Nexus

Large-Scale Simulation Platform for Capacity Analysis and Emergency Planning of Multi-Modal Transit Networks


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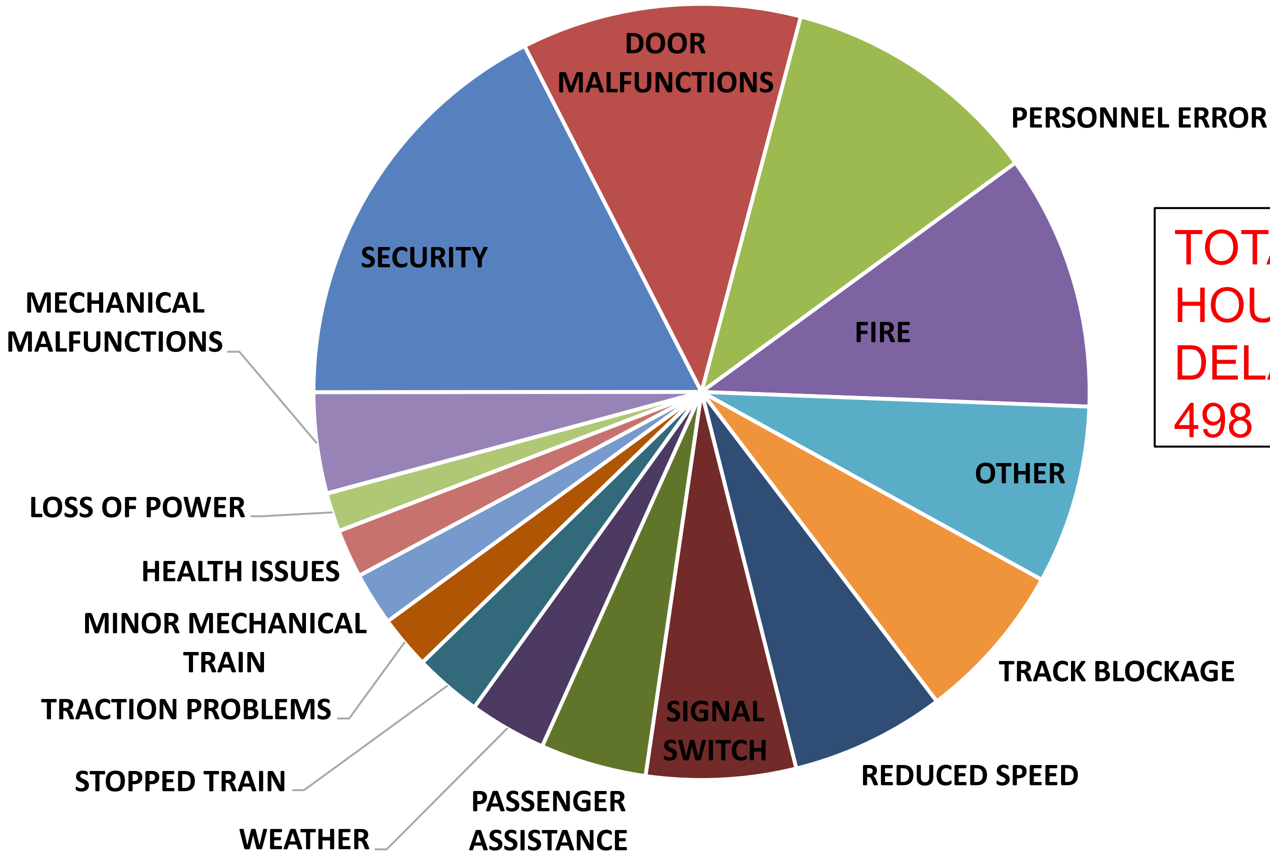
Overview

- Motivation
- Description of Nexus
- Potential Applications
- Nexus Research Projects
- Prototype Examples

