Canadian Automobile Association

Final Report - 20 Road Safety Innovation Labs Deployed Coast to Coast

Presented by:

Craig Milligan, Ph.D. P.Eng. RSP2I
Senior Specialist Road Safety Engineer
Fireseeds North Infrastructure Corporation
craig.milligan@fireseedsnorth.ca

Olivia Babcock, P.Eng., RSP1
Sales Engineer, Miovision

Zach Bogdon, M.E.S. Planning
Account Executive
Miovision
zbogdon@miovision.com

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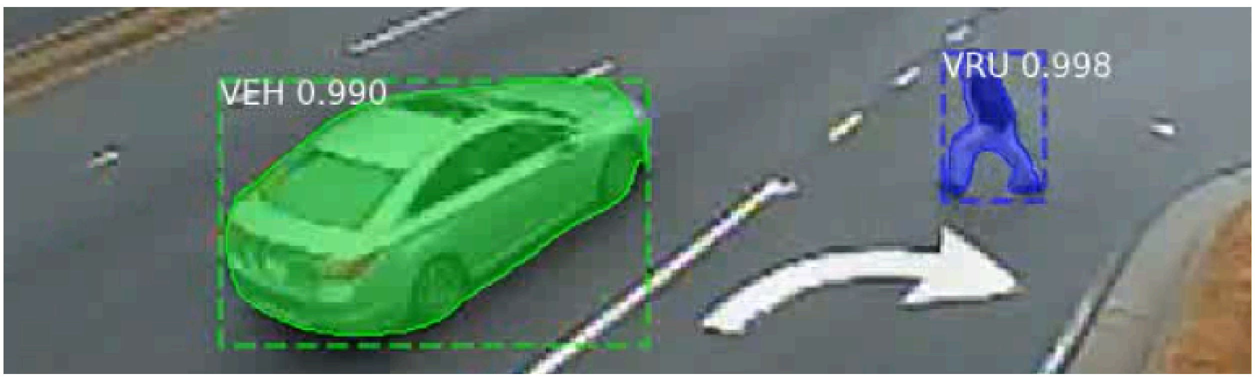
Executive Summary

A CAA-funded study by Miovision at 20 intersections across Canada used video analytics to gather Canada's largest database of pedestrian and cyclist near-misses. The study showed that about 1 serious near-miss occurs for every 770 times a pedestrian crosses an intersection - a daily occurrence at most busy intersections. The study has revealed a number of design practices for cities to consider which are associated with fewer near-misses and increased road safety.

Cities are turning to near-miss data to be more proactive about road safety in line with the safe systems approach. Collision data is reactive, and it doesn't reveal risk factors when there is a serious problem that is still an 'accident waiting to happen'. Using near-miss data helps to predict where crashes will happen next.



Miovision Automated Video-Based Conflict Analysis Tool to measure Near-Misses, also called Conflicts to help Cities be Proactive about Road Safety

The objective of the study was to use video analytics technology to measure pedestrian and cyclist near-misses at 20 intersections in Canada to better understand the magnitude and nature of risk factors on Canadian roads and to discover design approaches that contribute to safety.

The process of selecting intersections ensured national representation by involving CAA, Miovision, and city representatives. Intersection locations were partly determined by where Miovision equipment was already available.

By leveraging brand new *Continuous Safety Monitoring* technology, this study achieved an unprecedented scale with 616,854 near-misses measured. *Continuous Safety Monitoring* technology pairs a Miovision Smart View 360 degree camera above the intersection with a Miovision Core computer in the roadside traffic control cabinet to measure near-misses automatically.

The risk level of near-misses is classified as critical, high, medium, or low risk based on kinetic energy involved in the potential impact. A critical risk conflict is associated with at least an 85% chance of serious injury if a crash would occur, and high risk conflicts are linked to at least a 40% chance of serious injury if a crash would occur.

By observing millions of pedestrians and cyclists, we found that 1 in every 770 pedestrians and 1 in every 500 cyclists was involved in a high risk or critical risk near-miss. The majority of these near-misses involve right turning vehicles (55% for pedestrians and 50% for cyclists), followed by left turning vehicles (34% for pedestrians and 36% for cyclists), and lastly through vehicles (11% for pedestrians and 14% for cyclists).

We statistically examined 21 design factors at each of these intersections to determine which were associated with lower frequencies of near-misses. We found that the use of turning lanes, left turn phasing, leading pedestrian intervals, and compact intersection design had the biggest impact on minimizing the number of near-misses.

This study has shown the power of *Continuous Safety Monitoring* technology to collect data for understanding road safety. Furthermore, the data collected in this study has been made accessible to city transportation staff via the Miovision data platform, made possible through the generous support of CAA.

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About CAA

CAA is a federation of eight clubs providing over 7 million Members with exceptional emergency roadside service, complete automotive and travel services, Member savings and comprehensive insurance services. As one of Canada's most trusted brands, CAA also advocates on issues of concern to its Members and all Canadians, including road safety, the environment, mobility, infrastructure, and consumer protection.

About Miovision

Miovision provides cities with modern tools to fix today's traffic problems. We offer solutions that collect multimodal traffic data and uncover actionable insights, helping municipalities get more out of their road network.

Introduction

In the field of road safety, cities are increasingly turning to near-miss data to better understand the nature of their road safety problems and to help plan their road safety improvements in the pursuit of Vision Zero.

Miovision has two safety technologies for measuring near-misses using video analytics. The first is *Safety Studies,* which extracts near-miss data from 3 days of video recorded using portable Miovision Scout video cameras. The second is *Continuous Safety Monitoring*, a brand new technology that pairs a Miovision Smart View 360 degree camera above the intersection with a Miovision Core computer in the roadside traffic control cabinet to measure near-misses automatically. In the *Road Safety Innovation Labs* project funded by the Canadian Automobile Association (CAA), these two near-miss technologies were deployed at 20 intersections across Canada as follows:

- 14 Cities with SmartView 360 Cameras and Core Edge Compute Devices received a *Continuous Safety Monitoring* license funded by CAA
- 6 Cities with Miovision Scout Portable Cameras received a 3-day *Safety Study* video processing project funded by CAA

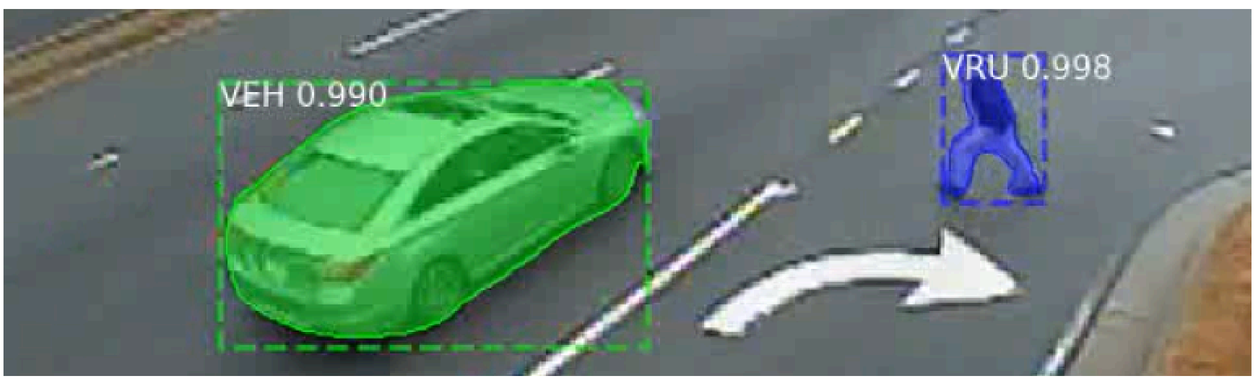

Figure 1: Miovision Automated Video-Based Conflict Analysis Tool to measure Near-Misses, also called Conflicts

Figure 2: Miovision CORE DCM and SmartView 360 Camera System

Project Scope and Steps

In this partnership CAA, Miovision, and Municipal Partners worked together to create and operate *CAA Road Safety Innovation Labs* at 20 intersections from coast to coast across Canada. This report summarizes the findings on vehicle, pedestrian and cyclist conflicts at these 20 locations.

Miovision used the data from the 14 deployed *Continuous Safety Monitoring* locations as well as data from six (6) short duration *Safety Study* locations to discover and summarize useful information for city designers, drivers, pedestrians and cyclists about right-turn and left-turn risks.

By leveraging the brand new *Continuous Safety Monitoring* tool over a 7 month period, this initiative gathered a database of near-miss conflicts that is unprecedented in scale, with a total of 616,854 conflicts.

The project scope included technology deployment, near-miss data collection, intersection design attribute data collection, and analysis of data to identify key safety trends.

Objectives and Expected Outcomes

The objectives of the project are to help drive policy change through new knowledge of road safety, and to provide data to CAA so they can help cities deploy emerging technology to gather data in support of vision zero efforts.

We aim to give city traffic engineers and city councillors detailed data on the nature of near-misses, and the intersection design factors associated with reduced near-miss rates so that they can be empowered to take practical steps to improve road safety.

The expected outcomes of the project remain the same as outlined previously:

Primary Outcomes

1. The Cities and CAA have come to understand key risk factors and trends at 20 intersections across Canada
2. The study locations included major urban metropolitan areas from each of the 8 CAA regional clubs in Canada.
3. Key insights were gained about road safety trends at Canadian intersections and are published in this report for the benefit of CAA, its members, city councillors and engineers, and the general public.

Additional Outcomes

4. Cities have received guidance on appropriate safety improvements to address risk factors revealed by continuous monitoring
5. Cities have gained familiarity with advanced safety technologies.

Methodology

The major steps in carrying out the Road Safety Innovation Labs project are detailed below.

City Selection, Technology Deployment, and Data Collection

Cities were selected by CAA to represent all regions in Canada. A short list of candidates was proposed and then refined based on equipment availability at the cities and availability of city staff to participate. The following cities were selected:

#	City	Participation Type
1	Montreal, QC	*Continuous Safety Monitoring*
2	Halifax, NS	*Continuous Safety Monitoring*
3	Winnipeg, MB	*Continuous Safety Monitoring*
4	Calgary, AB	*Continuous Safety Monitoring*
5	Waterloo, ON	*Continuous Safety Monitoring*
6	Lethbridge, AB	*Continuous Safety Monitoring*
7	Peterborough, ON	*Continuous Safety Monitoring*
8	Prince George, BC	*Continuous Safety Monitoring*
9	Saint-Jean-sur-Richelieu, QC	*Continuous Safety Monitoring*
10	Sault Ste Marie, ON	*Continuous Safety Monitoring*
11	Guelph, ON	*Continuous Safety Monitoring*
12	Niagara Region, ON	*Continuous Safety Monitoring*
13	Granville Island, BC	*Continuous Safety Monitoring*
14	Coquitlam, BC	*Continuous Safety Monitoring*
15	Edmonton, AB	*Safety Study*
16	Longueuil, QC	*Safety Study*
17	Regina, SK	*Safety Study*
18	Saskatoon, SK	*Safety Study*
19	Ottawa, ON	*Safety Study*
20	Toronto, ON	*Safety Study*

For the 14 cities using *Continuous Safety Monitoring*, the necessary hardware was already in place at the intersection prior to the project. The *Continuous Safety Monitoring* software was deployed to the Miovision CORE at the intersection via an over-the-air update as soon as the license funded by CAA was assigned to the intersection. The near-miss data was then continuously streamed to a cloud platform called Miovision One which is the central hub used by Miovision customers for traffic management.

For the 6 cities using *Safety Studies*, the city staff deployed portable *Miovision Scout* video collection units to collect 3 days of intersection video. In some cases, a contractor deployed the cameras. The video was uploaded to Miovision for processing and automatic extraction of near-miss data.

