Integrated Microsimulation Modelling of Crowd & Subway Network Dynamics for Disruption Management Support

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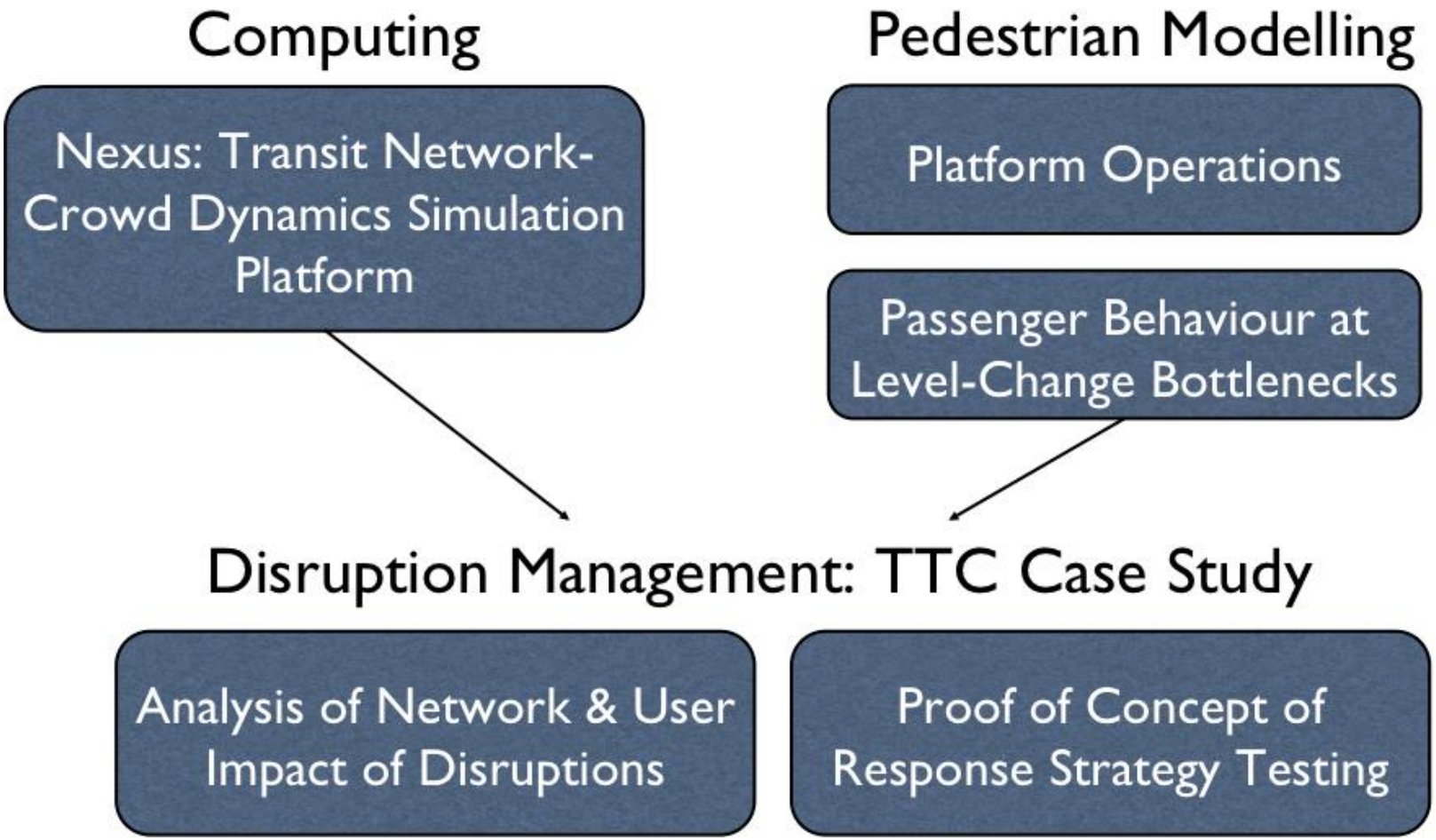
Background

- Understanding the impact of crowd dynamics on transit systems is becoming increasingly important
- Particularly true in the case of disruption situations
- Ad hoc disruption management methods currently used with manual intervention
- Network level analysis difficult with existing tools

