Impact of Curb Radius Reduction on Pedestrian Safety: A Before-After Surrogate Safety Study in Toronto

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Introduction

- Compare to vehicles data, pedestrian data are not widely/easily available

- Two main streams of safety analysis:

  1. Based on historical observed accidents and injury data
     - Limited number of observed accident
     - Requires several years of observation and data gathering
     - Does not provide detail about the cause(s) of the accident

  2. Based on surrogate measures of safety
     - Focuses on dangerous conflicts instead of accidents
     - Conflicts occur more frequently than accidents
     - Statistically sufficient data can be collected in a shorter time period
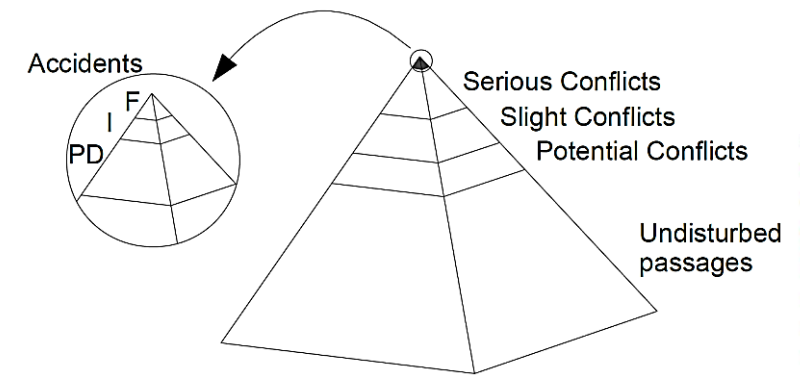
Introduction

- Large curb radii at intersection corners
  - reduce pedestrian visibility
  - high-speed turning movements
- This can lead to dangerous interactions and potentially collisions with pedestrians
- Adjustment to intersection curb radius
  - reduce turning vehicle speeds
  - reduce crossing distance for pedestrians
  - Improve pedestrian safety at intersections

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Introduction

- Geometric modifications at various intersections in City of Toronto
- Following complaints from the public and observation from staffs
  - Davenport / Christie
  - Yorkwoods / Driftwood

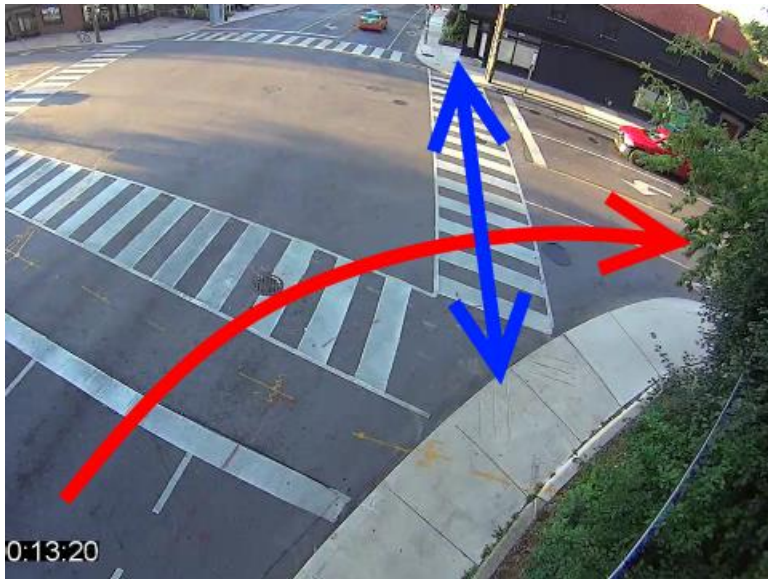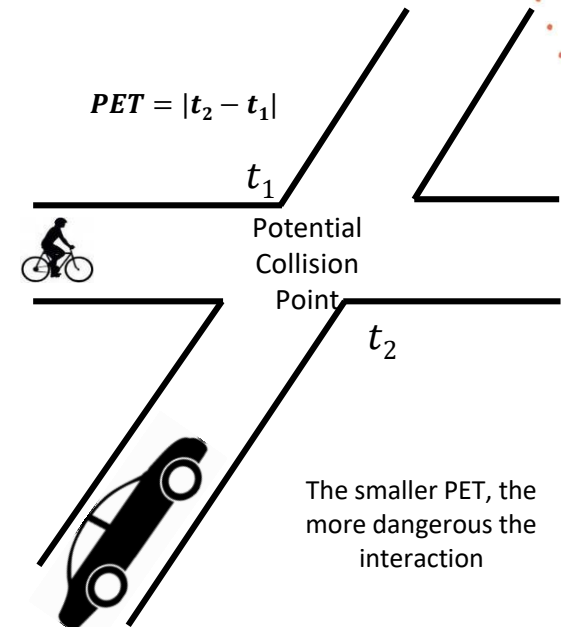| Davenport / Christie		Yorkwoods / Driftwood	
Before	After	Before	After

Objectives

- Applying a surrogate safety approach to evaluate the effectiveness of curb radii reduction
  - speed of turning vehicles
  - frequency and severity of conflicts between turning vehicles and pedestrians

Methodology

- Two surrogate safety indicators
  - traffic speed
  - vehicle-pedestrian conflicts
- Post Encroachment Time (PET) between a pedestrian and a turning vehicle
- PET is defined as the time between the first road user leaving the common spatial zone (where two road users could potentially collide) and the second road user arriving to the common spatial zone

$PET = |t_2 - t_1|$

t_1

Potential Collision Point

t_2

The smaller PET, the more dangerous the interaction

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Methodology

- 3 days of video for before study and 3 days for after study
- Video data were recorded on weekdays from 7am to 7pm
- Total of 144 hours for 2 intersections

Davenport / Christie		Yorkwoods / Driftwood	
Before	After	Before	After
August 2nd , 2016	November 8th , 2016	September 13th , 2016	May 9th , 2017
August 3rd , 2016	November 9th , 2016	September 14th , 2016	May 10th , 2017
August 4th , 2016	November 10th , 2016	September 15th , 2016	May 11th , 2017

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Results - Trajectory Heatmaps

Davenport / Christie

	Before	After
Right turning vehicles		
Pedestrians		
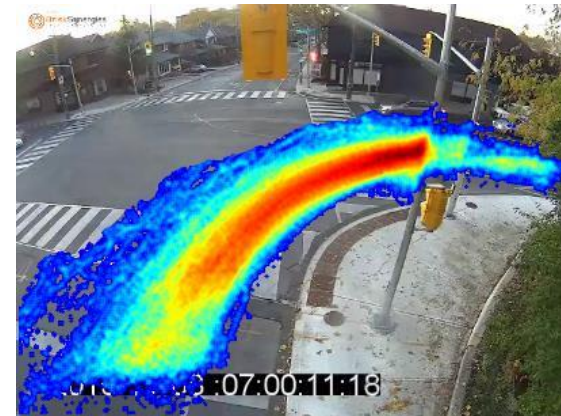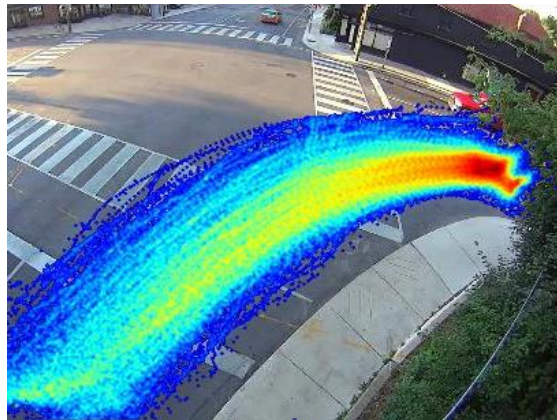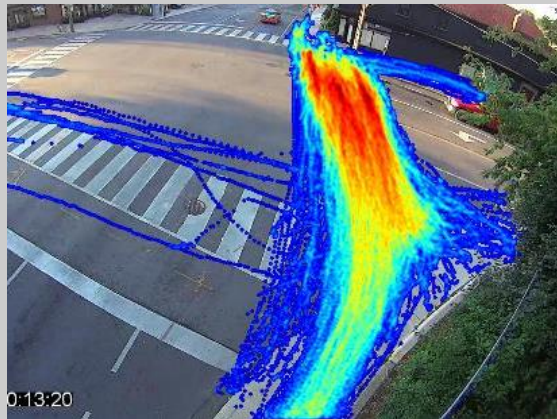
Results – Speeds and Counts

	Right turning vehicles		Pedestrians	
	Before	**After**	**Before**	**After**
Count	1335	1298	600	415
Avg. Speed	18.7 km/h	19.7 km/h	6.9 km/h	6.8 km/h
Std. Dev.	5.8 km/h	6.3 km/h	2.8 km/h	3.4 km/h
Median Speed	19.7 km/h	20.9 km/h	6.0 km/h	5.7 km/h

Davenport / Christie

VEHICLE SPEED DISTRIBUTION, BEFORE-AFTER
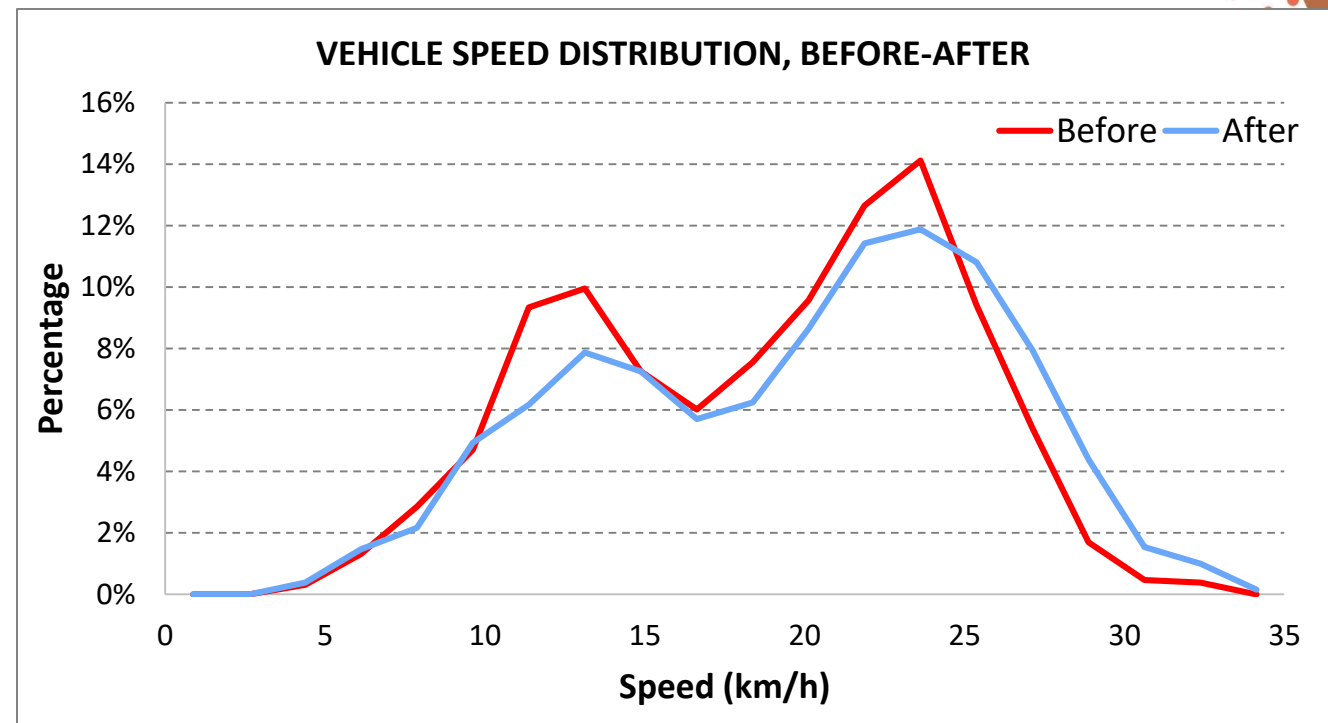
Results - Conflict Heatmaps

Davenport / Christie

	PET ≤ 1s	1s < PET ≤ 3s	3s < PET ≤ 5s
Before			
After			

Results - Conflict Rates
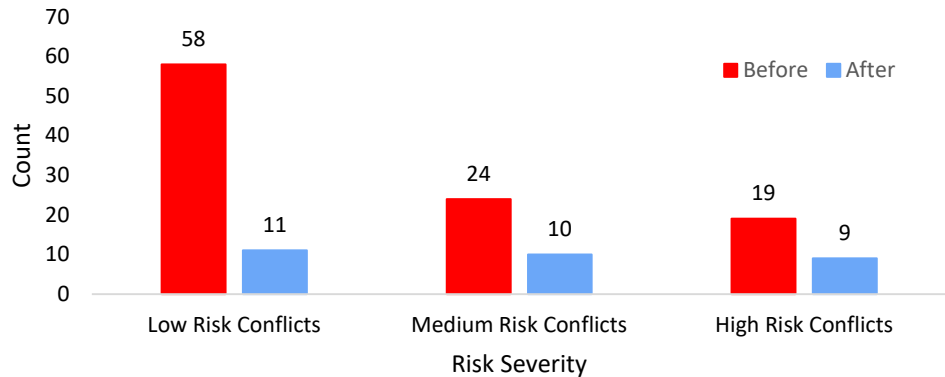
CONFLICT FREQUENCY, BEFORE-AFTER
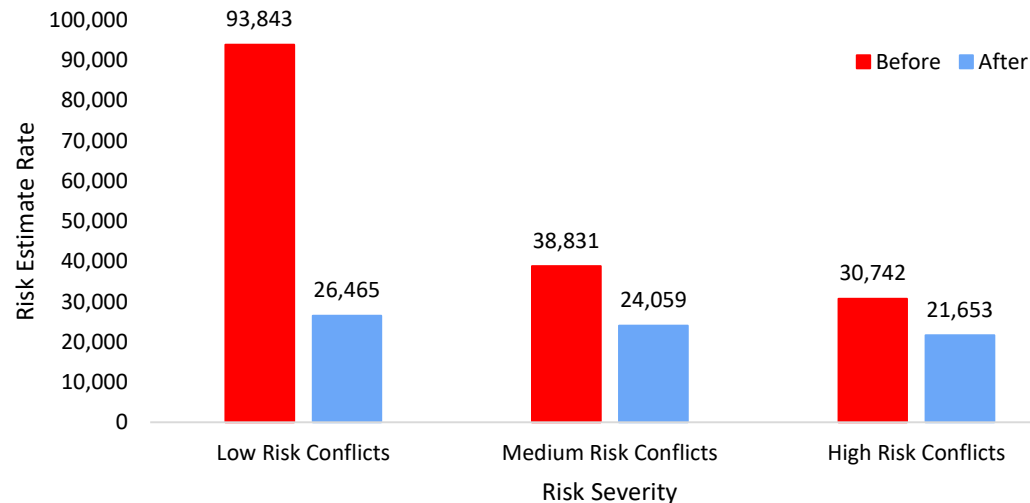
Davenport / Christie

$$High\ Risk\ Conflict\ Rate = \frac{(NPET_H) * 10^6}{(Pedestrians\ per\ hour) * (Turning-Vehicles\ per\ hour)}$$

$$Medium\ Risk\ Conflict\ Rate = \frac{(NPET_M) * 10^6}{(Pedestrians\ per\ hour) * (Turning-Vehicles\ per\ hour)}$$

$$Low\ Risk\ Conflict\ Rate = \frac{(NPET_L) * 10^6}{(Pedestrians\ per\ hour) * (Turning-Vehicles\ per\ hour)}$$

RISK ESTIMATE RATES, BEFORE-AFTER

- Low Risk Conflict Rate was reduced by 72%

- Medium Risk Conflict Rate was reduced by 38%
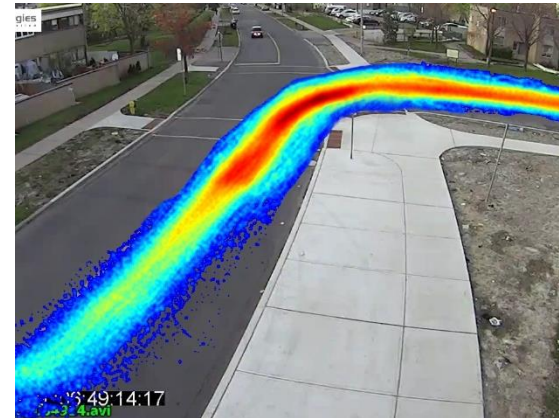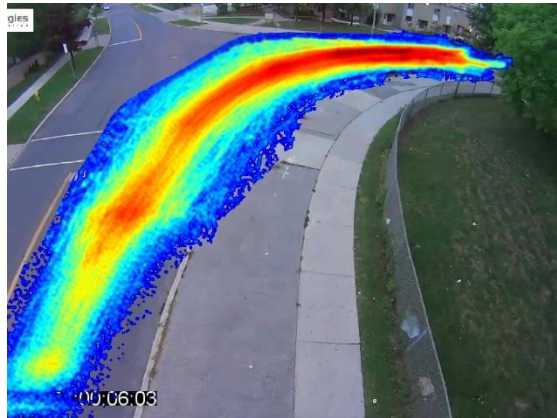
- High Risk Conflict Rate was reduced by 30%
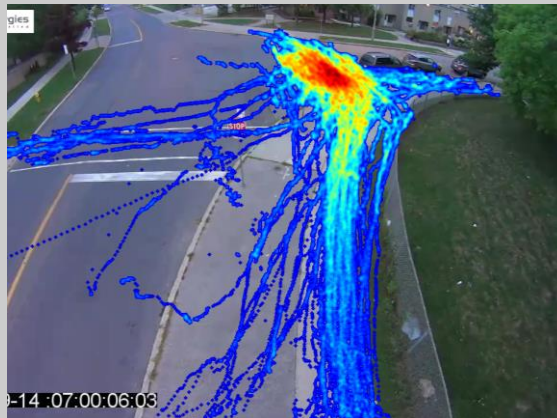
Results - Trajectory Heatmaps

Yorkwoods / Driftwood

	Before	After
Right turning vehicles		
Pedestrians		

Results – Speeds and Counts

	Right turning vehicles		Pedestrians	
	Before	**After**	**Before**	**After**
Count	1645	1542	348	297
Avg. Speed	17.7 km/h	17.9 km/h	6.2 km/h	5.7 km/h
Std. Dev.	4.5 km/h	4.4 km/h	2.1 km/h	2.7 km/h
Median Speed	17.9 km/h	18.0 km/h	5.8 km/h	5.0 km/h

Yorkwoods / Driftwood

VEHICLE SPEED DISTRIBUTION, BEFORE-AFTER
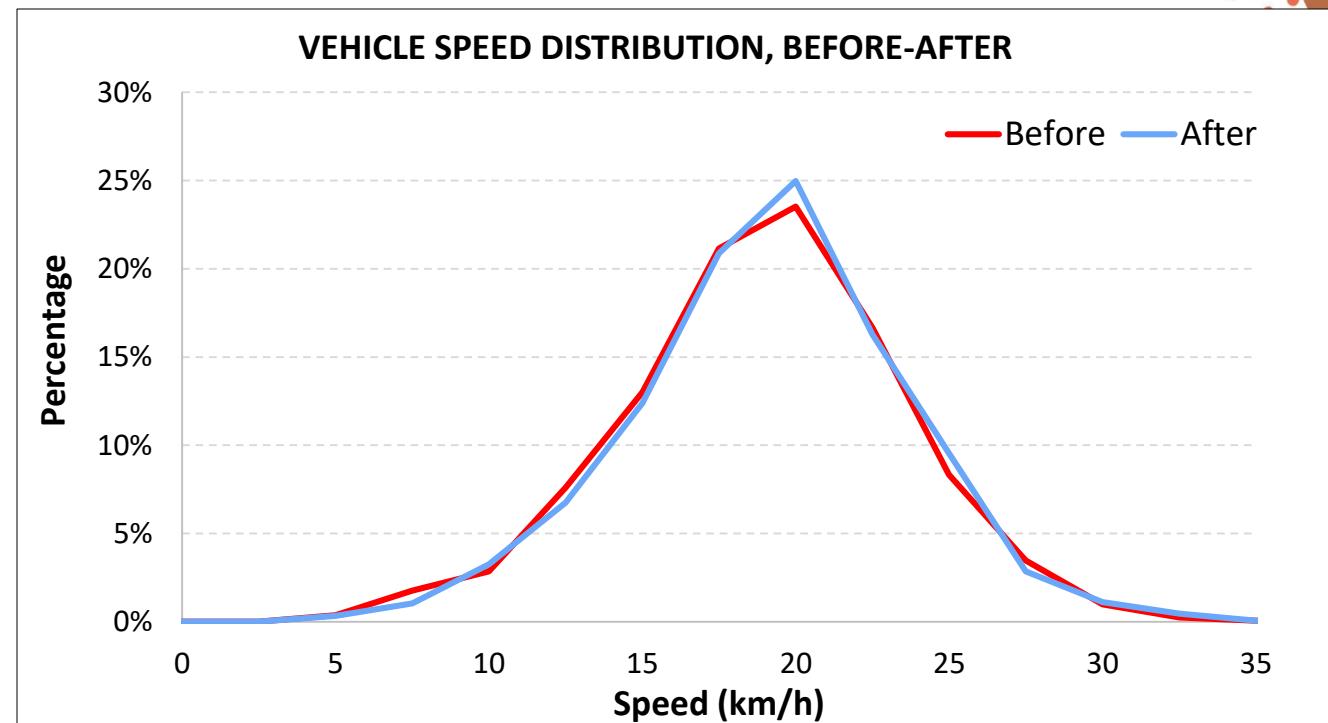
Results - Conflict Heatmaps

