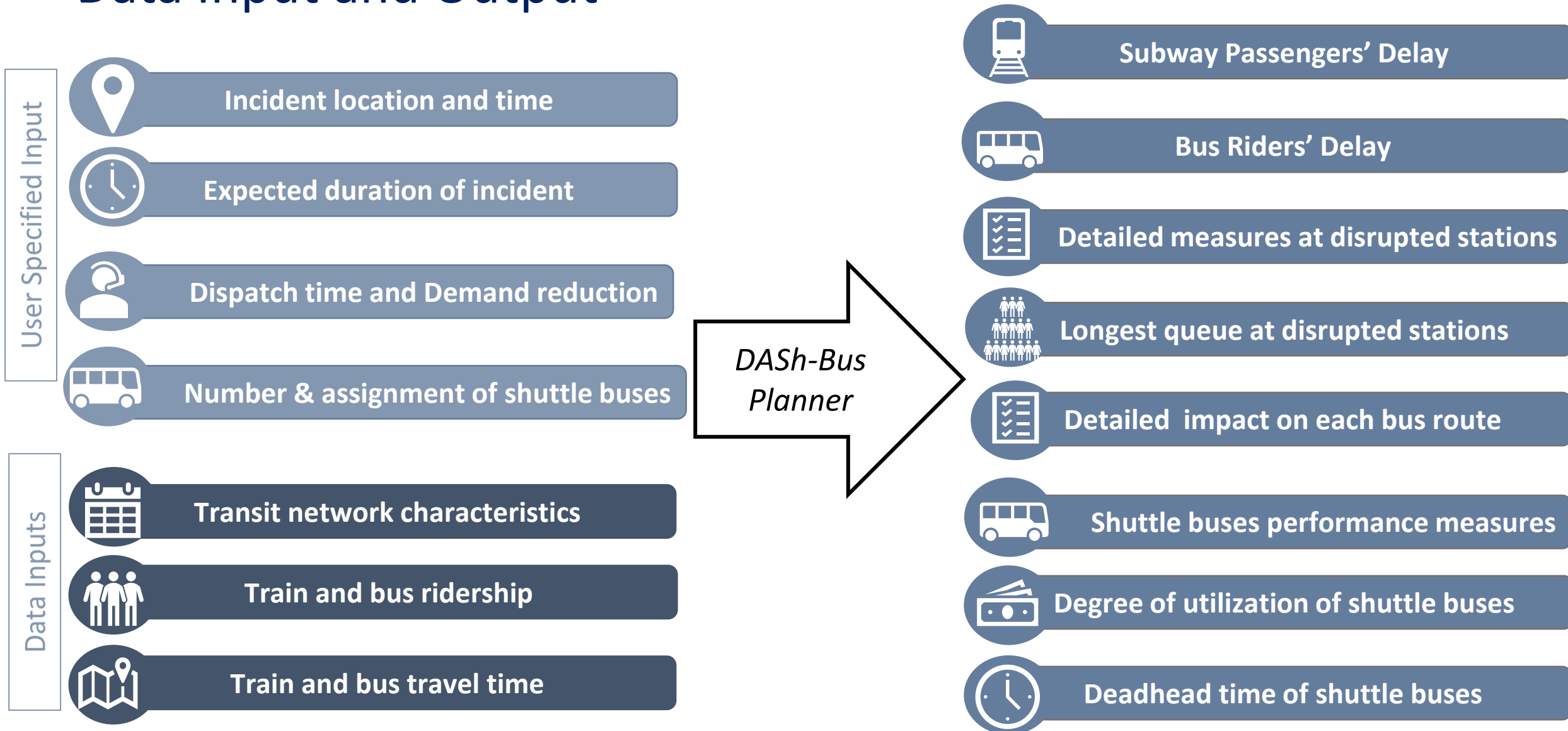
➔ *DASh-Bus Optimizer*



Use Case #1: Bus Bridging Scenario Assessment

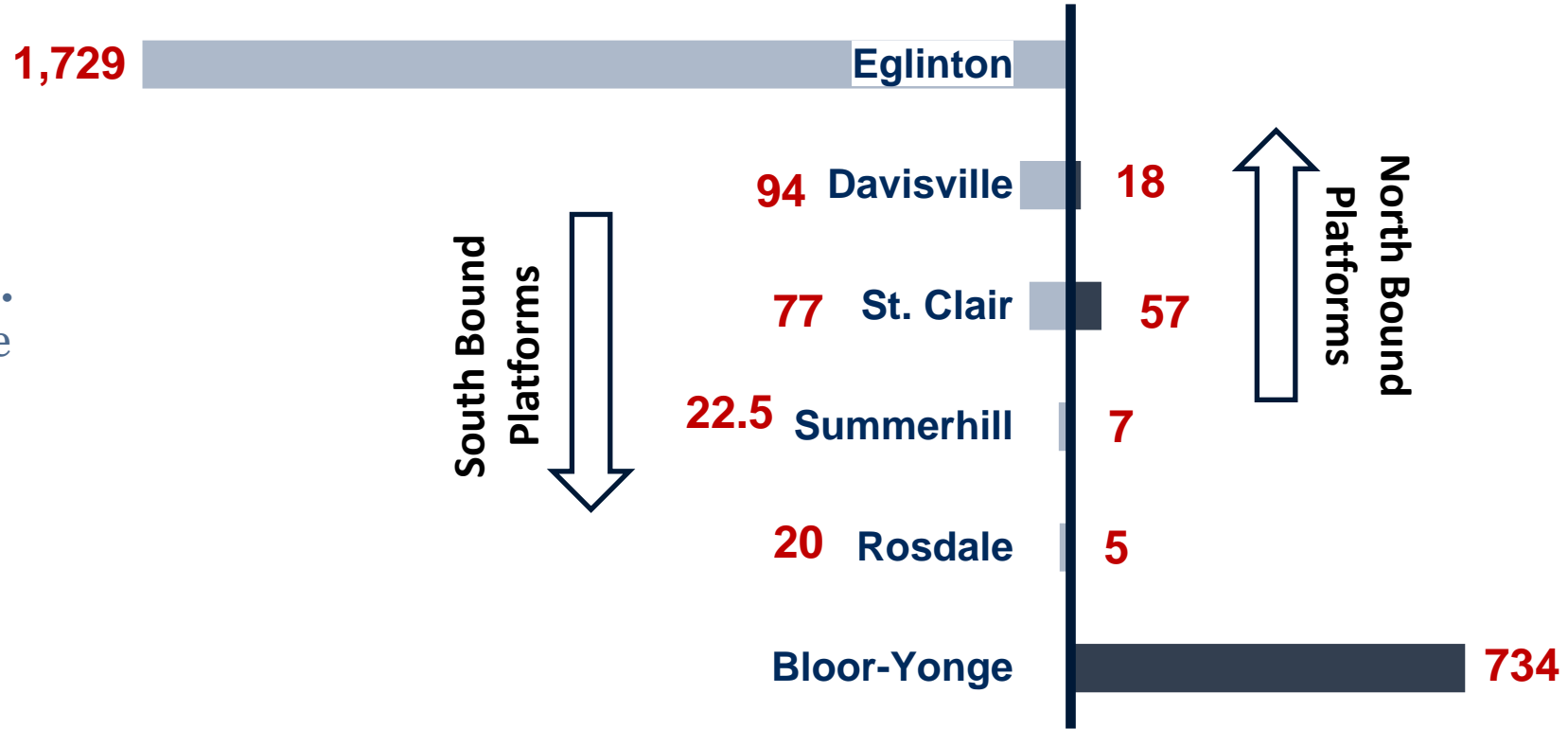


Data Input and Output



Case Study: Assessing an Existing Bus Bridging Plan

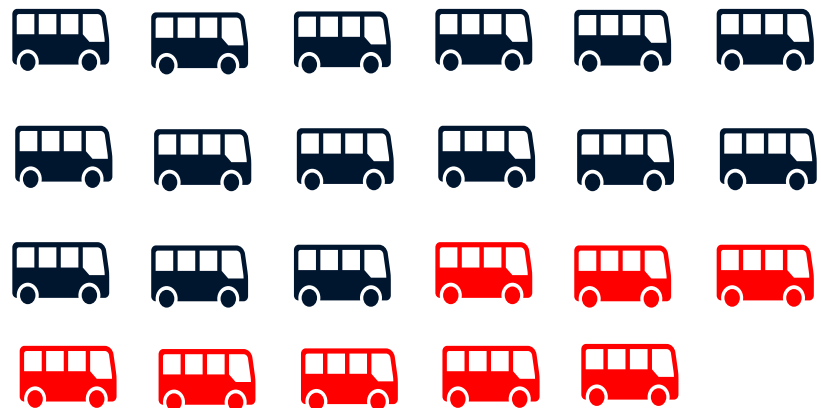
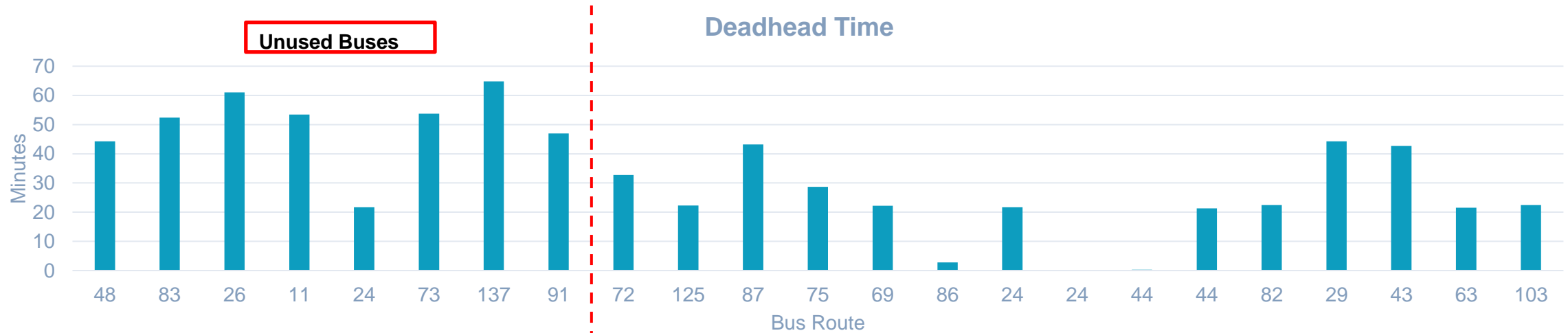
