Managing Unplanned Rail Disruptions: Policy Implications and Guidelines Towards an Effective Bus Bridging Strategy

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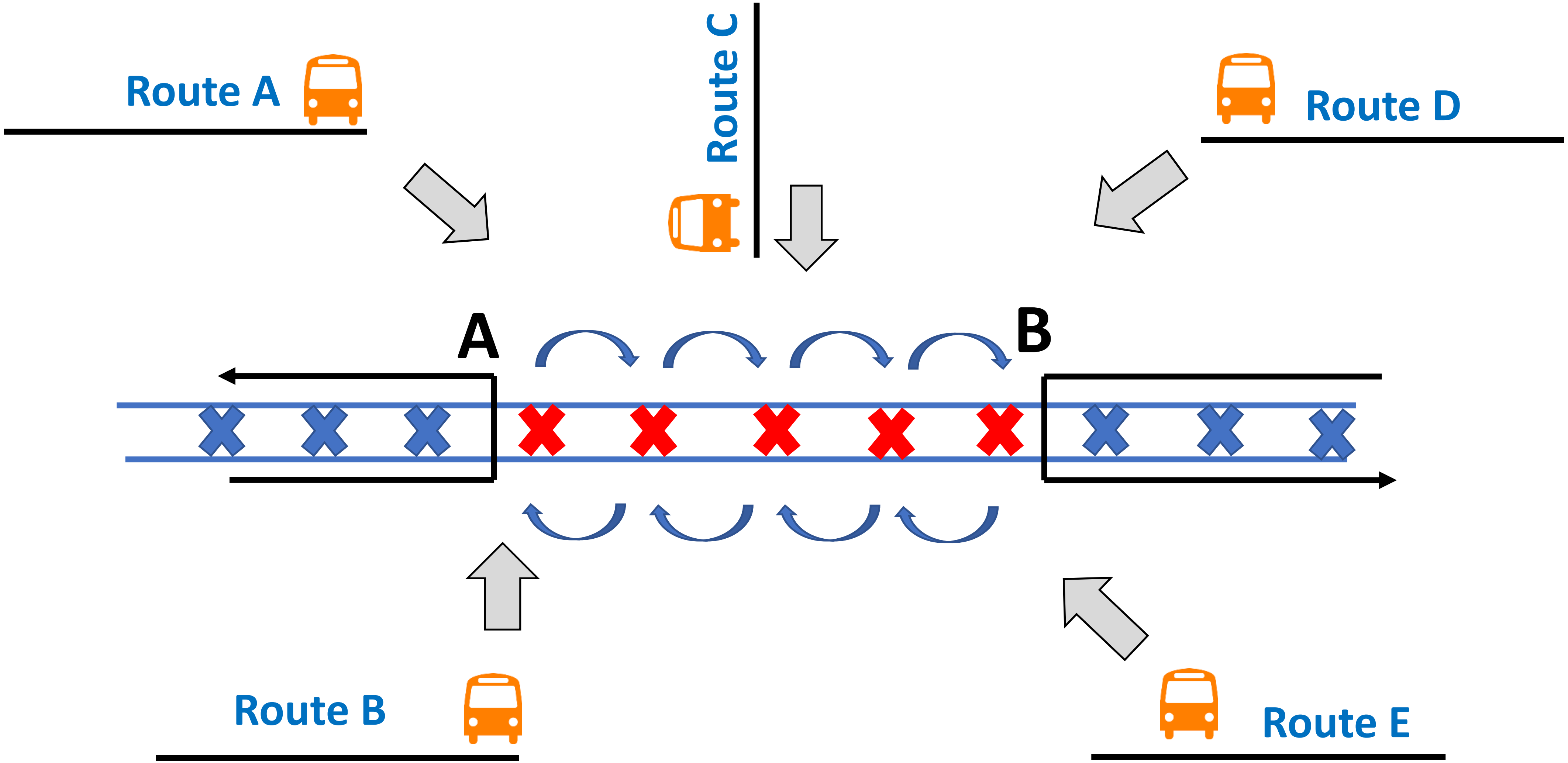
Alaa Itani (alaa.itani@mail.utoronto.ca), **Aya Aboudina**
Ehab Diab, Siva Srikukenthiran and Amer Shalaby

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

Introduction

- Public transit is an essential service for any city
- When **unexpected interruptions** occur, they reduce the quality of service provided to the public and affect negatively user experience
- Thus, transit agencies implement several **disruption management strategie**s to mitigate the impact of unexpected disruptions and incidents on user delays

Bus Bridging Strategy



Work Phases

Collecting and Processing Data

- Real Incident Data obtained from TTC
- Transit Network information and travel time data

Developing an analytical tool: User’s Delay Modelling Tool (UDMT)

- Transit Network user’s delay and waiting time
- Shuttle Buses performance measures

