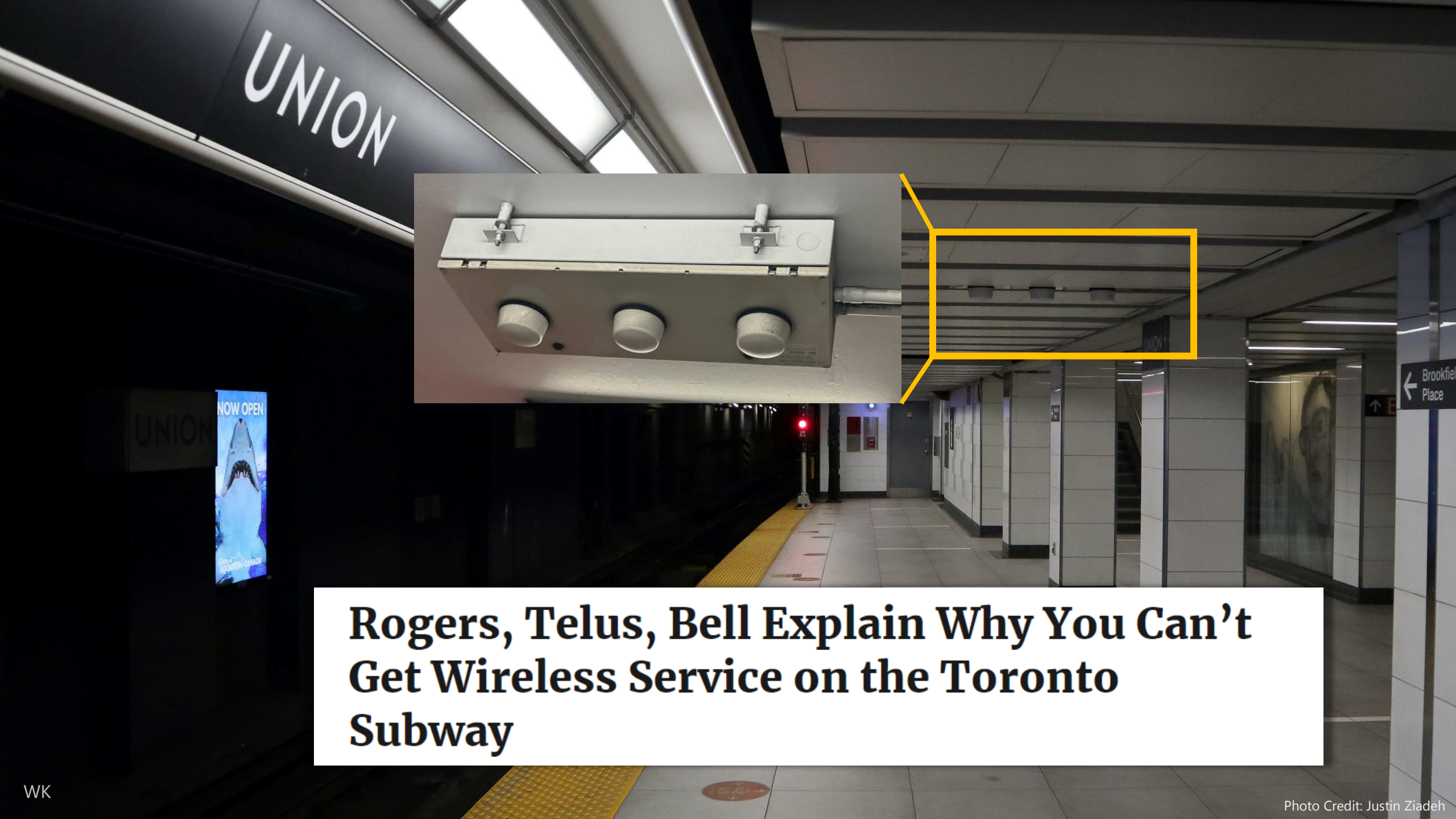
System Performance with Wi-Fi Connection Data

Aidan Grenville, **Willem Klumpenhouwer**,
Natalie Chui, Amer Shalaby

TRB Annual Meeting | January 10, 2023

TAL
TRANSIT ANALYTICS LAB

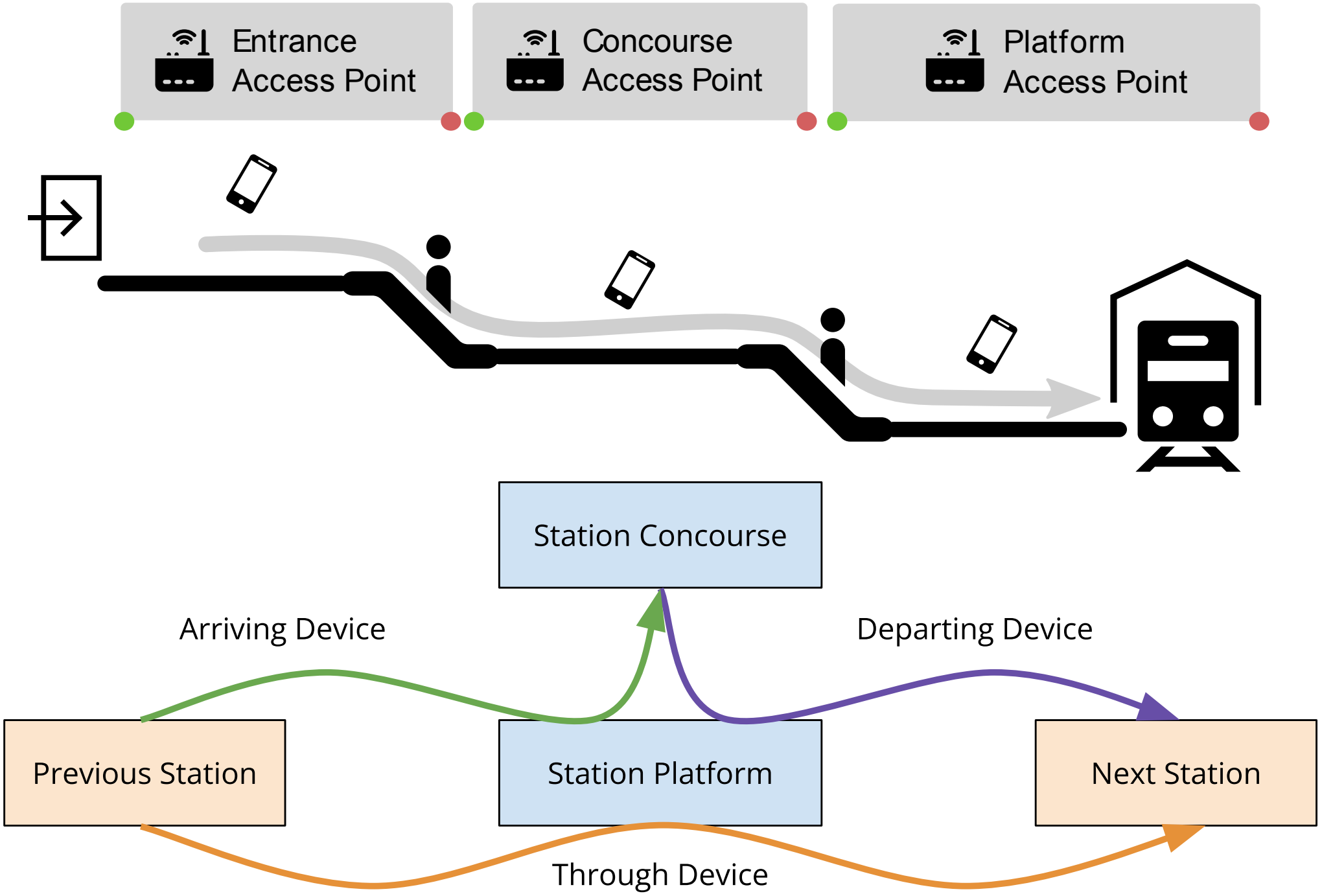
Photo Credit: Jed De La Cruz



Rogers, Telus, Bell Explain Why You Can't Get Wireless Service on the Toronto Subway

WK

Photo Credit: Justin Ziadeh


Entrance
Access Point
Concourse
Access Point
Platform
Access Point
Station Concourse
Arriving Device
Departing Device
Previous Station
Station Platform
Next Station
Through Device

WK

Requires Train Location Information

headway regularity: How consistently are trains spaced apart?

brownian motion: How does the randomness on a line evolve downstream?

missed trains: How often are devices missing a train?

indexing and aggregation over various temporal spans (month, week, period, hour)

Doesn't Require Train Location Information

platform wait time: How long and consistent is the platform wait time?

