cycling safety study

Transportation Association of Canada (TAC)

Nomination for 2016 TAC Technical Excellence Awards

Road Safety Engineering Award Category

February 15, 2016

URBAN systems

CITY OF VANCOUVER

TRANSPORTATION ASSOCIATION OF CANADA (TAC)
NOMINATION FOR 2016 TAC TECHNICAL EXCELLENCE AWARDS
ROAD SAFETY ENGINEERING AWARD CATEGORY

Submitted for:
CITY OF VANCOUVER
CYCLING SAFETY STUDY

Submitted by:

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INTRODUCTION

The City of Vancouver is one of the most bicycle-friendly cities in North America. It has an extensive bicycle network that is well used by residents and visitors, as well as one of the highest cycling mode shares among major North American cities. According to the 2011 Canadian National Household Survey, cycling accounts for approximately 4.4% of all trips to work in the City of Vancouver.

The City recognizes the critical role that cycling can play in creating green and livable communities, and is committed toward making cycling safe, convenient, and comfortable for people of all ages and abilities. The City's Transportation Plan, Transportation 2040, set a target that two-thirds of all trips by 2040 will be made by walking, cycling or transit. Transportation 2040 also sets a target to work towards zero traffic-related fatalities, and places a special emphasis on safety for vulnerable road users, including pedestrians and cyclists. One of the recommended actions in Transportation 2040 was the development of a city-wide Cycling Safety Study to provide a better understanding of cycling safety hotspots and concerns.

The City has taken several significant steps in recent years to improve cycling safety, including the installation of a number of engineering treatments such as protected bicycle lanes and protected intersections, spot improvements at high collision intersections, installation of signage and pavement markings, traffic control upgrades at key intersections, and installation of coloured pavement markings in vehicle-bicycle conflict zones.

Urban Systems was retained by the City of Vancouver to develop the Cycling Safety Study, which is a companion to the 2012 Pedestrian Safety Study which was also developed by Urban Systems. The Cycling Safety Study builds on these initiatives and provides critical information on key safety and design concerns within the bikeway network that, if addressed, can further position cycling as a safe, comfortable, and attractive transportation choice for people of all ages and abilities. The Cycling Safety Study was presented to City Council in June, 2015.

The Cycling Safety Study provides a comprehensive and objective review of the safety of cycling in the City of Vancouver along with an evidence-based action plan to improve cycling safety. This study involved an unprecedented in-depth analysis of all collisions reported to the Insurance Corporation of British Columbia (ICBC) involving bicycle users and motor vehicles in the City of Vancouver between 2007 and 2012. In addition, the study analyzed injury data from bicycling crashes that resulted in treatment at a hospital emergency room in Vancouver in 2008 and 2009 from the Bicyclists' Injuries and Cycling Environment (BICE) study conducted through the University of British Columbia Cycling and Cities program. Based on these datasets, the analysis examined WHERE reported cycling collisions and injury crashes took place, HOW they occurred, WHEN they took place, and WHO was involved. The resulting action plan is informing the City's cycling infrastructure designs.

Urban Systems and the City of Vancouver are very excited to submit this nomination for a Transportation Association of Canada (TAC) 2016 Technical Excellence Award in the Road Safety Engineering Award category for our work on the Cycling Safety Study. The City of Vancouver is currently actively implementing the recommendations of the Cycling Safety Study. In doing so, it is anticipated that the resulting safety improvements will make cycling a safer and more comfortable transportation option for people of all ages and abilities, which will in turn lead to further behaviour change and continue to increase the number of cycling trips made in Vancouver. The results and insights gained from this study are also transferable to other communities and the transportation profession as a whole by providing a detailed evidence-based understanding of the nature of cycling-collisions, which can help to inform the design of better, safer cycling facilities in other communities.

REALIZED OR ANTICIPATED BENEFITS

As noted above, Transportation 2040 set a target to work towards zero traffic-related fatalities, and places a special emphasis on safety for vulnerable road users including bicyclists. In the six year period between 2007 and 2012 there were an average of 500 collisions involving bicycle users and motor vehicles each year in the City of Vancouver. Collisions involving bicycle users over this period made up 1% of all reported collisions involving motor vehicles in Vancouver (see **Figure 1**); however, this 1% of all collisions translates to 4% of all traffic-related fatalities (see **Figure 2**). In total, vulnerable road users, accounted for 80% of traffic-related fatalities in the City. By taking evidence-based measures to improve safety with a specific emphasis on vulnerable road users, it is anticipated that the City will make significant progress in improving overall road safety.

The overall number of reported collisions involving bicycle users and motor vehicles in Vancouver has been relatively stable on an annual basis over the past fifteen years and beyond (see **Figure 3**); however, this has occurred despite a significant increase in the City's population as well as the number of bicycle trips made over this period. As a result, the rate of cycling collisions in Vancouver has been steadily declining over the past fifteen years. In fact, the annual cycling collision rate in Vancouver decreased by approximately 59% between 1996 and 2012, from approximately 48 to 20 reported cycling collisions per million bicycle trips (see **Figure 4**). This decrease has occurred at the same time as the City has invested in cycling infrastructure that is comfortable for people of all ages and abilities.

This trend in Vancouver supports the "safety in numbers" principle. Safety in numbers refers to a phenomenon that as the proportion of trips by bicycle increases, the cycling fatality rates decrease. This has been observed by researchers in a number of cities with a high bicycle mode share. The evidence suggests that as levels of cycling increase, cycling injury and fatality rates per-trip and per-kilometre travelled decrease substantially. Safety in Numbers has been documented in studies from California, Australia, and Europe and supports the theory that if there are increases to participation in cycling, there are returns in terms of increased safety. The Cycling Safety Study also examined Vancouver's cycling safety record in relation to the fifty largest North American cities, including 44

American and six Canadian cities. In comparison to other North American cities, Vancouver has the lowest cycling fatality rate among (0.07 cycling fatalities per million annual bicycle trips), despite having one of North America's highest cycling mode shares (see **Figure 5**). The analysis found that North American cities with the highest level of bicycle mode share have some of the lowest average bicycle fatalities per million bicycle to work trips. This demonstrates that providing high quality bicycle infrastructure that is comfortable for people of all ages and abilities can help increase the number of bicycle users, which can in turn lead to safety in numbers and improve cycling safety.