Using the UDMT as an assessment tool

- Highlight lessons learned and policy implications from historical incidents

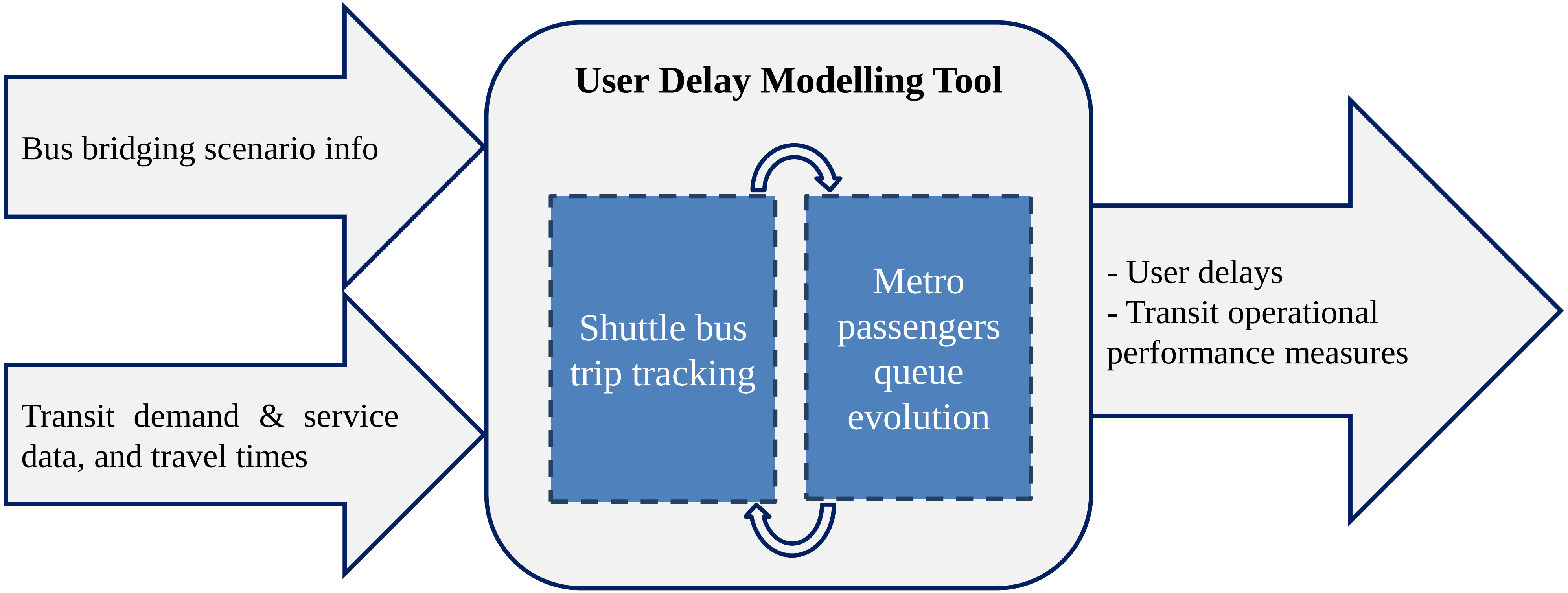
Developing a user interface for UDMT

- Easily used by transit agencies
- Integrated with NEXUS and real-time data

Optimization Module leading to the “best” bus bridging plan

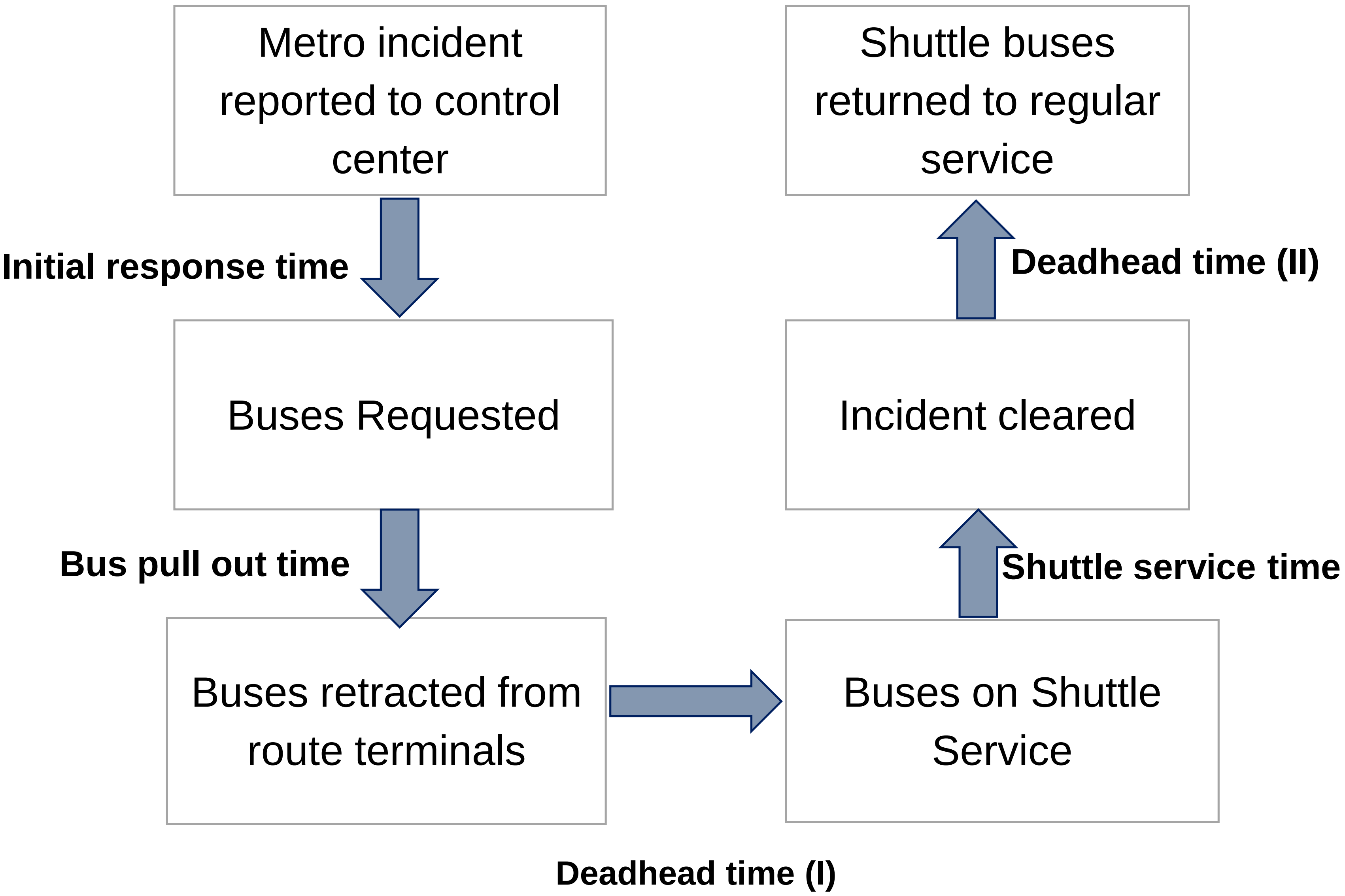
- Pre-defined constraints and spatial limitations
- Integrating optimization with real-time data

User’s Delay Modelling Tool (UDMT)