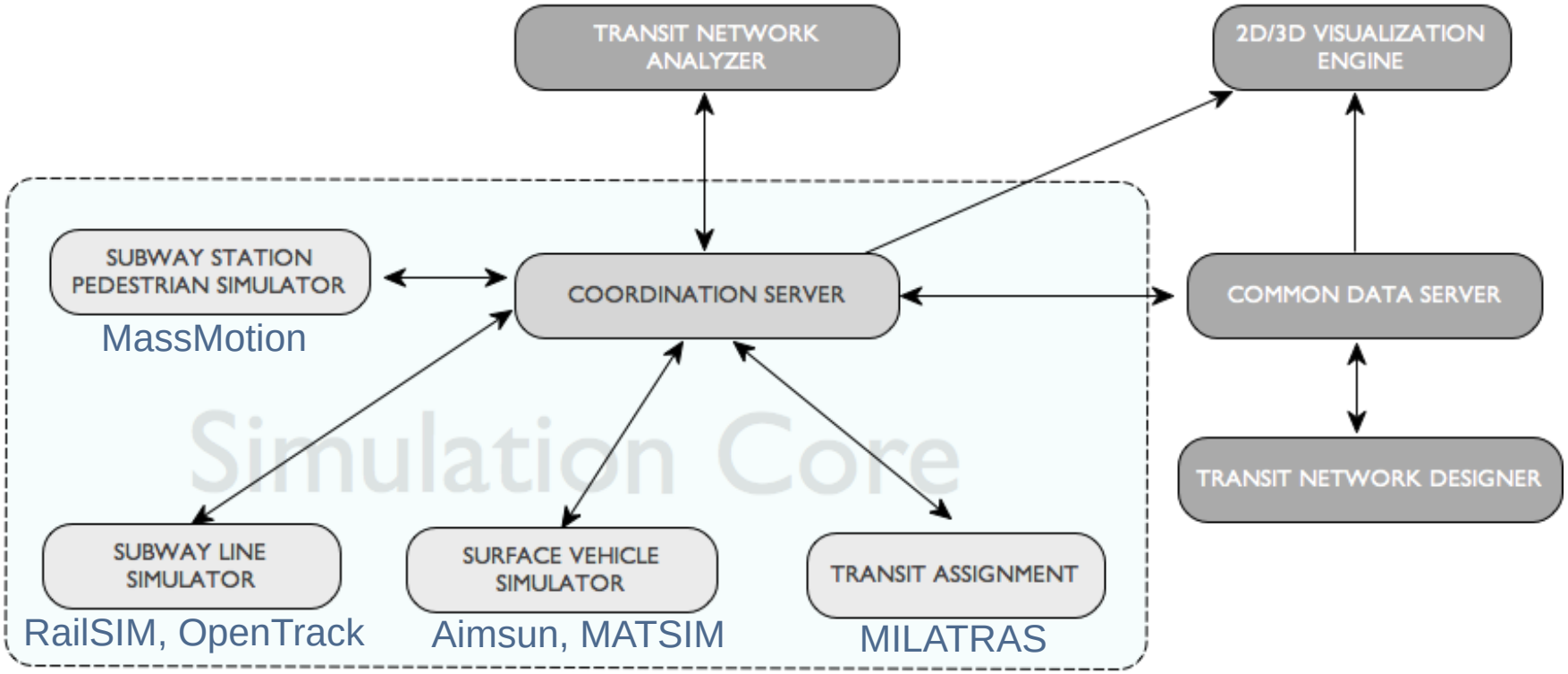
Research Objectives



The *Nexus* Platform

- Connected platform to link existing separate simulators (surface transit, separated rail, stations) in a network
- Pedestrians are agents, passing between simulators as they travel
- Permits simulation to be run across multiple computers to handle large crowds
- Platform for future transit research

Nexus Framework



Nexus Prototype

- Built to show proof-of-concept
- Network structure built automatically using GTFS data
- Stand-in simulators for each component
  - MassMotion integrated for modelling key stations
- Visualization of vehicles, graphs of metrics
- Incorporated two passenger models

Modelling Level Transitions

- Passenger choice between adjacent stairs and escalators
- Used standard binary and mixed-logit models
- Factors considered
  - mobility group of pedestrian
  - facility physical characteristics
  - conditions at time of choice (queuing, existing use of stairs and escalators, opposing flow on stairs)

Modelling Level Transitions

- Estimated using field data from several stations
- Incorporated within MassMotion
- 90% success rate in predicting 10-sec flows

Passenger Distribution on Platforms

- The main interface between stations and lines
- Passenger distribution key input into boarding/alighting models
- Developed a model of the process of dispersion of passengers along a subway platform
  - Considers entrance flows and positioning, relative to the arrival time of trains
  - Accounts for awareness of layout of destination platform for commuters