Disruption occurred during the **morning peak** period lasting for **31 min**
 Closing **6 stations**, between **Bloor-Yonge** and **Eglinton**



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

Testing Other Response Plans

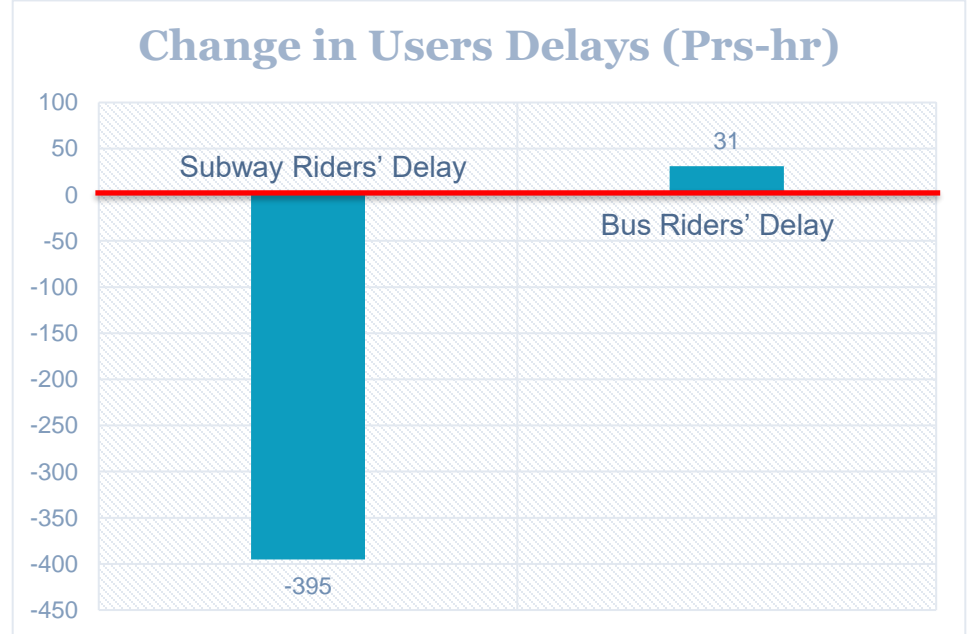
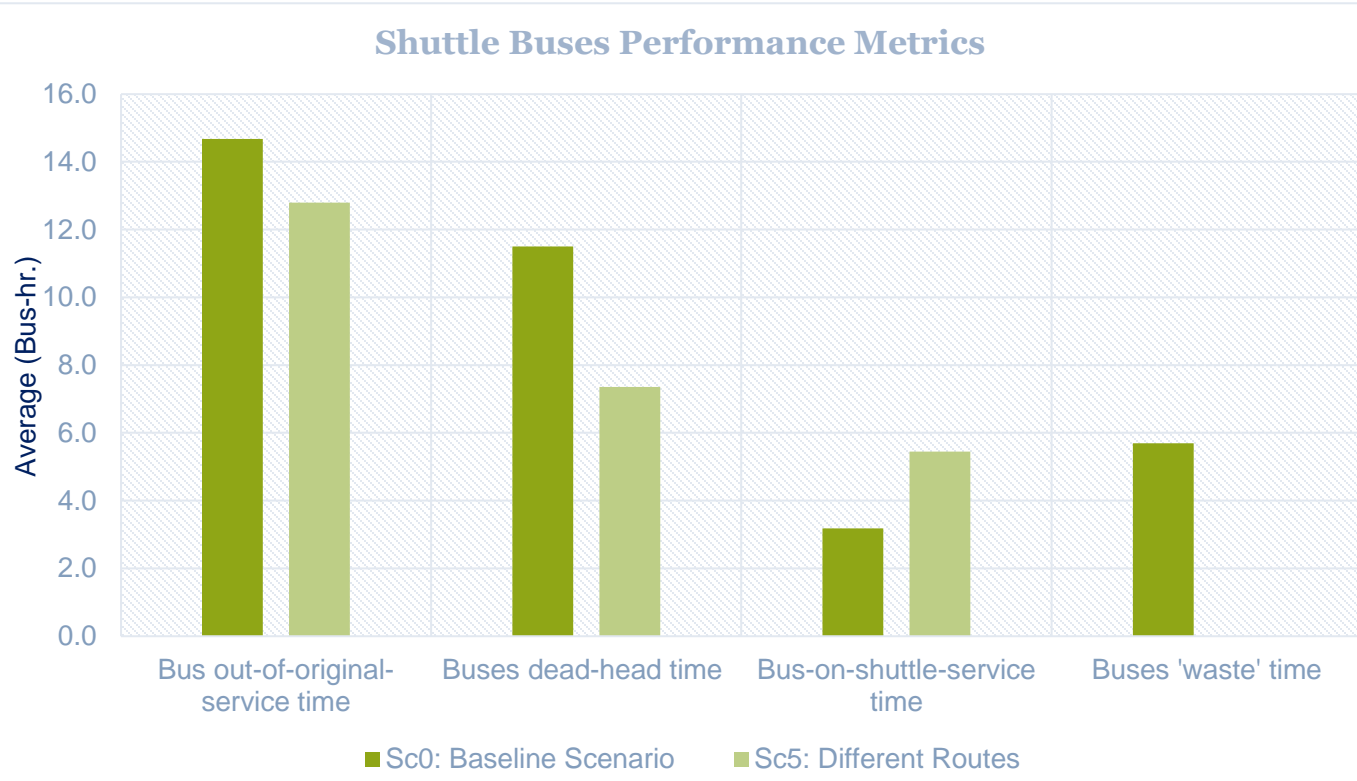
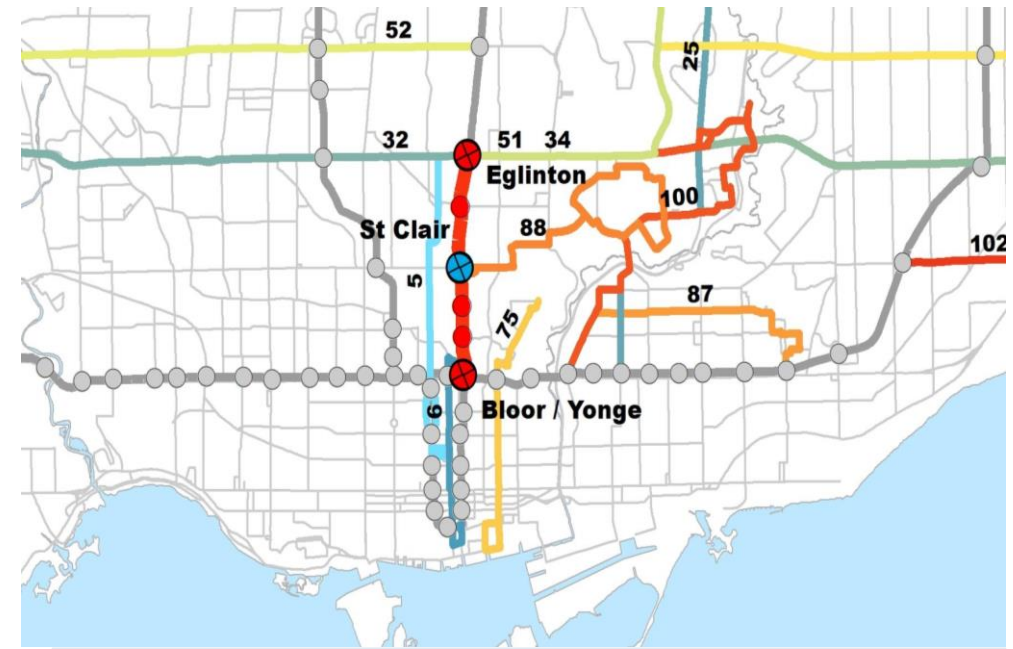
1 *Eliminate non-utilized buses*