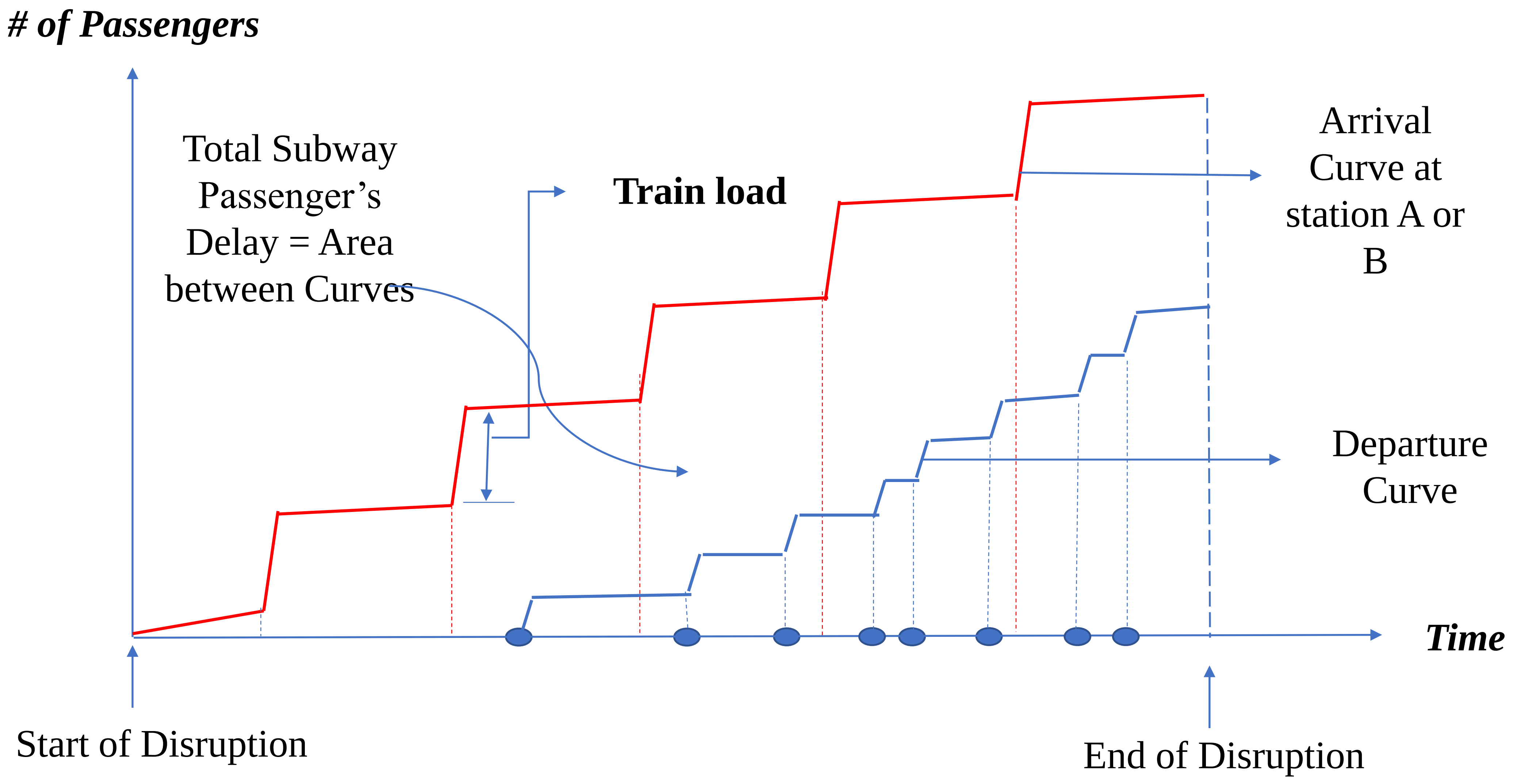
User Delay Modelling Tool Methodology

1) Shuttle Bus Trip Tracking



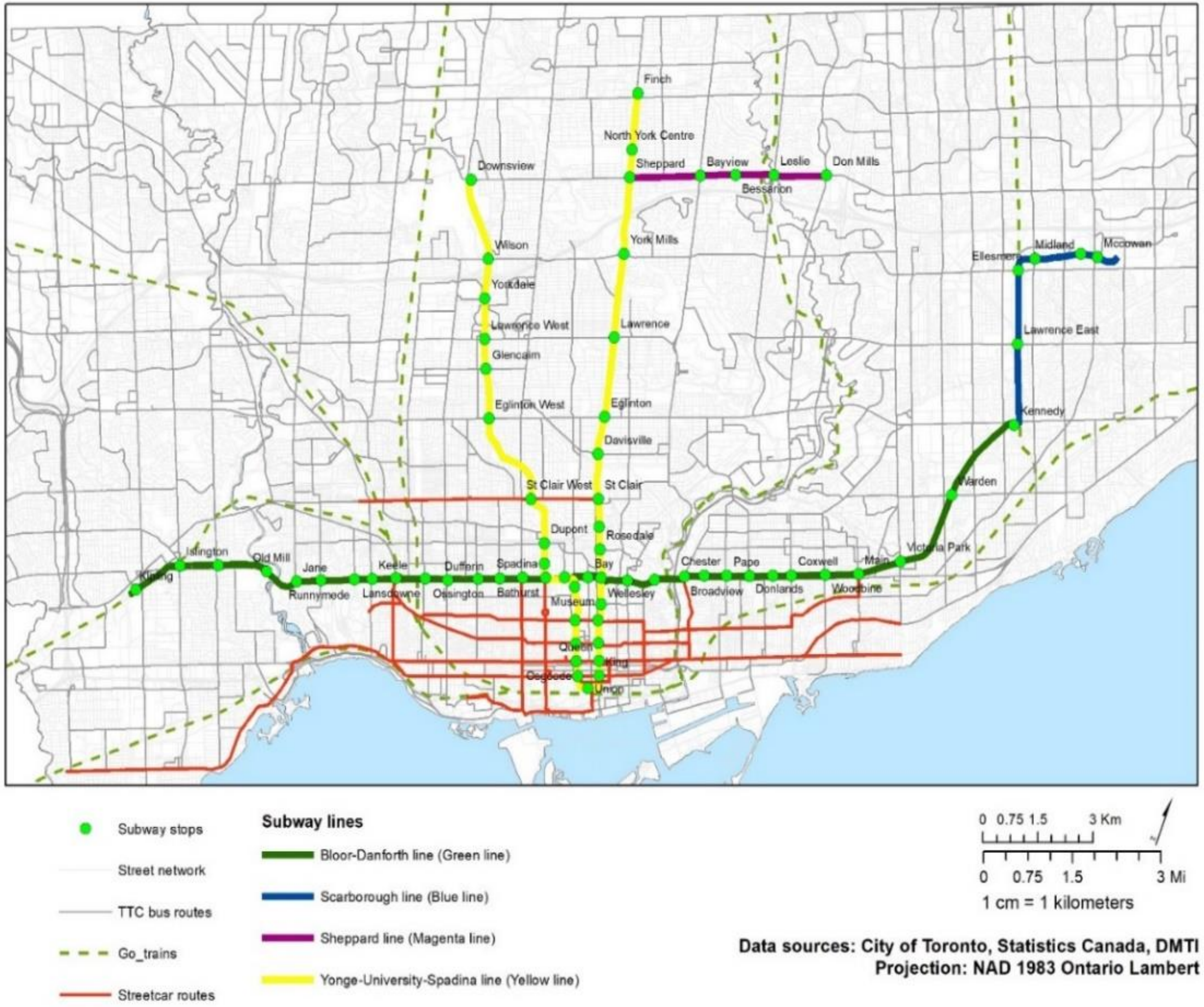
User Delay Modelling Tool Methodology (Cont.)

2) Metro Passengers Queue Evolution



Actual Disruptions from TTC Subway Network

- Major incidents that had long durations and disrupted segment lengths.
- Incidents that happened on different lines of the system.
- Incidents that started and ended during the AM peak period, for its significance due to the high passenger volumes.



Policy Analysis and Implications

Policies under Study	Modified Specifications
Initial Dispatch Direction	Alternating the number of buses serving from each end of the disrupted segment
Dispatch time of shuttle buses	Changing the dispatch time by 1 minute increment
Uncertainty in predicting the incident duration	Forecasting error ranging from -50% to +50% of the estimated incident duration
Demand reduction along the disrupted segment	Reducing the demand from 0% reduction to 100% reduction at increments of 10%

Initial Dispatch Direction: Tested Strategies

50% Random

- Shuttle buses are assigned equally to both end stations in an ad-hoc procedure.

50% Distance

- Shuttle buses are assigned equally to both end stations while considering the proximity of the bus route terminal to the assigned end station.

Closest End Station

- Shuttle buses are assigned to the closest end station, without considering the ratio of buses assigned to each end station.

Demand at End Stations

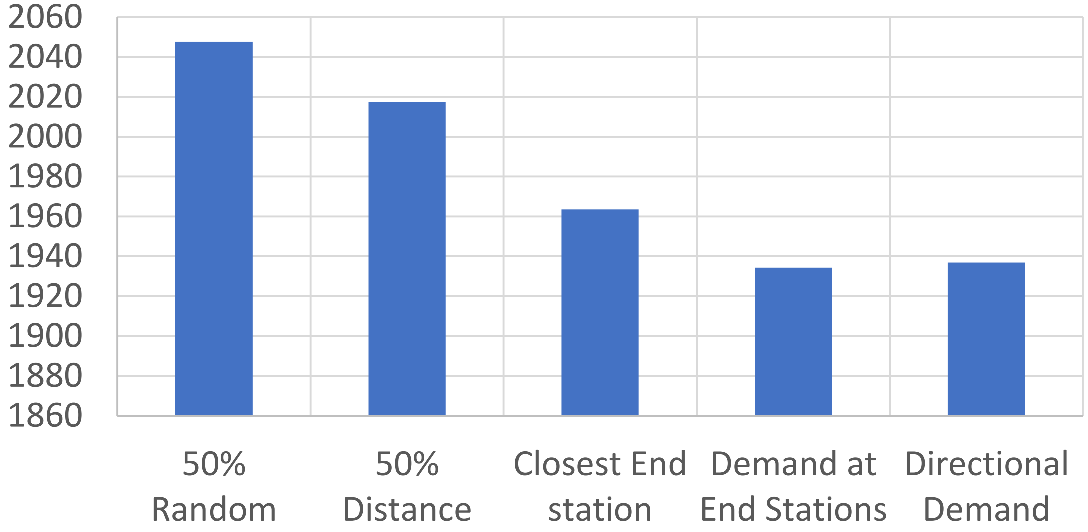
- Shuttle buses are assigned proportionally to the demand at end stations, i.e., more shuttle buses start the shuttle service at the more congested end station.