In addition to these general trends, the Cycling Safety Study identified specific cycling safety issues and developed an evidence-based action plan to address these issues in order to realize safety benefits. The study included a comprehensive literature review and case study interviews to compile evidence regarding the safety benefits anticipated from different types of bicycle infrastructure, as well as a comprehensive analysis of cycling collisions and injury crashes in Vancouver to understand local cycling safety issues needing to be addressed. This led to the identification of twelve specific cycling safety issues in Vancouver:

- Key Issue 1 Doorings
- Key Issue 2 Conflict Zones
- Key Issue 3 Right Hooks
- Key Issue 4 Left Crosses
- Key Issue 5 Sidewalk Cycling
- Key Issue 6 Two-way Stop Signs
- Key Issue 7 Non Motor Vehicle Collisions
- Key Issue 8 Collision Hotspots
- Key Issue 9 High Collision Locations
- Key Issue 10 Designated Bikeways
- Key Issue 11 PM Peak
- Key Issue 12 Adverse Weather and Low Light

A targeted action plan was then developed to improve cycling safety that identified anticipated safety benefits based on the literature review, case studies, and review of data. The action plan addresses these twelve cycling safety issues, including a description of each issue as well as engineering, education and enforcement countermeasures recommended to address each issue. A summary of the engineering, education, and enforcement countermeasures that were identified to address each of these cycling safety issues is presented in **Table 1.**

The study provided the City of Vancouver with detailed new insights into the nature of cyclist-involved collisions that are now helping to inform the design of better, safer bicycle facilities. The City is now actively moving forward with implementing the recommendations of the study. In doing so, it is anticipated that this will contribute to improving safety for cyclists as well as all road users by focusing on specific measures to reduce collision frequency at hotspot locations and by developing targeted strategies to address the most common types of cycling collisions. It is anticipated that this will help to reduce the frequency of cycling collisions, and will also help to reduce the severity of collisions in Vancouver by targeting vulnerable road users who are the most likely be killed or seriously injured when involved in a collision.

DEGREE OF INNOVATION

Cycling safety is an under-researched topic in North America and around the world. This is one of the most comprehensive analyses of cycling collision data that has been conducted to date in North America, and provides a critical, evidence-based safety rationale to improve cycling infrastructure throughout the City. This study involved complex, and in-depth data analysis of nearly 3,000 individual collision records as well as injury data.

This analysis included a series of innovative Geographic Information Systems (GIS) analyses to understand the spatial distribution of reported cycling collisions and injury crashes. Heat maps were developed to graphically represent concentrations of reported cycling collisions and injuries (see **Figure 6**). Areas with higher collision concentrations are shown in red and indicate "hot spots" of cycling collision activity. As shown in this figure, there is a high concentration of collisions in the Downtown core and the Metro Core of Vancouver including Burrard Street, Main Street, 10th Avenue, Cypress Street, and Commercial Drive in particular.

In terms of collision data, the analysis included a detailed review and analysis of each individual collision record, and required the assembly, documentation, manipulation, and integration of a wide variety of datasets, including infrastructure, weather, lighting, and spatial data in addition to collision and injury data. This analysis allowed for an innovative approach to classifying each individual cycling collision to determine trends and to help identify situations that resulted in cycling collisions. The incident description field for each individual collision record was reviewed to determine the scenario that resulted in a collision based on the following six factors:

- **Collision location** (intersection, mid-block, alley, parking lot, and unknown locations);
- **Driver movement** (straight, left turn, right turn, passing, changing lanes, parking, opening door, and completing a U-turn);
- **Cycling movement** (straight, left turn, right turn, passing, changing lanes, and stopped);
- **Traffic control device** (traffic signal, half signal, stop sign (two-way or fourway), traffic circle, and crosswalk);
- **Cycling action** (bicycle user crossing with right of way, did not stop at stop sign, stopped waiting to cross, and cross against signal); and
- **Other characteristics** (travel direction, and riding on sidewalk).

The classification framework combined each of the possible results for each of these six factors, resulting in a total of 85 potential types of cycling collisions (see **Table 2**). Based on this classification, it was possible to determine the most common types of cycling collisions. The top ten types of reported cycling collisions accounted for 69% of all known collision types, while the top five accounted for 44%. The top types of reported cycling collisions are described below:

1. **Doorings:** Vehicle and bicycle user collided mid-block as vehicle door was opening (15.2% of reported cycling collisions).

2. **Conflict Zones:** Vehicle and bicycle user collided mid-block as the vehicle as entering or exiting an alley, parking lot, or driveway (10.7%).
3. **Right Hooks:** Vehicle turned right at a signal as bicycle user crossed at signal with right-of-way (6.5%).
4. **Sidewalk Riding:** Bicycle user was riding on the sidewalk prior to collision (6.1%, including 2.7% mid-block and 3.4% intersection).
5. **Mid-Block:** Vehicle and bicycle user collided while travelling in the same direction (5.7%).
6. **Left Cross:** Vehicle turned left at a signal while a bicycle user entered intersection with right-of-way (5.4%).
7. **Intersections:** Vehicle proceeded straight through a signal when right-of-way was unclear (5.2%).
8. **Traffic Circles:** Vehicle and bicycle user collided in an intersection with a traffic circle (4.9%).
9. **Left Cross (Stop Signs):** Vehicle turned left as a bicycle user crossed at two-way stop with right of way (4.6%).
10. **Two-Way Stops:** Vehicle went straight as bicycle user crossed at two-way stop with right-of-way (4.5%).

This innovative, systematic classification methodology is easily transferable and can be replicated for other communities in British Columbia and elsewhere wanting to obtain an understanding of cycling collisions and how to improve cycling safety.

This study was also innovative in that it included injury crash data, which provided additional insights into causes of cycling injuries, including those that did not involve motor vehicles. This was possible because the study brought together a team of both professional and academic expertise. In addition to a consulting team made up of bicycle planning and design specialists and road safety experts, our team included Dr. Kay Teschke and Dr. Meghan Winters from the Cycling in Cities Research Program at the University of British Columbia. This provided our team with expertise in all areas of cycling safety, and also allowed us to include additional data sets to investigate cycling injuries based on hospitalization data. In addition to the collision data, the study analyzed the injury data from bicycling crashes that resulted in treatment at a hospital emergency room in Vancouver in 2008 and 2009 from the Bicyclists' Injuries and Cycling Environment (BICE) study conducted through the University of British Columbia Cycling and Cities program.

The BICE data enabled the study to classify the types of cycling injury crashes. This analysis found that 37% of injury crashes were direct collisions with motor vehicles, and another 10% resulted from manoeuvres to avoid a motor vehicle collision (see **Figure 7**). Other collisions involved mainly infrastructure (e.g., bollards, furniture, curbs, fences, speed bumps, stairs) and surface features (bumps, potholes, gravel, leaves, train tracks, roots, icy or wet surfaces), although some crashes involved other cyclists, pedestrians or animals. This was a critical finding for this study that is important for all communities to understand. In short, this means that only just over a third (37%) of crashes that resulted in a cycling injury were the result of a direct collision with a motor vehicle. This is important because, in most communities, vehicle collision data is often the only source of available data, and safety assessments are often based on only this limited

information. This analysis helped shed light on the full range of reasons why cycling crashes occur, and led to specific recommendations to improve safety for those instances that do not just involve motor vehicles.

The study provided insight into the nature of cyclist-involved collisions that in some cases supported City staff's previous understanding of how, where and when these collisions were happening and in other cases provided new insight. The new insights include:

- Half of all bicycle collisions leading to hospital visits did not involve vehicles;
- Only 50% of collisions between bicycles and vehicles happen at intersections, less than previously thought;
- More than half of collisions happen on arterial streets;
- Where is was possible to determine, right-of-way was held by the cyclist in 93% of cases;
- Vehicle left and right turns contributed to more than one quarter of all collisions; and
- Car doors opening into bicycles are the leading cause of bicycle vehicle collisions.