- **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

User Specified Input



Incident location and time



Expected duration of incident



Dispatch time and demand reduction



Number & assignment of shuttle buses

Data Inputs



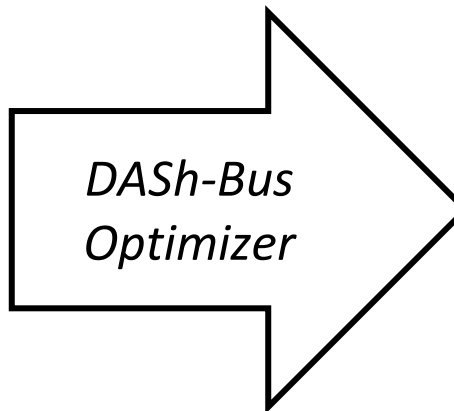
Transit network characteristics



Train and bus ridership



Train and bus travel time



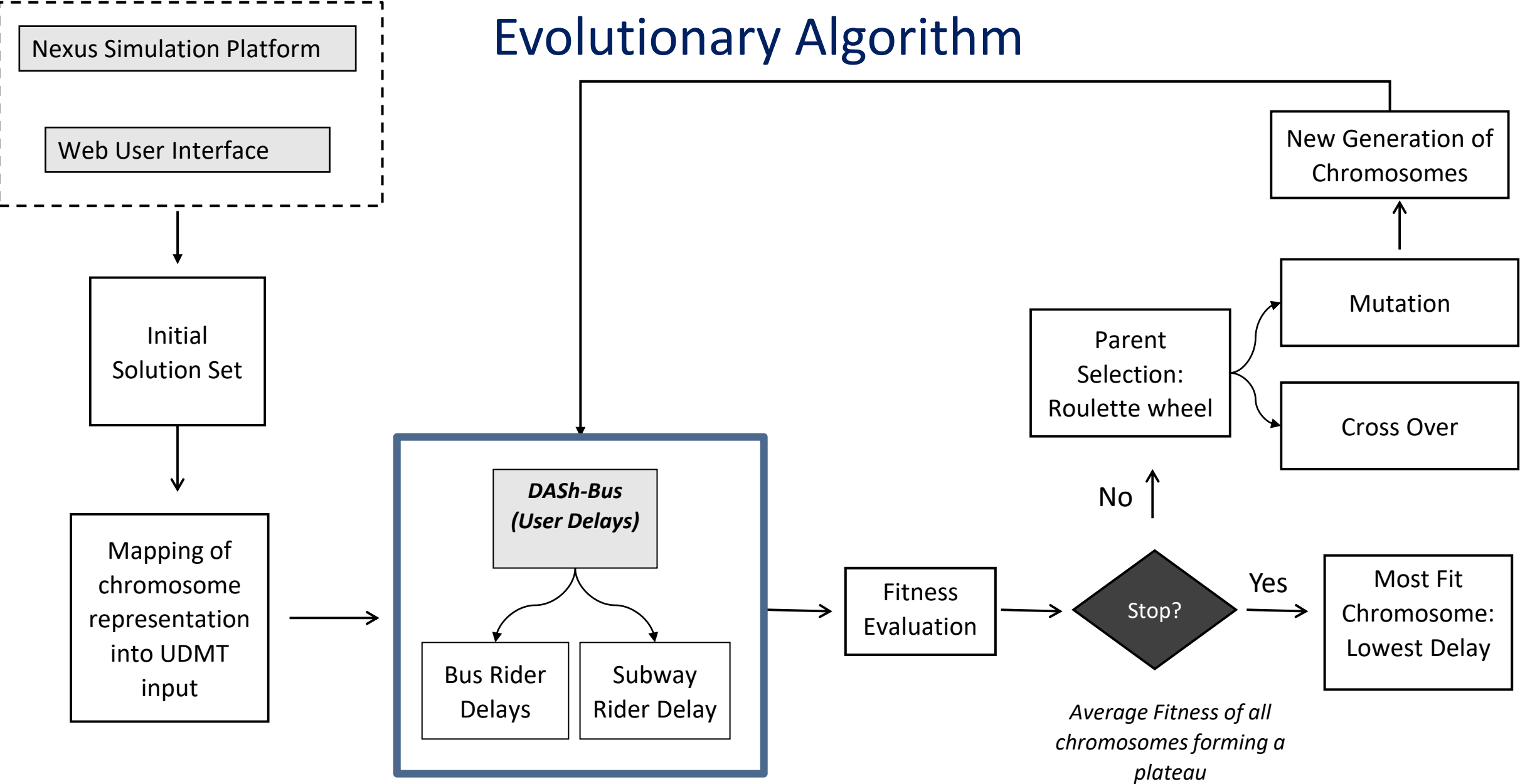
Number of shuttle buses

Optimal Bus routes

Number of buses from each route

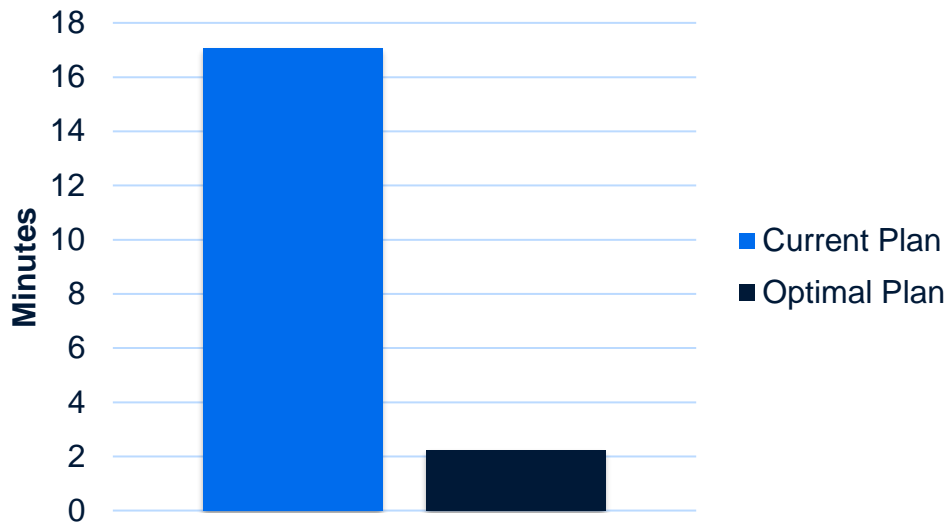
Initial end station for each bus

Evolutionary Algorithm



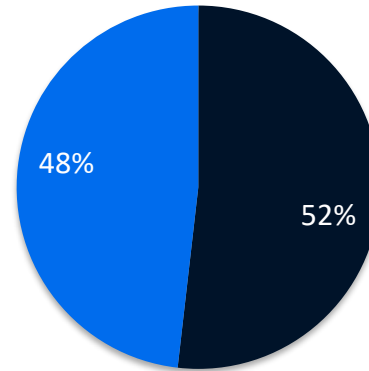
Comparison of Outcomes

Average Deadhead Time

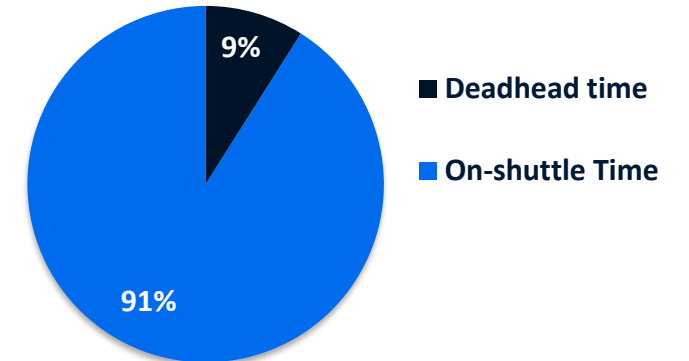


15 mins, on average, is saved in deadhead time of each shuttle bus

Current Plan



Optimal Plan



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

Publications

- Aboudina, A., Itani, A., Diab, E., Srikuenthiran, 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. Srikuenthiran and A. Shalaby, 2020. “*Capacity-Constrained Bus Bridging Optimization Framework*”, Transportation Research Record.
- Itani, I., A. Aboudina, E. Diab, S. Srikuenthiran 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.

Trapeze™ Bus Bridging **UTTRI**

NAME: KiplingKeele_Plant SELECT SAVED

NETWORK: GTHA
SIGNUP: GTHA with HSR F2017
SCENARIO: Demo Scenario

Disruption Occurred: DATE Select, START TIME 08:00 AM

Pick Shuttle: AGENCY TTC, 97

Assign to Terminal: Search Terminal #

Expected Duration: DURATION 55 mins

Affected Stations: FIRST Kipling, LAST Keele

Available Routes: TTC 97:Yonge, TTC 90:Vaughan, TTC 79:Scarlett Rd, TTC 53:Steeles East, TTC 199:Finch Rocket, TTC 85:Sheppard East, TTC 195:Jane Rocket, TTC 35:Jane

Set Parameters: Dispatch Time: 5, Demand Reduction: 0 CALCULATE

Initial Visualization Dashboard

Trapeze™ Bus Bridging **UTTRI**

NETWORK: GTHA
SIGNUP: GTHA with HSR F2017
SCENARIO: Demo Scenario

Effectiveness Summary