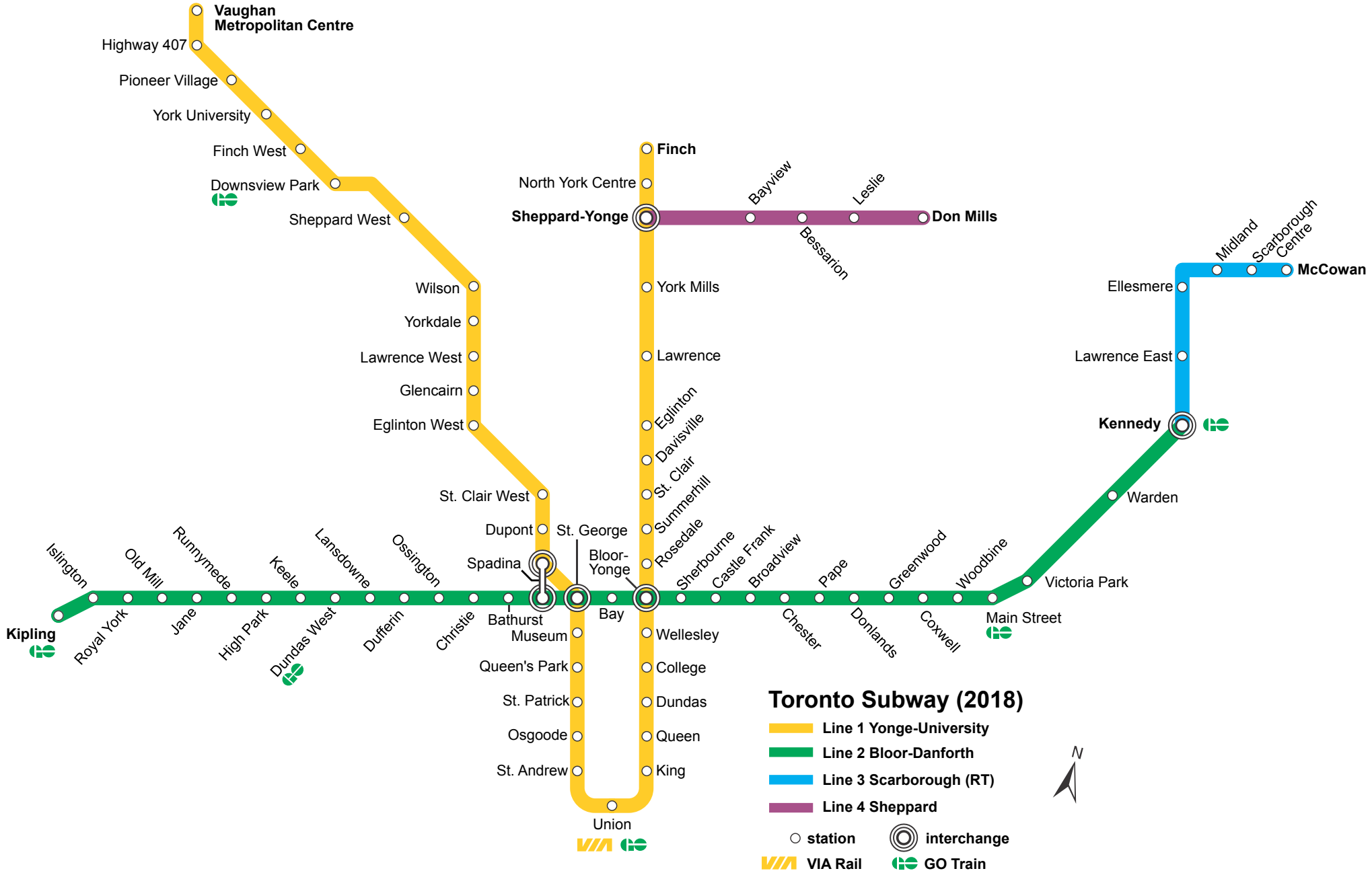
origin-destination regularity: How consistent is the journey between two points?

rider regularity: How consistent is a given device's experience over a month?

incident impact: How much extra wait time is caused during an incident?

incident behaviour: How do devices react during an incident?

WK



AG

Map Credit: Wikimedia

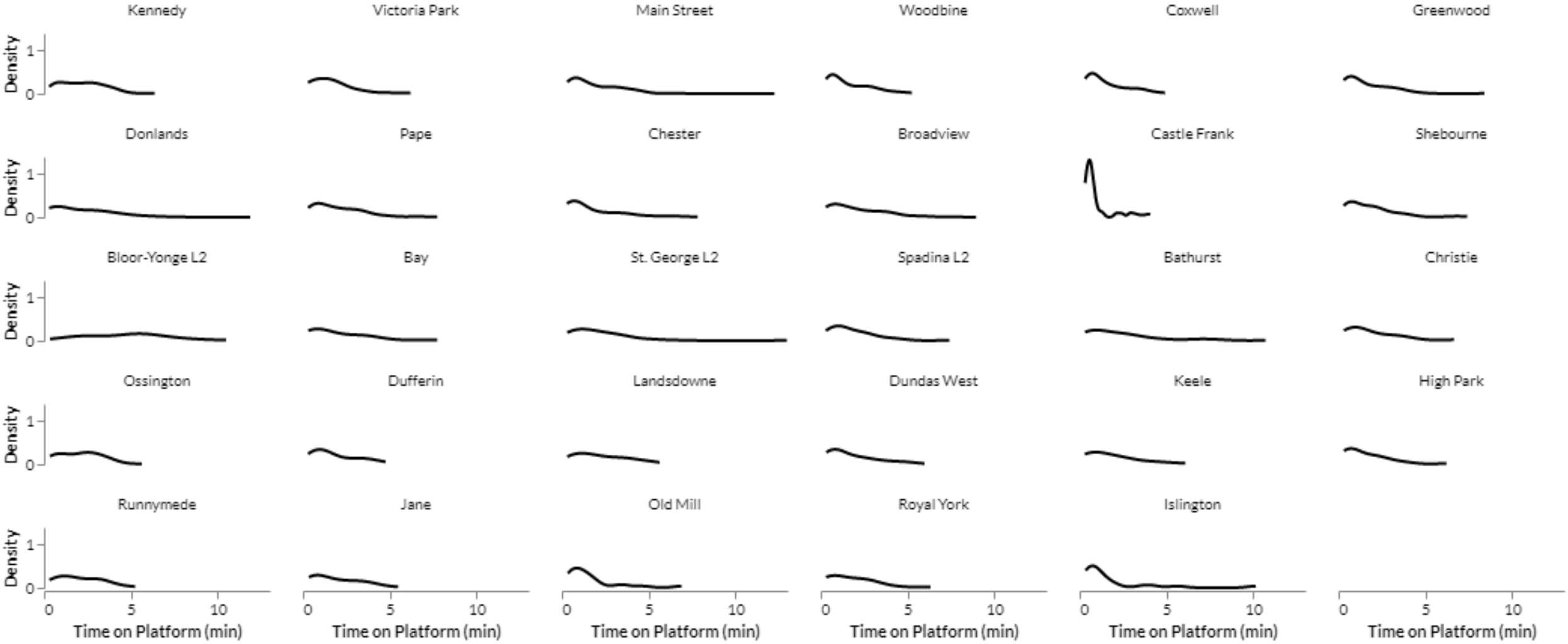
Wait Time Estimation

AG

Photo Credit: Tobias (Unsplash)

