Methods to enhance inter and intra modal transfers

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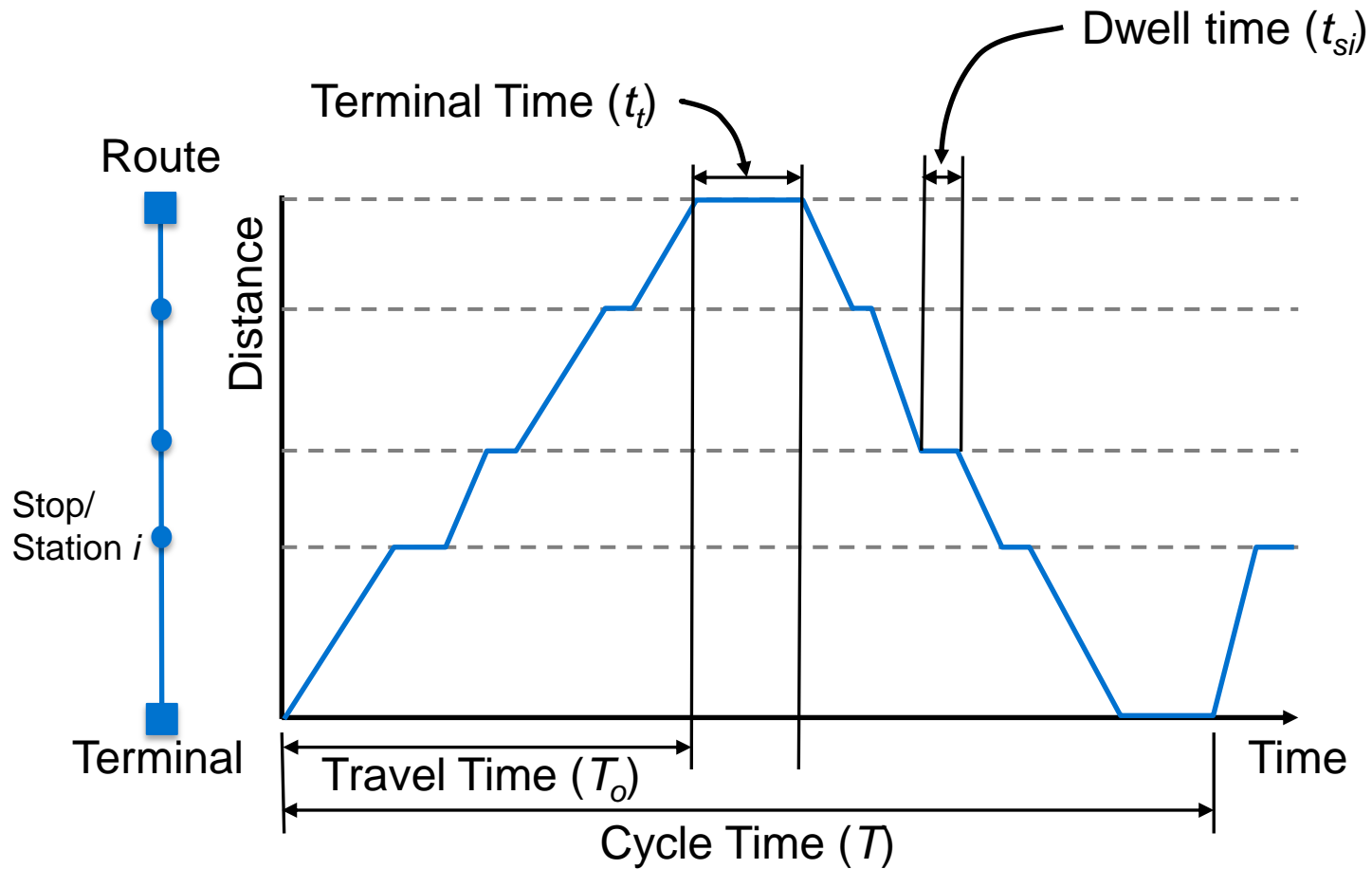**WATERLOO**

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Outline

Intermodal network planning and operations - what has changed?

– Information!!!

Three examples:

- Reducing variability of bus arrival times when operating in shared ROW

- Connected Vehicle applications

- Modelling travel behaviour

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Bus operations in shared ROW

Route

Dwell time (t_{si})

Terminal Time (t_t)

Distance

Stop/
Station i

Terminal

Travel Time (T_o)

Cycle Time (T)

Time

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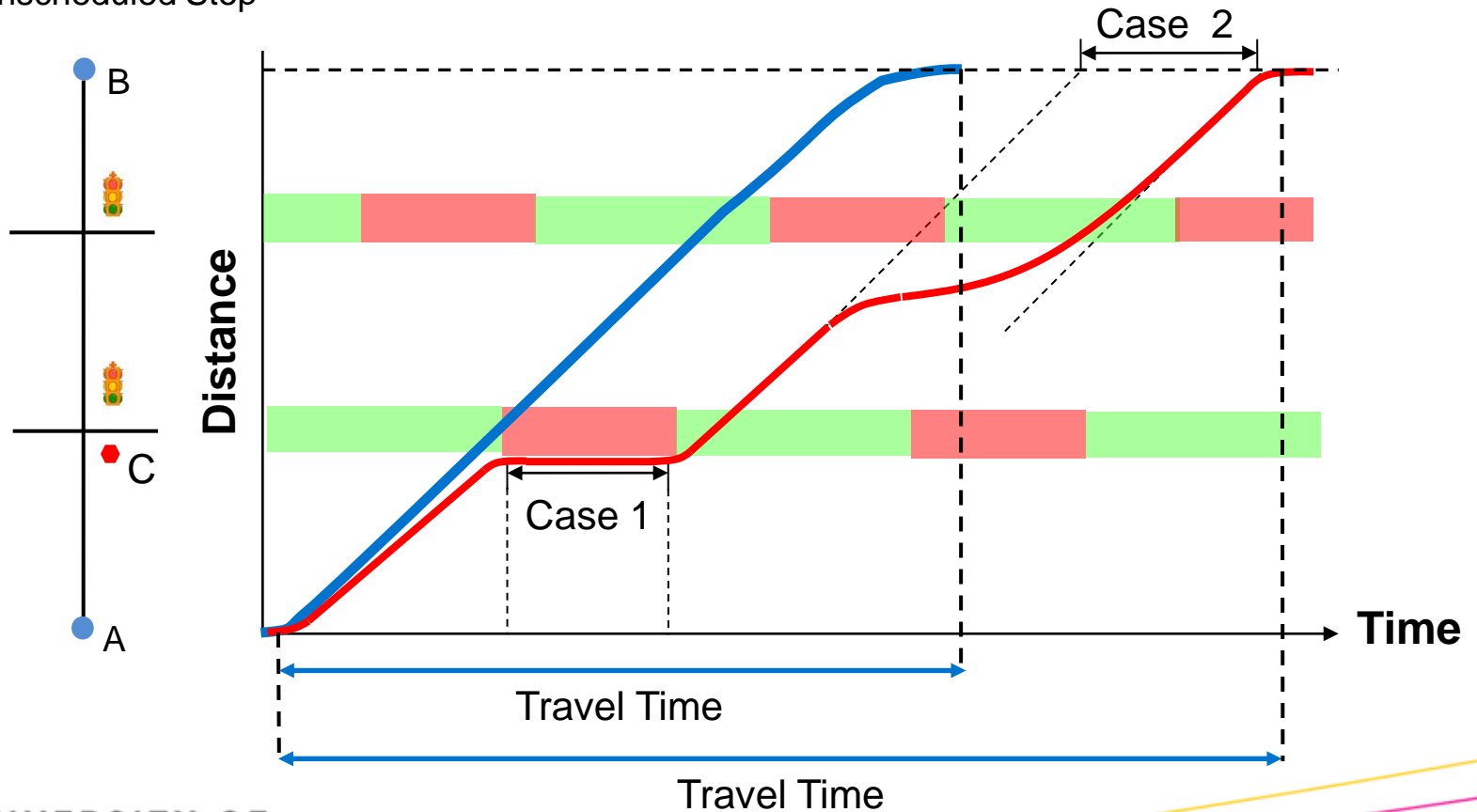WATERLOO