Growing Congestion

- Demand outpacing capacity expansion
- Recurring service disruptions

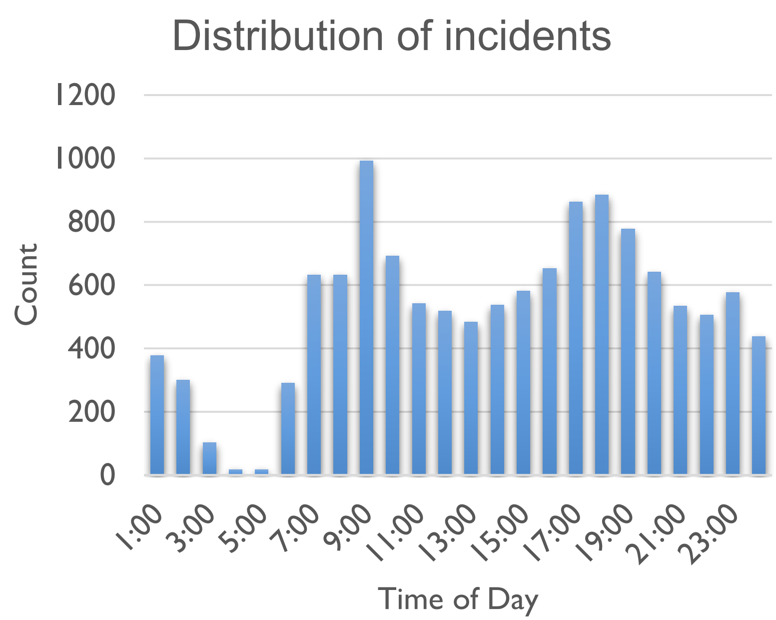
Transit Incidents

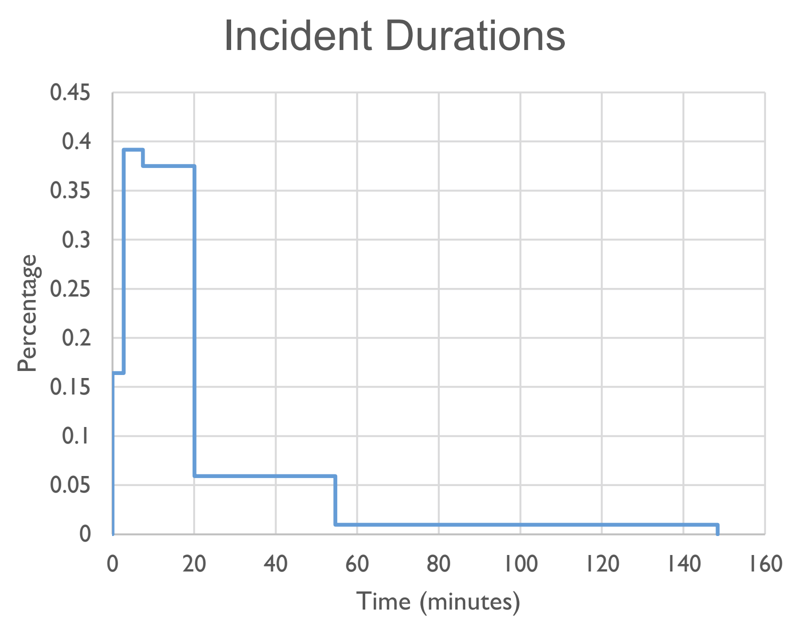


TOTAL HOURS OF DELAY: 498 Hrs

2013 TTC Subway Delays

Profile of Subway Delays





- Delays in subway network concentrated during rush hour, majority less than 20min in length

Agency Response

- Network capacity building (strategic)