Observed On-Plaform Waiting Time Distributions

Line 2 towards Kipling - May 5, 2022 0700-0900

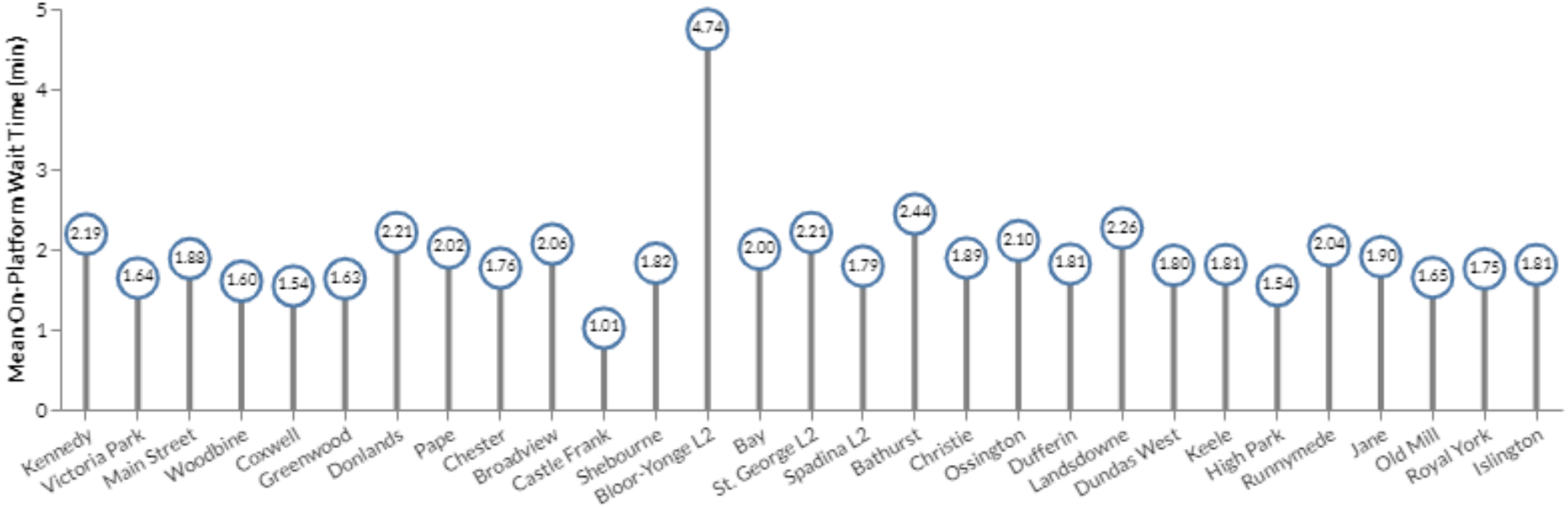


Wait time: First platform association to last platform disassociation

AG

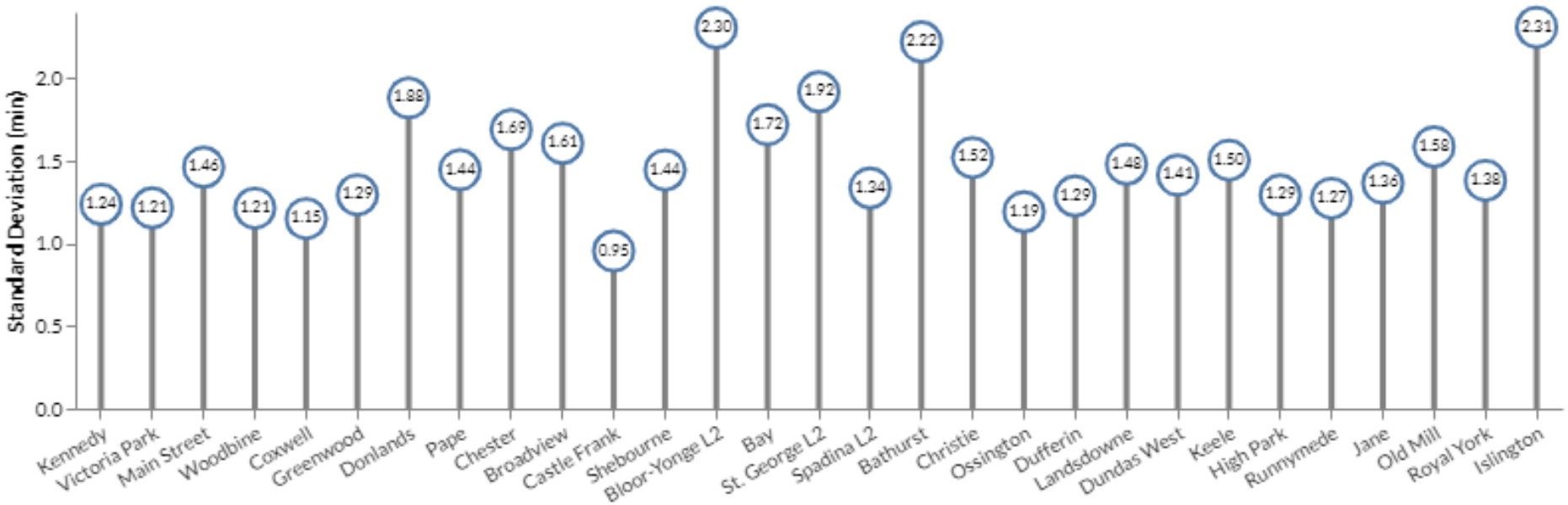
Mean Device On-Platform Wait Time for Trips Originating At Station

Line 2 towards Kipling - May 5, 2022 0700-0900



Standard Deviation of Device On-Platform Wait Time for Trips Originating At Station