Schedule adherence

- Function of:
  - Intersection delays
  - Dwell times
  - Weather
  - Incidents
  - Driver characteristics
  - Traffic conditions
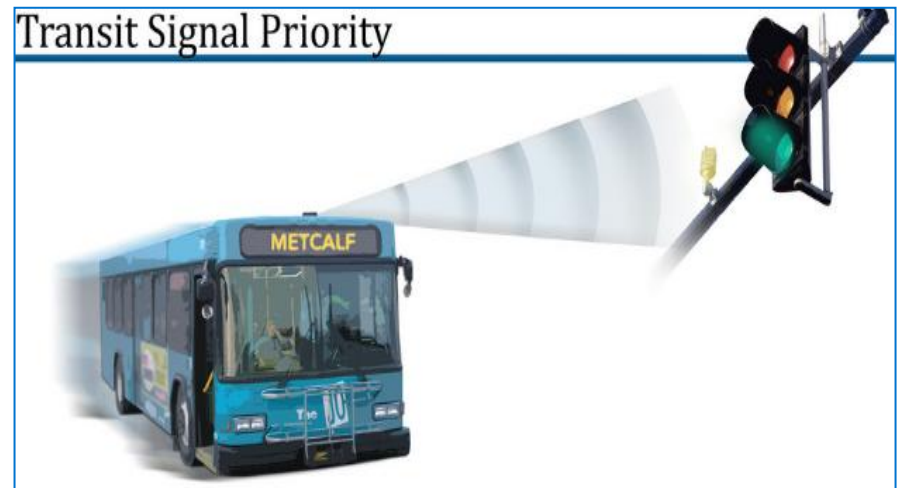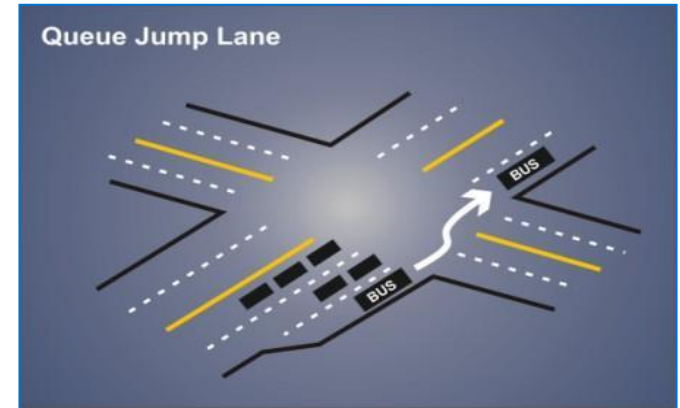
Impact of Signalized Intersections