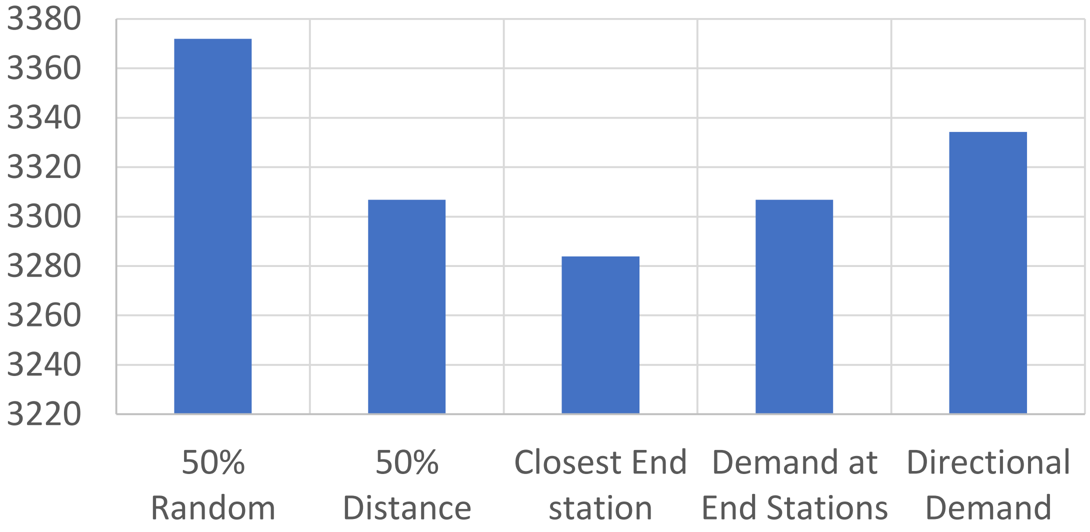
Directional Demand

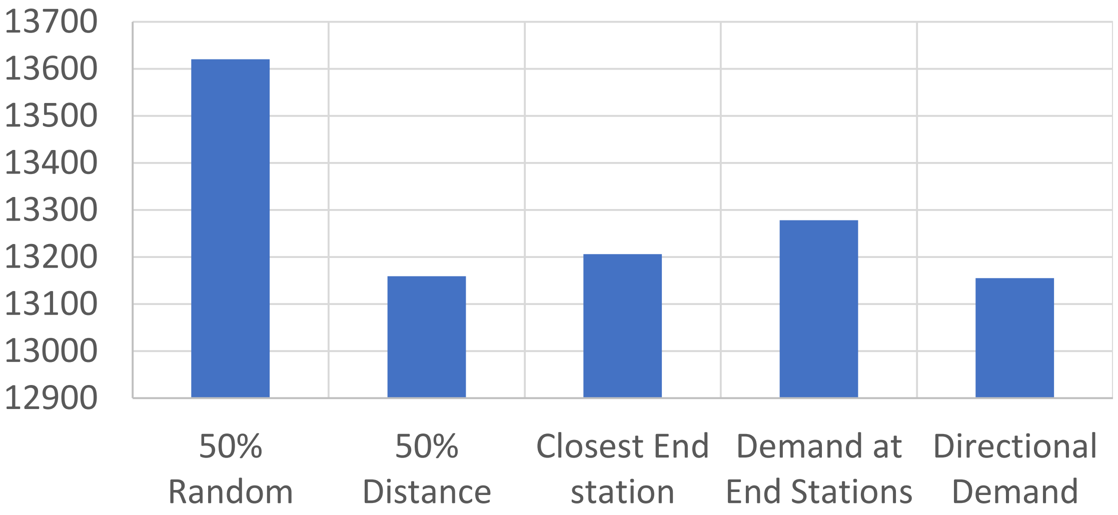
- Shuttle buses are assigned proportionally to the directional demand, i.e., considering the combined demand of all stations per direction.

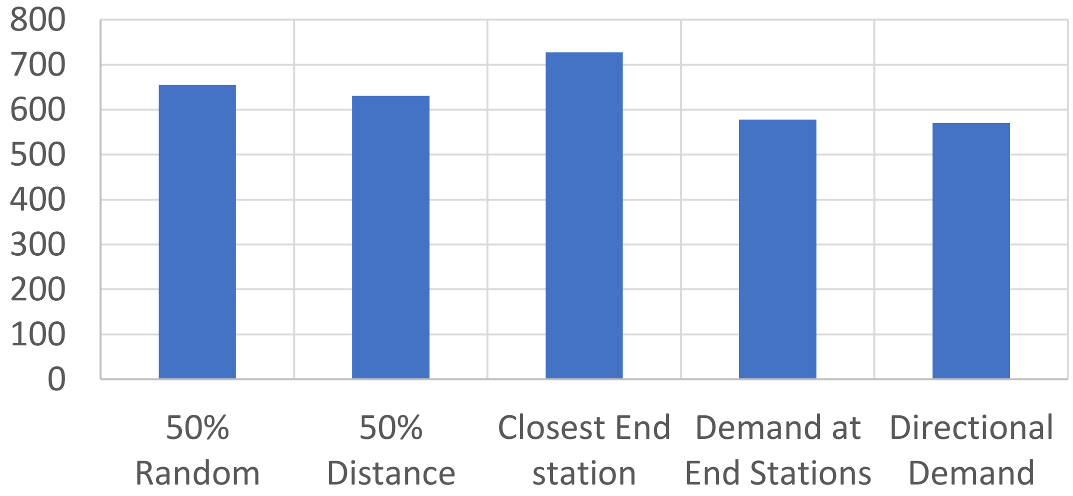
Initial Dispatch Direction: Results

1) Metro Passengers' Delay (*Passenger-hr.*)