The new understanding City of Vancouver staff now have about the nature and contributing factors of collisions and injuries affecting cyclists will help them design better, safer bicycle facilities. Measures and approaches that staff have been using but will now receive higher priority as a result of this study include: protected bicycle lanes, particularly on busy commercial high streets; bicycle signals with vehicle turn lanes; pavement markings and green paint at lanes, driveways and intersections; improved visibility at intersections, lanes, and driveways; separation for people walking and people biking; and designing for slow cycling on Seawall and other paths.

In addition, new focusses leading from the study include: exploring more protected intersections; providing sufficient and consistent width on busy local street bikeways by revisiting parking regulations; and providing on-street bicycle facilities where sidewalk cycling is prevalent.

TRANSFERABILITY

The methodology and results of the Cycling Safety Study are replicable and transferable to other communities. The findings of the study also represent a significant advancement in our understanding of cyclist-involved collisions that can serve the transportation profession as a whole.

The study involved the development of an objective collision classification framework that can be replicated in other communities. This classification framework was based on an automated methodology using data that is typically available in collision datasets. With an automated, objective methodology, other communities can easily replicate this analysis, which could serve to add further insights by understanding how cycling collision patterns may be similar or vary in other communities.

In addition, the study includes a comprehensive, evidence-based action plan to improve cycling safety through a combination of education, engineering and enforcement

measures. The results of the analysis and recommendations in the action plan are also transferable to other communities and the transportation profession as a whole by providing a detailed evidence-based understanding of the nature of cycling-collisions, which can help to inform the design of better, safer cycling facilities in other communities.

The study also includes a toolkit describing the relative benefits and costs of a wide range of cycling safety countermeasures based on academic research and case studies (see **Table 3**). This toolkit, along with the findings of the analysis, are transferable to other Canadian communities that are working to improve safety for all road users, particularly vulnerable road users.

The results of this study will not only help the City of Vancouver work towards its target to have zero traffic-related fatalities, but also align with Canada's Road Safety Strategy 2025 and British Columbia's Road Safety Strategy. At a national level, the Cycling Safety Study focuses on safety improvements for vulnerable road users, which are a key target group under Canada's Road Safety Strategy. From a Provincial perspective, the Cycling Safety Study supports British Columbia's goal in its Road Safety Strategy to have the safest roads in North America by 2020. In line with the Vision Zero movement, the ultimate goal of the British Columbia Road Safety Strategy is to eliminate motor vehicle crash fatalities and serious injuries, and the strategy places a specific emphasis on vulnerable road users. The Cycling Safety Study directly aligns with and supports these municipal, provincial, and national road safety initiatives, and directly contributes to strengthening infrastructure elements in road safety by identifying engineering countermeasures that have been demonstrated to improve cycling safety, along with education and enforcement measures.

CONCLUSION

Concern for safety is one of the most important deterrents to increasing cycling. By conducting this project, the City is demonstrating its commitment to a sustainable transportation system and the high degree of importance placed on vulnerable road users in creating a safe, multi-modal transportation system. By focusing on targeted improvements to improve cycling safety, the City can help to make cycling more convenient, attractive, safe, and normal way to travel through the City. This project will help the City to achieve its targets related to increasing the mode share of sustainable transportation and reducing traffic related injuries and fatalities. This will, in turn, help the City achieve its goal of being the greenest city in the world by 2020 by having a safe transportation system for all road users. The Action Plan in the study provides a comprehensive, evidence-based toolkit to improve cycling safety through a combination of education, engineering and enforcement measures, and this toolkit can help other communities to improve road safety.

Figures

Figure 1
Reported Collisions in Vancouver by Road User (2007-2012)
Source: ICBC Collision Data (2007-2012)

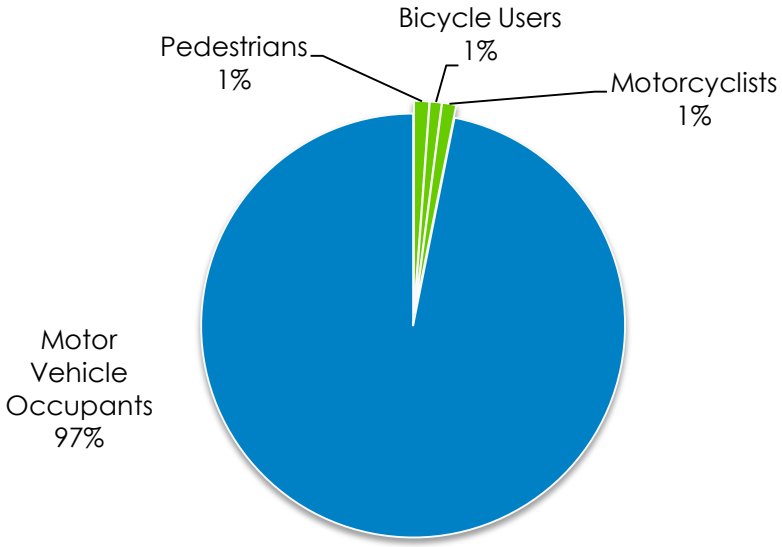


Figure 2
Reported Collisions Resulting in Fatality in Vancouver by Road User (2007-2012)
Source: Vancouver Police Department Traffic Fatality Data (2007-2012)

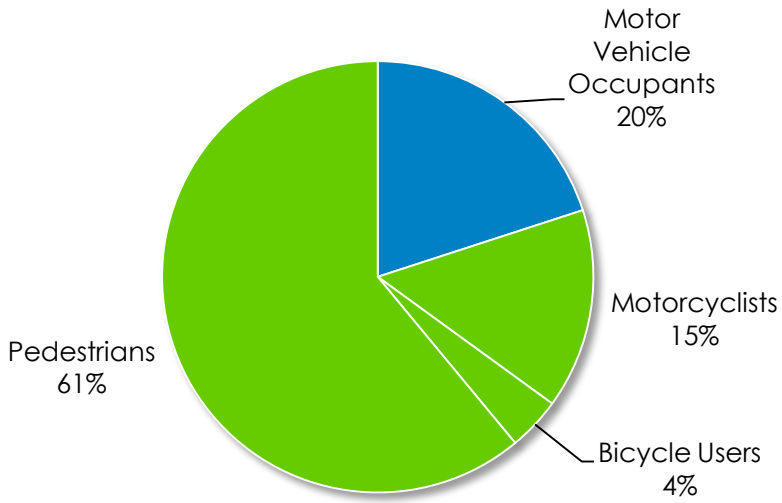


Figure 3
Annual Number of Reported Bicycle Collisions and Daily Bicycle Trips (1996-2012)
Source: ICBC Collision Data (1996-2012); TransLink Trip Diary (1994, 1999, 2004, 2008, 2011)