Yorkwoods / Driftwood

	PET ≤ 1s	1s < PET ≤ 3s	3s < PET ≤ 5s
Before			
After			

Results - Conflict Rates

CONFLICT FREQUENCY, BEFORE-AFTER
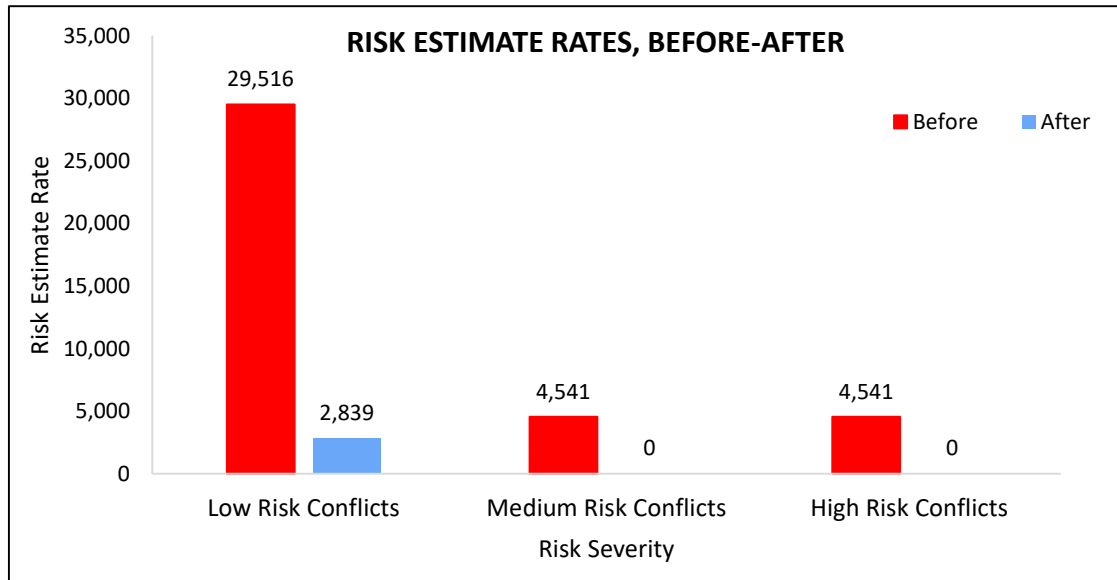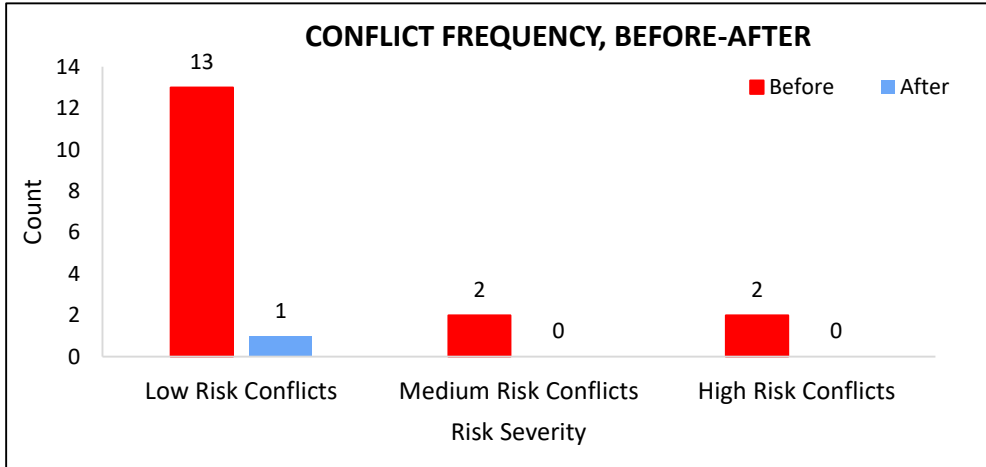
Yorkwoods / Driftwood

$$High\ Risk\ Conflict\ Rate = \frac{(NPET_H) * 10^6}{(Pedestrians\ per\ hour) * (Turning-Vehicles\ per\ hour)}$$

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RISK ESTIMATE RATES, BEFORE-AFTER

- Low Risk Conflict Rate was reduced by 90%

- Medium Risk Conflict Rate was reduced by 100%

- High Risk Conflict Rate was reduced by 100%

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Medium Risk Conflict

2016-08-03 :16:47:24:04

Conclusion

- Conflict frequencies and rates dropped significantly after adjustment in curb radius of the studied intersections

- For signalized intersection of Davenport / Christie:
  - Low Risk Conflict Rate was reduced by 72%
  - Medium Risk Conflict Rate was reduced by 38%
  - High Risk Conflict Rate was reduced by 30%