- Operational Improvements

- Disruption management strategies

Motivation for *Nexus*

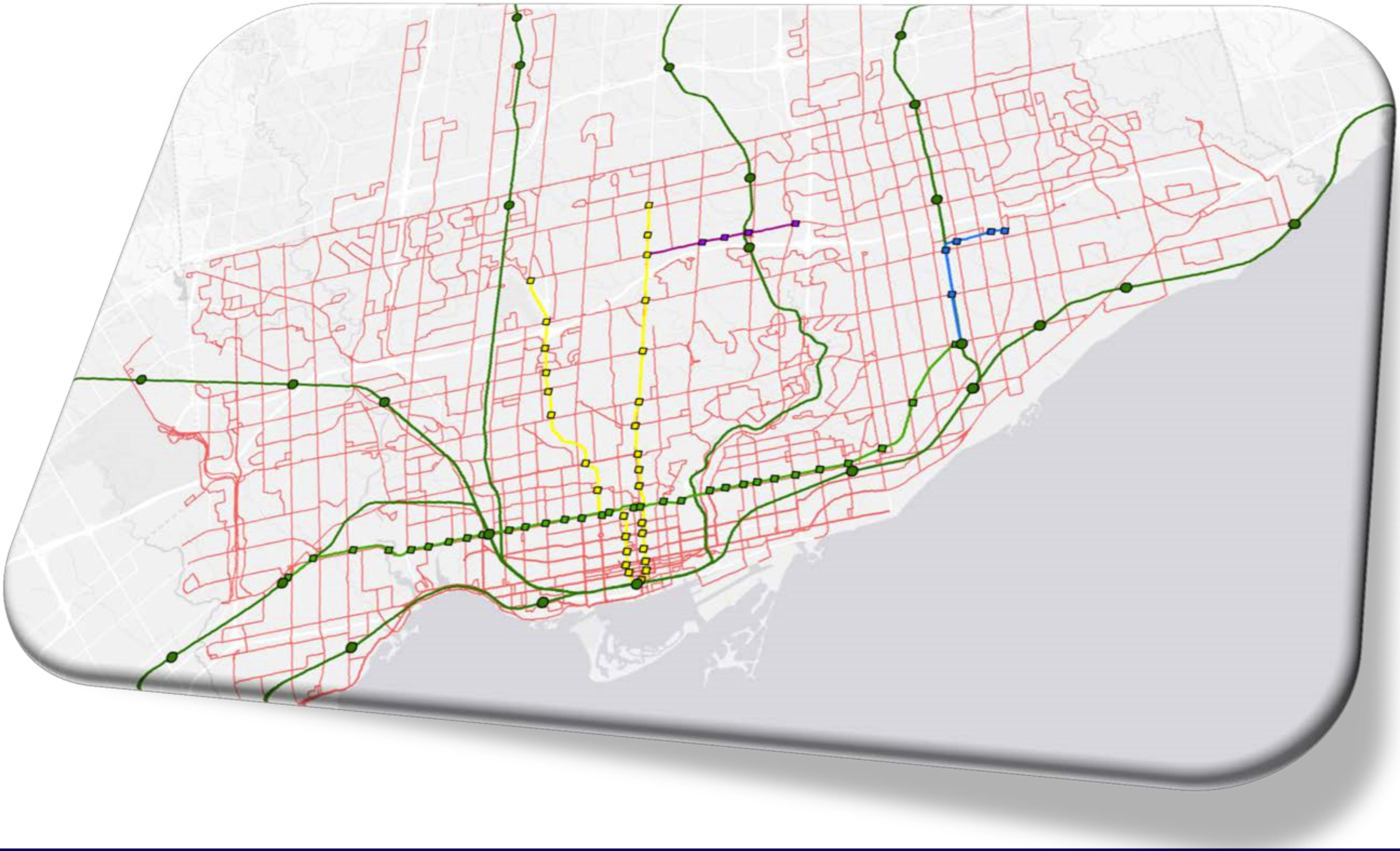
- Large-scale regional models generally use aggregate or high-level techniques
- Simulation is difficult to do for large regions
- Complexity of rail systems and passenger behaviour generally ignored
- Tools do not exist for understanding transient events like short-term disruptions

Motivation for *Nexus*

- Need for a high-fidelity multimodal transit network modelling system with capability to:
  - Represent the dynamic behaviour of transit lines and stations
  - Predict passenger travel behaviour under normal and irregular conditions
  - Scenario analysis of disruptions, response strategies, and longer range planning

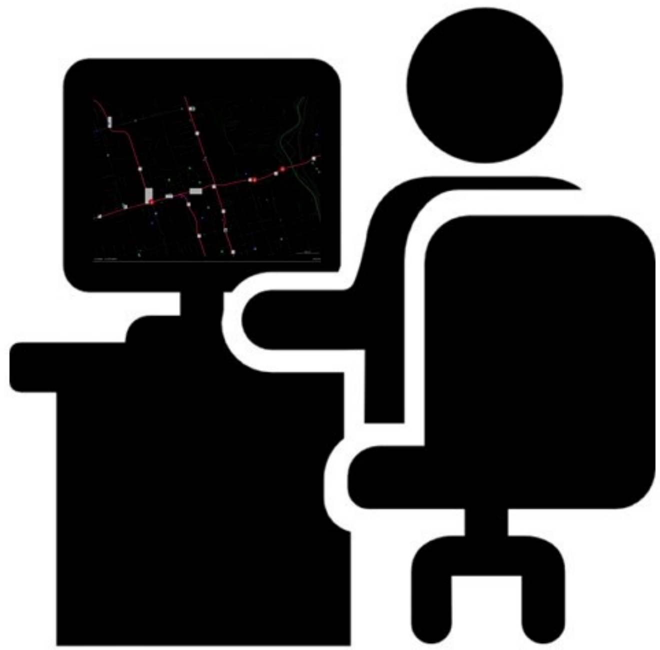
Designing Nexus

Designing Nexus



Nexus Main Features

In-simulation manipulation of transit service (of particular importance in being able to test response strategies to disruptions)