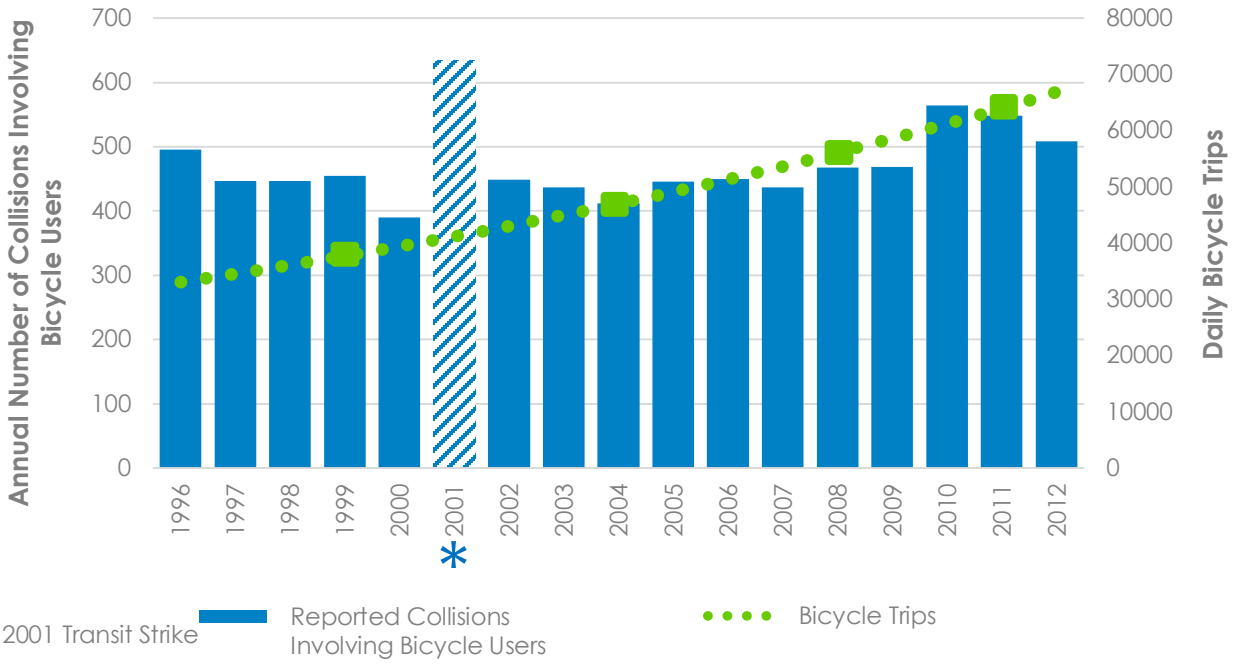


Figure 4
Cycling Collisions per Million Bicycle Trips (1996 – 2012)
Source: ICBC Collision Data (1996-2012), TransLink Trip Diary (1999, 2004, 2008, 2011)

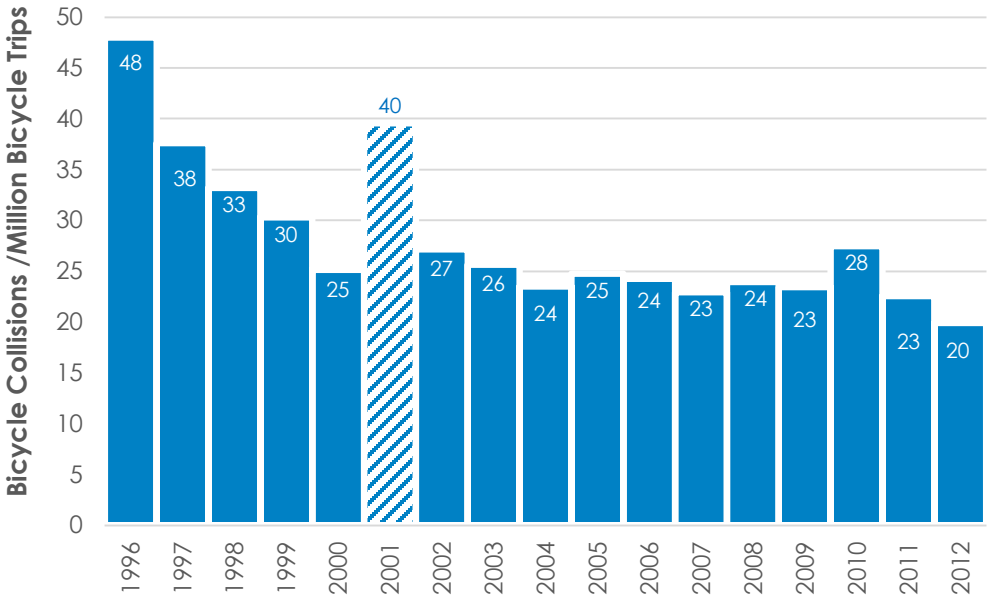


Figure 5
Bicycle Mode Share and Average Bicycle Fatalities per Million Bicycle to Work Trips Among Major North American Cities
Source: Information provided directly from Canadian Cities, American Cities: National Highway Traffic Safety Administration Fatality Data (2007-2012), Canadian and American Census information Statistics Canada, 2011, United States Census Bureau, 2012

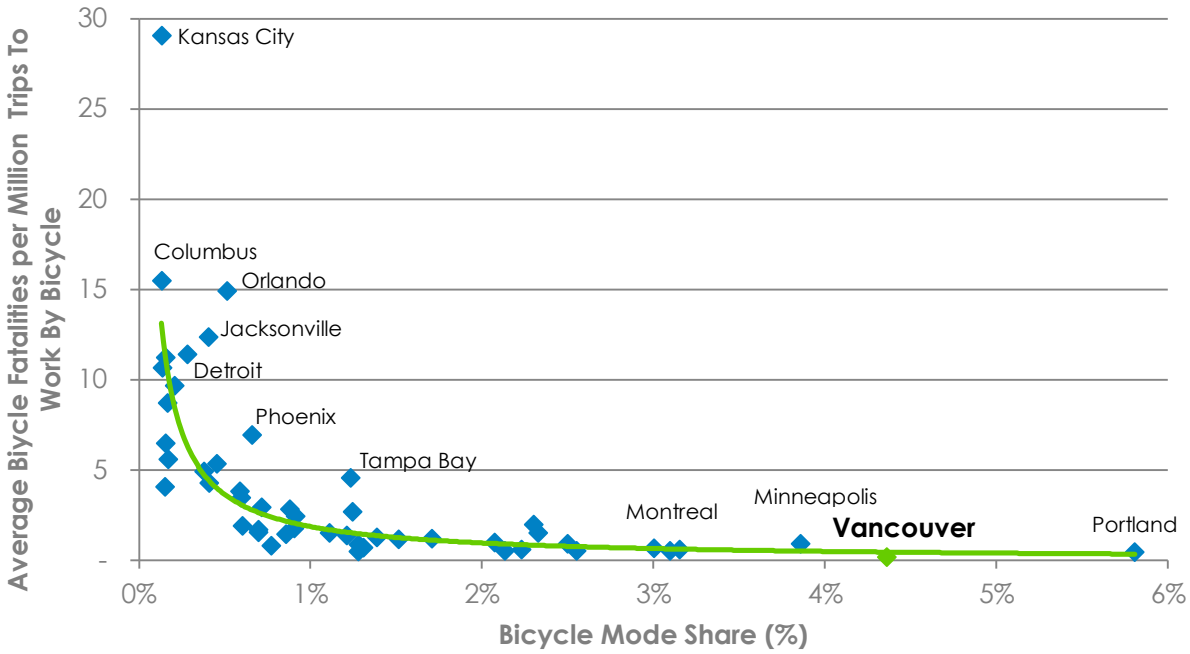


Figure 6
Concentration of Reported Cycling Collisions (2007-2012)
Source: ICBC Collision Data (2007-2012)