Near-miss data was extracted and categorized using Miovision's computer vision system and kinetic energy risk models. The kinetic energy risk models identify conflicts and classify them as critical, high, medium, or low risk based on the temporal separation of road user paths and the road user speeds, which correlate to potential impact forces and injury likelihood. Miovision's kinetic energy risk models represent the best-in-class methodology for near-miss measurement with a proven 94% accuracy in predicting long-term injury crash risk.

Download, Disaggregate, and Normalize Data

The data was downloaded from the Miovision One cloud platform for analysis. During the download phase, small portions of data were excluded for various reasons including privacy permissions and quality control criteria.

The data had to be normalized for varying time periods. The *Safety Studies* datasets contain much shorter datasets of about 3 days and daytime hours. The *Continuous Safety Monitoring* datasets have several months of data but different total sizes due to different install dates. To make these datasets comparable, they were all restricted to the 7 AM to 7 PM time period and converted to 'per-day' conflict quantities. The period between 7 AM and 7 PM is when most road users are on the road.

Some intersections are expected to have more conflicts simply because they have more vehicles, pedestrians, and cyclists. This does not necessarily mean that they are less safe on a 'per-person basis'. Therefore, a version of the database was also created that was normalized to how busy the intersections were, yielding insight into 'conflicts per pedestrian per day' and 'conflicts per bicyclist per day' as metrics which are comparable across locations.

Intersections have different design attributes on different approaches. For example, an intersection may have a left turn lane on the northbound approach but not the southbound approach. The conflicts involving these two approaches should be analyzed separately to determine the safety impact of the left turn lane. The conflicts were therefore disaggregated by approach and crosswalk, creating a conflict database of 72 intersection approaches and 72 crosswalks. Conflicts were additionally disaggregated by vehicle turning direction (left or right), conflict location (near-side and far-side), and severity level (critical, high, medium, and low).

The severity level disaggregation depends on the speed of the vehicle in conflict with the pedestrian. Critical risk conflicts have a minimum vehicle speed of 50 km/h, which corresponds to an 85% chance of a MAIS 3+ injury upon impact. High risk conflicts have a minimum vehicle speed of 35 km/h which corresponds to a 40% chance of a MAIS 3+ injury upon impact. Medium risk conflicts have a minimum vehicle speed of 15 km/h which corresponds to a 5% chance of a MAIS 3+ injury upon impact. Finally, low severity conflicts have vehicle speeds below 15 km/h. Although injuries and even death can result from a vehicle strike at these low vehicle speeds, more than 95% of strikes at these speeds will not cause a serious injury.

The downloaded, normalized, and disaggregated database was combined with the attribute database for trend analysis.

Attributes

Miovision created a list of left-turn and right-turn design attributes which are hypothesized to have a potential impact on safety, and collected these attributes for each approach in the intersection database.

The following intersection attributes were collected:

- Approach speed
- Crossing width
- Leading pedestrian interval

The following right turn attributes were collected:

- Right turn on red allowed (Yes or No)
- Curb radius
- Presence of right turn lane (Yes or No)
- Pavement marking rating (absent, low conspicuity, high conspicuity)
- Lateral offset from right edge of entry travel lane to left edge of crosswalk
- Lateral offset from right edge of entry travel lane to left edge of bike lane (use crosswalk where bike lane not present)
- Turn volume
- Pedestrian volume
- Conflict warning sign (Yes or No)

The following left turn attributes were collected:

- Left turn phasing type (permissive, protected, protected-permissive)
- Left turn radius
- Presence of left turn lane (Yes or No)
- Pavement marking rating (absent, low conspicuity, high conspicuity)
- Lateral offset from left edge of entry travel lane to right edge of crosswalk
- Lateral offset from left edge of entry travel lane to right edge of bike lane (use crosswalk where bike lane not present)
- Turn volume
- Pedestrian volume
- Conflict warning sign (Yes or No)

This generated a large attribute database which was joined to the conflict database for trend analysis.

Statistical Analysis

A statistical analysis was completed which includes descriptive statistics of conflict frequency, type, and severity for the national dataset, and which also includes an investigation of significant associations between conflict data and intersection design attributes. For example, the investigation of associations may show if the 'no-right-turn on red' attribute is associated with lower conflicts of a certain type.

Results

The first results section is a summary of conflicts that seeks to characterize the magnitude and general breakdown of the near-miss problem at intersections. It looks at how many near-misses occurred, the breakdown by mode (vehicle, pedestrian, and cyclist), the breakdown by vehicle turning movement (left, right, and through), the breakdown by severity level, and involvement rates per-pedestrian and per-cyclist.

The second results section looks at factors influencing pedestrian conflict frequency, with insights gained through regressing the daily conflict rate against design attributes. This section looks separately at left and right turning vehicles.

The third results section looks at factors influencing bicycle conflict frequency, with insights gained through regressing the daily conflict rate against design attributes. This section looks separately at left and right turning vehicles.

The fourth and final results section contains a descriptive exploration of the intersections experiencing the highest conflict rates on a per-pedestrian and per-cyclist basis.

Conflict Summary

Overall Summary and Breakdown by Mode

More than 7 million pedestrian and cyclist crossings were observed and a total of 616,854 conflicts were collected across the 72 approaches between August 2024 and February 2025. This resulted in an average of 4300.09 conflicts per day. Not all of these were high and critical risk events, and the breakdown by severity is included below.

The majority of the conflicts observed were between vehicles and pedestrians. The table below details the conflict type, conflict count and conflict percentage of all the conflicts observed.

Conflict Type	Conflict Count	Conflict Percentage (per day)
Vehicle - Pedestrian	397,731	57.72%
Vehicle - Vehicle	153,163	32.97%
Vehicle - Cyclist	17,066	2.38%
Other	48,895	6.92%

Vehicle - Pedestrian Conflicts

Total Pedestrian Conflicts and Breakdown by Vehicle Movement

We measured a total of 397,731 pedestrian conflicts. Over 55% of vehicle-pedestrian conflicts occurred between a right turning vehicle and a pedestrian. Conflicts with left turning vehicles ranked second at 33.9%. Taken together, left and right turning movements are responsible for almost 90% of vehicle-pedestrian conflicts, while vehicles going straight through are only responsible for only about 10% of vehicle-pedestrian conflicts.

Vehicle Movement	Conflicts per Day	Percentage of Vehicle-Pedestrian Conflicts (%)
Right Turn	1106.27	55.57%
Left Turn	674.83	33.90%
Through	209.78	10.53%

Percentage of Pedestrians Involved in Conflicts By Each Severity Level

We found that 8.79% of crossing pedestrians were in a conflict with a vehicle. Most of these conflicts were low and medium severity, which involved 3.2% and 5.45% of pedestrians, respectively. About 1 in every 770 pedestrians, (0.13% of pedestrians) were involved in high or critical risk conflicts. Since most busy intersections in Canada have more than 770 pedestrians per day, this means that high and critical risk conflicts are a daily occurrence - and at some intersections it can be multiple high risk conflicts per day.

Severity Level	Conflicts per day	Conflict per Pedestrian (%)
Critical	14.88	0.05%
High	23.23	0.08%
Medium	1540.64	5.45%
Low	903.42	3.20%

Vehicle - Cyclist Conflicts

Total Cyclist Conflicts and Breakdown by Vehicle Movement

We measured a total of 17,006 cyclist conflicts. About half (50.22%) of vehicle-cyclist conflicts occurred between a right-turning vehicle and a cyclist. Conflicts with left turning vehicles ranked second at 35.72%. Taken together, left and right turning movements are responsible for 85.94% of vehicle-cyclist conflicts, while vehicles going straight through are only responsible for only 14.06% of vehicle-cyclist conflicts. This percentage breakdown by vehicle turning movement is very similar to the breakdown by turning movement for cyclists.

Vehicle Movement	Conflicts per Day	Conflict Percentage (%)
Right Turn	51.48	50.22%
Left Turn	36.61	35.72%
Through	14.41	14.06%

Percentage of Cyclists Involved in Conflicts By Each Severity Level

We found that 9.01% of crossing cyclists were in a conflict with a vehicle. Most of these conflicts were low and medium severity, which involved 3.25% and 5.56% of cyclists, respectively. About 1 in every 500 cyclists, (0.2% of cyclists) were involved in high or critical risk conflicts. The percentage involvement rate of cyclists by severity level and in total is very similar to the same breakdown for pedestrians. Although the absolute number of cyclist conflicts is much lower than the number of pedestrian conflicts, this is because there are fewer cyclists. On a per-person basis, the risk to each cyclist is slightly higher than the risk to each pedestrian.

Severity Level	Conflicts per day	Percentage Conflict per Cyclist (%)
Critical	0.53	0.05%
High	1.66	0.15%
Medium	63.33	5.56%
Low	36.98	3.25%

Pedestrian Conflicts - Influencing Factors

We ran regression analysis to determine which attributes have a statistically significant and material impact on pedestrian conflict frequency, first for left turn conflicts and then for right turn conflicts. Below we report the direction but not the magnitude of the effects. This was because when we ran different types of regressions, the direction was often consistent but there was enough variability in the magnitude that it could be misleading to suggest a specific magnitude of impact.

It is important to note that for the other attributes we measured and investigated (the full list is in the methodology), even though we did not reach a statistically significant finding, it does not mean that they do not impact conflict frequency. A significant finding could be made in the future with a larger sample size of locations or more variability within the sample concerning some of these attributes.

Pedestrian Left Turn Conflicts Influencing Factors

We consistently found statistically significant and material correlations between left turn pedestrian conflict frequency and exposure, the presence of a left turn lane, the use of left turn phasing (protected or protected permissive. Exposure (volume) increased conflicts while the presence of a left turn lane or the use of left turn phasing reduced conflicts.

In some but not all of the regressions we found statistically significant and material correlations between left turn pedestrian conflict frequency and lateral offset and crossing width. In both of these cases, lower offset and lower crossing widths were associated with lower conflict frequencies.

Pedestrian Right Turn Conflicts Influencing Factors

We consistently found statistically significant and material correlations between right turn pedestrian conflict frequency and exposure and lateral offset. Exposure (volume) increased conflicts while increased lateral offset decreased conflicts.

In some but not all of the regressions we found statistically significant and material correlations between right turn pedestrian conflict frequency and approach speed limit (lower speed reduces conflicts), and right turn lanes (reduces conflicts).

Cyclist Conflicts - Influencing Factors

We ran regression analysis to determine which attributes have a statistically significant and material impact on cyclist conflict frequency, first for left turn conflicts and then for right turn conflicts. Below we report the direction but not the magnitude of the effects. This was because when we ran different types of regressions, the direction was often consistent but there was enough variability in the magnitude that it could be misleading to suggest a specific magnitude of impact.

Cyclist Left Turn Conflicts Influencing Factors

We consistently found statistically significant and material correlations between left turn cyclist conflict frequency and exposure, the use of left turn phasing (protected or protected permissive), crossing with, and the use of a leading pedestrian interval.

Higher exposure was associated with higher conflict frequency. The use of left turn phasing was associated with lower conflict frequency. Counterintuitively, a higher crossing width was associated with a lower conflict frequency. The use of a leading pedestrian interval was associated with a lower conflict frequency.

Cyclist Right Turn Conflicts Influencing Factors

We consistently found statistically significant and material correlations between right turn cyclist conflict frequency and exposure and leading pedestrian intervals. Exposure (volume) increased conflicts while leading pedestrian intervals were associated with fewer conflicts.

Summary of Pedestrian and Cyclist Safety Factors

Based on the statistical analysis we can conclude that intersections with dedicated left turn and right turn lanes, protected left turn phasing, leading pedestrian intervals, and a compact design are generally safer, meaning that they will have fewer pedestrian and cyclist conflicts for a given volume of road users. These are the characteristics of safety intersections, which are illustrated below.