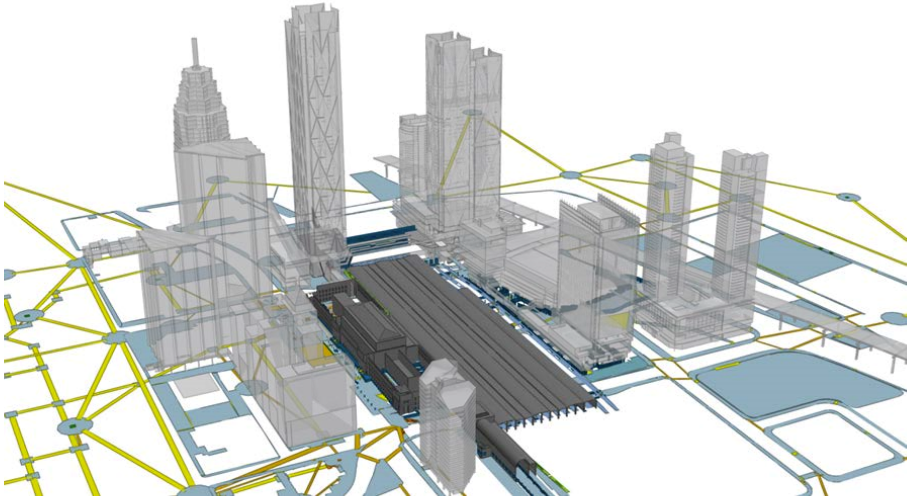


Potential Applications

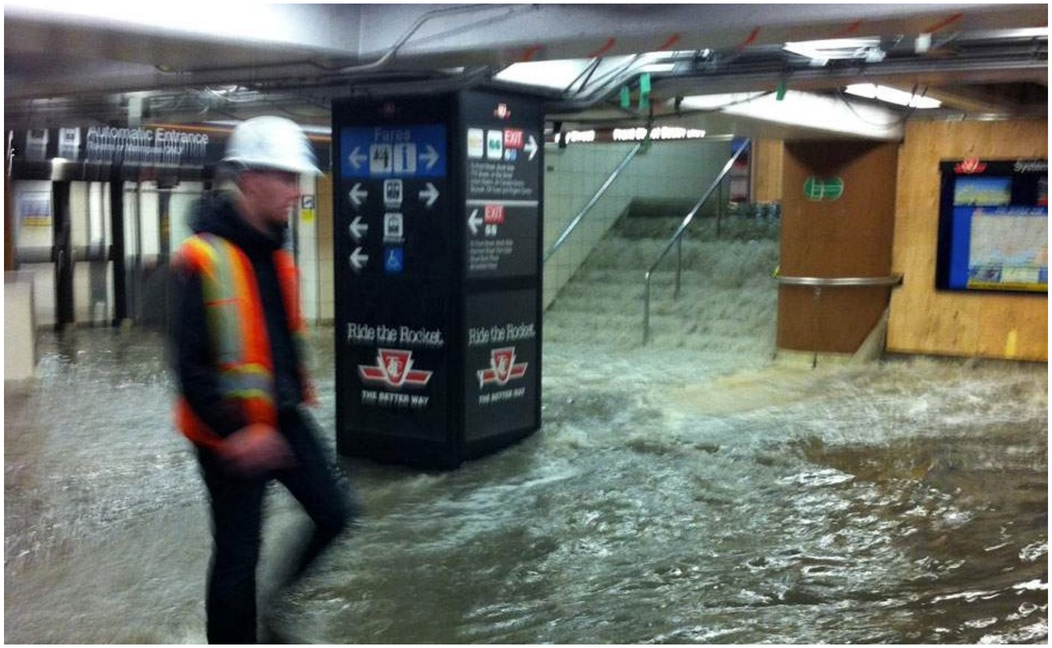
Capacity Analysis

- Capacity analysis of train lines under ATC and other operational improvements, while including impact/effect of stations