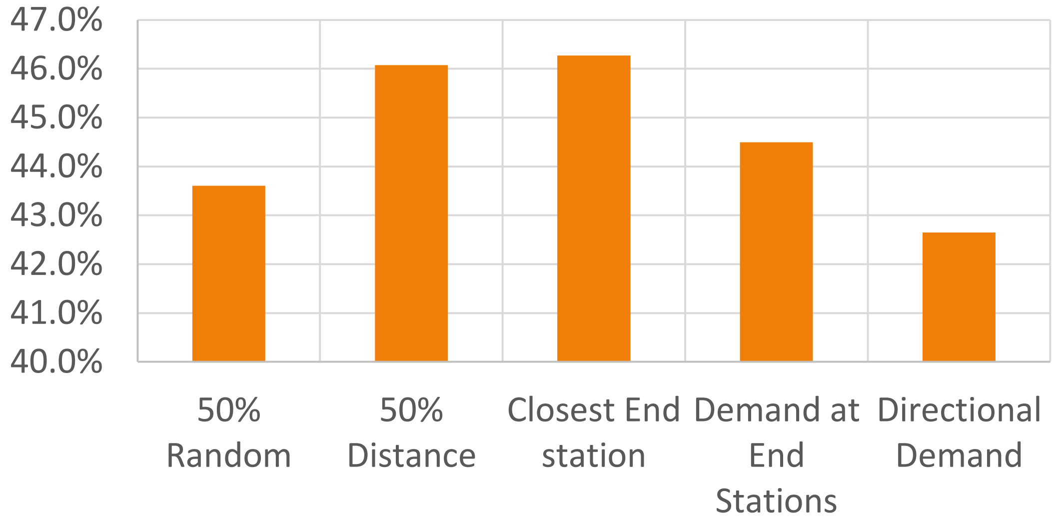


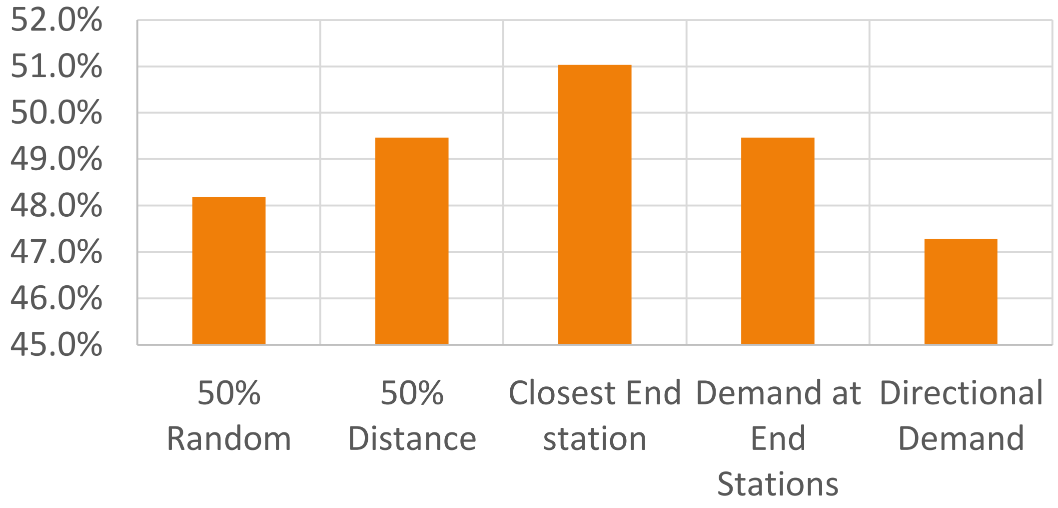


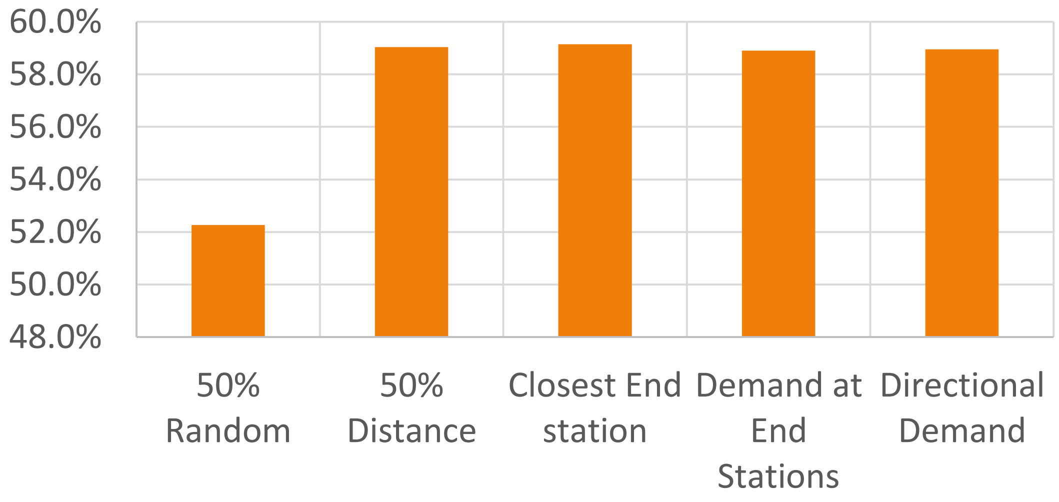


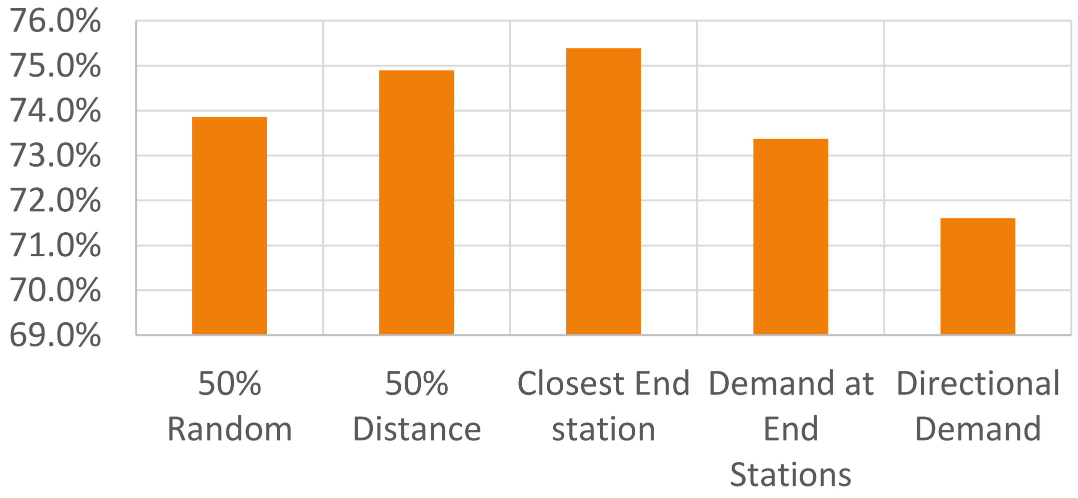
Initial Dispatch Direction: Results

2) Shuttle Buses utilization efficiency (*Percentage of On-Shuttle Service Time*)









Policy Analysis and Implications

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Dispatch Time of Shuttle Buses

Long dispatch times increase the gap between the incident start time and the time at which shuttle buses arrive at the disrupted segment

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The dispatch time is quantified through 1 min increments in the dispatch time from 0 to 5 mins.