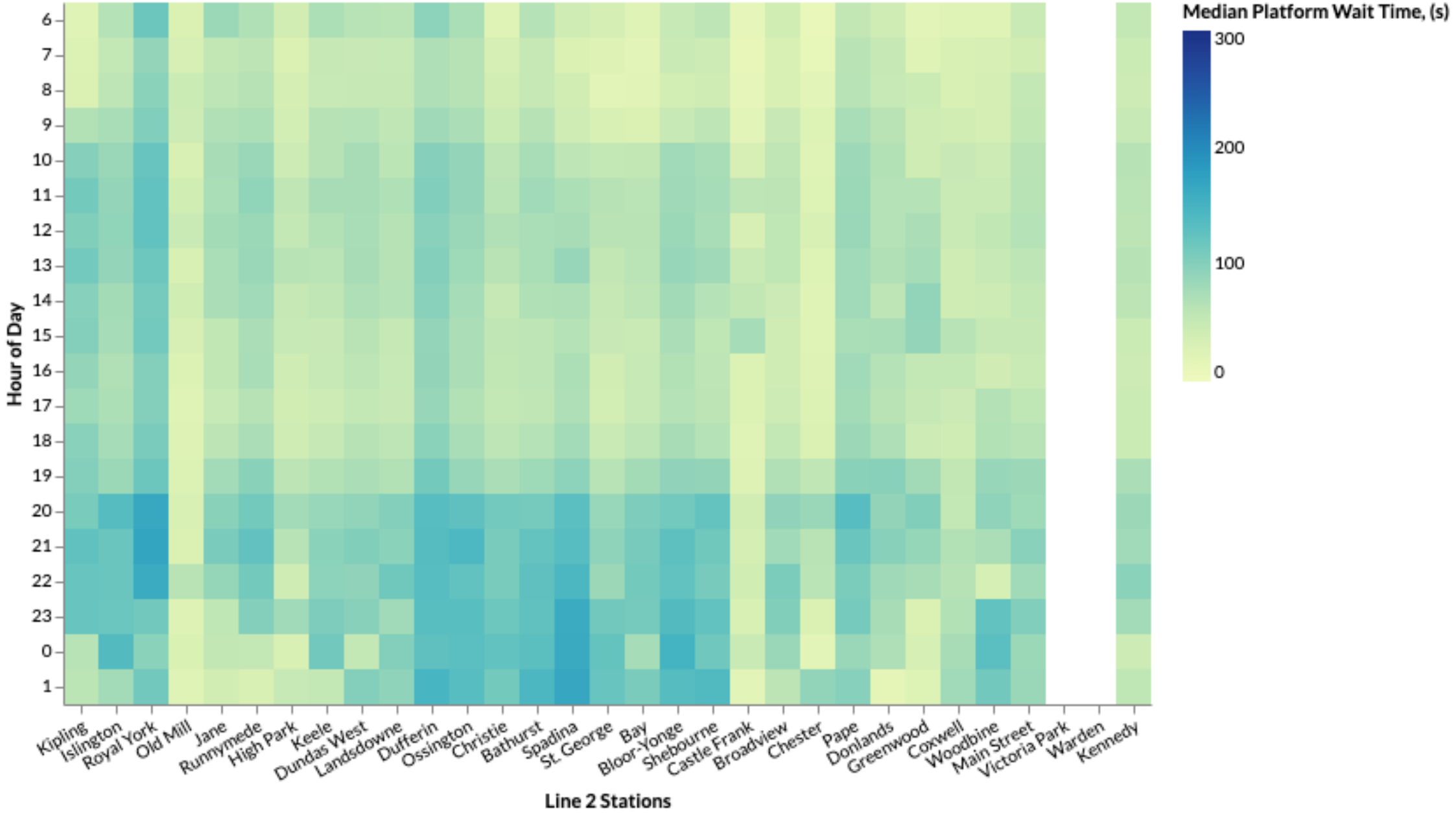
Line 2 towards Kipling - May 5, 2022 0700-0900



AG

Median Platform Wait Times by Station, Line 2, Weekdays

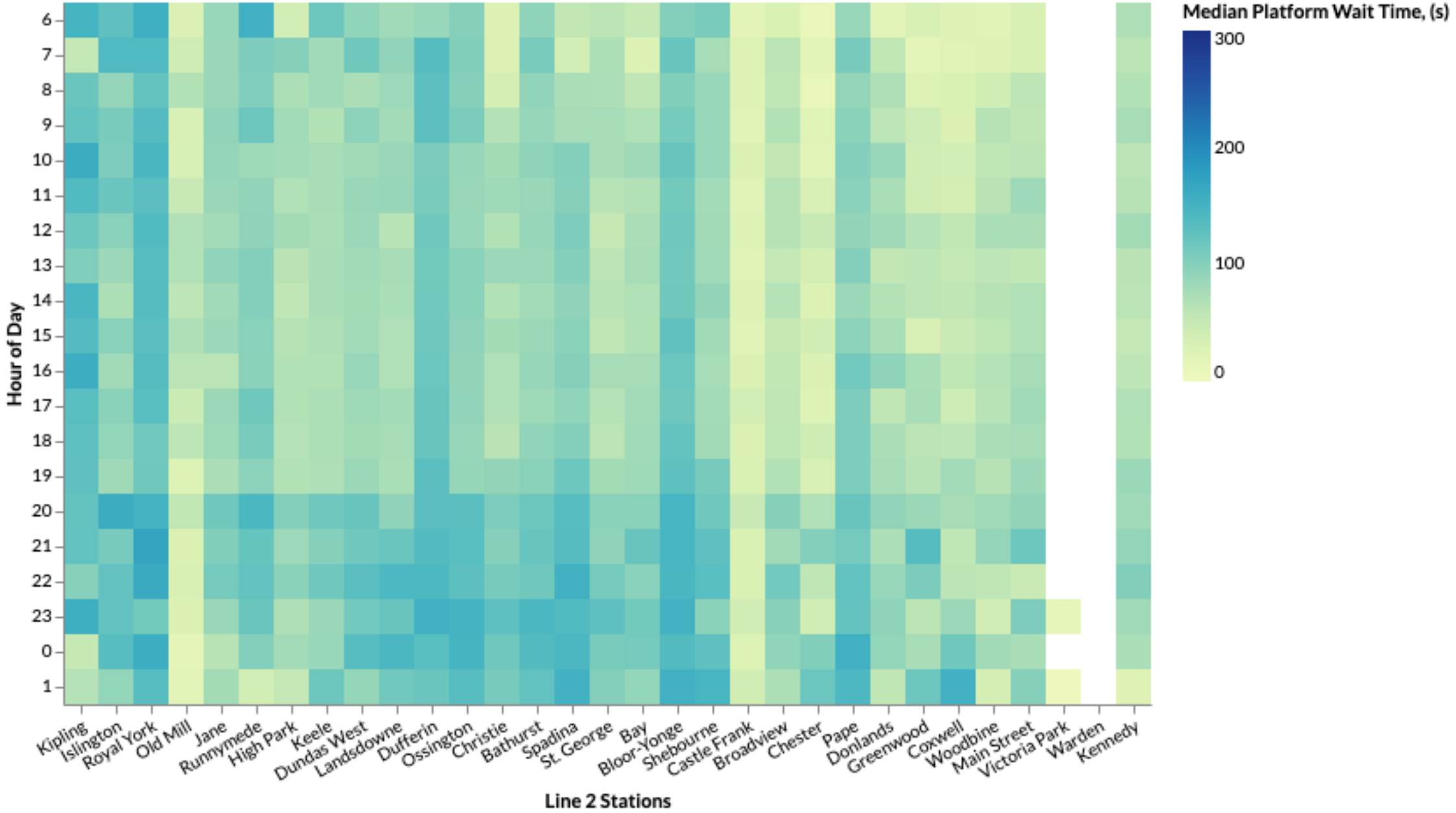
Median calculated per station for each hour; white indicates insufficient or unavailable data