- Impact of new lines and service on key transit hubs

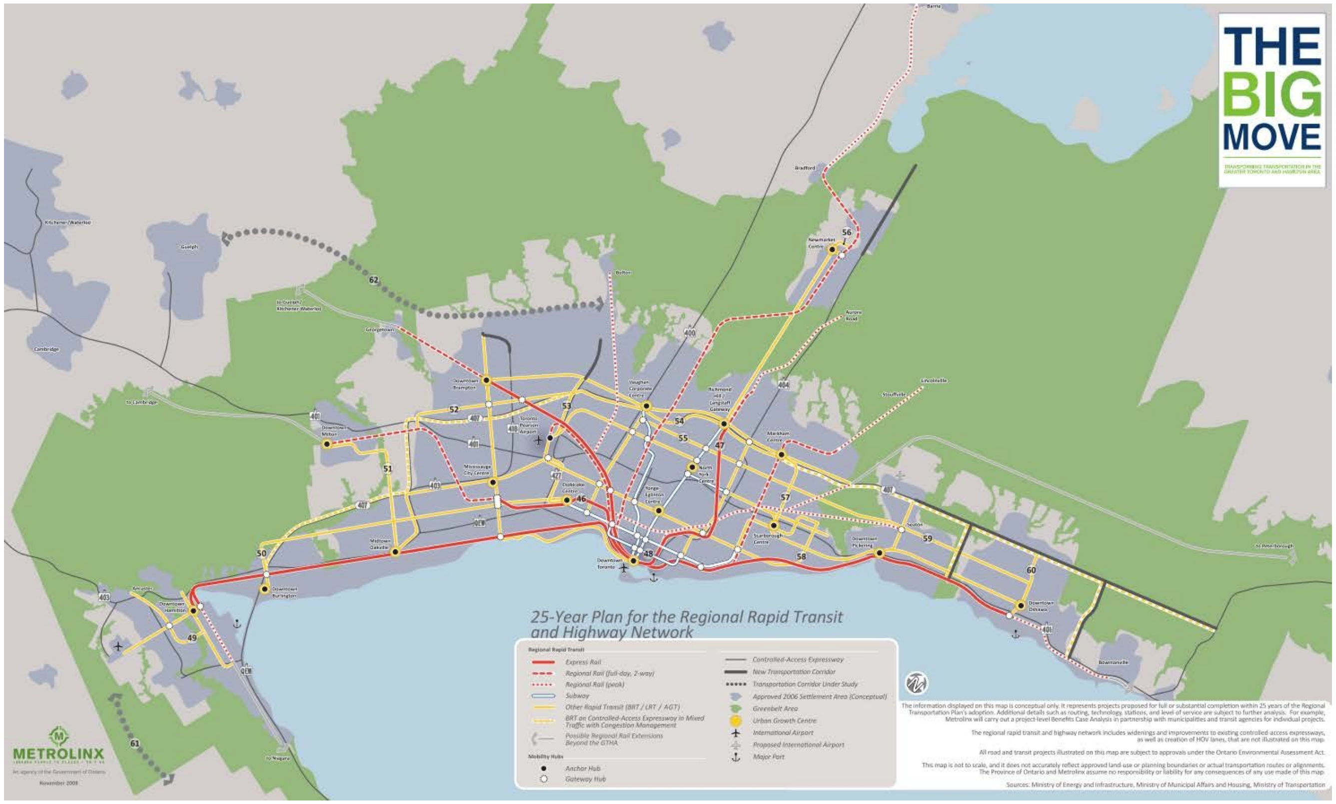


Network Resilience & Response



- Current analysis is performed using simplified network models, and can only handle complete removals of network segments
- Nexus will allow for a broader range of examination, including testing of transient disruptions and accounting for passenger behaviour

Policy and Planning Evaluations



- Nexus aims to offer the ability to examine the behavioural response of users at both the network and local level to policy and network changes

Nexus Research Projects

- Set of graduate research projects to better model behaviour of all transit actors
  - Agency decision-making during/after disruptions
  - Models of user behaviour under disrupted conditions using a joint RP-SP survey
  - Surface transit simulator based on GPS data
  - Basic research into models of crowd dynamics