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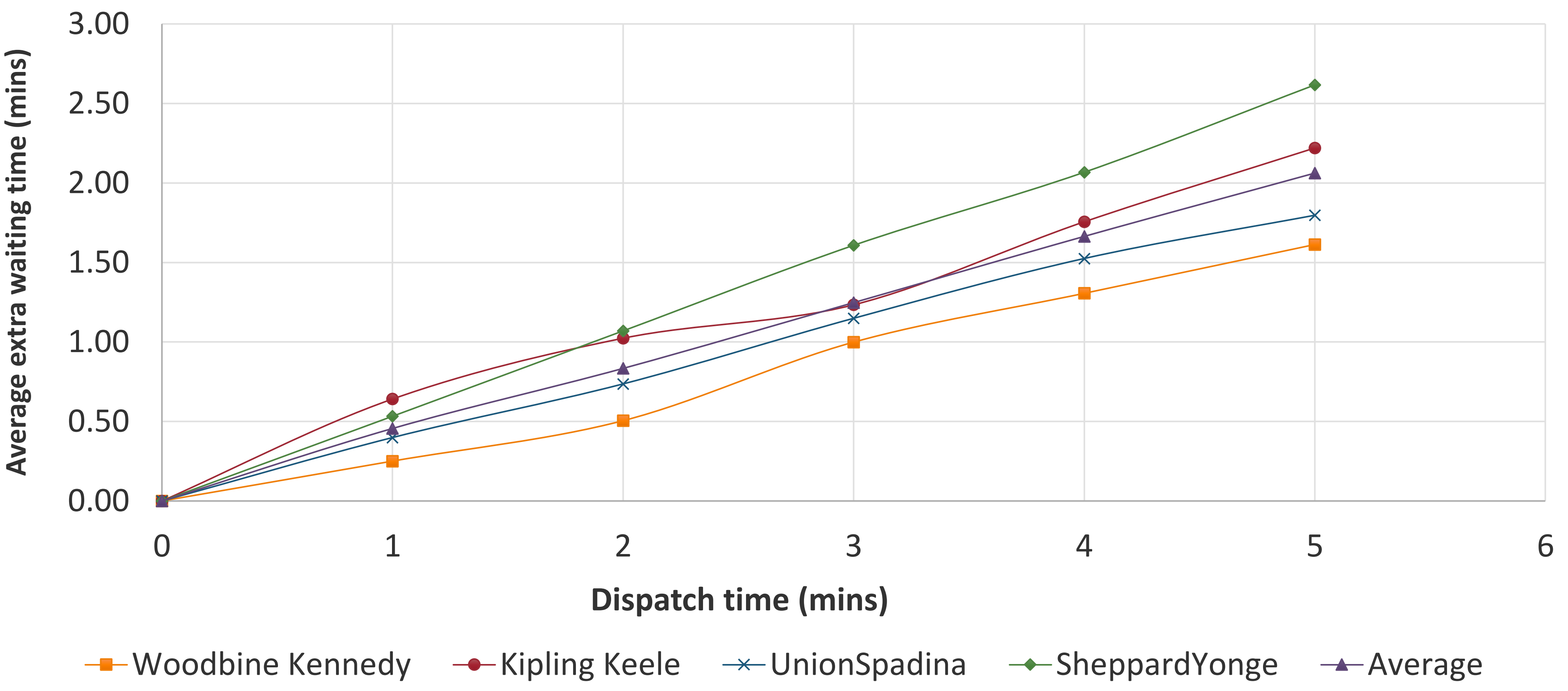
Average extra waiting time

Metro passengers' delay

Dispatch Time of Shuttle Buses: Results

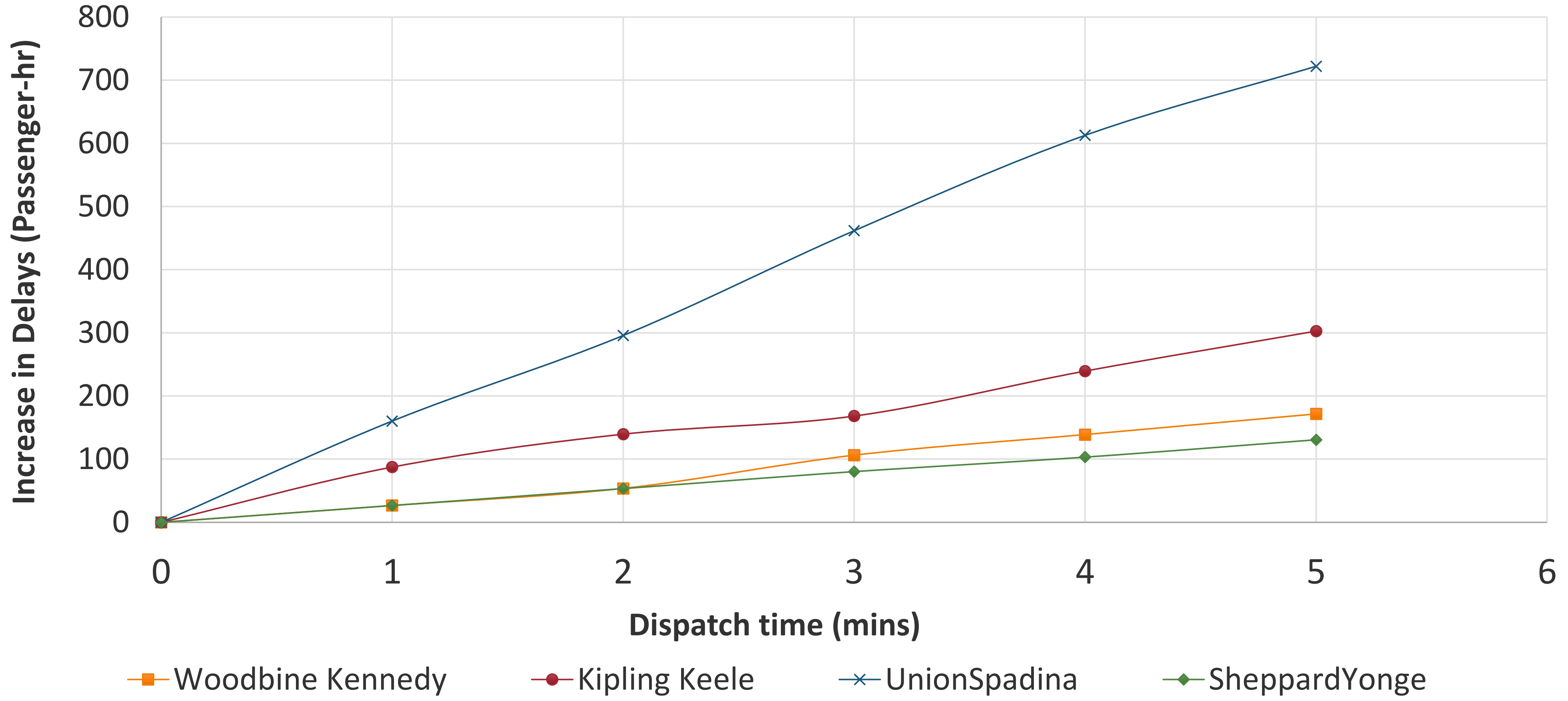
1) Average Extra waiting time



Increase by around 0.41 min for each minute increase in the dispatch time. This entails substantial increase in the aggregate ***delays of all metro passengers*** affected by the disruption.

Dispatch Time of Shuttle Buses: Results

2) Metro Passengers' Delay



1-minute increase in the dispatch time brings an increase of around 145 passenger-hr. in the incident involving Union station, which is the highest value observed among all incidents. This observation is because this closure involves the **highest demand.**