- Bus Scheduled/On-Call Stop
- Unscheduled Stop

Case 2

B

C

A

Distance

Time

Case 1

Travel Time

Travel Time

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Transit Priority Measures

Impact:
- Mean delay
- Variance of delay

Queue Jump Lane

Transit Signal Priority
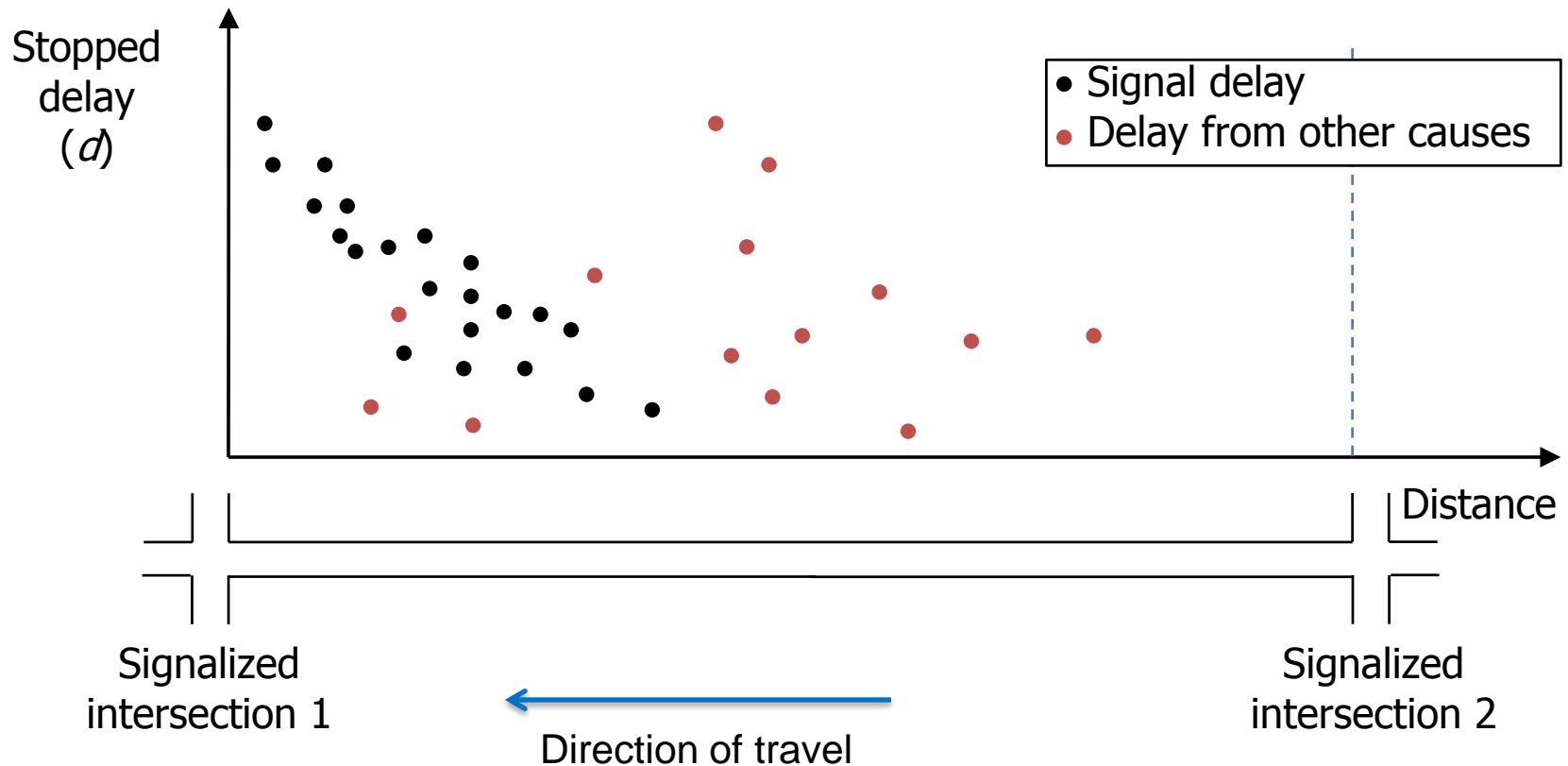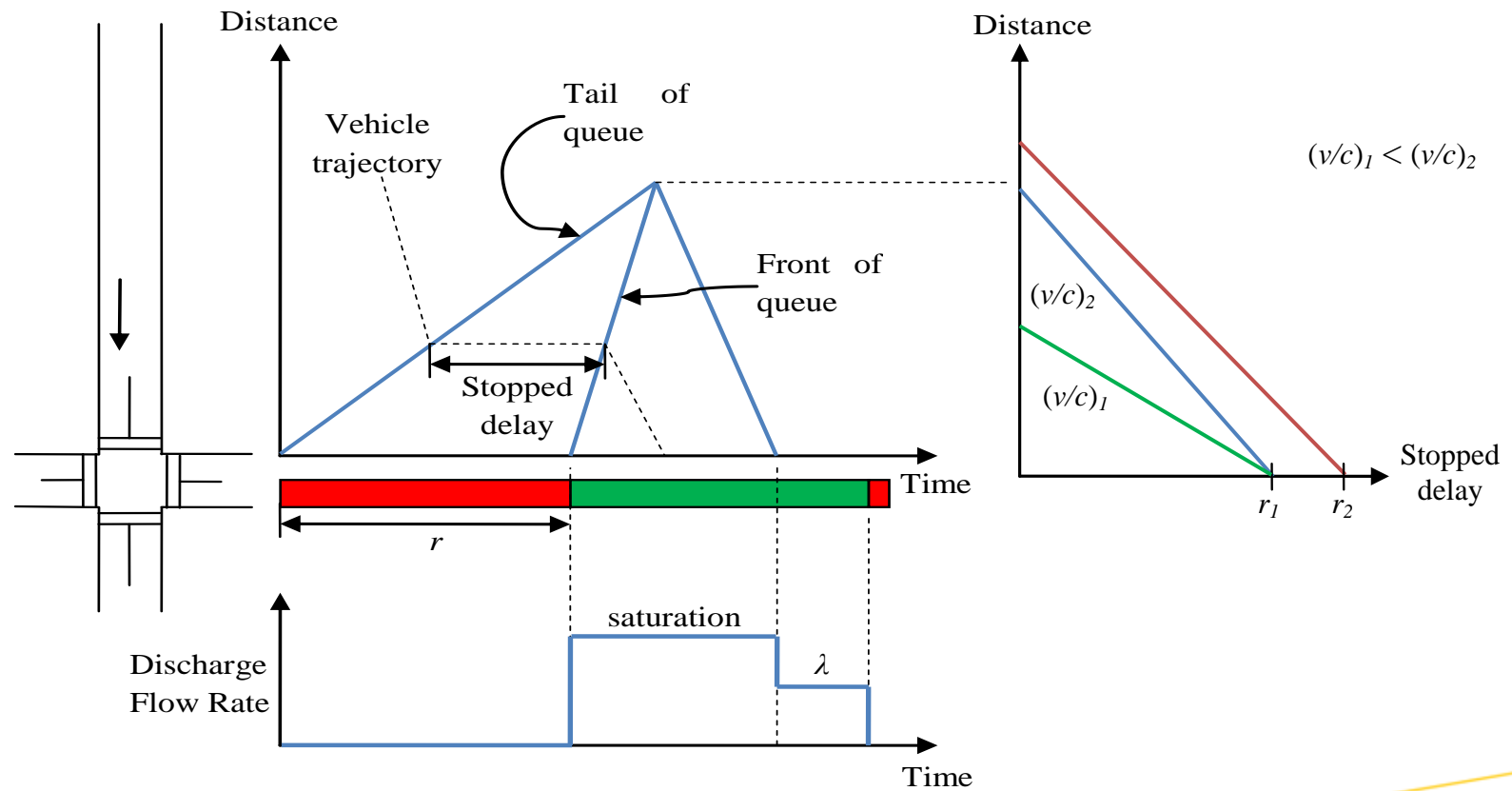
Where to implement?

- However, where should these treatments be applied?
  - Require reliable data to quantify delays.
- Current methods:
  1. field observation;
  2. simulation;
  3. analytical methods.

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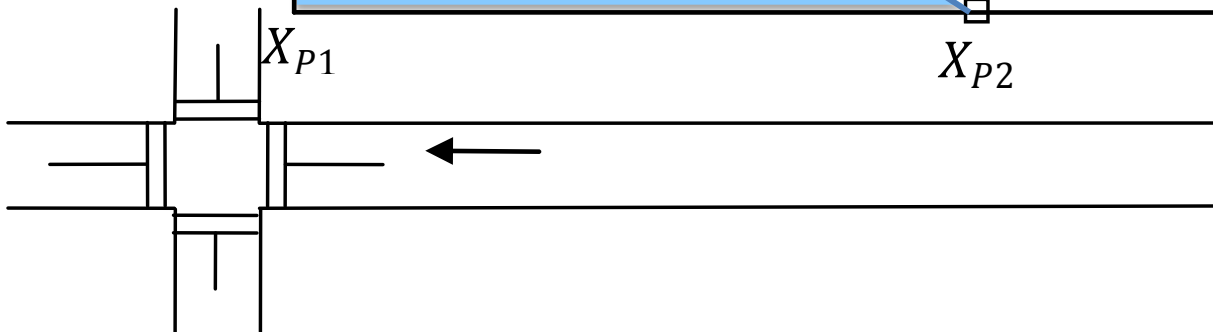
Use of AVL/APC data

Theoretical foundation

- Deterministic under-saturated queuing

Proposed Methodology

Find the best fit "Boundary Line" to data

d_{max}

Stopped delay (d)

X_{P1}

X_{P2}

Distance (X)

Can Compute:
- # obs
- Mean
- Stdev
- Percentiles

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Proposed Methodology

Stopped delay (d)

d_{max}

X_{P1}

X_{P2}

Distance (X)