TOTAL DELAYS: 2878.7 hours For Subway Riders, 99.3 hours For Bus Riders TABLE VIEW

Map View

SAVE MODIFY

Effectiveness Summary

TOTAL DELAYS: 2878.7 hours For Subway Riders, 99.3 hours For Bus Riders MAP VIEW

DELAYS PER STATION

Station Name	No Riders Affected	Riders Delays (h)	Queue at End (p)	To Clear Queue (min)	Extra Wait
Keele Station - Westbound Platform	1,692.9	412.86	572.68	0	13.09
Kipling Station - Eastbound Platform	1,851.6	492.23	1,191.64	0	15.95
High Park Station - Westbound Platform	42.8	3.71	60.19	1.56	3
Islington Station - Eastbound Platform	1,136.1	554.07	1,115.37	4.37	25.56
Royal York Station - Eastbound Platform	793.8	425.8	774.04	8.6	25.46
Runnymede Station - Westbound Platform	103.2	8.01	5.29	9.5	4.17
Old Mill Station - Eastbound Platform	261.7	154.31	257.65	10.11	25.71
Jane Station - Eastbound Platform	507.2	303.41	491.6	11.33	25.49
Jane Station - Westbound Platform	136.9	18.16	26.75	13.26	5.37
Old Mill Station - Westbound Platform	59.8	8.03	3.67	14.86	7.14
Runnymede Station - Eastbound Platform	459.7	297.37	445.16	14.99	25.53
Royal York Station - Westbound Platform	81.4	17.18	14.4	16	9.94
High Park Station - Eastbound Platform	231.5	172.94	287.09	16.03	24.73

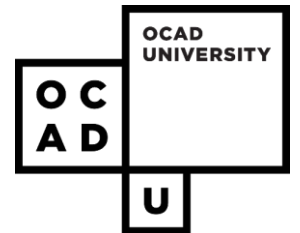
NETWORK: GTHA
SIGNUP: GTHA with HSR F2017
SCENARIO: Demo Scenario

SAVE MODIFY

Visualization Dashboard



UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING
Transportation Research Institute



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

000
Model Bus Bridging Tool

Disruption Information

Time- 11:00 AM

Date- 23 May 2020

Direct Impact of Incident

Agency:

Assign to Terminal:

Passenger Count:

Train:

Bus:

Pedestrrian:

Indirect Impact of Incident

Passenger Count

Train:

Bus:

Pedestrrian:

Start

End

Selected Buses

- 501
- 502
- 6
- 6A
- D1

Shuttle Service Time:

Initial Response Time:

Dispatch Time:

Allow Consecutive Buses:

Release Periodic Public Updates:

Impact on TTC Subway System

Number of Stations:

Number of Trains:

Passenger Count:

Customer Live Feedback Ratings

☆☆☆☆☆

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

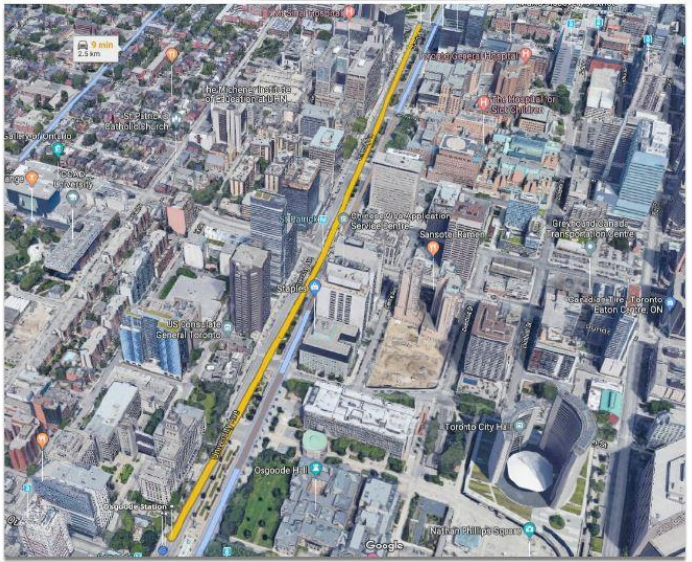
Model Bus Bridging Tool

Disruption Information
Time: 11:00 AM
Date: 29 May 2020

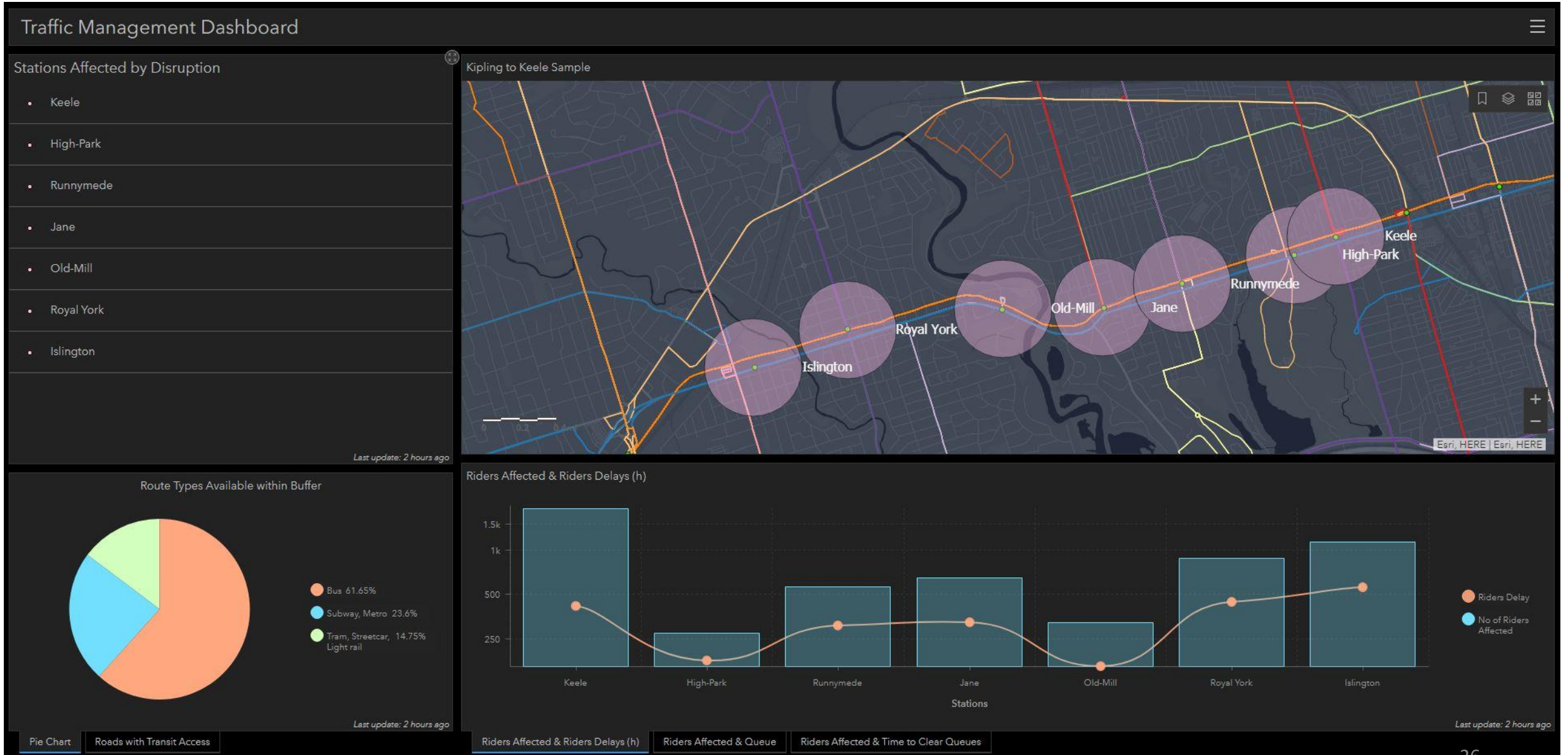
Start: Osgoode
End: Queens Park

Impact on TTC Subway System
Number of Stations:
Number of Trains:
Passenger Count:
Train:
Bus:
Pedestrian:
Direct Impact of Incident
Agency: TTC
Passenger Count: Q 6A
Assign to Terminal: Birchmount Garage

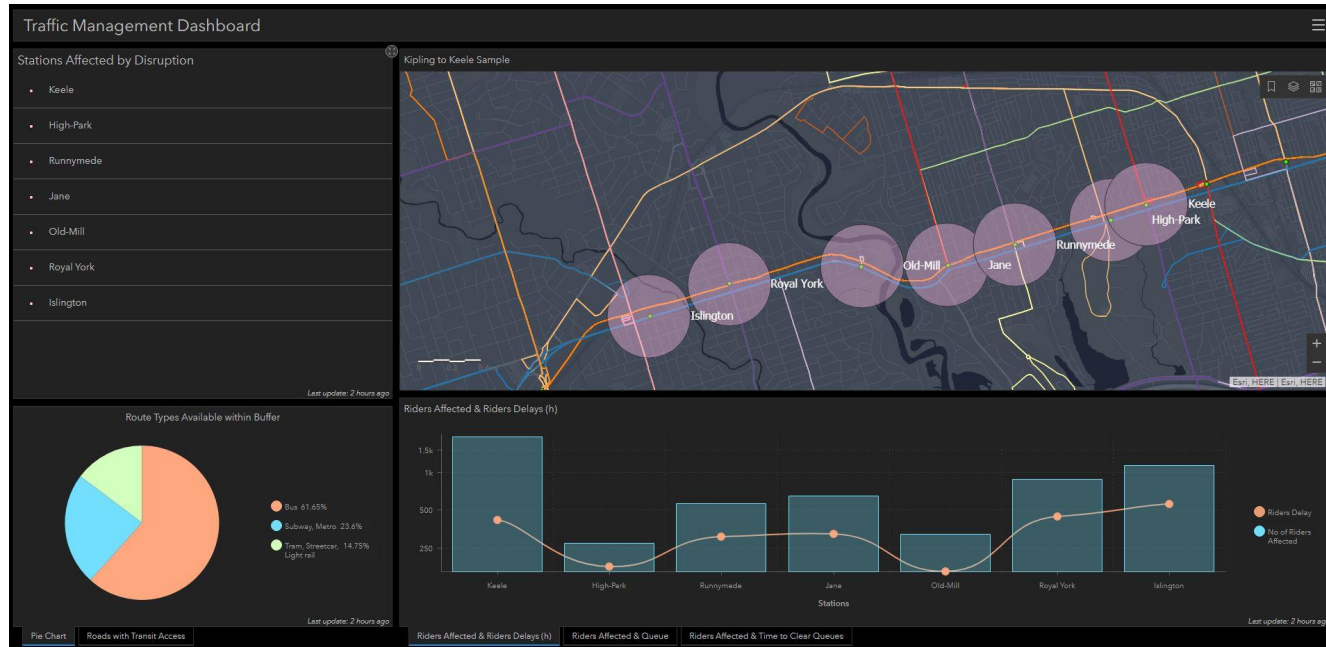
Indirect Impact of Incident
Passenger Count
Train:
Bus:
Pedestrian:
Selected Buses
501: 0
502: 1
6: 3
6A: 5
61: 0
Shuttle Service Time: 1 Hr 07 Min 45 Sec
Initial Response Time:
Dispatch Time:
Allow Consecutive Buses:
Release Periodic Public Updates:
Customer Live Feedback Ratings: ☆☆☆☆☆