Policy Analysis and Implications

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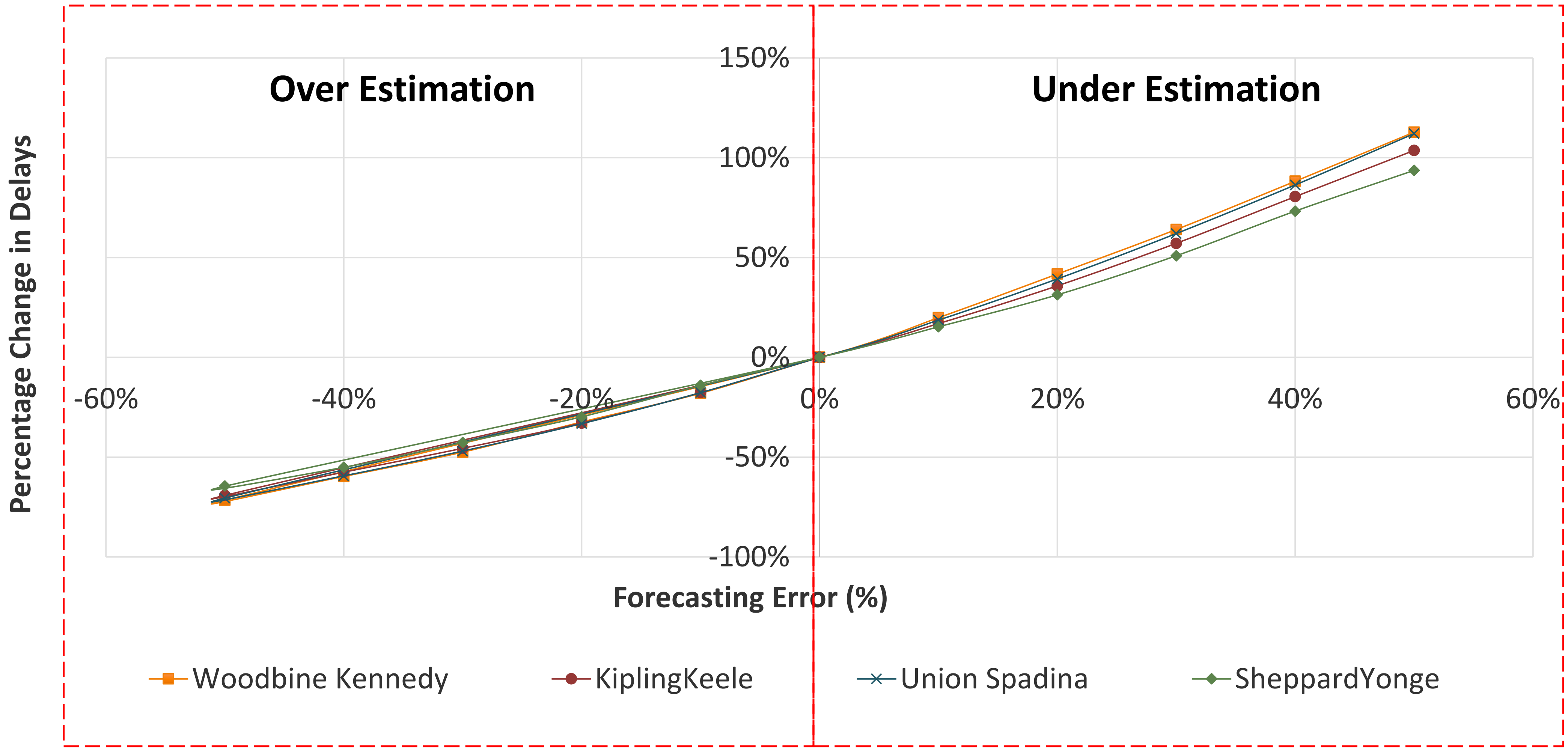
Uncertainty in Predicting Incident Duration

- Under estimation (Incident lasts longer)
  - Extra waiting time
  - High metro passengers’ delay
- Over estimation (Incident lasts shorter)
  - Inefficiency in shuttle buses utilization
  - Some shuttle buses could be wasted

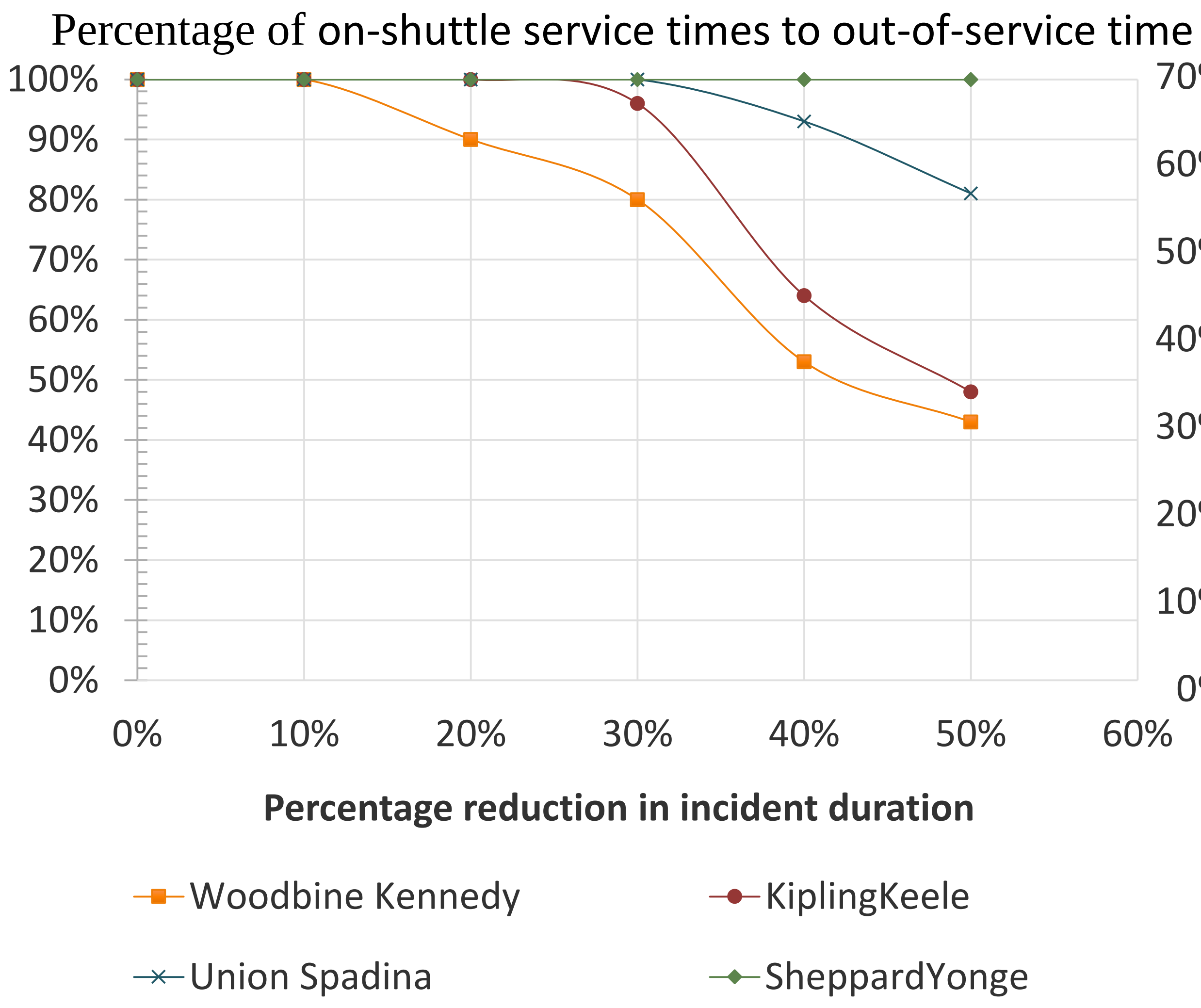
Uncertainty in Predicting Incident Duration: Results