Passenger Distribution on Platforms

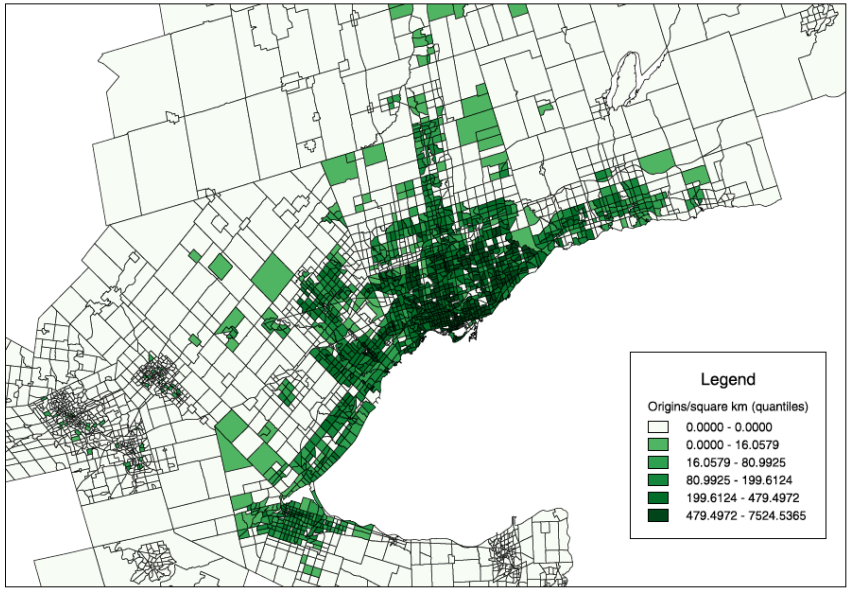
- Used a diffusion-inspired approach for spacing of passengers as they enter the platform
  - Movement based on density gradient caused by surrounding pedestrians
- Also incorporated waiting-section preference for a sub-population of aware commuters
- Calibrated model against Toronto survey data and field data collected at several stations

TTC Case Study

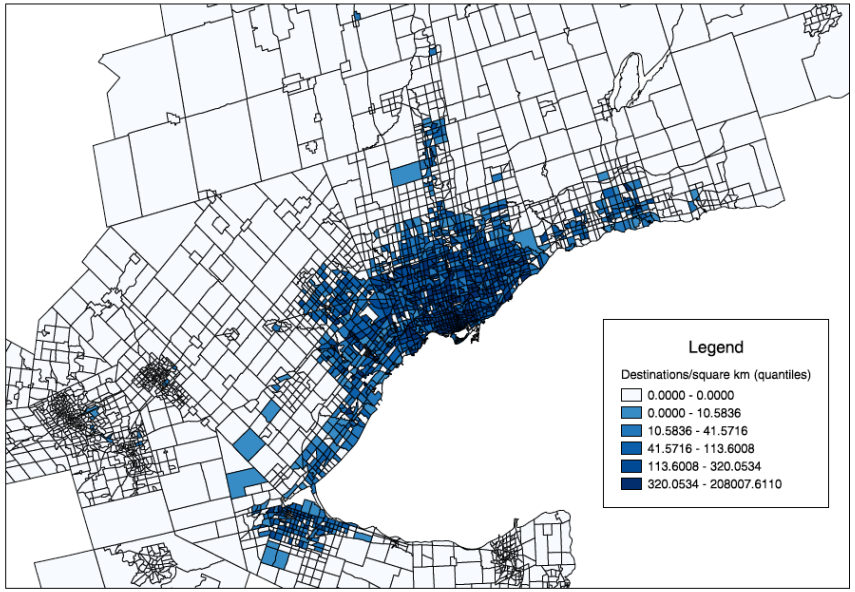
- Skeleton network constructed in the prototype
  - Show proof-of-concept of examining impact of disruptions, resulting crowding
  - Simulated testing of response strategies
- Also modelled connecting transit
  - GO Rail, Brampton, Mississauga, York
- Transit assignment not calibrated

TTC Case Study

- Agent population for morning peak commute synthesized using 2011/2012 TTS data fused with land-use data