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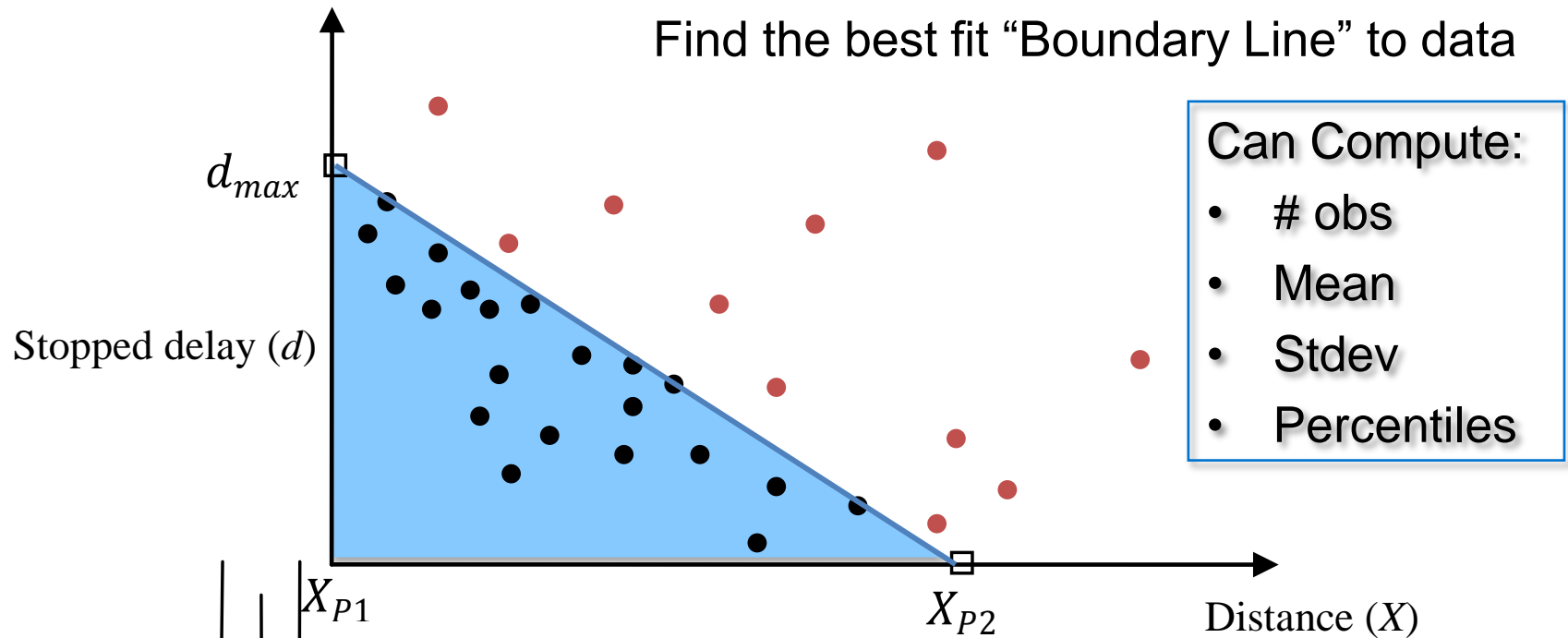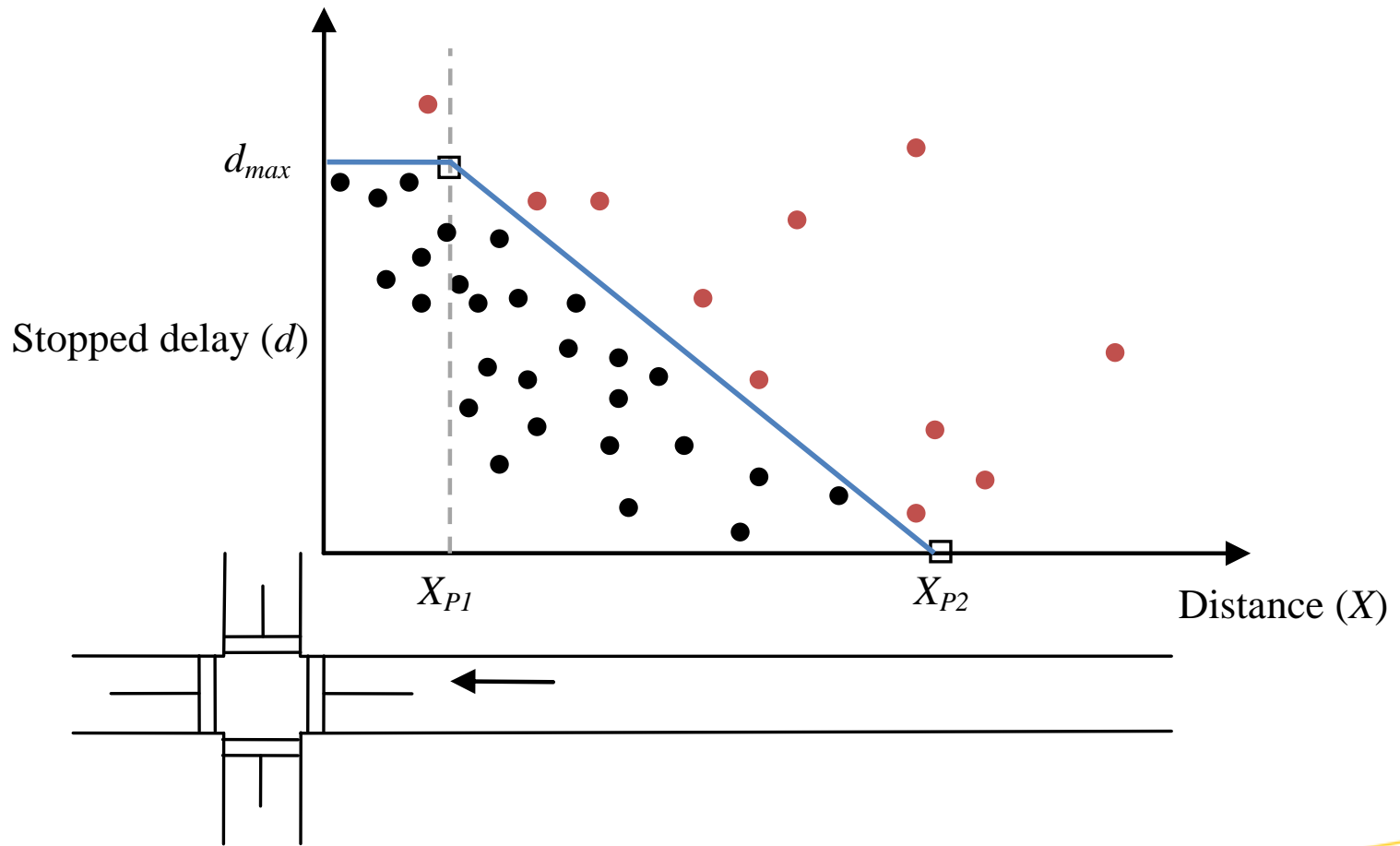
GIS Data