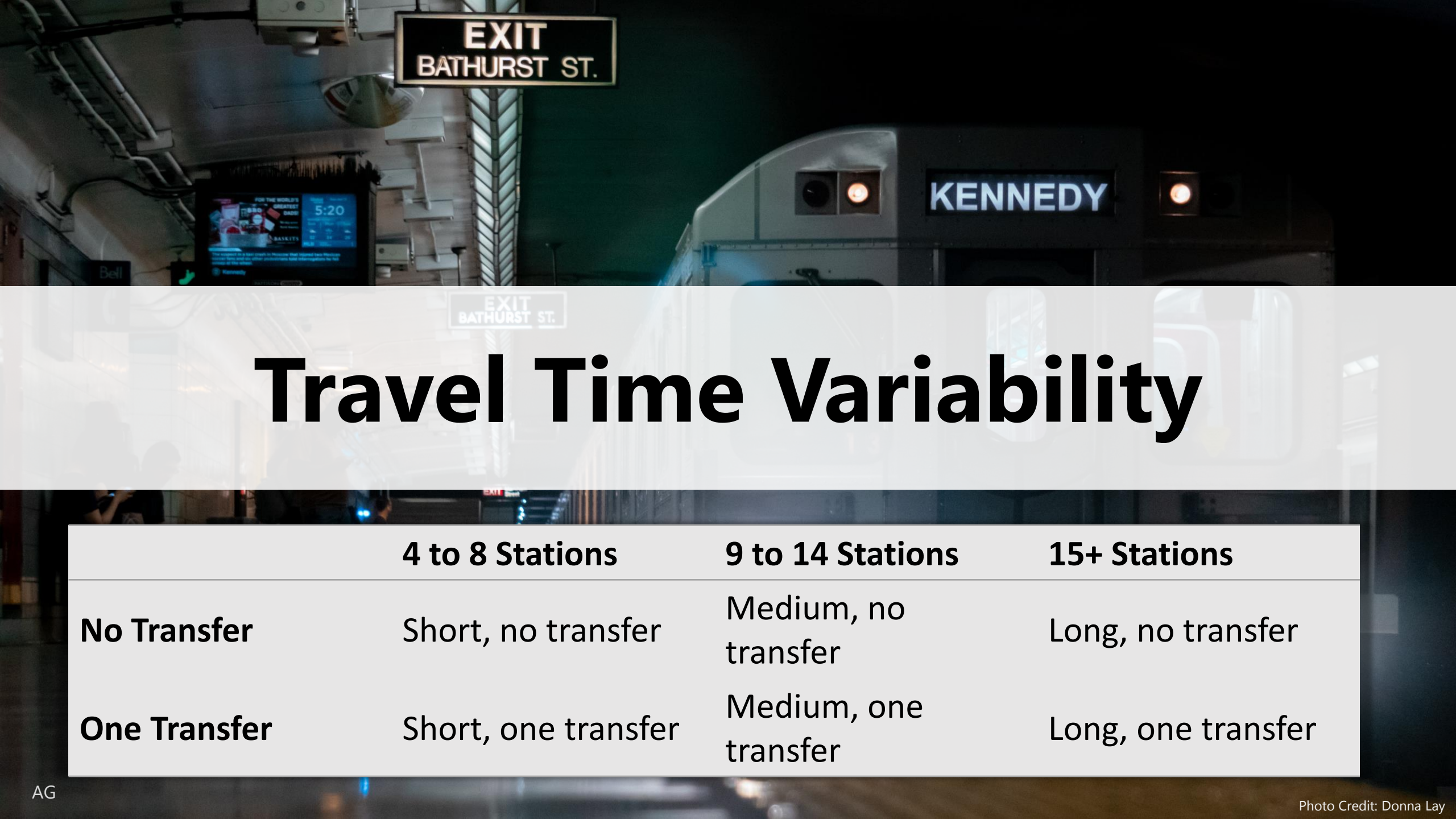
AG

Median Platform Wait Times by Station, Line 2, Weekends

Median calculated per station for each hour; white indicates insufficient or unavailable data



AG



Travel Time Variability

	4 to 8 Stations	9 to 14 Stations	15+ Stations
No Transfer	Short, no transfer	Medium, no transfer	Long, no transfer
One Transfer	Short, one transfer	Medium, one transfer	Long, one transfer

AG

Photo Credit: Donna Lay

All devices traveling on each station pair are aggregated and the station pair's travel time **Coefficient of Variation** is calculated.

Museum – St. Andrew ⇨ *Short, w/o transfer*

Finch – Wellesley ⇨ *Long, w/o transfer*

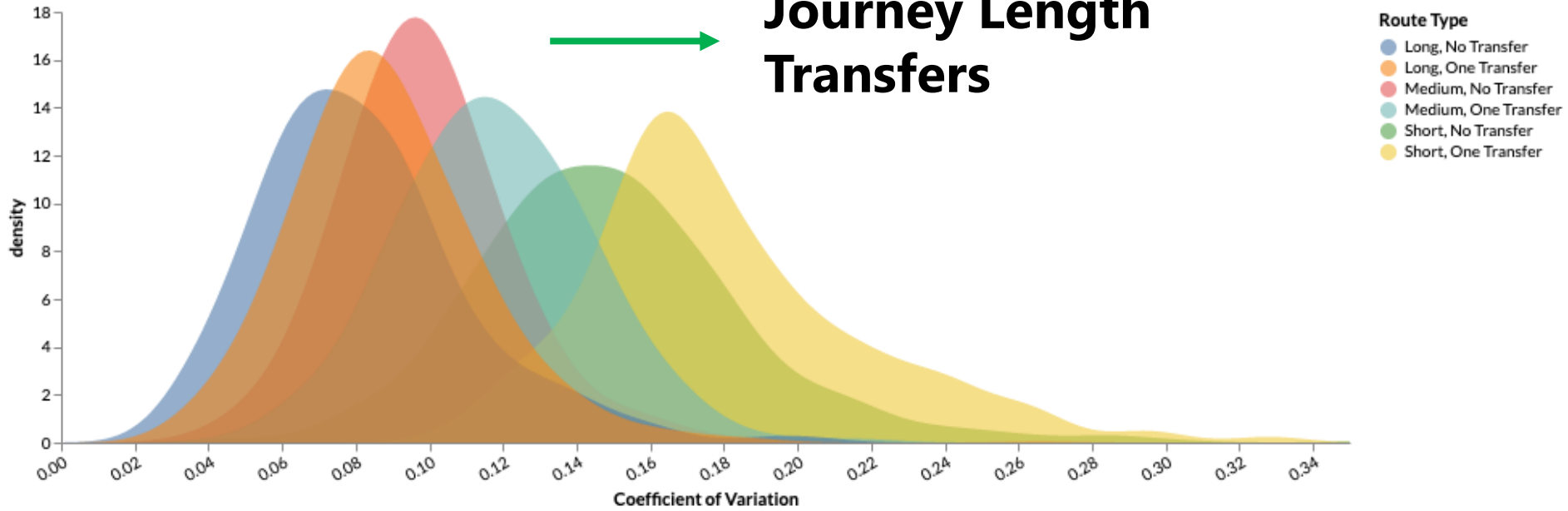
Bathurst – Union ⇨ *Medium, w/ transfer*

Station pairs are **classified** and the Coefficient of Variation distribution curve for each category is plotted.