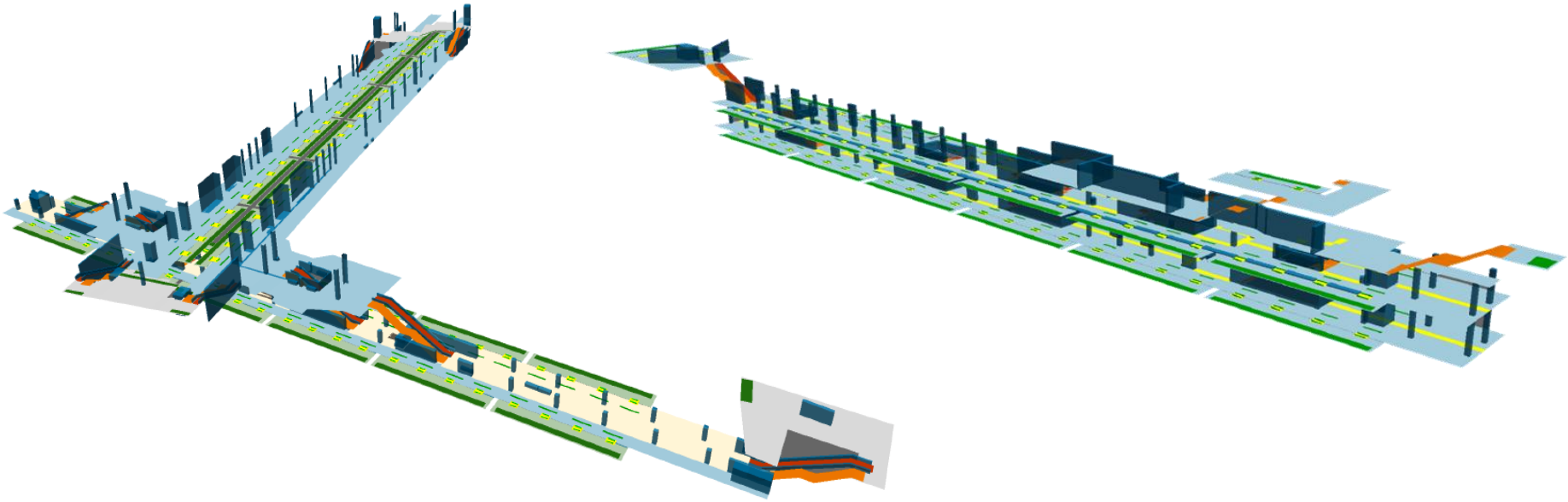
(a) Origin Points by TTS Zone



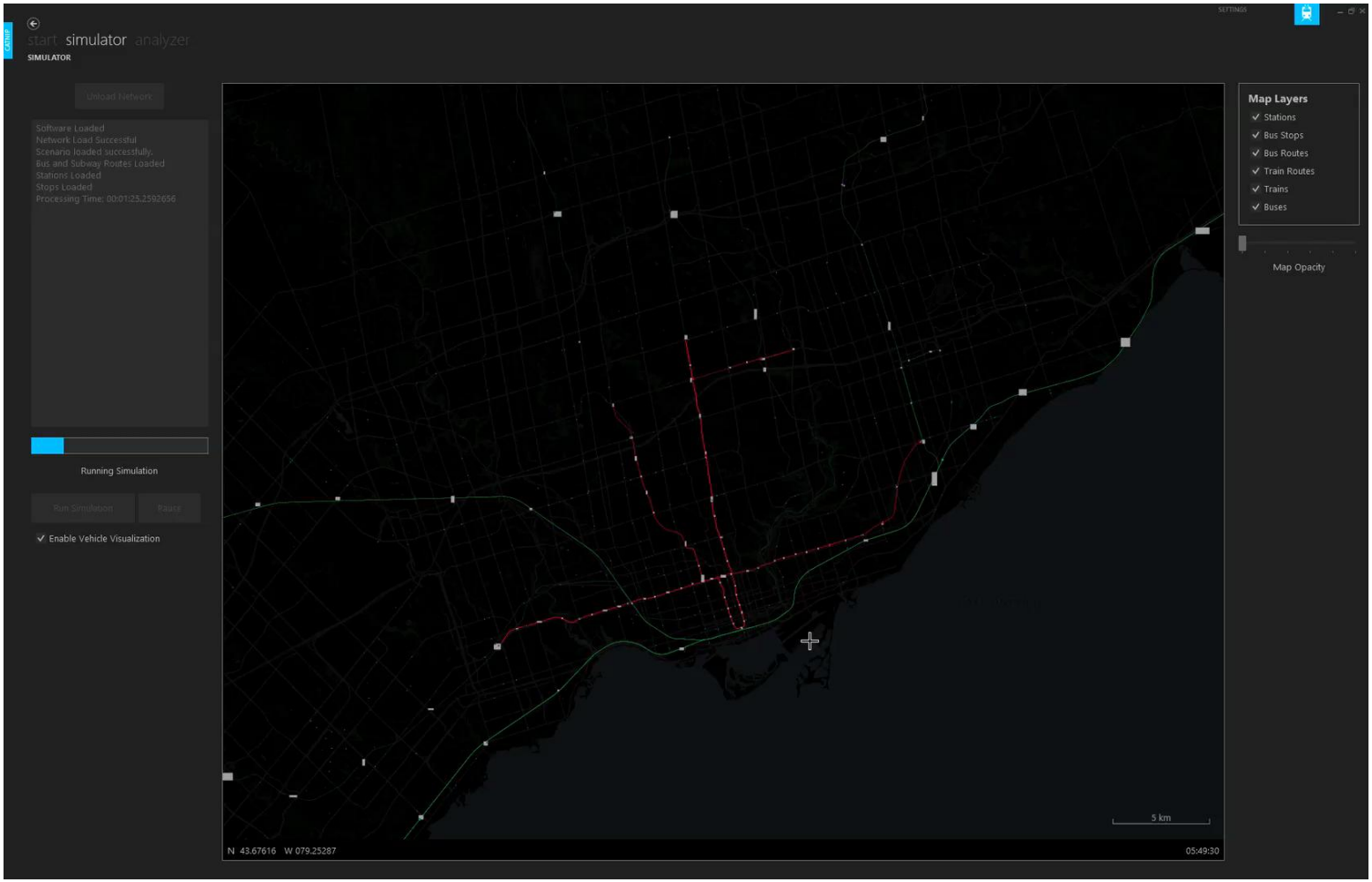
(b) Destination Points by TTS Zone