- Transit routes
- Signalized intersections
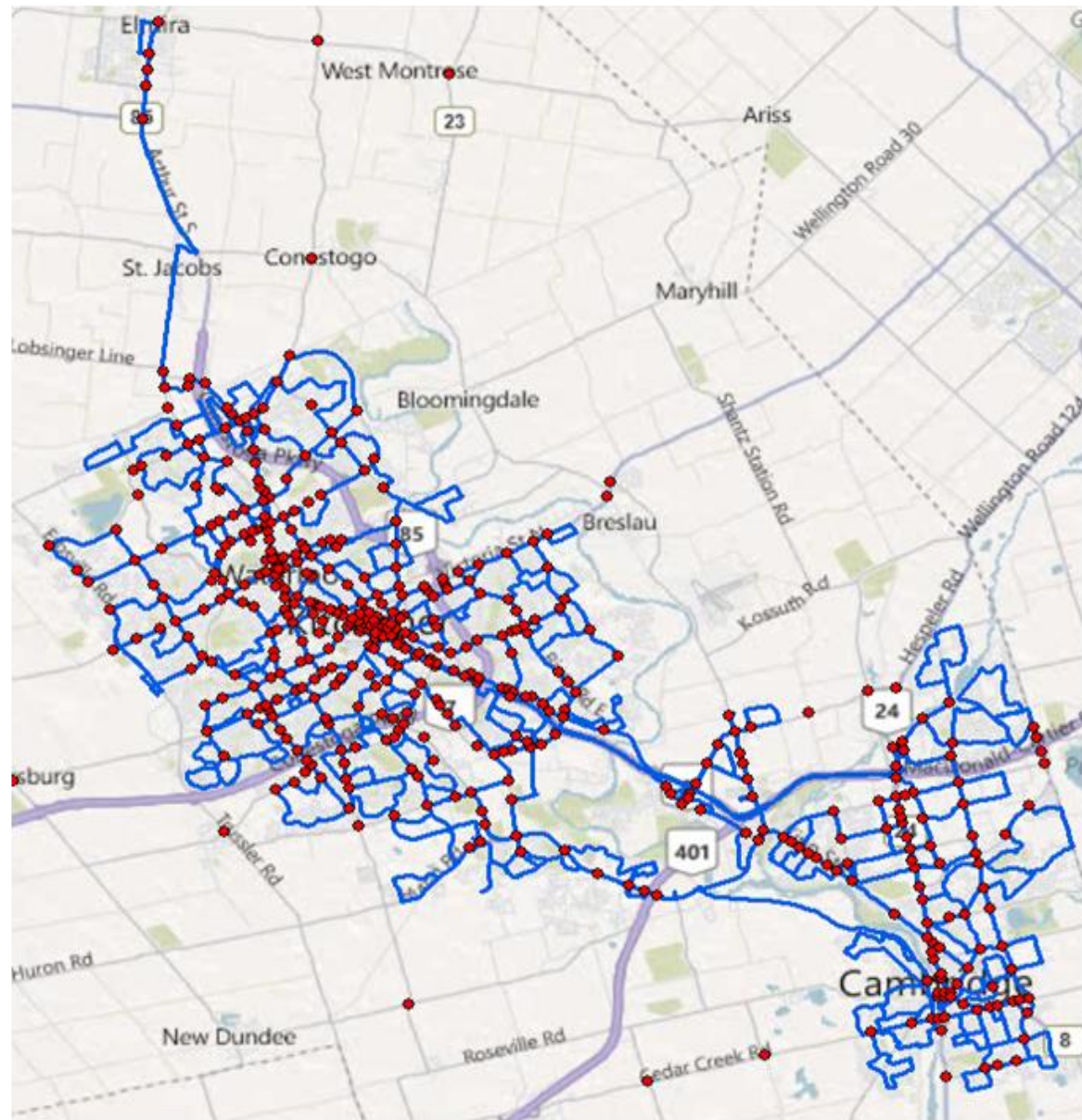
Segmenting