Agency Response During Disruptions

- Survey of Canadian and international transit agencies with rail systems

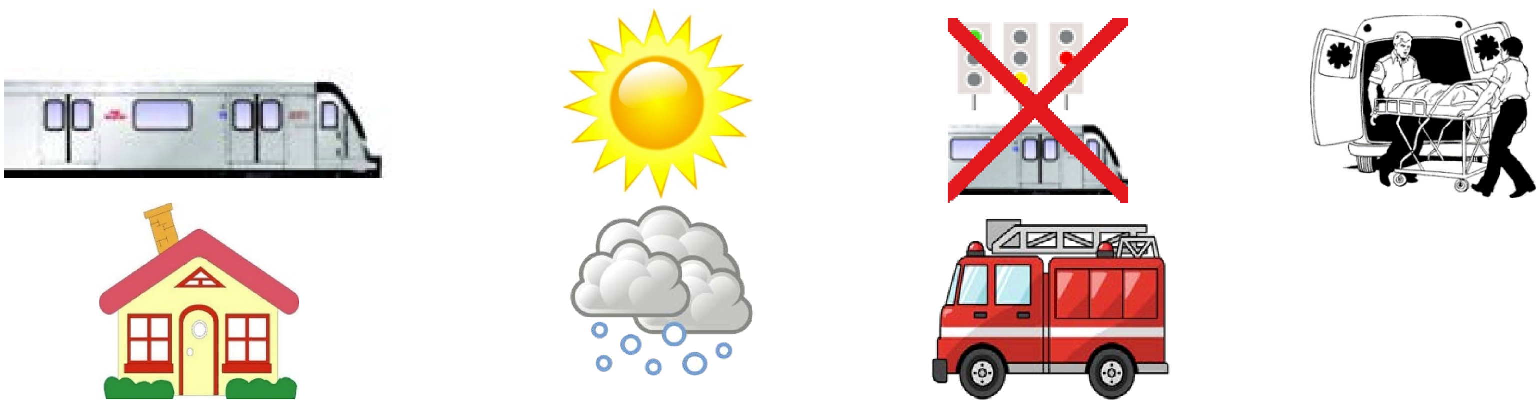
- Focus: process followed by agencies from disruption detection to response

- Goal: providing understanding to allow for better modelling of decisions made during response

User Behaviour During Disruptions

- Goal

  Understand the mode choice of passengers when facing different types of rapid transit disruptions



Survey Scope

- Riders of TTC rapid transit system
- Peak period school and work trips
- Immediate actions: pre-trip and en-route
- 7 available mode options
- Revealed Preference: last experience
- Stated Preference: hypothetical scenarios

You are **on your way** to your destination and the weather is **not comfortable** outside with rain, snow or extreme temperature. You are approaching *Spadina Station* and you have just found out that there is a "**Medical Emergency**" at *St George Station*, causing the subway service to be suspended between *Spadina Station* and *Union Station. You have the following mode options shown in the table with the associated attributes.* ***Please choose your most preferred option to get to your destination from Spadina Station given the situation.***

	Taxi	Other TTC Routes	Shuttle	Walk	Wait	Cancel Trip
Length of Delay (minutes)			No Information Provided		50-60	
Cost (CAD)	$6.7	$0	$0	$0	$0	$0
Number of Transfers		0	2		1	0
Access Time (minutes)		0	0		0	1
In-vehicle Travel Time (minutes)	6	1	15		7	23
Transfer Time (minutes)		0	9		4	6
Egress Walking Time (minutes)		13	2		2	0
Total Travel Time (minutes)	6	14	At least 27	17	64-74	30
Total Travel Distance (KM)				1		
Choice						