AG

AM Rush - WiFi Coefficient of Variation by Station Pair

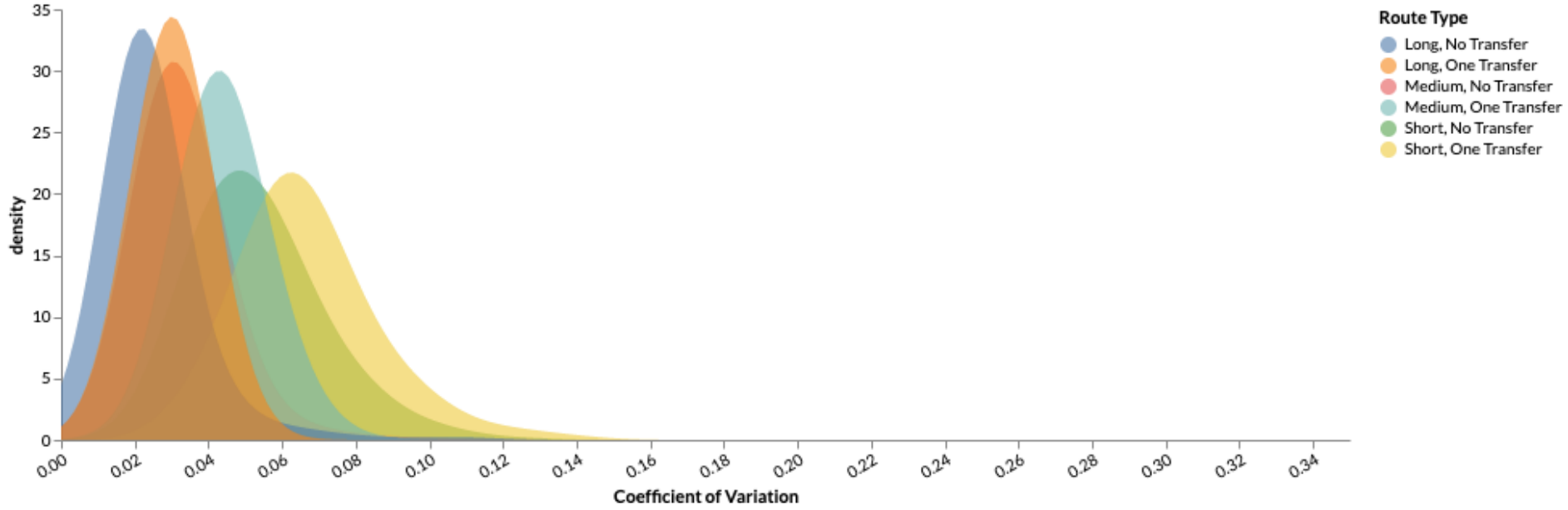
7-9 AM, Weekdays, May 1-31, 2022



Journey Length
Transfers

AM Rush - R5 Coefficient of Variation by Station Pair

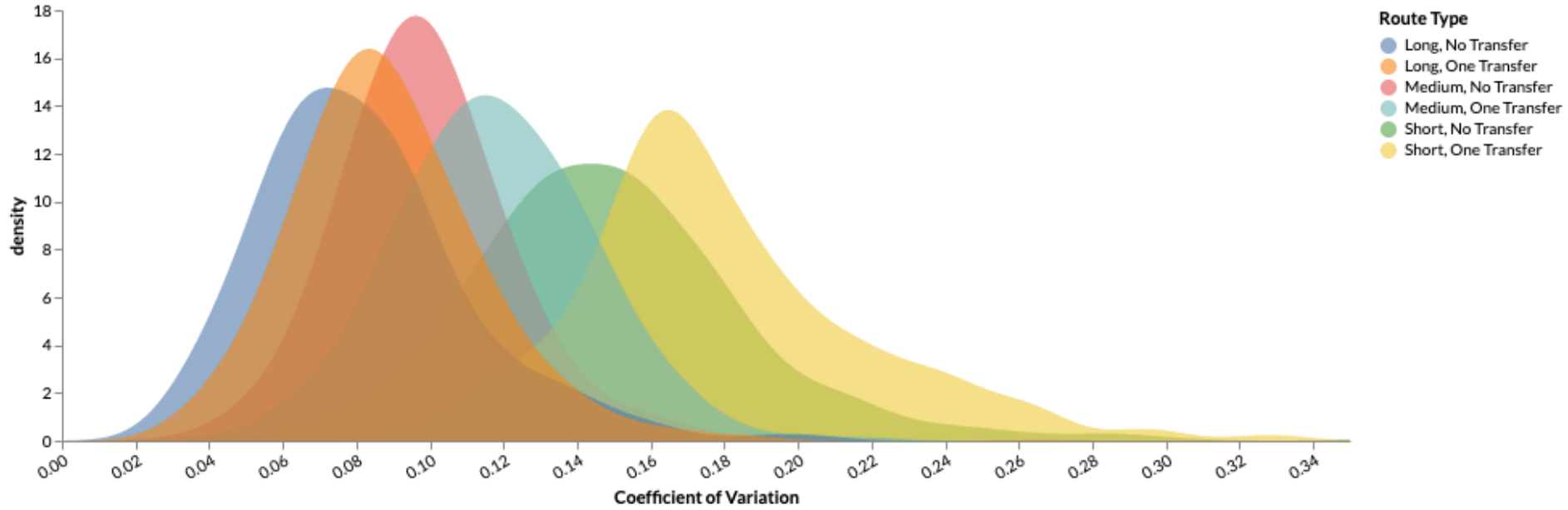
7-9 AM, Weekdays, May 1-31, 2022



AG

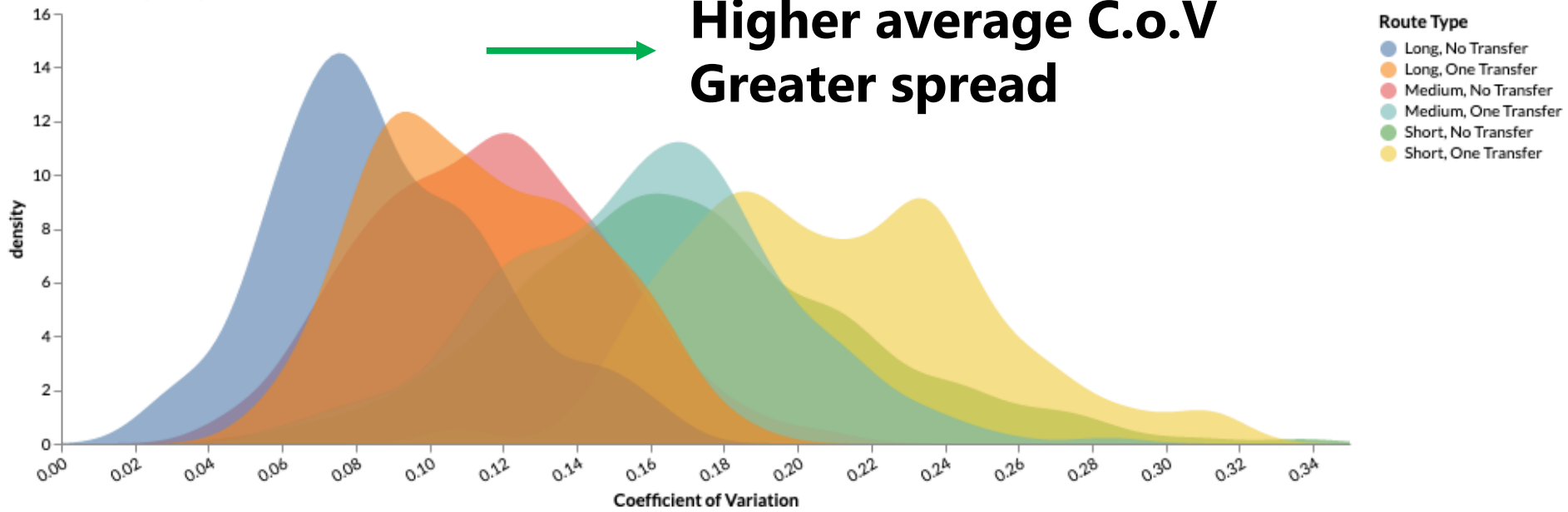
AM Rush - WiFi Coefficient of Variation by Station Pair