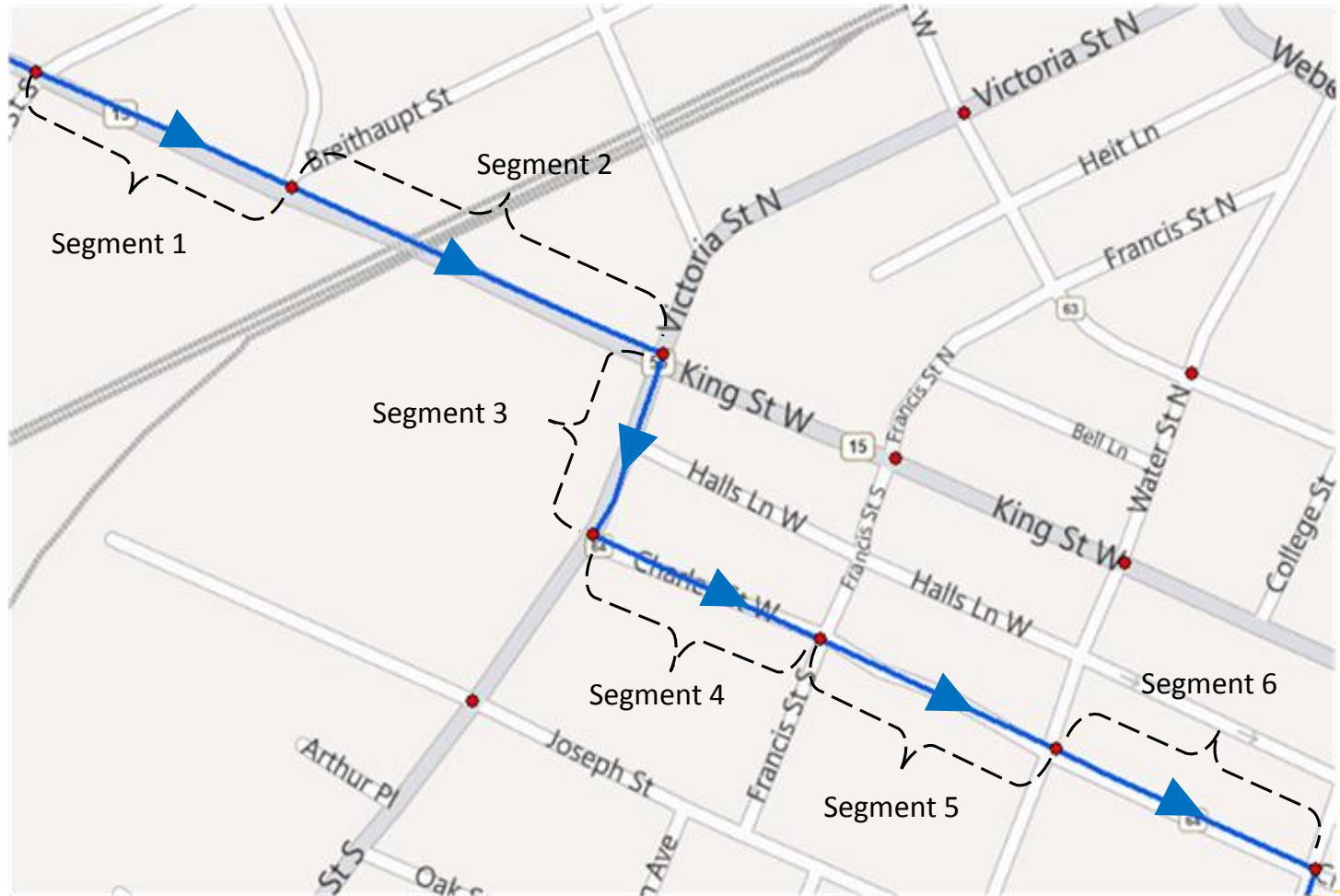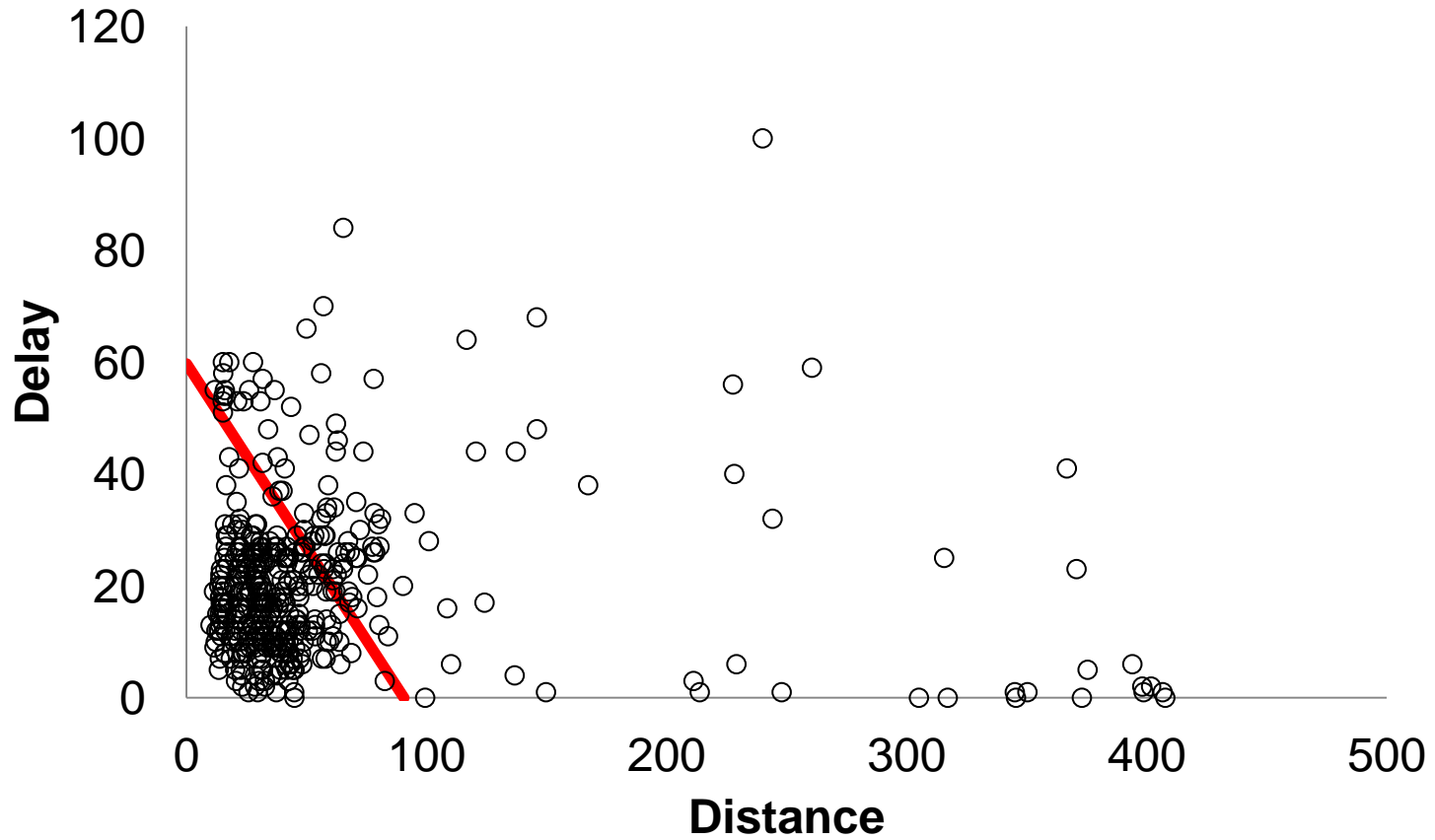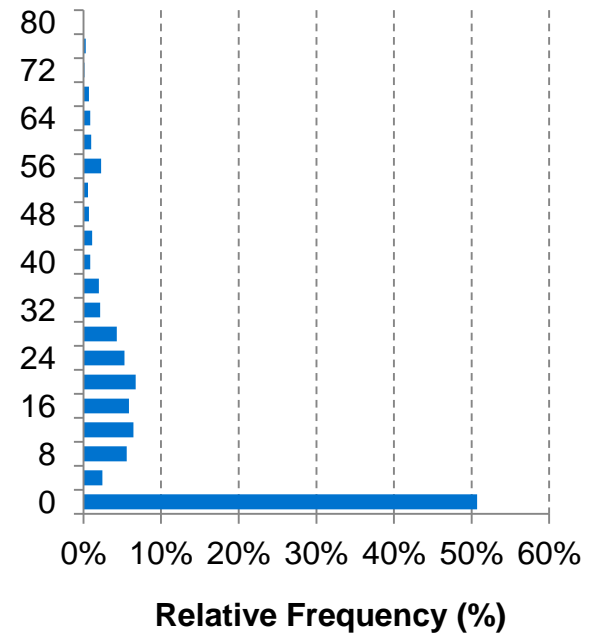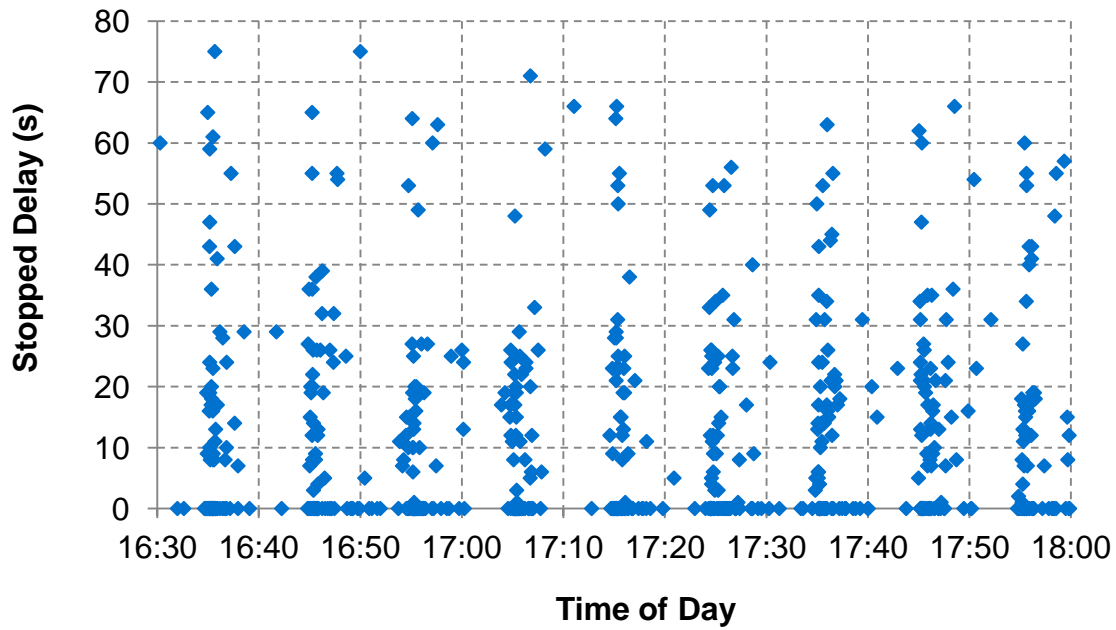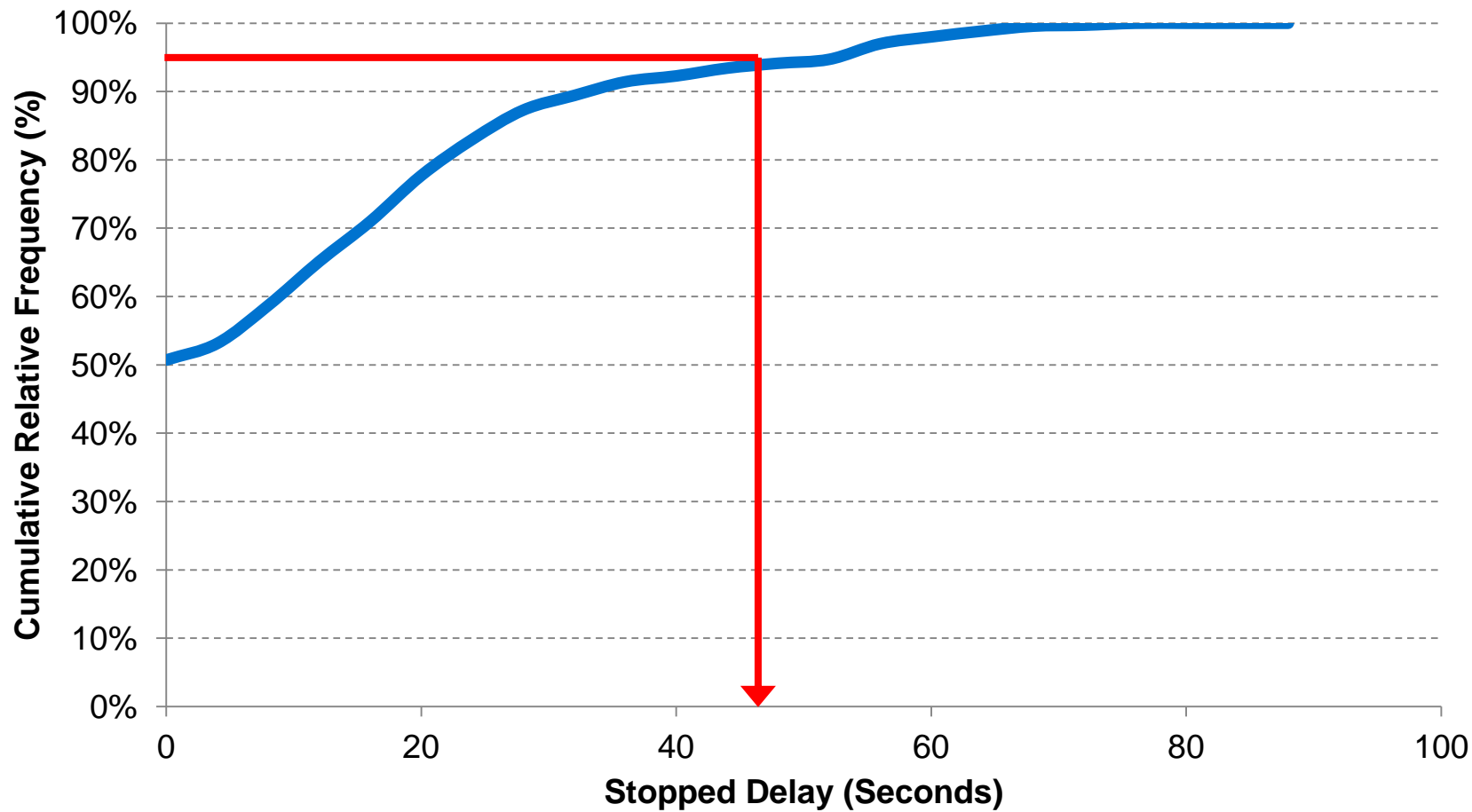| Route	Direction	Intersection	Mean delay (seconds)	Std (s)	COV	90 % delay (seconds)	Queue Length (metres)	Proportion of trips with identified signal delay	Sample size	Total number of service trips	Segment length (metres)
10	up	HOMER WATSON @ Manitou Doon Village	34	25	0.7	69	91	81%	201	217	467
10	down	FAIRWAY @ Wilson	32	28	0.9	65	120	71%	258	214	165
13	WB	FISCHERHALLMAN @ Columbia	26	19	0.7	51	273	76%	250	230	721
201	up	ERB @ FischerHallman	22	22	1	55	75	65%	231	314	534
201	dn	FISCHERHALLMAN @ Queens	18	20	1.1	48	120	55%	213	319	184
53	OB	DUNDAS @ Main	18	21	1.2	52	90	55%	131	225	374
1	ob	QUEEN @ Charles	15	18	1.2	40	91	44%	180	330	106
200	dn	HESPELER @ Dunbar	14	21	1.5	49	91	46%	363	658	684
11	IB	KING @ Stirling	14	22	1.6	51	88	29%	84	252	123
11	OB	OTTAWA @ Alpine	11	15	1.4	36	60	54%	182	248	196