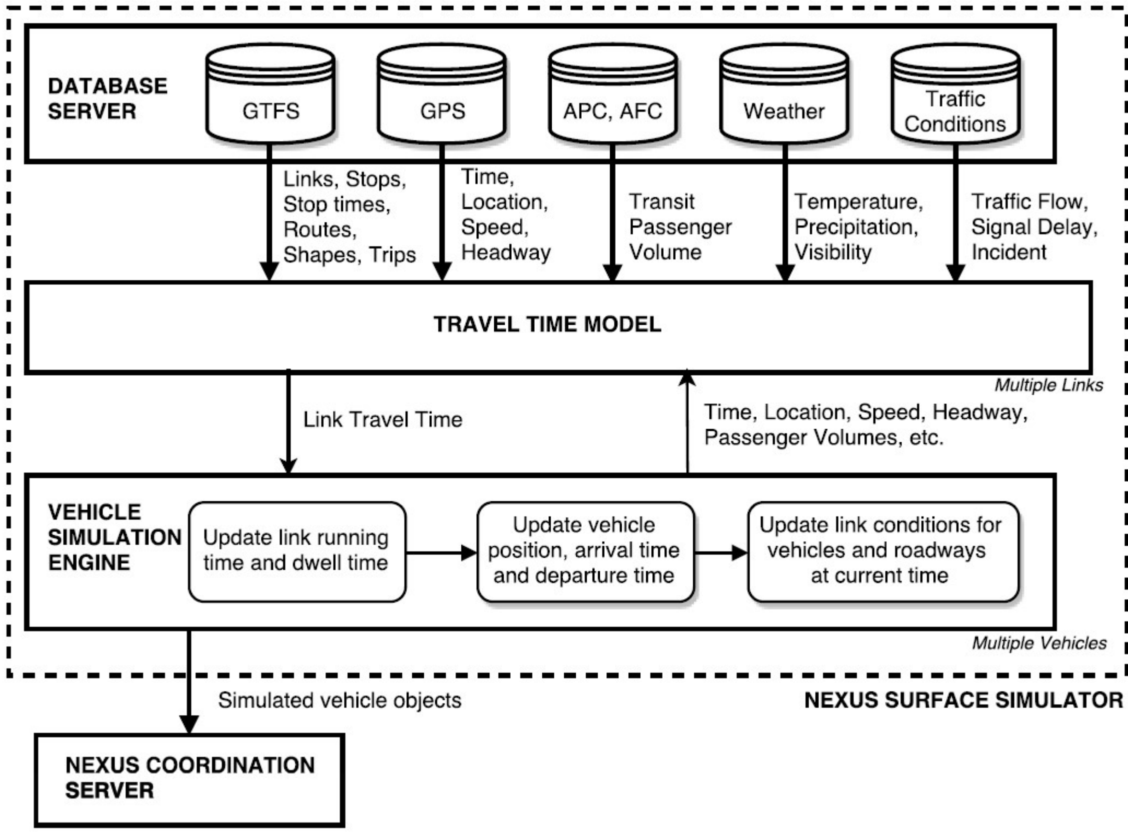
In the future, how likely are you to get to your destination using your selected choice above if you encounter this scenario in real life?

-- select an option --

Nexus Surface Simulator

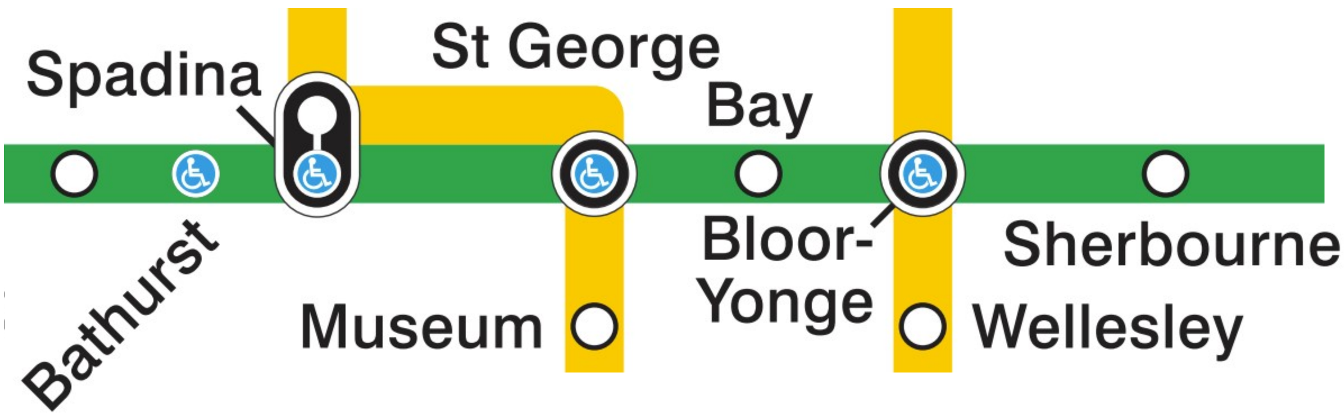
- Main goal: Produce accurate arrival/departure patterns at subway stations
- Existing methods of modelling public transit impose high computational requirements
- Instead, travel time models constructed using open data and machine learning algorithms

Nexus Surface Simulator Framework



Nexus Station Simulator

- Currently, MassMotion is the simulator of choice for accurate station models – very demanding in terms of data, computer resources, and time
- Ideal solution is to use a simplified station simulator for smaller and less complex facilities