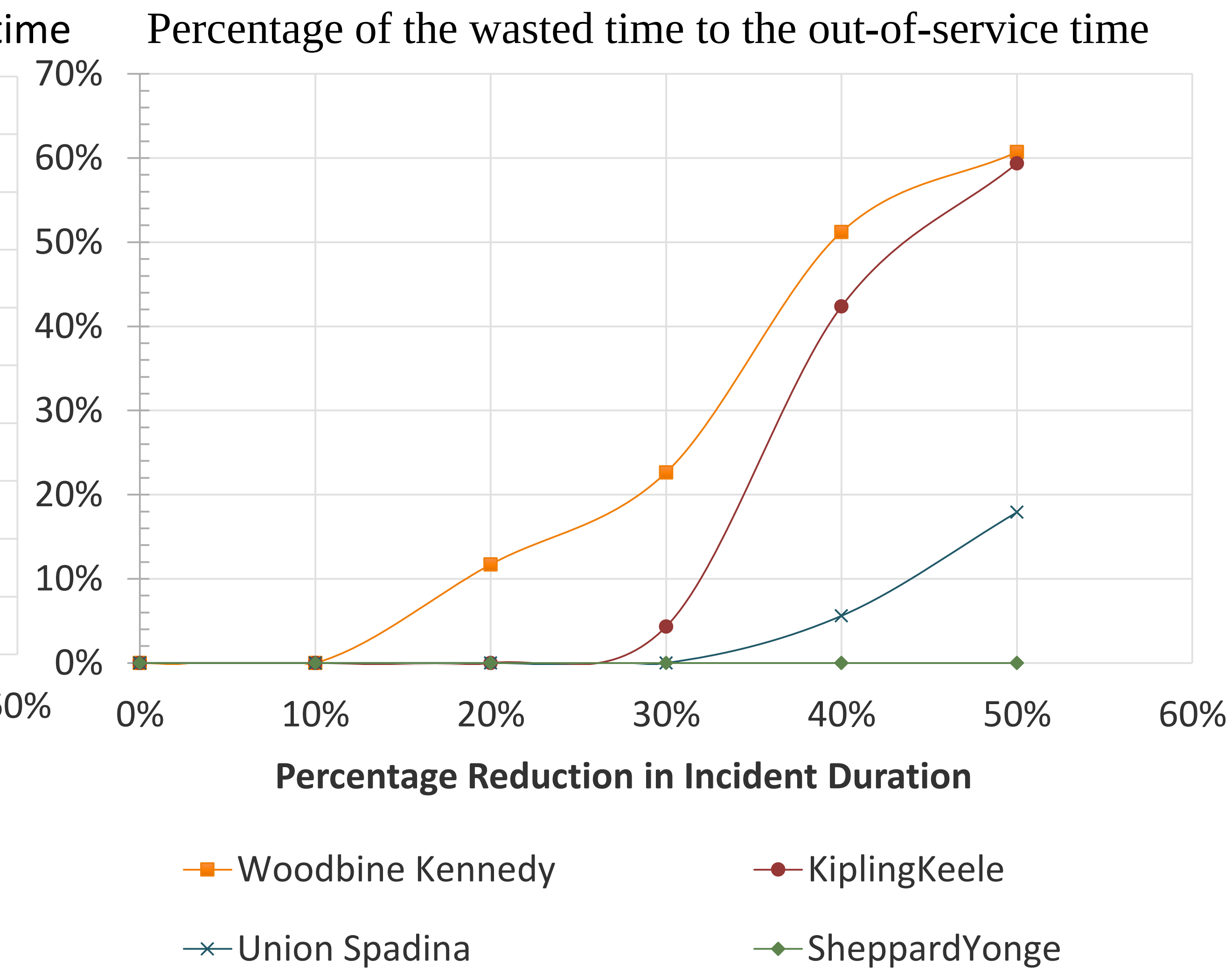
1) Metro Passengers' Delay



Uncertainty in Predicting Incident Duration: Results

2) Shuttle Buses Utilization





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Demand Reduction

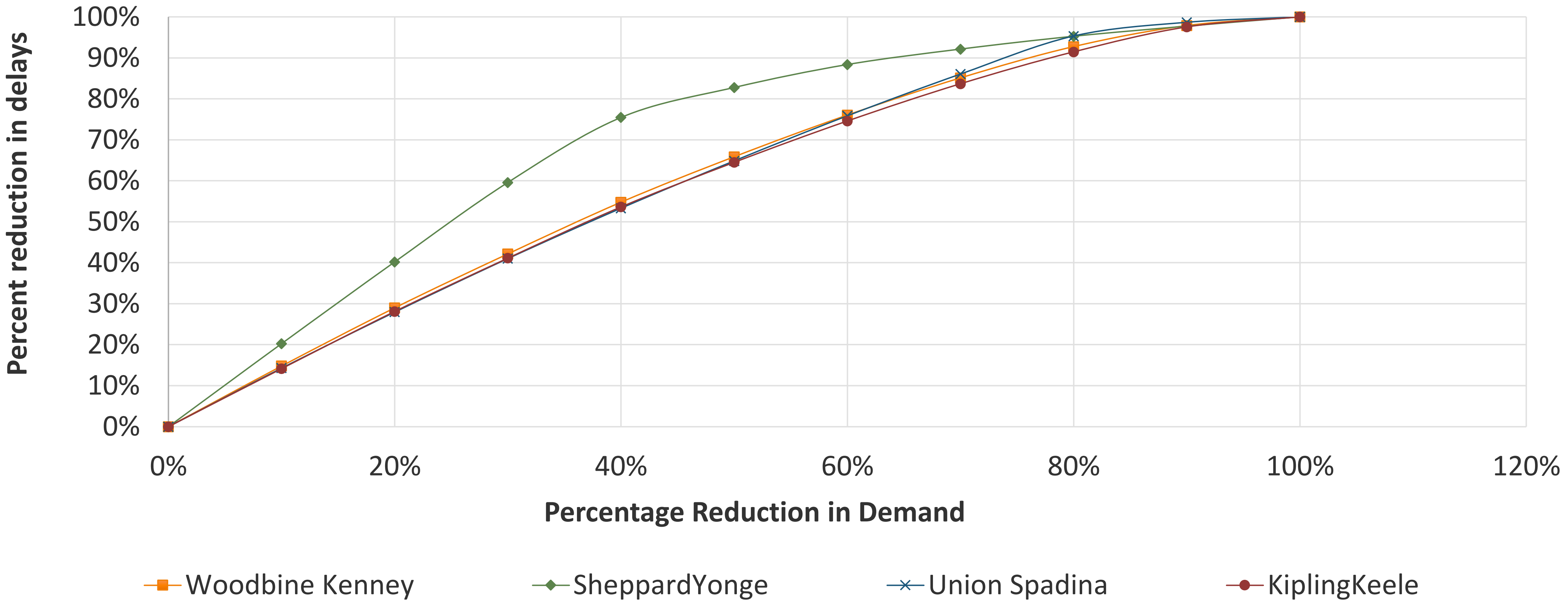
In response to a disruption, some affected metro passengers might switch to other functioning transit lines or modes, based on either their experience with the transit system or as a result of directions given by the transit agency.

None of the metro passengers leave the disrupted station (all wait for shuttle buses)

All metro passengers leave the disrupted stations (none wait for shuttle buses)

Demand Reduction: Results

Metro Passengers' delay



The savings in metro passenger delay curve has a logarithmic trend, which means reduction in demand brings *larger* percentage saving in metro passenger delays

Conclusion and Recommendations

Dispatch Direction

Maximize the utilization efficiency of shuttle buses.

Consider the demand profile over the disrupted metro segment

Dispatch Time

Dispatching shuttle buses earlier by 1 min saves, on average, 0.4 min/passenger at the disrupted stations.

Uncertainty in Predicting Incident Duration

High forecasting errors could result in significant disutility

There's a need for accurate prediction models

Demand Reduction

Directing passengers to other transit lines during disruption can achieve major savings in user delays.

What's Next?

User Interface

- Easily used by transit agencies to asses bus bridging plans prior to deployment

Integration of real-time data

- Integrating the user interface with real time data such as APC, AVL, and travel time data

Optimization Framework

- Develop an optimization model which utilizes the user delay modelling tool to determine the optimal bus bridging response plan under a given set of conditions

- Paper describing in details the methodology of the User’s Delay Modelling Tool CASPT link:
- Current paper link available on: