Network Optimization to Reduce Emergency Response Times

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Overview

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- Key Objectives
- Data Analysis
- Methodology
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Introduction

- Goal: Safer communities
- Reduce average emergency response times and average travel distance
- To reduce time, take into account:
  - Traffic
  - Speed Restrictions
  - Distance
  - Number of Officers

Key Objectives

- Minimize mean response time for WRPS Priority 1 Calls
- Minimize mean distance travelled by units responding to Priority 1 calls
- Demonstrate use of network optimization for police applications

Data

- Priority 1 calls from niche RMS
  - Calls that must be responded to ASAP
  - Example: Offensive Weapon
- Spatially referenced to nearest intersection for privacy
- Road Network Open Data for Waterloo
- Divisions and Zones (4 Divisions with 6 Zones each)
- Times – Peak times
  - Mon – Thurs exhibited homogenous number of calls between days
  - Fri – Sun exhibited different call volumes between days

Methodology

Building the Road Network

- Impedances:
  - Relative: Network distance, traffic delays and speed restrictions
  - Absolute: Driving directions and connectivity

Specify the attributes for the network dataset:

!	Name	Usage	Units	Data Type
	Length	Cost	Meters	Double
	Travel_Time	Cost	Minutes	Double

Source Values | Default Values

!	Source	Direction	Element	Type	Value
	N4_Streets	From-To	Edge	Field	<expression>
	N4_Streets	To-From	Edge	Field	<expression>
	N4_Zone_ND_Juncti...		Junction		

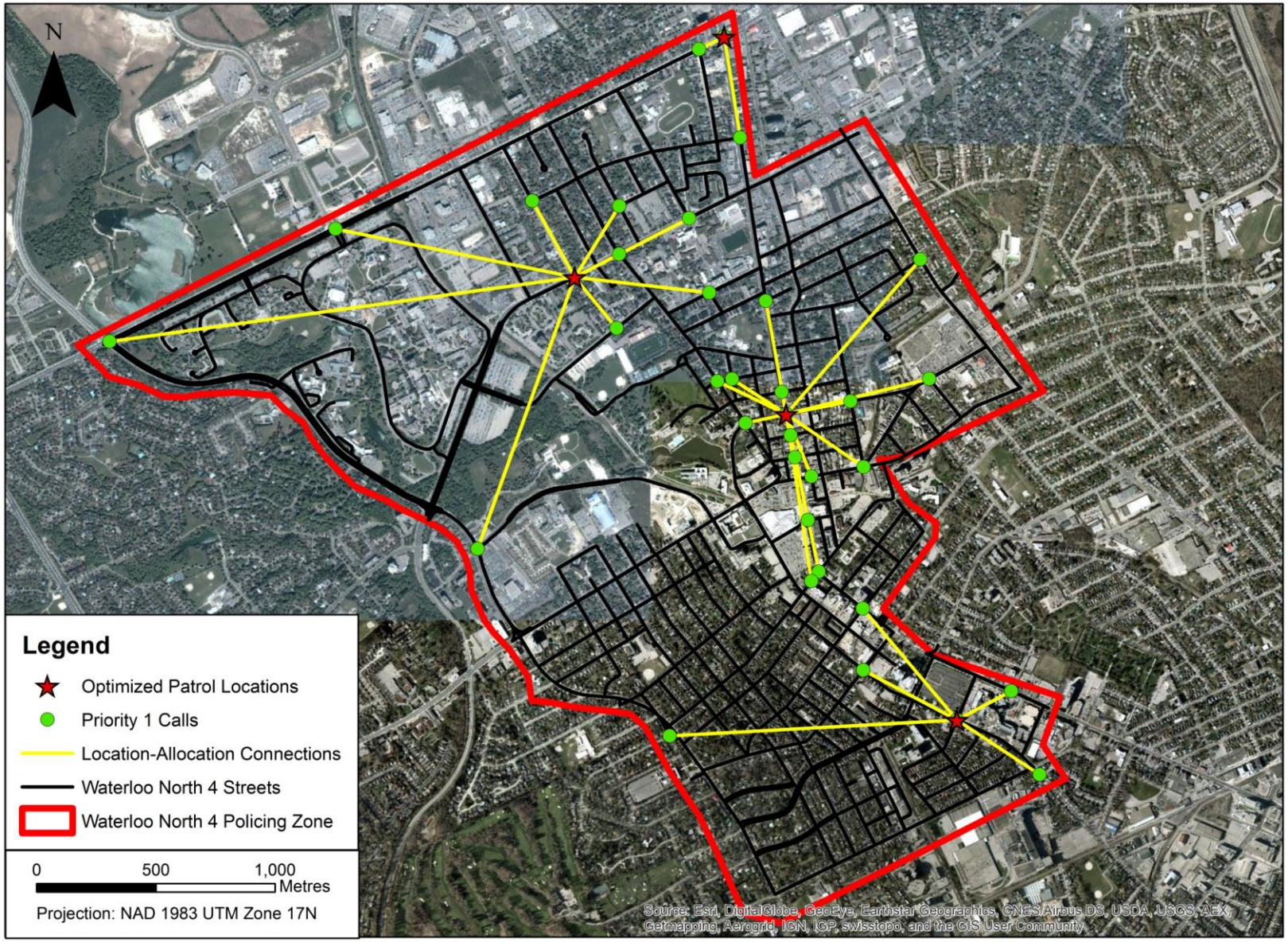
Value =

```
(60 / 1000) * ([Shape_Length] / [SPEEDRES_1])
```

Location-Allocation

- Optimal patrol locations
- Terminology :
  - Service Point
  - Demand Point
- Assumed 4 units on duty at any given time
- All intersections treated as candidate patrol locations

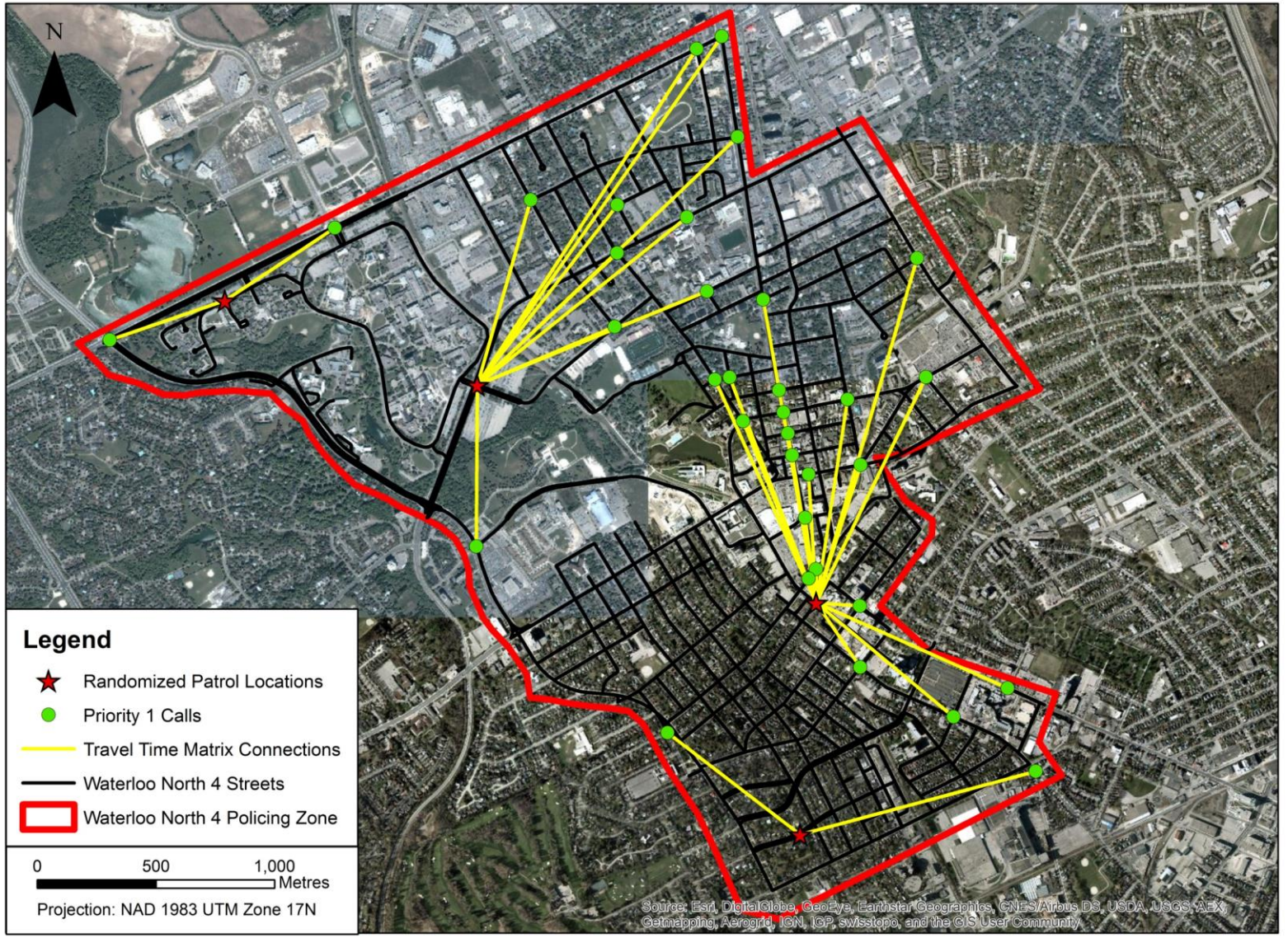
Optimized Patrol Locations For 4 Police Units in Waterloo North 4 Policing Zone: Monday to Thursday, 6pm to 9pm, 2014



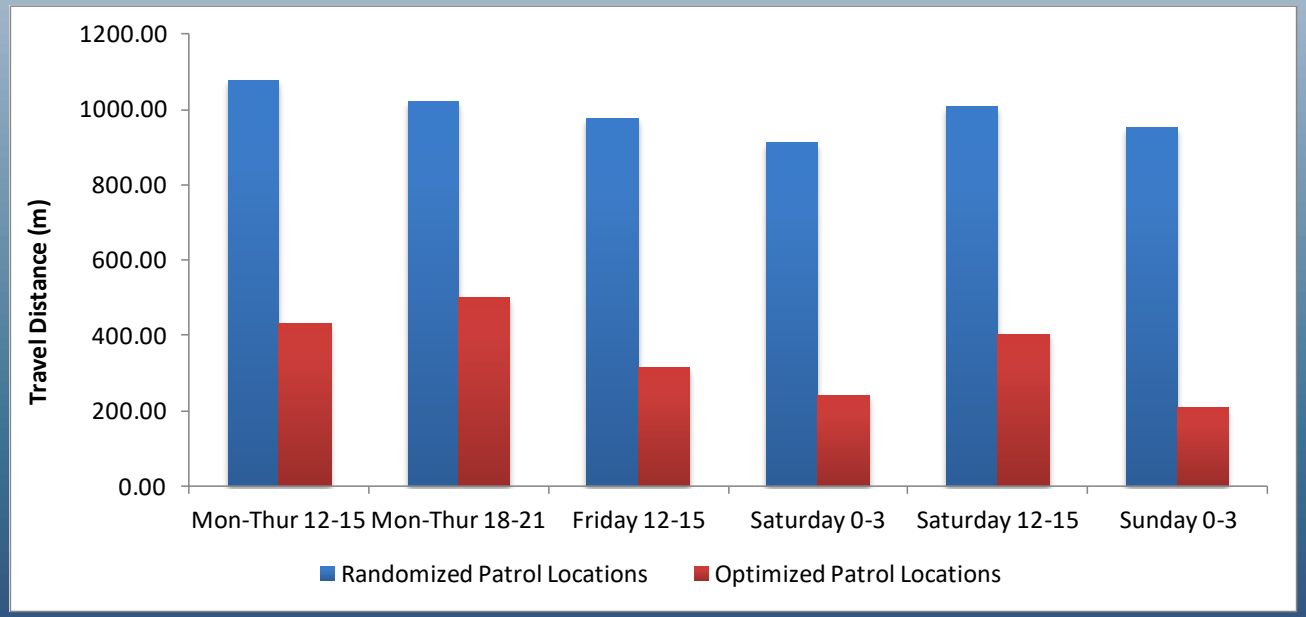
Cost Matrix Analysis

- Randomized patrol locations
- Selection of 4 randomized patrol locations
- Replication (n=9)
- Travel Time Adjustment Factor:
  - $F = T_{Niche} / T_{Estimated}$
- T-Test: times/distances for randomized vs. optimized patrol locations

Travel Time Matrix from 4 Random Patrol Locations in Waterloo North 4 Policing Zone: Monday to Thursday, 6pm to 9pm, 2014

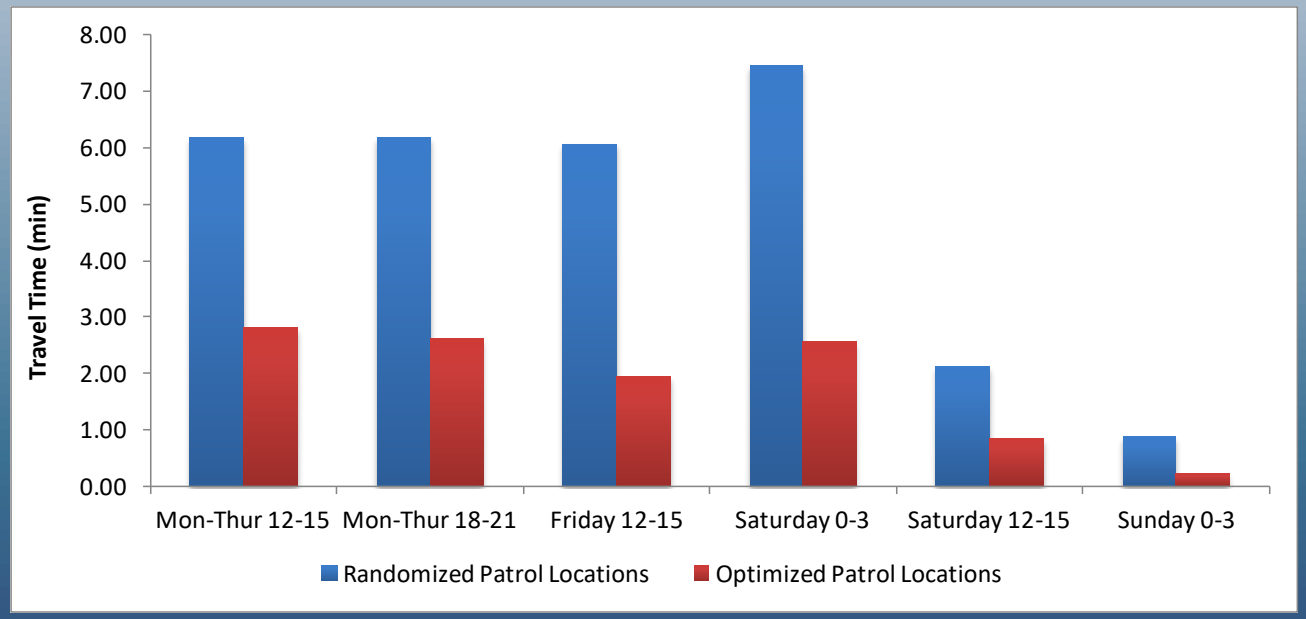


Results- Distance



Time	Mean Travel Time To Priority 1 Calls (Minutes)		95% Confidence Interval for Travel Time Reduction (%)		Significance of Travel Time Reduction
	Randomized Patrol Locations	Optimized Patrol Locations	Upper	Lower	
Mon-Thur 12-15	6.17	2.81	56.74	51.89	p-value < 0.01
Mon-Thur 18-21	6.18	2.62	59.72	55.34	p-value < 0.01
Friday 12-15	6.06	1.94	69.70	69.70	p-value < 0.01
Saturday 0-3	7.45	2.55	68.86	68.86	p-value < 0.01
Saturday 12-15	2.11	0.84	62.83	62.83	p-value < 0.01
Sunday 0-3	0.87	0.22	76.98	76.98	p-value < 0.01
Overall	4.50	2.06	57.04	51.02	p-value < 0.01

Results- Time



Time	Mean Travel Distance To Priority 1 Calls (Minutes)		95% Confidence Interval for Travel Time Reduction (%)		Significance of Travel Time Reduction
	Randomized Patrol Locations	Optimized Patrol Locations	Upper	Lower	
Mon-Thur 12-15	1079.04	430.82	62.11	57.81	p-value < 0.01
Mon-Thur 18-21	1019.14	500.90	53.23	48.22	p-value < 0.01
Friday 12-15	976.40	312.79	69.65	66.08	p-value < 0.01
Saturday 0-3	911.93	239.64	76.11	70.80	p-value < 0.01
Saturday 12-15	1007.26	404.19	62.46	56.90	p-value < 0.01
Sunday 0-3	949.41	210.06	79.78	75.57	p-value < 0.01
Overall	1100.86	459.10	61.22	54.90	p-value < 0.01

Conclusion

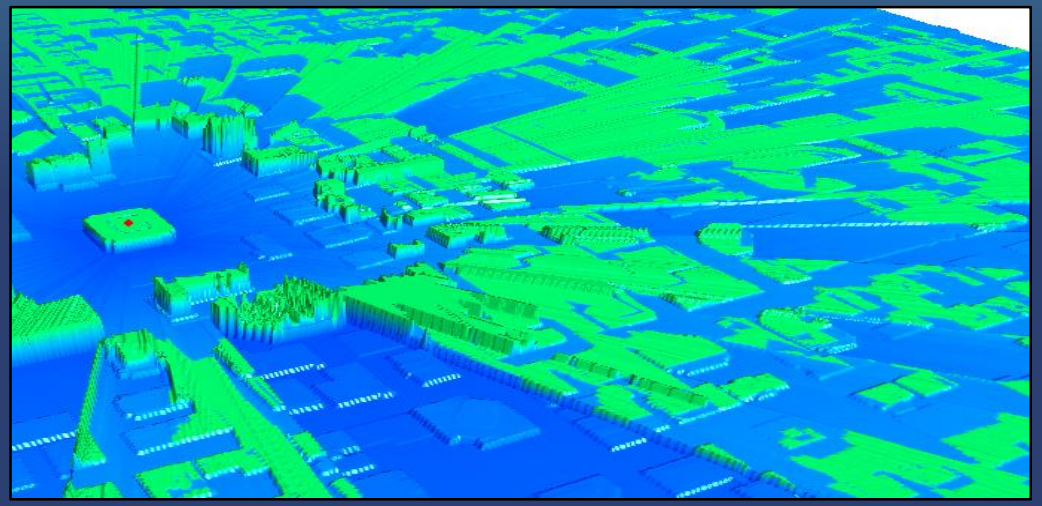
- Optimized locations: 51 to 57% decrease in response times ($P<0.01$)
- Optimized distance: 55 to 61% decrease in response times ($P<0.01$)
- Faster response times will likely improve public safety
  - Allow officers to de-escalate emergency situations in their early stages

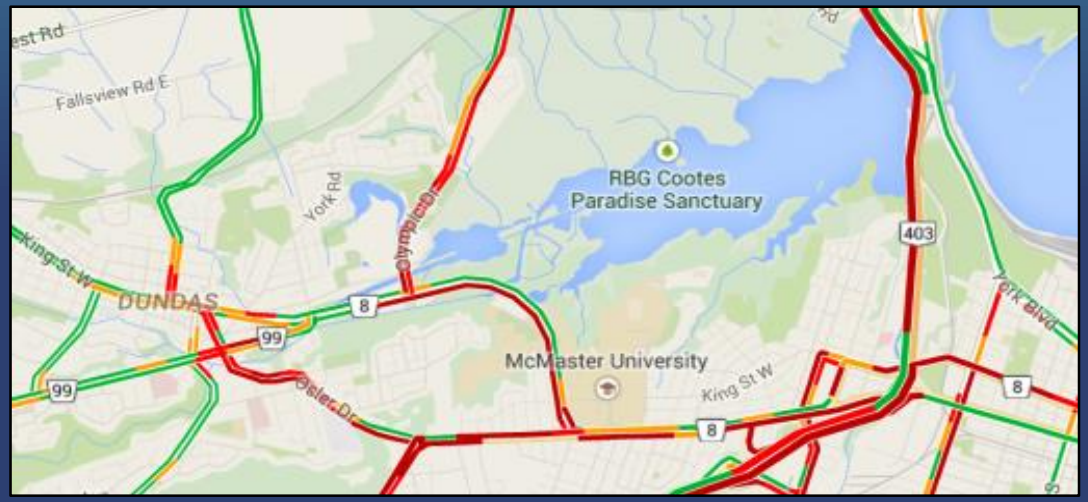
Limitations

- Static location analysis
- Estimated traffic conditions and physical barriers
- Estimated start and end points
- Assumed constant staffing
- Speed restrictions not limiting

Future Directions

- Extrapolation to all zones and all times of day
- Real-time traffic conditions and route optimization (Google Maps API)
- Optimized patrol routes using viewshed analysis
- Support for multiple policing strategies and frameworks
- Patrol shift schedule integration





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