7-9 AM, Weekdays, May 1-31, 2022

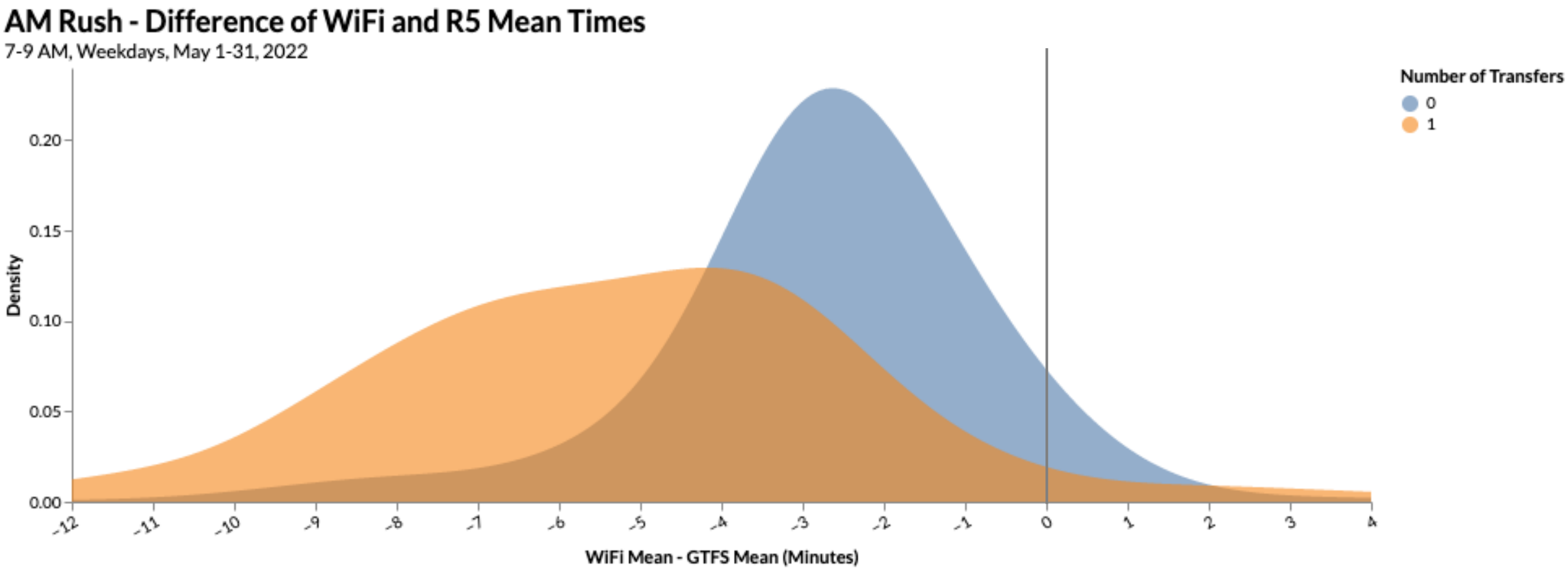


Saturday - WiFi Coefficient of Variation by Station Pair

3-5 PM, Saturdays, May 1-31, 2022



AG



Most journey pairs are faster than predicted, but *especially* trips with a transfer.

AG

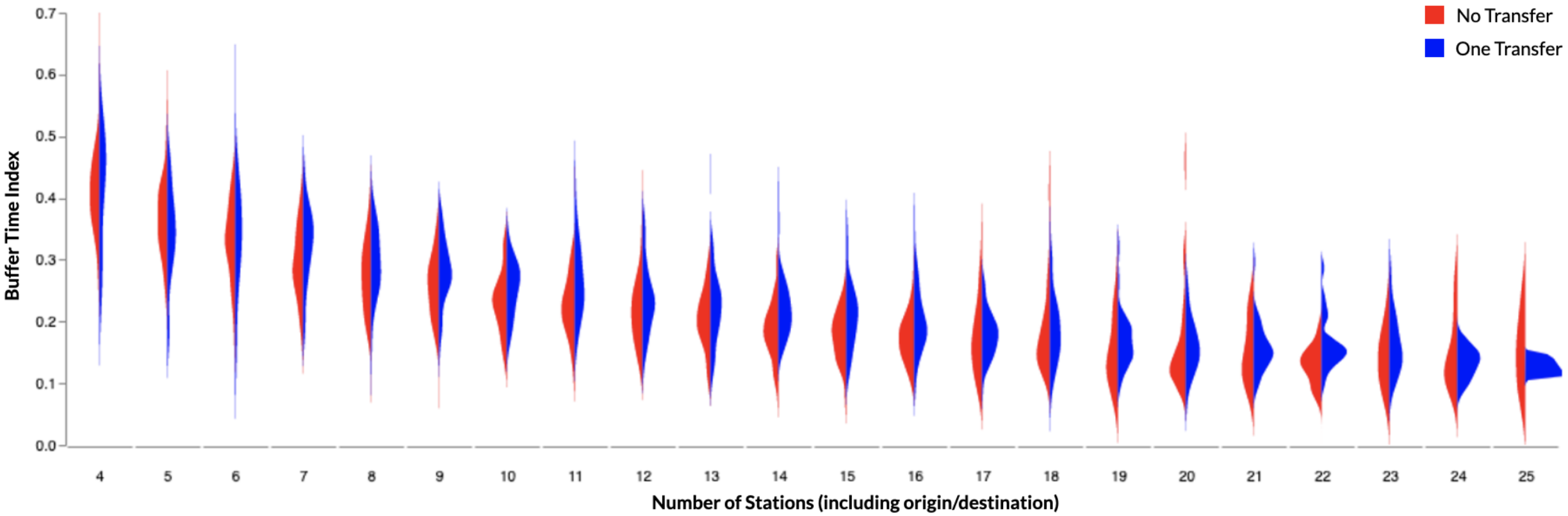
"The Buffer Time Index (BTI) **expresses the amount of extra "buffer" time needed to be on-time 95 percent of the time** (late one day per month)" - US DOT

$$\text{Buffer Time Index} = \frac{t_{95} - t_{\mu}}{t_{\mu}}$$

AG

Buffer Time Index by Journey Length

May 1-31, 2022, AM Peak Period (7-9 AM, Weekdays)



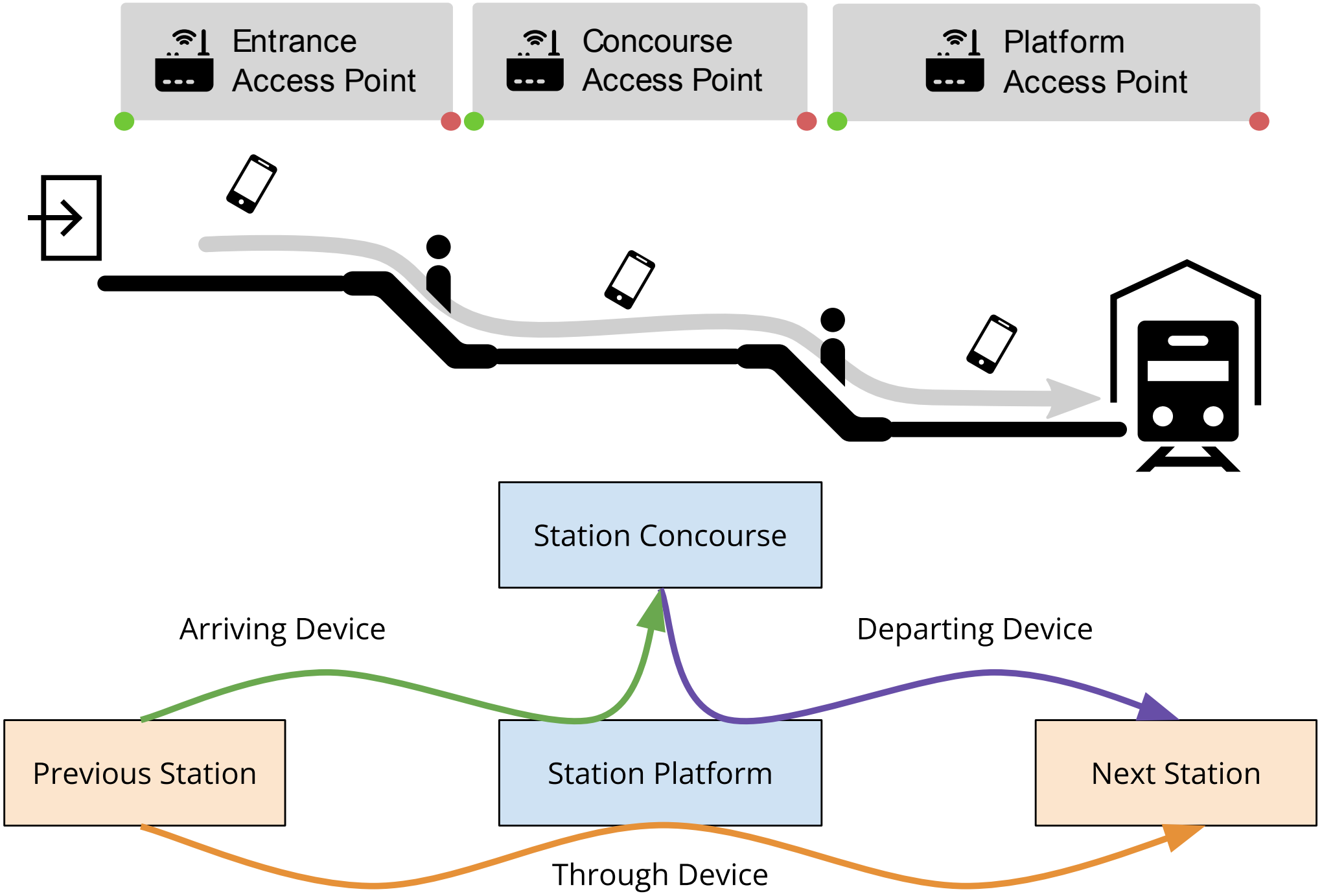
Buffer time inversely proportional to journey time increases with transfers and journey length.