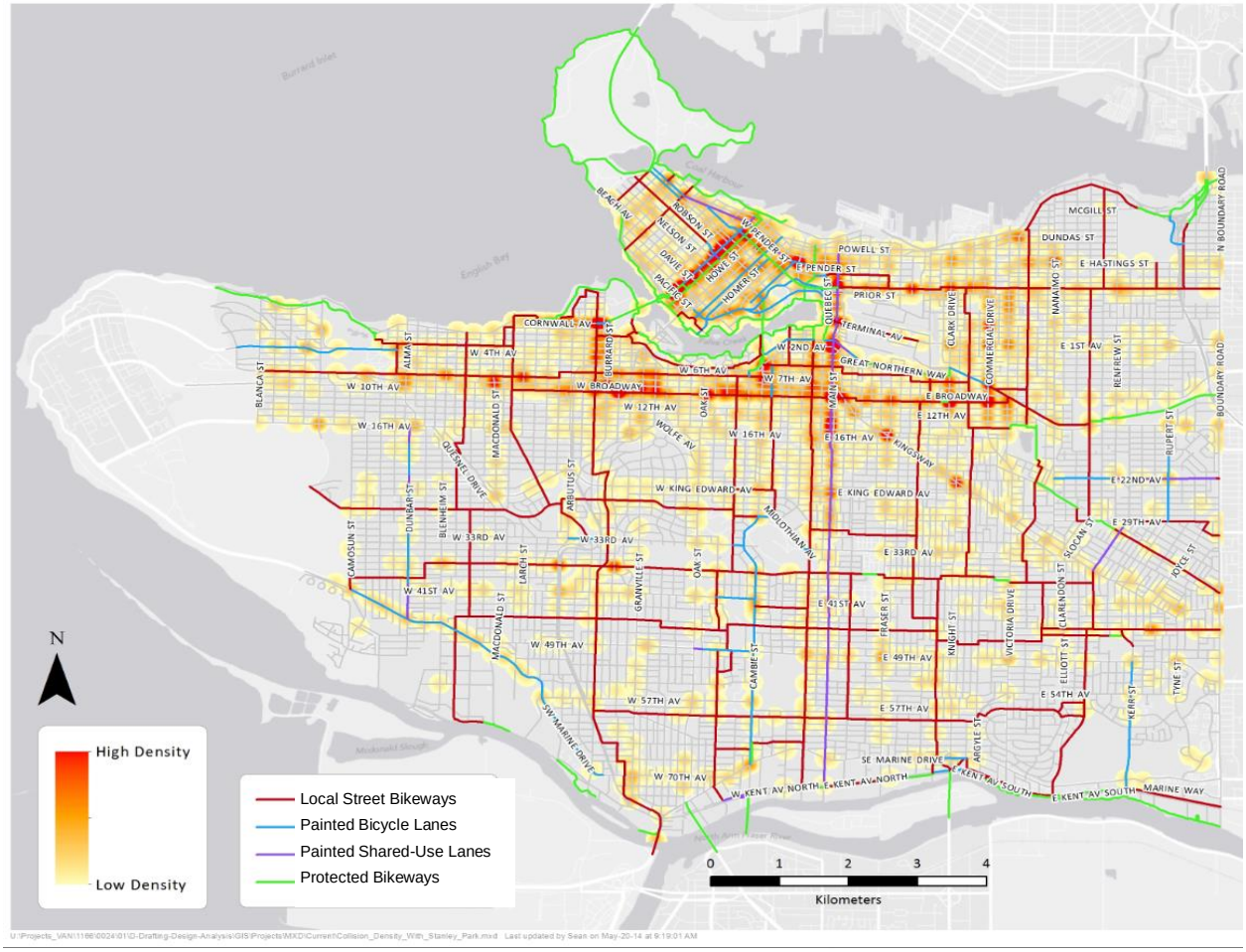
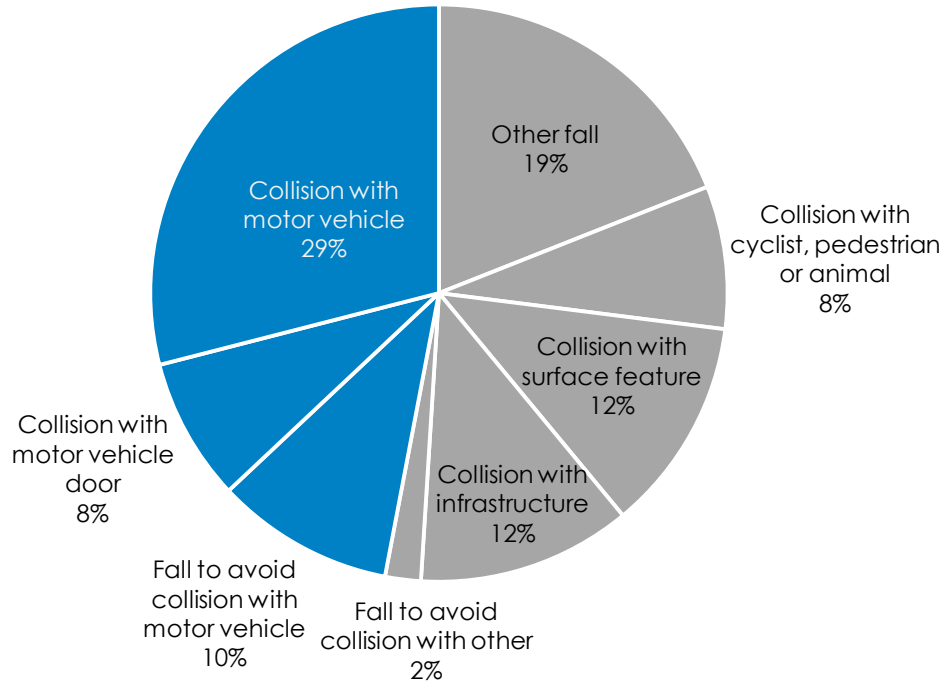


Figure 7
Types of Cycling injury Crashes (2008 – 2009)
Source: UBC BICE data, May 2008 – November 2009



Tables

Table 1
Summary of Engineering, Education, and Enforcement Countermeasures to Address Cycling Safety Issues

Action	Typical Application	Doorings	Conflict Zones	Right Hooks	Left Crosses	Sidewalk Cycling	Two-Way Stop Signs	Non Motor Vehicle Collisions	High Collision Locations	Bikeways	PM Peak	Adverse Weather and Low Light
Engineering												
Corridor Treatments												
Protected Bicycle Lanes	▪ Streets with higher traffic speeds and volumes and with identified cycling safety issues to provide physical separation.	✓				✓		✓		✓	✓	
Parking Protected Bicycle Lanes	▪ Streets with higher traffic speeds and volumes and with on-street parking. Located adjacent to the curb with motor vehicle parking located between the bicycle lane and the moving vehicles	✓				✓		✓		✓	✓	
Buffered Bicycle Lanes	▪ Streets with higher traffic speeds and volumes and with identified cycling safety issues to provide increased shy distance between moving vehicles or parked cars and the bicycle lane	✓				✓		✓		✓	✓	
Painted Bicycle Lanes	▪ Streets with moderate traffic speeds and volumes. Avoid placing next to on-street parking on the driver side of parked motor vehicles unless buffer can be provided.					✓		✓		✓	✓	
Off-Street Bicycle and Pedestrian Pathways	▪ Off-street pathways that provide separated facilities for bicycle users and pedestrians	✓	✓			✓		✓		✓	✓	
Off-Street Multi-Use Pathways	▪ Consider off road pathways that bicycle users and pedestrians share the space	✓	✓			✓		✓		✓	✓	
Local Street Bikeways	▪ Shared facilities on lower volume streets. Consider designated local street bikeways to provide routes parallel to arterials that have lower traffic volumes and speeds					✓		✓		✓	✓	
Shared Use Lanes	▪ Streets with moderate traffic speeds and volumes. Avoid placing next to on-street parking on the driver side of parked motor vehicles unless buffer can be provided. Generally not recommended.											
Intersection Treatments												
Full Traffic Signal	▪ Install at half signal intersections with a high number of collisions						✓		✓		✓	
Dedicated Pedestrian and Bicycle Signal	▪ New dedicated bicycle signals at high collision intersections to allow bicycle users to clear the intersection separate from other vehicles.				✓		✓		✓		✓	
Bicycle Activated Signal	▪ Install at intersections where local roads and arterial roads intersect						✓		✓		✓	
Signal Timing	▪ Adjust signal timing to minimize cycling delay ▪ Coordinate signal timing to reduce vehicle speeds ▪ Provide separate phasing plans to provide additional cycling time at select intersections during the PM peak period			✓	✓		✓		✓		✓	
Coloured Conflict Zone Markings	▪ Use green coloured conflict zone markings that denote areas where conflict between vehicles and bicycle users		✓	✓	✓				✓		✓	
Bike Box/Advance Stop Lines	▪ Treat high collision intersections with bike boxes and advance stop lines that provided dedicated spaces for bicycle users to wait and have a head start at intersections			✓	✓				✓		✓	

Action	Typical Application	Doorings	Conflict Zones	Right Hooks	Left Crosses	Sidewalk Cycling	Two-Way Stop Signs	Non Motor Vehicle Collisions	High Collision Locations	Bikeways	PM Peak	Adverse Weather and Low Light
Launch Pad/ Two-Stage Left Turn	▪ Install facilities that allow bicycle users to make left turns from a protected bicycle lane to move through the intersection and compete the left turn more efficiently and safely				✓				✓		✓	
Median Refuge	▪ Providing a refuge space in the median that provides a space for bicycle users to wait for traffic to clear								✓		✓	
Protected Intersection	▪ Provides a protection for bicycle users riding on cycle tracks as they enter an intersection			✓	✓				✓		✓	
Raised Crossings	▪ Provide a raised speed hump that also functions as a crossing, slowing down vehicles as they approach the hump.			✓							✓	
Traffic Calming												
Median Barriers	▪ Consider installing median barriers to limit left turn movements particularly at locations where there are a high number of left turn movements into driveways.								✓		✓	
Diverters	▪ Consider to restrict vehicle assess while allowing travel by other road users								✓		✓	
Curb Extensions	▪ Consider to calm traffic and make road users more visible			✓					✓			
Road Closures	▪ Consider closing roads for motor vehicle traffic								✓			
Traffic Circles	▪ Install traffic circles instead of 2-way and 4 way stops to slow traffic while maintaining some flow						✓		✓			
2-Way Stop	▪ Consider converting a 4-way or traffic circle into a 2-way stop if the volume on one road is much higher than the other.								✓			
Parking Removal	▪ Consider removing on street parking on corridors where there is a high number of doorings and collisions resulting from entering and exiting on street parking spots	✓								✓		

Action	Typical Application	Doorings	Conflict Zones	Right Hooks	Left Crosses	Sidewalk Cycling	Two-Way Stop Signs	Non Motor Vehicle Collisions	High Collision Locations	Bikeways	PM Peak	Adverse Weather and Low Light
Education and Encouragement												
Road Safety Awareness Campaigns	▪ Consider the following targeted road safety awareness campaigns: ▪ High collision arterials ▪ Encourage bicycle users to be safe and cautious road users ▪ Remind road users that most cycling collisions occur at intersections ▪ Remind road users to practice safe road use at all times of day, emphasizing the end of the day commute during the PM peak ▪ Encourage slow speeds on local streets ▪ Target young bicycle users and male bicycle users to make safe traffic decisions ▪ Target distracted driving ▪ Focus on promoting and teaching proper use of traffic circles and how to safely enter and exit ▪ Campaigns targeted at ensuring vehicle drivers open their door with caution when parking on street (sticker campaigns & in car reminders) ▪ Safety in Numbers Campaigns	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Operations and Maintenance												
Pothole Reporting Program	▪ Consider developing a pot hole reporting program on bike routes					✓		✓				
Regular Street clearing	▪ Ensure to regularly clear bike routes of debris, leaves, snow and ice					✓		✓				
Enforcement												
Right Turn on Red Restrictions	▪ Consider prohibiting and enforcing right turns on red at intersections with high numbers of bicycle user collisions with right turning vehicles									✓		
30 km/h Speed Limit Areas/Slow Zones	▪ Consider reducing speed limits in areas on local routes with a high number of collisions					✓	✓		✓	✓	✓	
Three foot passing space requirement	▪ Implement and enforce laws that require drivers to leave three feet of passing width between bicycle users and motor vehicles					✓			✓		✓	

Table 2
Cycling Collision Classification Methodology

No Collisions matching the description

Collisions that match the description were coded

Number	Classification Code	Location	Driver Movement	Cyclist Movement	Intersection (Signals)	Cyclist Action in Intersection	Collision Description
1	I1	Intersection			Traffic circle		Vehicle and cyclist collided in traffic circle
2	L1	Intersection	Left turn	Straight	2-Way Stop	Cross with right of way	Vehicle turns left at an intersection with a 2-Way Stop while the cyclist crossed with right of way
3	L2	Intersection	Left turn	Straight	2-Way Stop	Cross at crosswalk (permitted)	Vehicle turns left at an intersection with a 2-Way Stop while the cyclist crossed in crosswalk (permitted)
4	L3	Intersection	Left turn	Straight	2-Way Stop	Cross at crosswalk (not permitted)	Vehicle turns left at an intersection with a 2-Way Stop while the cyclist crossed in crosswalk (not permitted)
5	L4	Intersection	Left turn	Straight	2-Way Stop	Did not stop at stop sign	Vehicle turns left at an intersection with a 2-Way Stop while the cyclist did not stop at stop sign
6	L5	Intersection	Left turn	Straight	4-Way Stop	Cross with right of way	Vehicle turns left at an intersection with a 4-Way Stop while the cyclist crossed with right of way
7	L6	Intersection	Left turn	Straight	4-Way Stop	Cross at crosswalk (permitted)	Vehicle turns left at an intersection with a 4-Way Stop while the cyclist crossed in crosswalk (permitted)
8	L7	Intersection	Left turn	Straight	4-Way Stop	Cross at crosswalk (not permitted)	Vehicle turns left at an intersection with a 4-Way Stop while the cyclist crossed in crosswalk (not permitted)
9	L8	Intersection	Left turn	Straight	4-Way Stop	Did not stop at stop sign	Vehicle turns left at an intersection with a 4-Way Stop while the cyclist did not stop at stop sign
10	L9	Intersection	Left turn	Straight	4-Way Stop	Unknown	Vehicle turns left at an intersection with a 4-Way Stop, cyclist action in intersection is unclear
11	L10	Intersection	Left turn	Straight	Half Signal	Cross with signal	Vehicle turns left at an intersection with a Half-Signal while the cyclist crossed with right of way
12	L11	Intersection	Left turn	Straight	Half Signal	Cross at crosswalk (permitted)	Vehicle turns left at an intersection with a Half-Signal while the cyclist crossed in crosswalk (permitted)
13	L12	Intersection	Left turn	Straight	Half Signal	Cross at crosswalk (not permitted)	Vehicle turns left at an intersection with a Half-Signal while the cyclist crossed in crosswalk (not permitted)
14	L13	Intersection	Left turn	Straight	Half Signal	Cross against signal	Vehicle turns left at an intersection with a Half-Signal while the cyclist did not stop at red light
15	L14	Intersection	Left turn	Straight	Half Signal	Unknown	Vehicle turns left at an intersection with a Half-Signal, cyclist action in intersection is unclear
16	L15	Intersection	Left turn	Straight	Signal	Cross with signal	Vehicle turns left at an intersection with a Signal while the cyclist crossed with right-of-way
17	L16	Intersection	Left turn	Straight	Signal	Cross at crosswalk (permitted)	Vehicle turns left at an intersection with a Signal while the cyclist crossed in crosswalk (permitted)
18	L17	Intersection	Left turn	Straight	Signal	Cross at crosswalk (not permitted)	Vehicle turns left at an intersection with a Signal while the cyclist crossed in crosswalk (not permitted)
19	L18	Intersection	Left turn	Straight	Signal	Cross against signal	Vehicle turns left at an intersection with a Signal while the cyclist did not stop at red light
20	L19	Intersection	Left turn	Straight	Signal	Unknown	Vehicle turns left at an intersection with a Signal, cyclist action in intersection is unclear
21	L20	Intersection	Left turn	Left turn	Signal	Stopped waiting to turn left/Cross with signal	Vehicle and cyclist are both turning left and collide
22	L21	Intersection	Left turn		Unknown		Vehicle is turning left in intersection while cyclist action is unknown
23	L22	Intersection	Left turn	Right Turn		Cross with right of way	Vehicle is turning left in intersection while cyclist is turning right, head on collision
24	R1	Intersection	Right turn	Straight	2-Way Stop	Cross with right of way	Vehicle turns right at an intersection with a 2-Way Stop while the cyclist crossed with right of way
25	R2	Intersection	Right turn	Straight	2-Way Stop	Cross at crosswalk (permitted)	Vehicle turns right at an intersection with a 2-Way Stop while the cyclist crossed in crosswalk (permitted)
26	R3	Intersection	Right turn	Straight	2-Way Stop	Cross at crosswalk (not permitted)	Vehicle turns right at an intersection with a 2-Way Stop while the cyclist crossed in crosswalk (not permitted)
27	R4	Intersection	Right turn	Straight	2-Way Stop	Did not stop at stop sign	Vehicle turns right at an intersection with a 2-Way Stop while the cyclist did not stop at stop sign
28	R5	Intersection	Right turn	Straight	4-Way Stop	Cross with right of way	Vehicle turns right at an intersection with a 4-Way Stop while the cyclist crossed with right of way
29	R6	Intersection	Right turn	Straight	4-Way Stop	Cross at crosswalk (permitted)	Vehicle turns right at an intersection with a 4-Way Stop while the cyclist crossed in crosswalk (permitted)
30	R7	Intersection	Right turn	Straight	4-Way Stop	Cross at crosswalk (not permitted)	Vehicle turns right at an intersection with a 4-Way Stop while the cyclist crossed in crosswalk (not permitted)
31	R8	Intersection	Right turn	Straight	4-Way Stop	Did not stop at stop sign	Vehicle turns right at an intersection with a 4-Way Stop while the cyclist did not stop at stop sign
32	R9	Intersection	Right turn	Straight	4-Way Stop	Unknown	Vehicle turns right at an intersection with a 4-Way Stop, cyclist action in intersection is unclear