- For un-signalized intersection of Driftwood / Yorkwoods:
  - Low Risk Conflict Rate was reduced by 90%
  - Medium Risk Conflict Rate was reduced by 100%
  - High Risk Conflict Rate was reduced by 100%

- No significant change in turning vehicle speed were observed

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- This project was completed for the City of Toronto by Brisk Synergies Tech Corp in collaboration with Ontario Traffic Inc. (OTI)
- OTI was in charge of camera installation and video recording, and Brisk Synergies Tech Corp carried out the video data generation and analysis
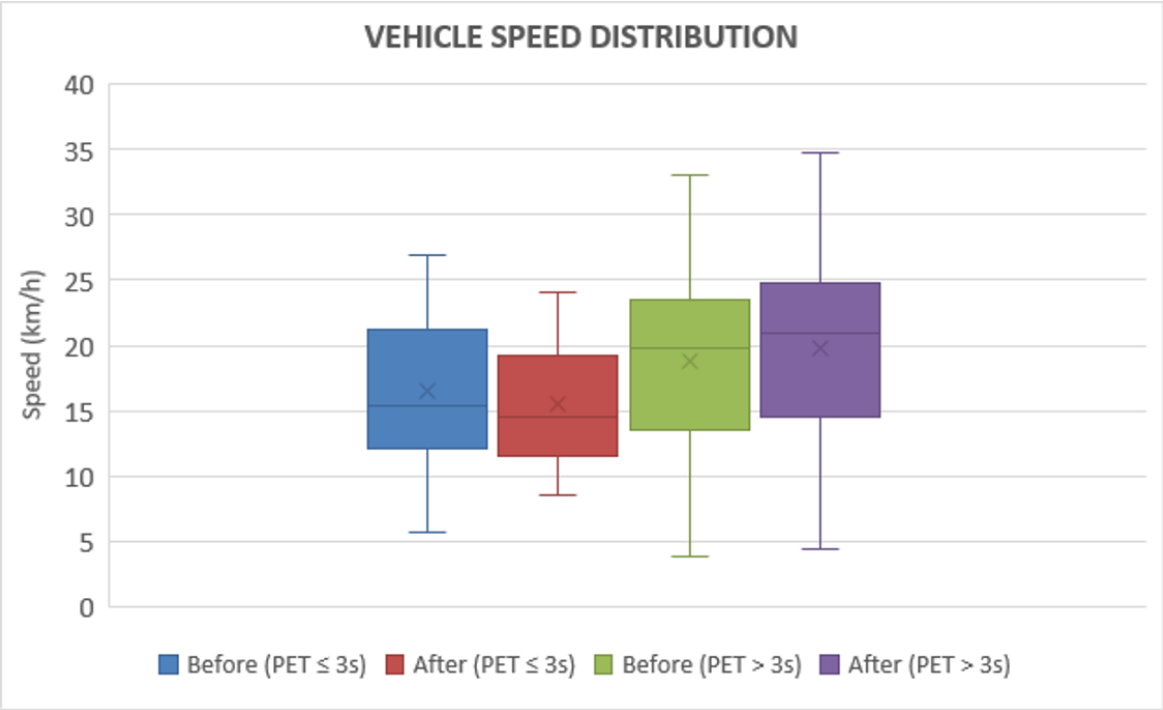
Thank you!

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Speed Distribution for Vehicles Involved in a Conflict

Davenport / Christie

VEHICLE SPEED DISTRIBUTION

Legend: Before (PET ≤ 3s), After (PET ≤ 3s), Before (PET > 3s), After (PET > 3s)

	PET ≤ 3s		PET > 3s	
	Before	**After**	**Before**	**After**
Average (km/h)	16.51	15.55	18.76	19.85
Median (km/h)	15.40	14.49	19.78	20.95
85th Percentile (km/h)	22.79	21.05	24.76	26.32