Second Iteration



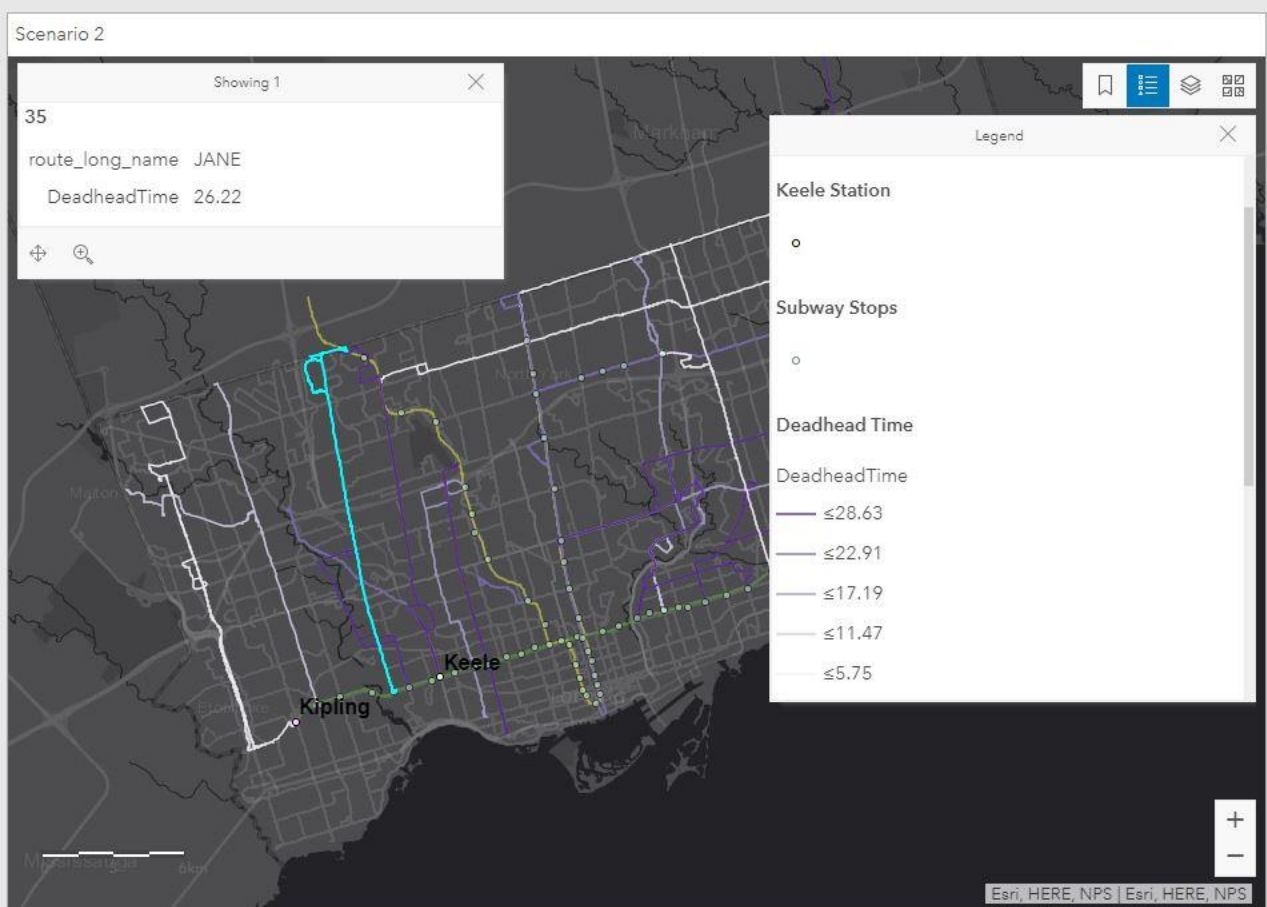
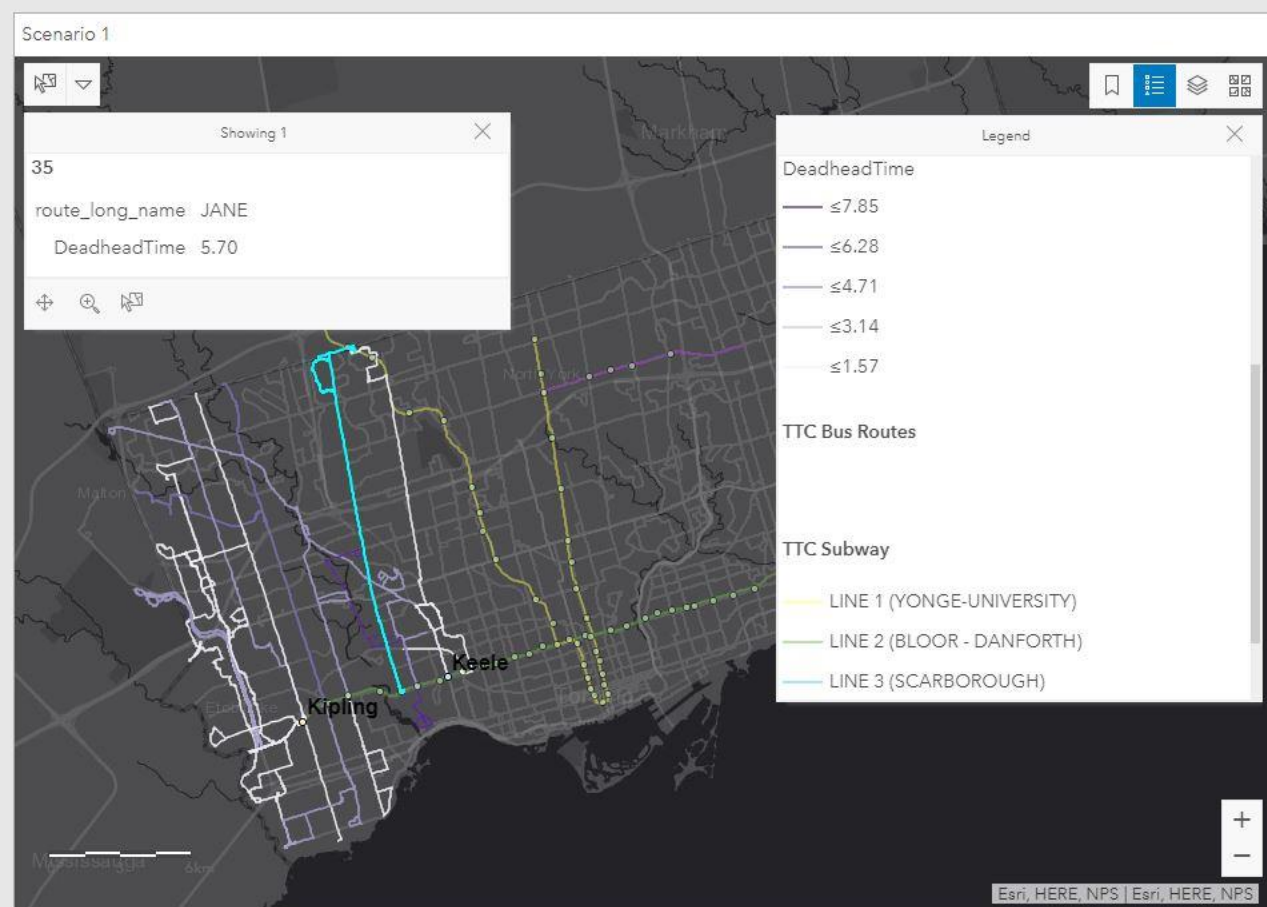
Assessment