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Prioritized on the basis of Index

Priority Index Value (%)

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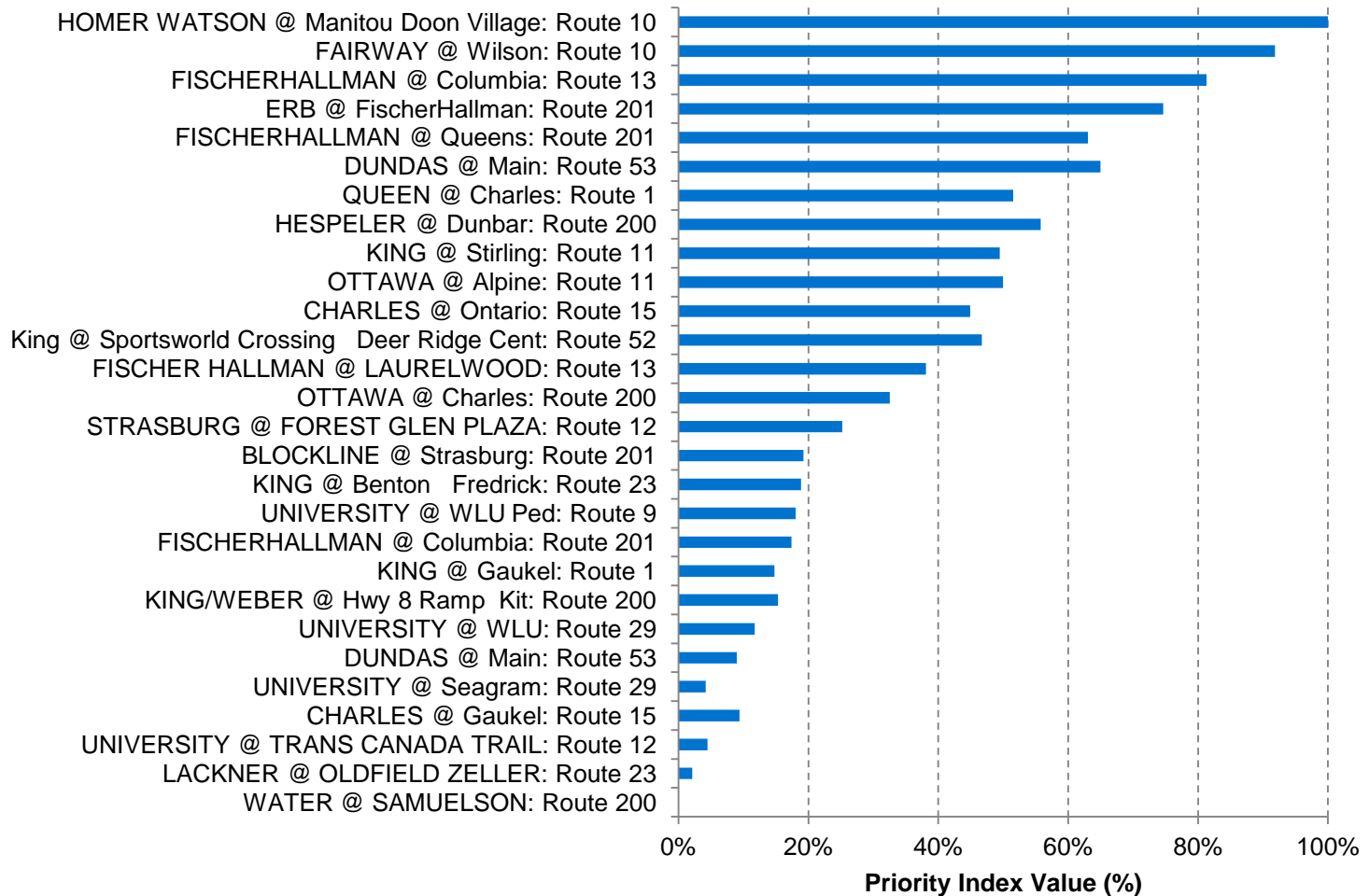
What type of priority treatment?

- Examine characteristics of intersection
    - E.g. turning movement being made by transit vehicle
    - Geometry
    - Estimates queue length
    - Signal timings
    - Location of upstream and downstream bus stops
- Options:
    - Queue jump lane
   - Special transit phase
    - TSP

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Estimating impact of TSP

		Lane Goup Summaries												
		Eastbound			Westbound			Northbound			Southbound			
		1	2	3	4	5	6	7	8	9	10	11	12	
Measure of Performance	Units	L	T	R	L	T	R	L	T	R	L	T	R	Transit
Lane Group Arrival Rate (l) vph	vph	60	812	705	70	612	785	40	0	455	35	0	345	8
Expected TSP Delay (seconds)	s/veh	10.1	13.6	8.0	12.3	8.9	11.1	11.5	0.0	17.6	15.4	0.0	18.9	6.7
Expected NO TSP Delay (seconds)	s/veh	10.4	14.3	8.4	12.5	9.3	11.6	11.3	0.0	16.3	14.3	0.0	18.6	10.9
Delta Delay (TSP - NO TSP)	s/veh	-0.3	-0.8	-0.4	-0.2	-0.4	-0.5	0.2		1.3	1.1		0.3	-4.2
Delta Fuel Consumption (TSP - NO TSP)	mL/veh	-0.15	-0.40	-0.21	-0.11	-0.24	-0.27	0.13		0.69	0.60		0.18	-2.96
Delta GHG Emissions (NO TSP - TSP)	g/veh	-0.36	-1.01	-0.52	-0.28	-0.60	-0.68	0.33		1.74	1.49		0.45	-8.17

		Approach Summaries				
Measure of Performance	Units	Eastbound	Westbound	Northbound	Southbound	Transit
Approach Volume	vph	1577	1467	495	380	8
Average Delay with TSP	s/veh	10.9	10.2	17.1	18.6	6.7
Average Delay without TSP	s/veh	11.5	10.7	15.9	18.2	10.9
Average Delta Delay	s/veh	-0.6	-0.5	1.2	0.4	-4.2
Average Fuel Consumption	mL/veh	-0.31	-0.25	0.65	0.22	-2.96
Average GHG Emissions	g/veh	-0.76	-0.63	1.63	0.55	-8.17

		Intersection Summary: Auto Based		
Measure of Performance	Units	per vehicle	Units	Total/hour
Intersection Volume (auto)	vph	3919	vehicles	3919
Average Delay with TSP	s/veh	12.2	veh-hrs	13.3
Average Delay without TSP	s/veh	12.4	veh-hrs	13.5
Average Delta Delay	s/veh	-0.2	veh-hrs	-0.2
Average Fuel Consumption	mL/veh	-0.11	mL	-443.50
Average GHG Emissions	g/veh	-0.28	kg	-1.11

		Intersection Summary: Person Based		
Measure of Performance	Units	per vehicle	Units	Total/hour
Intersection Volume	person/h	5063	persons	5063
Average Delay with TSP	s/person	9.46	person-hrs	16.61
Average Delay without TSP	s/person	9.62	person-hrs	17.31
Average Delta Delay	s/person	-0.17	person-hrs	-0.70
Average Fuel Consumption	mL/person	-0.09	mL	-443.50
Average GHG Emissions	g/person	-0.21	kg	-1.11

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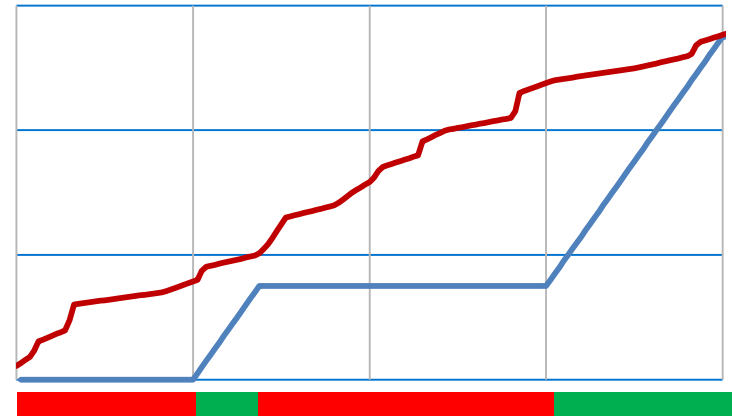
Connected Vehicles

- US DOT CV program
  - Integrated Dynamic Transit Operations (IDTO)
    - Enable travellers to "reserve" a connection
    - In real-time system can evaluate number of reservation from passengers on the inbound transit unit and decide if outbound TU should wait.
- Wide range of possible approaches but much work to still do!

Thank you!

Q&A