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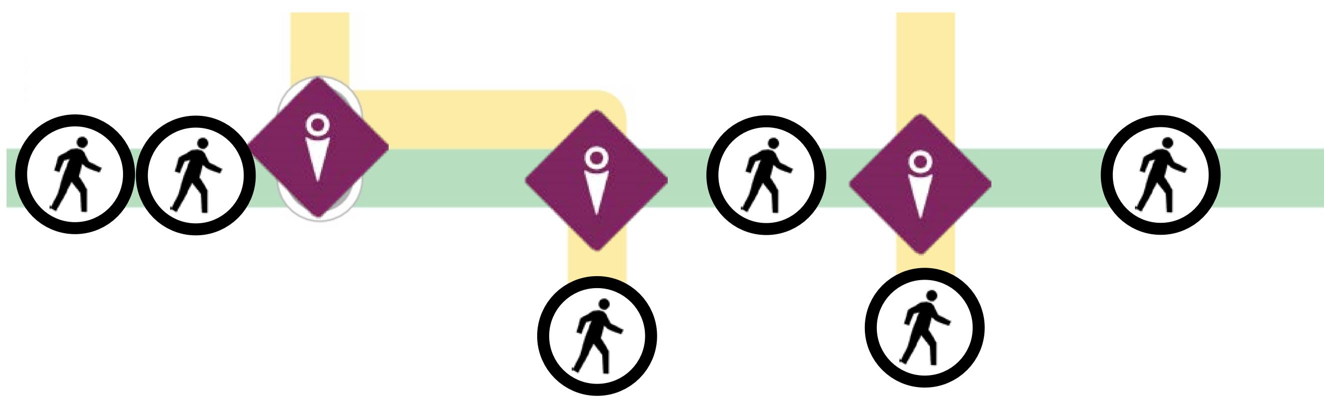


Understanding Performance of Crowd Dynamics Models

- Some performance/accuracy trade-offs are acceptable

- Several types of crowd dynamics models exist

- Little research done to compare their performance and accuracy

Crowd Model Evaluation Framework

Simulation Models

Test Scenarios

Metrics /KPIs

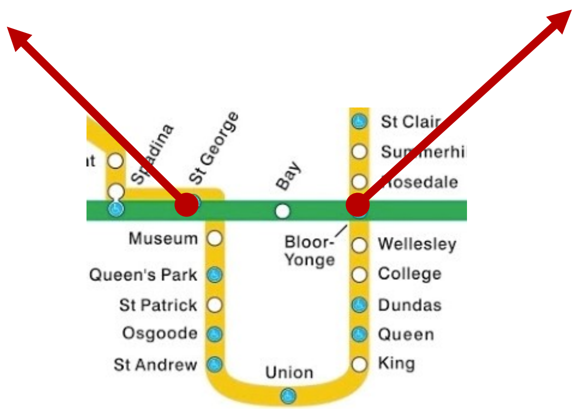
- Fruin Queueing
- Fluid Flow
- Cellular Automata
- Social Forces (MassMotion)
- Gradient Steps

GTA Prototype Examples

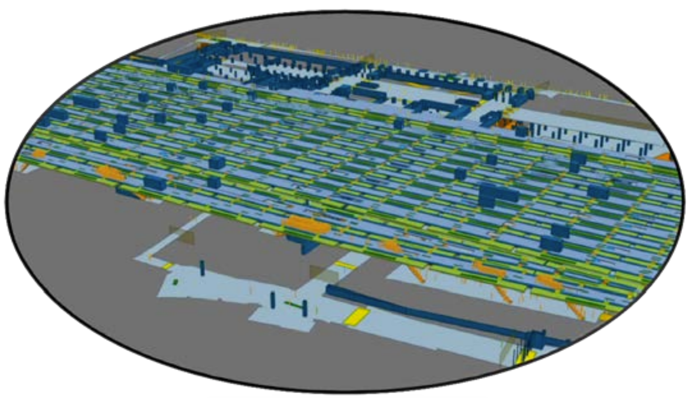
Yonge/Bloor Station

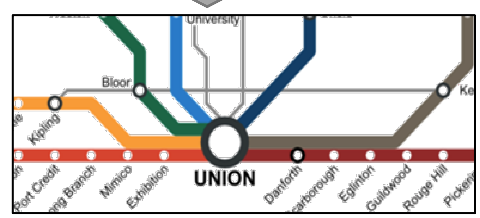
GTHA Case Study

GTHA Case Study



Example: USRC Model





Questions?