TTC Case Study

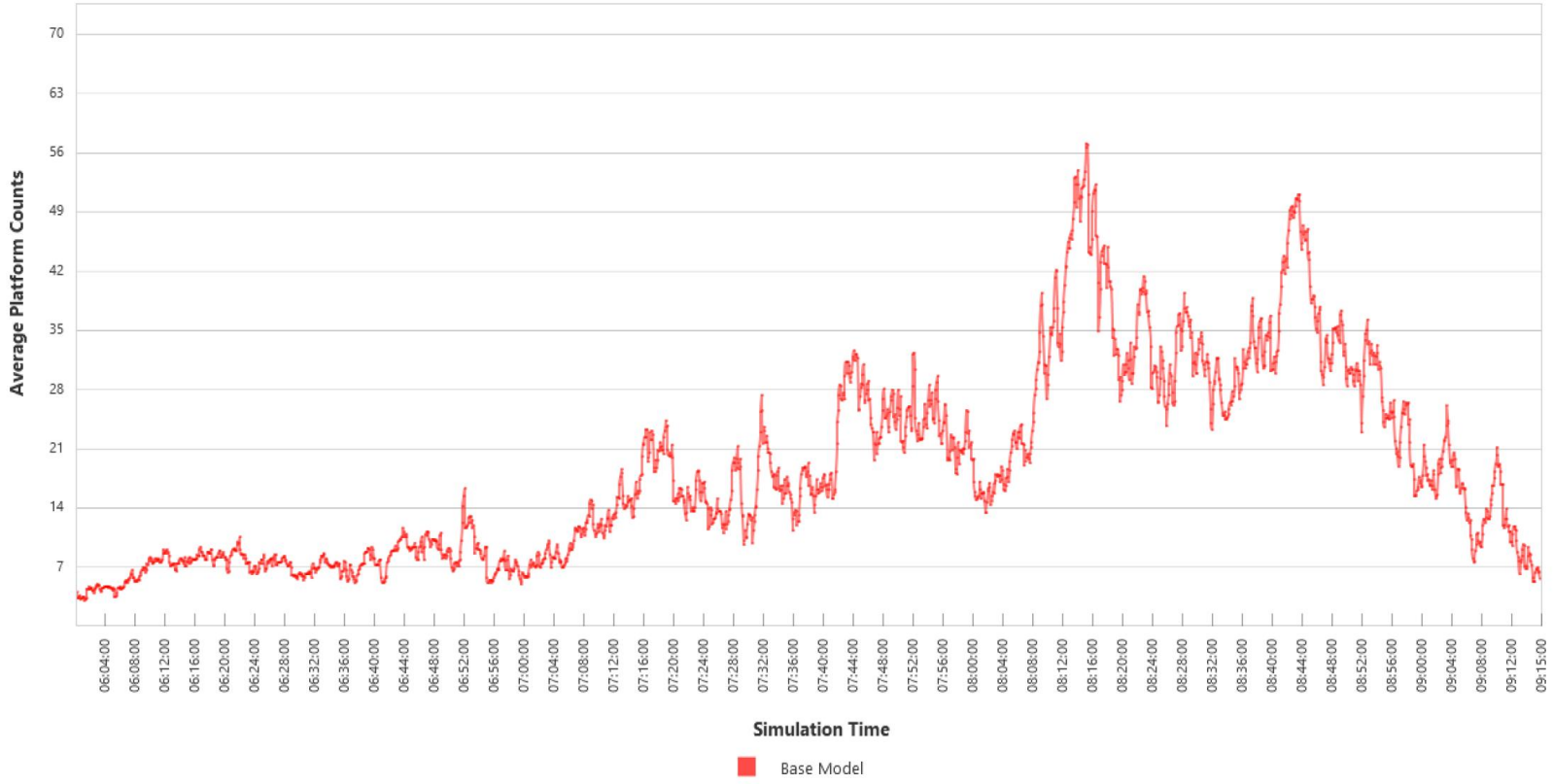
- Bloor/Yonge and St George stations built within MassMotion