AG

Subway Arrival Detection

WK

Photo Credit: Donna Lay

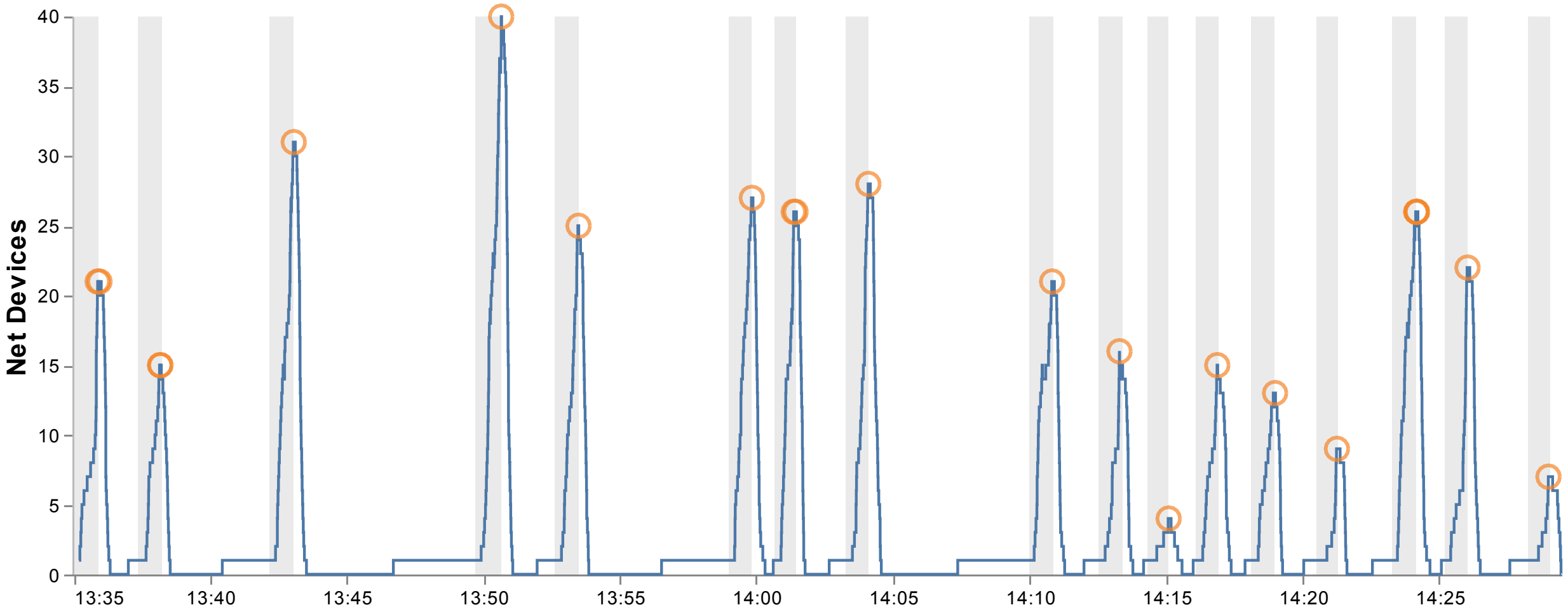

Entrance
Access Point
Concourse
Access Point
Platform
Access Point
Station Concourse
Arriving Device
Departing Device
Previous Station
Station Platform
Next Station
Through Device

WK

Net Through-Trip Device Associations at Sherbourne Station

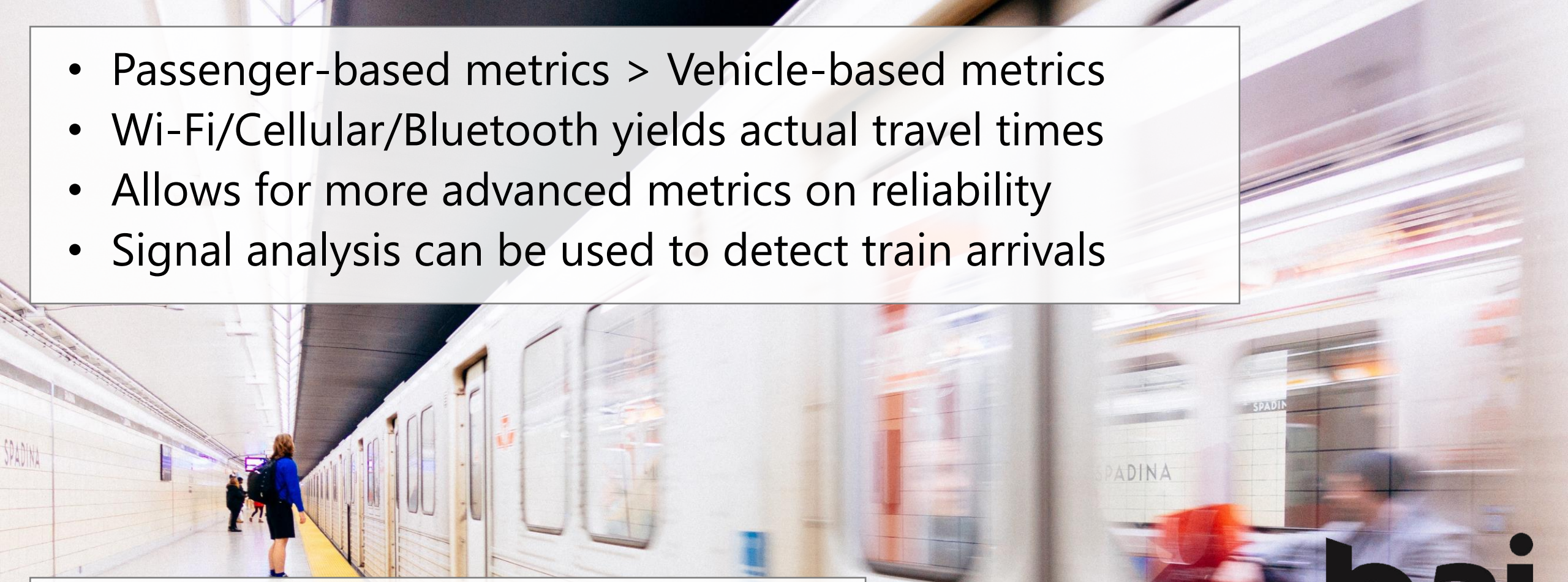
Toronto's Line 2 towards Kipling - August 26, 2022 1330-1430

Peaks are identified with orange circles; actual arrival and departures indicated with grey bars



WK

- Passenger-based metrics > Vehicle-based metrics
- Wi-Fi/Cellular/Bluetooth yields actual travel times
- Allows for more advanced metrics on reliability
- Signal analysis can be used to detect train arrivals



Aidan Grenville, Willem Klumpenhouwer,
Natalie Chui, Amer Shalaby

aidan.grenville@mail.utoronto.ca

willem.klumpenhouwer@utoronto.ca

bai canada

TAL TRANSIT ANALYTICS LAB

Photo Credit: Jed De La Cruz

WK