Figure 3: Safe Design Features from Left to Right: (A) Auxiliary turn lanes are lanes exclusive to turning vehicles; (B) Left turn phasing allows vehicles to turn left exclusively with no oncoming traffic or pedestrians on the downstream crosswalk; (C) Leading Pedestrian Intervals give pedestrians a head start of about 5 seconds before traffic is released, to minimize conflicts with turning vehicles.

These features cannot be applied to every intersection because they come with some tradeoffs. For example, using protected left turn phasing and leading pedestrian intervals slightly increases overall vehicle delay at many intersections. Compact intersection design makes it harder for trucks and buses to navigate intersections. And roadway width is not always available to install dedicated turning lanes. The features should be considered for safety but local engineers will always have to consider individual sight constraints and additional objectives before deciding what intersection design to apply.

High Risk Approaches

The following is an exploration of the individual approaches that experienced the highest risk of exposure-adjusted conflicts, broken down by pedestrians, cyclists, left turns, and right turns. This section of the results is exploratory and observational, and even though the characteristics below were observed at the highest risk approaches, this does not mean that these characteristics are always associated with higher risk.

The first noteworthy finding is that there is no overlap between the intersections subject to the highest left turn pedestrian risk and the highest right turn pedestrian conflict risk. There is a small amount of overlap between areas with the highest pedestrian risk and the highest cyclist conflict risk. This highlights the importance of measuring risk at a disaggregated level because intersections with high risk for one specific thing are often lower risk for other factors, and without disaggregation the high risk factor can be lost.

Characteristics of highest risk pedestrian left turn conflict approaches

- Very wide crossing street resulting in long distance between start of left turn and arrival at conflict point (observed two times)
- Trees on median partially blocking view to crossing point (observed two times)
- Left turn from one way street possibly resulting in left turning drivers applying less caution to conflict management or having poor sight angles to pedestrians crossing in the same direction
- High truck traffic limits view to downstream pedestrians

Characteristics of highest risk pedestrian right turn conflict approaches

- Transit hub and university retail area
- Skewed suburban intersection
- Skewed urban intersection in tourist location
- Note: skew means the two roads intersection at an angle significantly different than the normal 90 degrees

Characteristics of highest risk bicyclist left turn conflict approaches

- Left turns from one way street and to a one way street, possibly resulting in left turning drivers applying less caution to conflict management or having poor sight angles to pedestrians crossing in the same direction.
- Conflict area in the shade of a building constructed over the roadway, possibly creating issues with driver contrast perception and eye adaptation
- Large intersection with significant distance to left turn conflict point

Characteristics of highest risk bicyclist right turn conflict approaches

- Right turn onto a one way street
- High radius right turn channel with long taper into the channel (observed two times)
- High radius right turn with extra wide 6.2m receiving lane (observed two times)

Conclusion + Next Steps

This report describes the largest database to our knowledge ever collected in Canada in a single project on conflicts between turning vehicles and pedestrians and cyclists.

The report has established which modes sustain more conflicts on an absolute basis (pedestrians) and a per capita basis (cyclists). The report has shown that the split between right and left turning conflicts, and between severe and non-severe conflicts is similar for cyclists and pedestrians, revealing that somewhere between 1 in 500 and 1 in 770 intersection crossings by a vulnerable road user results in a high or critical risk conflict.

This report has also revealed factors associated with lower conflict intersections, showing that cities should be considering auxiliary turn lanes, left turn phasing, and leading pedestrian intervals where possible, as well as compact intersection designs. These design approaches are statistically associated with lower conflict frequencies.

Finally, this report has explored some of the attributes observed for approaches and turning involvements that made the 'top five list' for conflicts per road user of each conflict type. This exploration suggests that road authorities should pay special attention to intersection size, right turn geometry, one-way operations, and visibility to downstream conflict points.

Some of the design attributes that we were interested in exploring did not have much variability across the 20 intersections in this study, and as a result we were not able to draw any conclusions about their impact on safety. It would be worthwhile to re-examine a similar dataset once continuous safety monitoring data is available from a much larger sample of intersections.

In addition to this global analysis of the national dataset, the data collected in this study has been made accessible to city transportation staff via the Miovision data platform, made possible through the generous support of CAA.