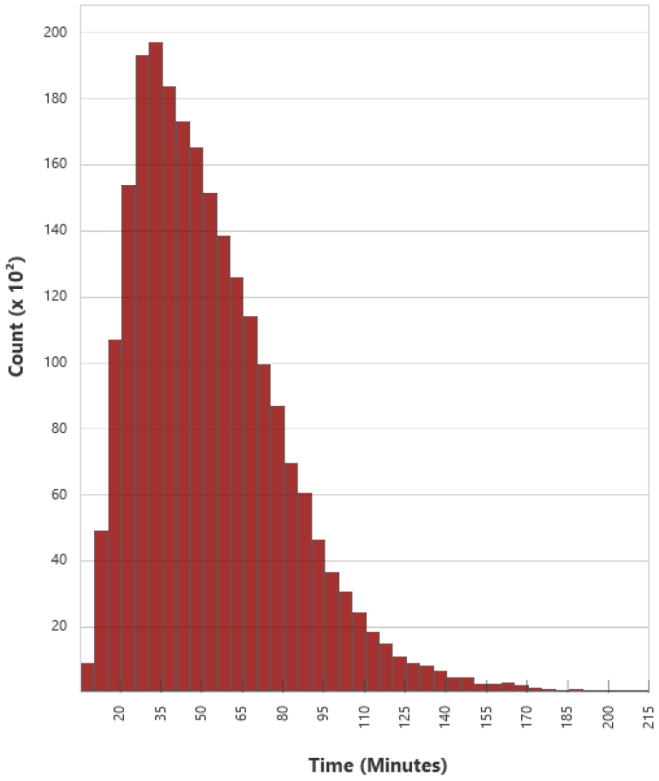
TTC Case Study



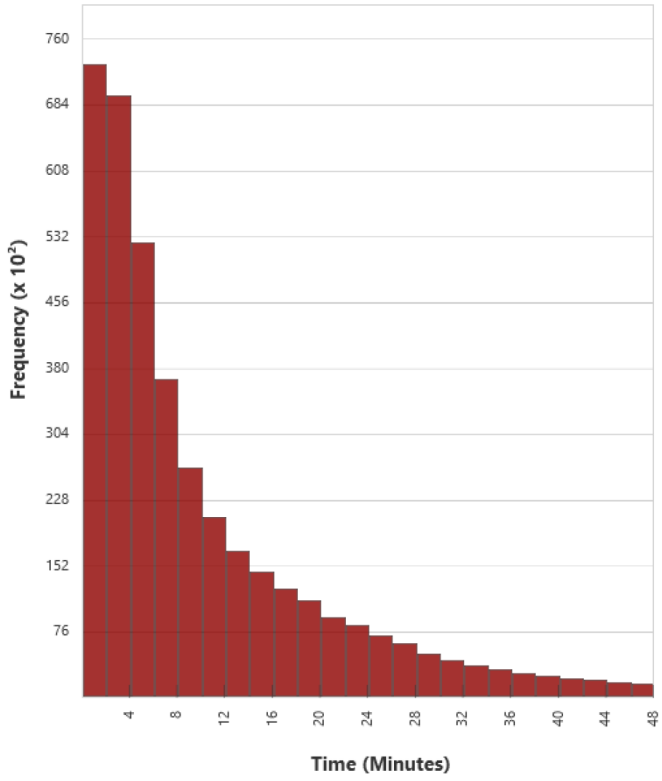
Network Performance



Agent Performance

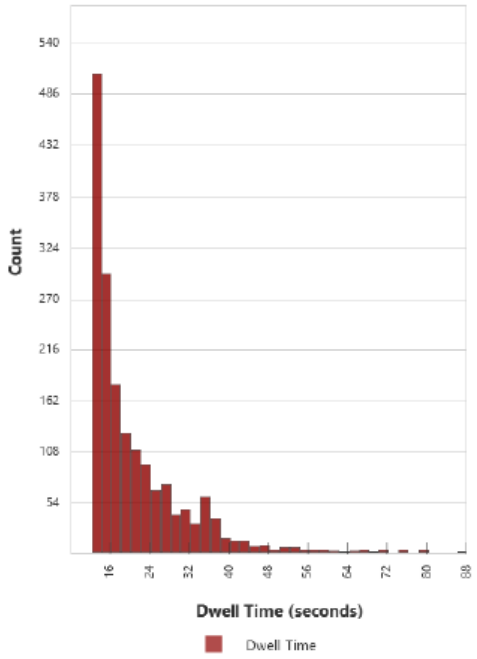


(a) Agent Travel Time for Base Model

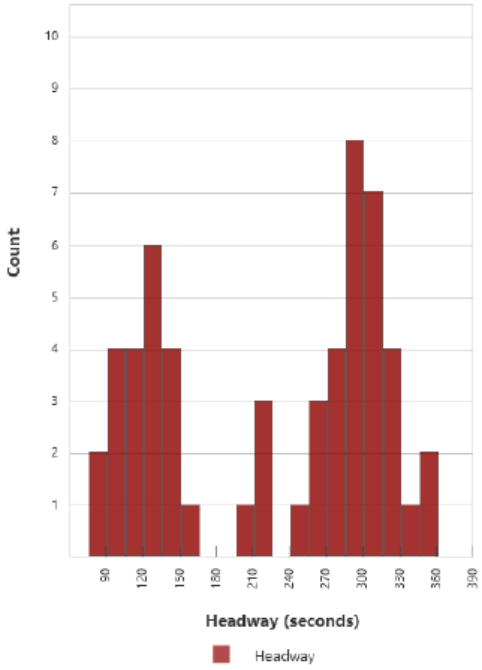


(b) Agent Waiting Time for Base Model

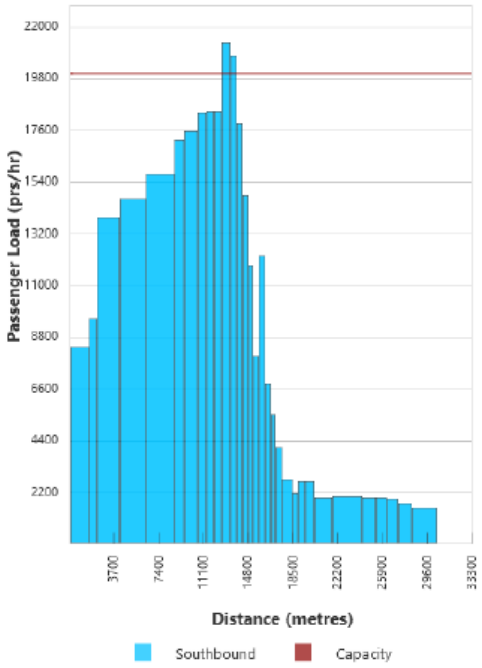
Yonge-University-Spadina



(a) Dwell Times