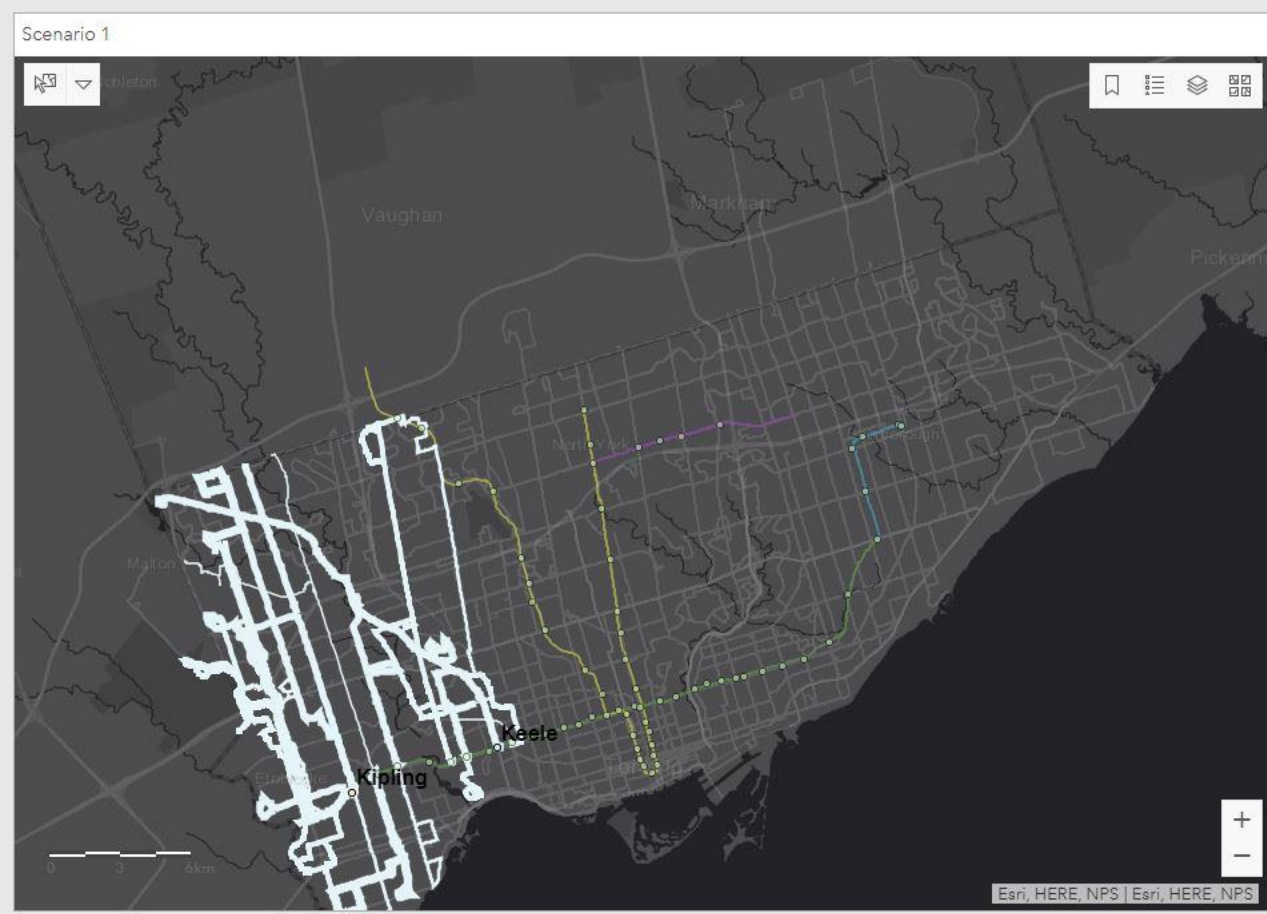


- Provide overview of entire scenario
- Display total user delay for each scenario
- Increase meaningful data displayed
- Further increase the interactivity of the dashboard
- Necessary for a display of 2 scenarios simultaneously
- Map elements should have tooltips and dialogue boxes when selected/hovered.