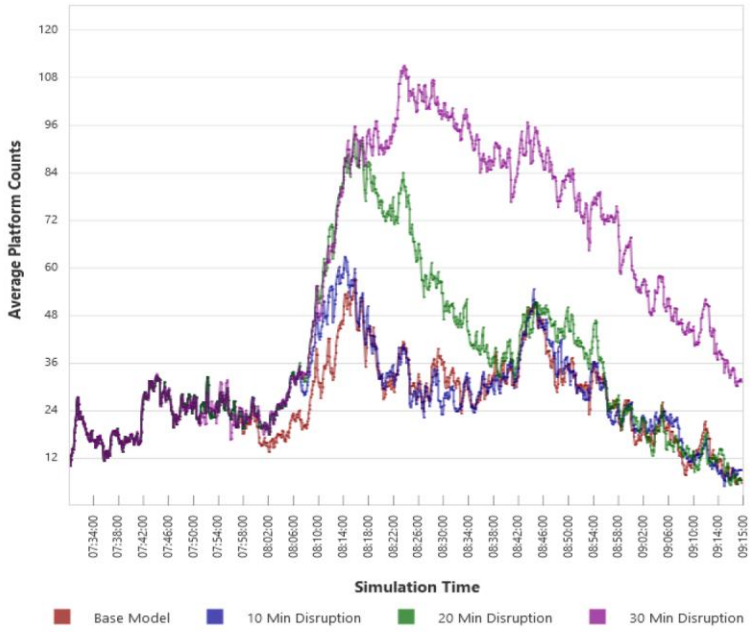
(b) Headways at Yonge/Bloor



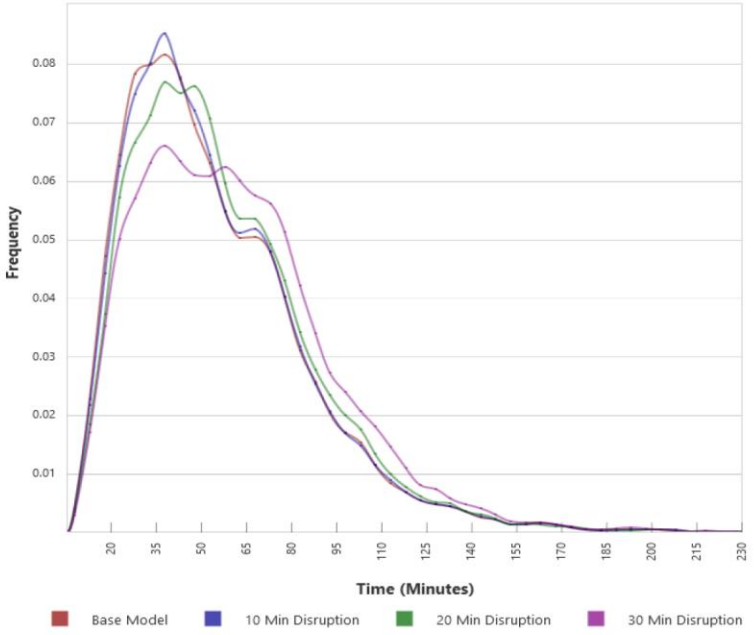
(c) Passenger Load

Disruption Impact Study

- Held southbound train at Yonge/Bloor station starting at 7:55 AM



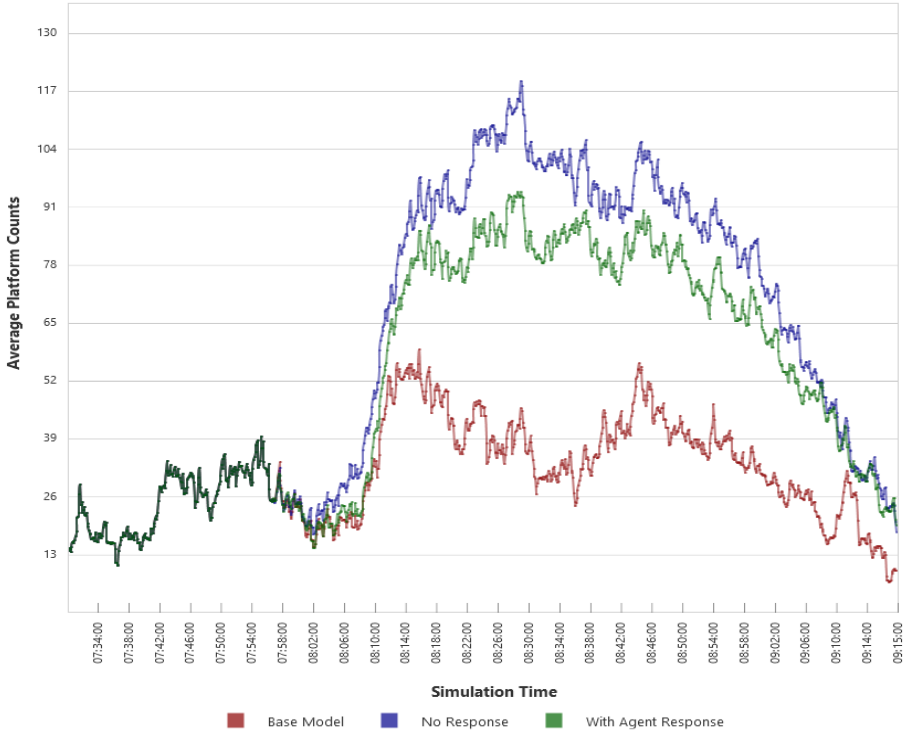
(a) Average Network Platform Counts



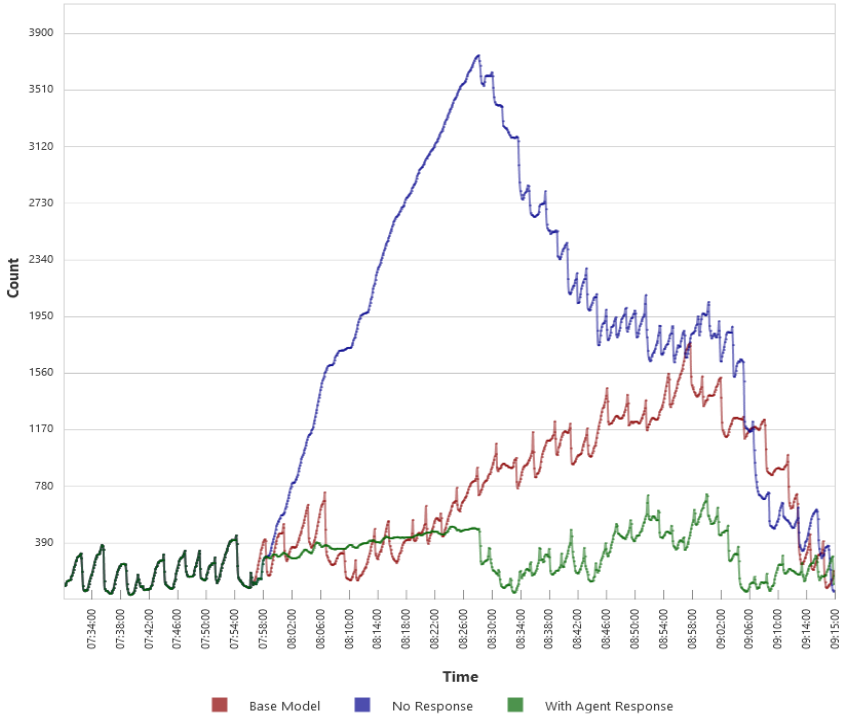
(b) Agent Travel Times

Response with Agent Re-routing

- With 30 min disruption, announcement made for agents on connecting line to avoid transfer at Bloor/Yonge



Average Counts at all Platforms



Southbound platform at Bloor/Yonge

Moving Forward

- Expansion of prototype to a commercial product and usable research platform
  - Used for projects/studies that require large-scale crowd and transit network simulation
- Full model of the GTHA transit network

Questions?