Third Iteration







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

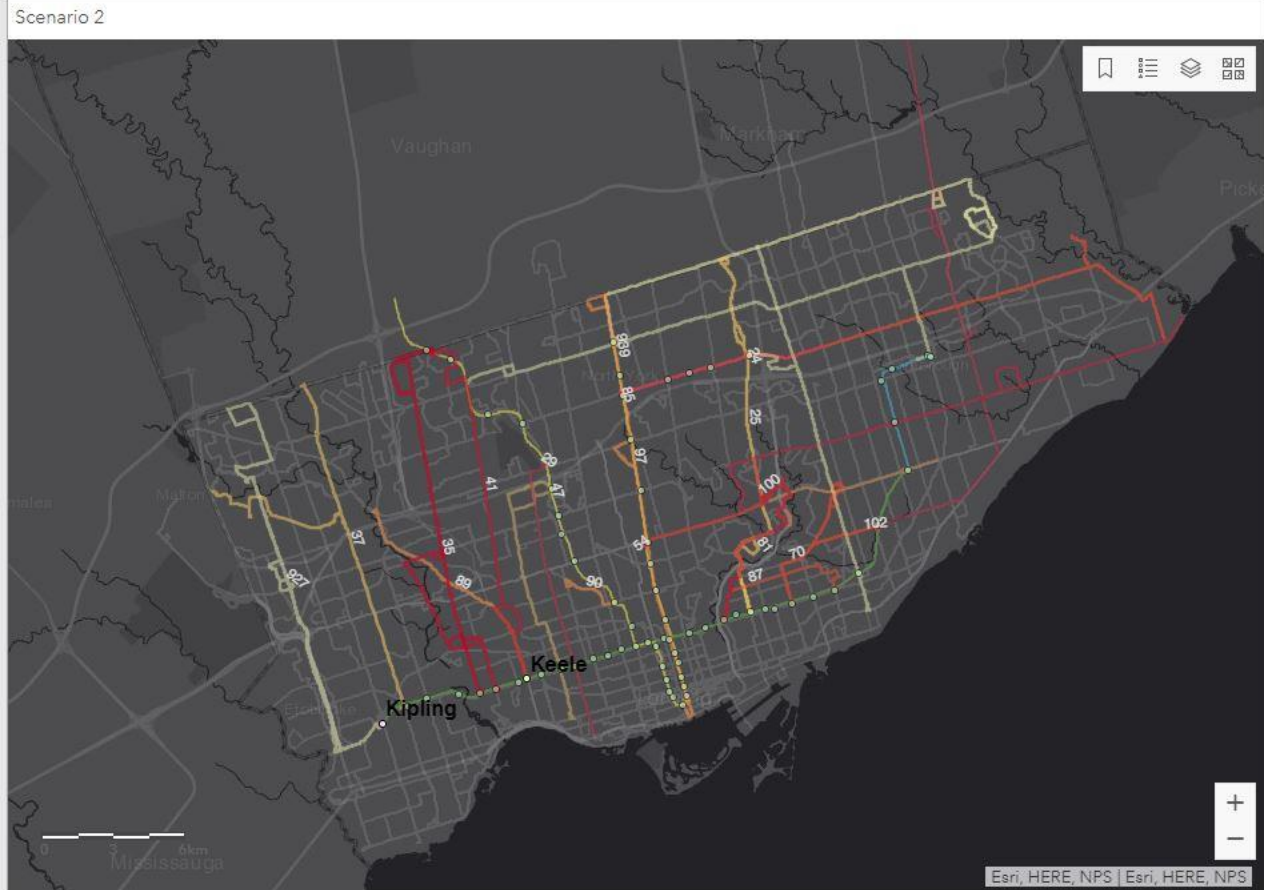
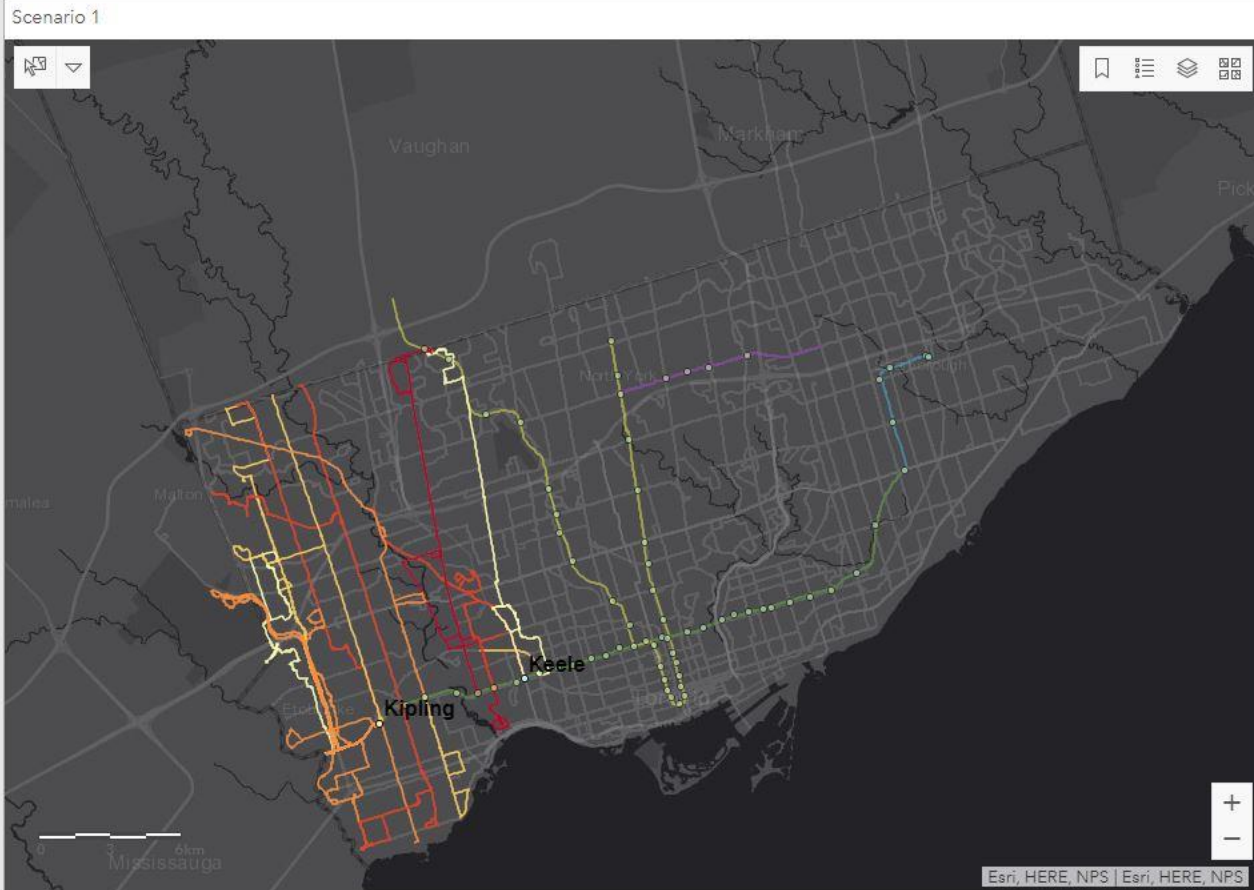
Total Bus Riders Delay

4.772k

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

Last update: 3 minutes ago



Acknowledgments

- ORF



- Trapeze Inc



- NSERC

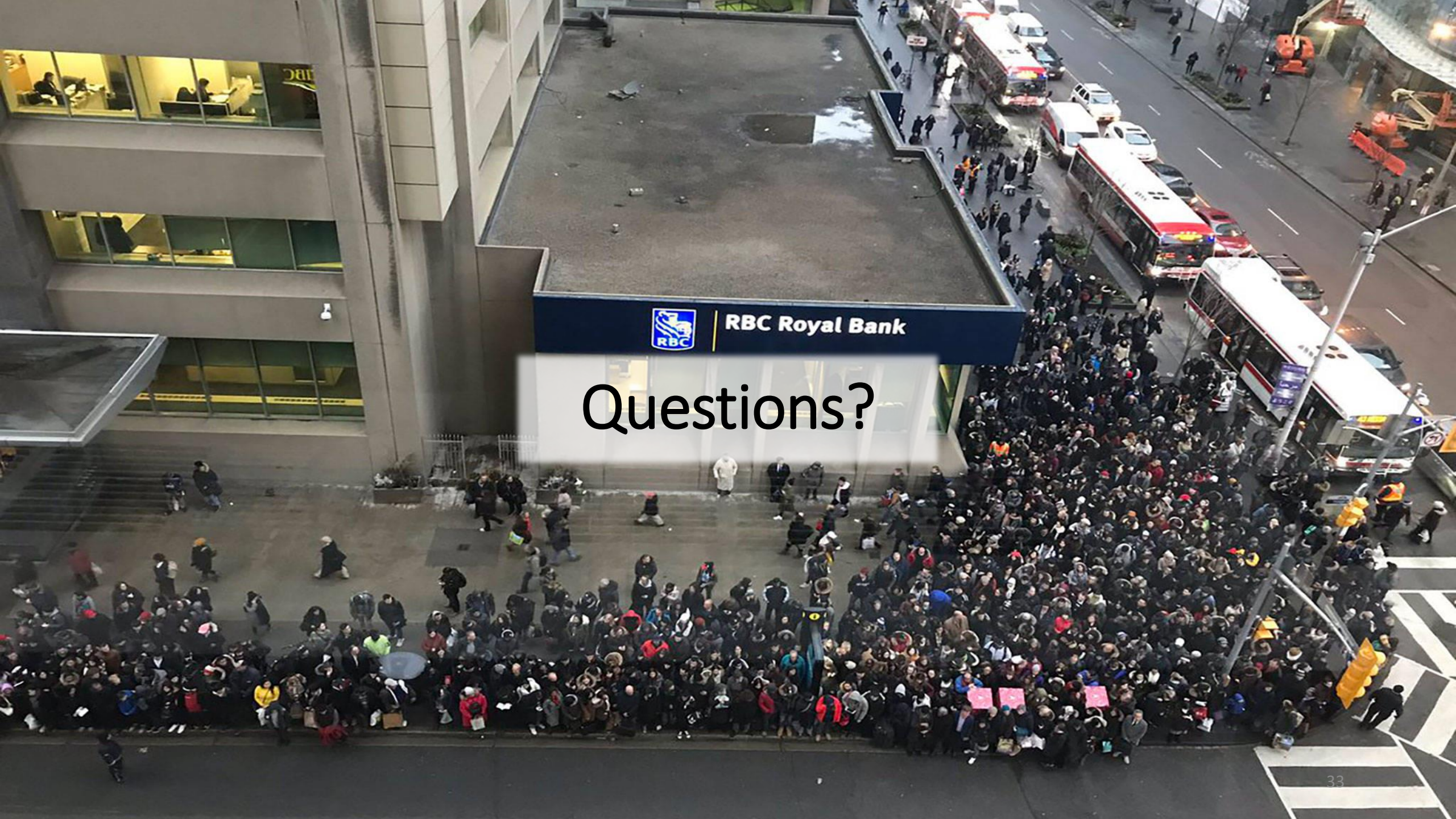


- OCE



- 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/>.