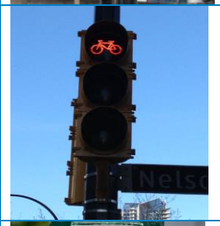
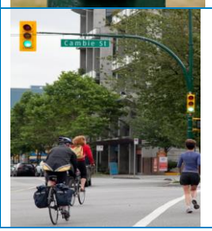
Number	Classification Code	Location	Driver Movement	Cyclist Movement	Intersection (Signals)	Cyclist Action in Intersection	Collision Description
33	R10	Intersection	Right turn	Straight	Half Signal	Cross with signal	Vehicle turns right at an intersection with a Half-Signal while the cyclist crossed with right of way
34	R11	Intersection	Right turn	Straight	Half Signal	Cross at crosswalk (permitted)	Vehicle turns right at an intersection with a Half-Signal while the cyclist crossed in crosswalk (permitted)
35	R12	Intersection	Right turn	Straight	Half Signal	Cross at crosswalk (not permitted)	Vehicle turns right at an intersection with a Half-Signal while the cyclist crossed in crosswalk (not permitted)
36	R13	Intersection	Right turn	Straight	Half Signal	Cross against signal	Vehicle turns right at an intersection with a Half-Signal while the cyclist did not stop at red light
37	R14	Intersection	Right turn	Straight	Half Signal	Unknown	Vehicle turns right at an intersection with a Half-Signal, cyclist action in intersection is unclear
38	R15	Intersection	Right turn	Straight	Signal	Cross with signal	Vehicle turns right at an intersection with a Signal while the cyclist crossed with right-of-way
39	R16	Intersection	Right turn	Straight	Signal	Cross at crosswalk (permitted)	Vehicle turns right at an intersection with a Signal while the cyclist crossed in crosswalk (permitted)
40	R17	Intersection	Right turn	Straight	Signal	Cross at crosswalk (not permitted)	Vehicle turns right at an intersection with a Signal while the cyclist crossed in crosswalk (not permitted)
41	R18	Intersection	Right turn	Straight	Signal	Cross against signal	Vehicle turns right at an intersection with a Signal while the cyclist did not stop at red light
42	R19	Intersection	Right turn	Straight	Signal	Unknown	Vehicle turns right at an intersection with a Signal, cyclist action in intersection is unclear
43	R20	Intersection	Right turn	Straight	Unknown		Vehicle turns right at an unknown intersection, cyclist action in intersection is unclear
44	R21	Intersection	Right turn	Other			Vehicle turns right at an intersection cyclist action is other
45	S1	Intersection	Straight	Straight	2-Way Stop	Cross with right of way	Vehicle crosses intersection with a 2-Way Stop while the cyclist crossed with right of way
46	S2	Intersection	Straight	Straight	2-Way Stop	Cross at crosswalk (permitted)	Vehicle crosses intersection with a 2-Way Stop while the cyclist crossed in crosswalk (permitted)
47	S3	Intersection	Straight	Straight	2-Way Stop	Cross at crosswalk (not permitted)	Vehicle crosses intersection with a 2-Way Stop while the cyclist crossed in crosswalk (not permitted)
48	S4	Intersection	Straight	Straight	2-Way Stop	Did not stop at stop sign	Vehicle crosses intersection with a 2-Way Stop while the cyclist did not stop at stop sign
49	S5	Intersection	Straight	Straight	4-Way Stop	Cross with right of way	Vehicle crosses intersection with a 4-Way Stop while the cyclist crossed with right of way
50	S6	Intersection	Straight	Straight	4-Way Stop	Cross at crosswalk (permitted)	Vehicle crosses intersection with a 4-Way Stop while the cyclist crossed in crosswalk (permitted)
51	S7	Intersection	Straight	Straight	4-Way Stop	Cross at crosswalk (not permitted)	Vehicle crosses intersection with a 4-Way Stop while the cyclist crossed in crosswalk (not permitted)
52	S8	Intersection	Straight	Straight	4-Way Stop	Did not stop at stop sign	Vehicle crosses intersection with a 4-Way Stop while the cyclist did not stop at stop sign
53	S9	Intersection	Straight	Straight	4-Way Stop	Unknown	Vehicle crosses intersection with a 4-Way Stop, cyclist action in intersection is unclear
54	S10	Intersection	Straight	Straight	Half Signal	Cross with signal	Vehicle crosses intersection with a Half-Signal while the cyclist crossed with right of way
55	S11	Intersection	Straight	Straight	Half Signal	Cross at crosswalk (permitted)	Vehicle crosses intersection with a Half-Signal while the cyclist crossed in crosswalk (permitted)
56	S12	Intersection	Straight	Straight	Half Signal	Cross at crosswalk (not permitted)	Vehicle crosses intersection with a Half-Signal while the cyclist crossed in crosswalk (not permitted)
57	S13	Intersection	Straight	Straight	Half Signal	Cross against signal	Vehicle crosses intersection with a Half-Signal while the cyclist did not stop at red light
58	S14	Intersection	Straight	Straight	Half Signal	Unknown	Vehicle crosses intersection with a Half-Signal, cyclist action in intersection is unclear
59	S15	Intersection	Straight	Straight	Signal	Cross with signal	Vehicle crosses intersection with a Signal while the cyclist crossed with right-of-way
60	S16	Intersection	Straight	Straight	Signal	Cross at crosswalk (permitted)	Vehicle crosses intersection with a Signal while the cyclist crossed in crosswalk (permitted)
61	S17	Intersection	Straight	Straight	Signal	Cross at crosswalk (not permitted)	Vehicle crosses intersection with a Signal while the cyclist crossed in crosswalk (not permitted)
62	S18	Intersection	Straight	Straight	Signal	Cross against signal	Vehicle crosses intersection with a Signal while the cyclist did not stop at red light
63	S19	Intersection	Straight	Straight	Signal	Unknown	Vehicle crosses intersection with a Signal, cyclist action in intersection is unclear
64	S20	Intersection	Straight	Straight	Unknown		Vehicle and cyclist collide going straight in an unidentified intersection
65	S21	Intersection	Straight	Left turn			Vehicle crosses intersection while the cyclist turns left
66	S22	Intersection	Straight	Stopped			Vehicle collides with a cyclist that is not moving
67	S23	Intersection	U-turn				Vehicle and cyclist collide when vehicle is making a U-turn in an intersection

Number	Classification Code	Location	Driver Movement	Cyclist Movement	Intersection (Signals)	Cyclist Action in Intersection	Collision Description
68	S24	Intersection	Straight	Right Turn			Vehicle crosses intersection while the cyclist turns right
69	S25	Intersection	Lane Change	Straight			Vehicle hits cyclist while changing lanes in intersection
70	S26	Intersection	Passing				Vehicle and cyclist collide as a result of the vehicle passing the cyclist at the intersection
71	ST	Intersection	Stopped				Cyclist collides with stopped vehicle at intersection
72	STL	Intersection	Straight	Stopped - Left			Vehicle and cyclist collide when cyclist is stopped waiting to turn left
73	M1	Mid-Block	UTURN	Straight		Straight	Vehicle and cyclist collide mid block while doing a U-Turn
74	M2	Mid-Block	P- Leaving/ENTERING Parking Space			Straight	Vehicle and cyclist collide mid block as vehicle is leaving/entering an on street parking space
75	M3	Mid-Block	P- Opening Door			Straight	Vehicle and cyclist collide mid block as vehicle door is opening
76	M4	Mid-Block	ALLEY/PARKING LOT/GAS STATION			Straight	Vehicle and cyclist collide as entering/exiting an alley/parking lot/gas station mid block
77	M5	Mid-Block	PASSING			Straight	Vehicle and cyclist collide as a result of the vehicle passing the cyclist midblock
78	M6	Mid-Block	Lane Change			Straight	Vehicle hits a cyclist while changing lanes
79	M7	Mid-Block	Backing			Straight	Vehicle and cyclist collide as vehicle is backing up mid block
80	M8	Mid-Block	Parked			Straight	Cyclist collides with parked car mid block
81	M9	Mid-Block	Other			Straight	Other incident occurs mid block
82	D1	Parking Lot					Vehicle and cyclist collide in a parking lot
83	D2	ALLEY					Vehicle and cyclist collide in an alleyway
84	O1	Other					Other
85	O2	Unknown					Cyclist or vehicle action is not known

Table 3
Cycling Safety Toolbox

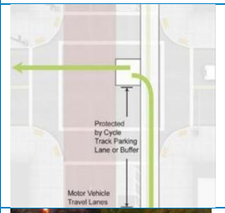
Treatment	Photo	Description	Application Guidance	Benefits	Cost	Relative Effectiveness for Cyclist Safety
Separated Bicycle Lanes		Often referred to as a cycle track they are on street facilities physically separated from moving vehicles on road and separated from pedestrians on the sidewalk.	• Considered on streets with high traffic volumes and speeds • May be one-way or two-way • Can be located at street or sidewalk level • Designated by some form of physical separation (planters, curbs, parking or bollards) • Ideally located on streets with few driveways and alleyways	• Offer protection from moving vehicles • Increases feelings of safety and comfort • Encourages cyclists to use on-street facilities as opposed to sidewalks • Provide cyclists with a designated space on street but physically separated	High	High
Parking Protected Bicycle Lanes		The bicycle lane is located between the on-street parking and the curb. The parked vehicles act as a buffer for the cyclists from moving traffic. An added buffer between the parked vehicles and the bicycle lane protect cyclists from doorings.	• Considered on streets with moderate traffic volumes and speeds and on-street parking • Buffer denoted by an interior of diagonal cross hatching or chevron markings • Makes use of existing pavement and drainage • On routes where there is short term, metered parking	• Parked cars act as a barrier from moving vehicles • Offer increased protection from doorings • Increase feelings of route safety and comfort	Low	High
Buffered Bicycle Lane		A buffered bicycle lane is a conventional painted bicycle lane with a painted buffer between cyclists and moving vehicles or parked vehicles or both.	• Considered anywhere a bicycle lane is being constructed • On streets with high traffic speeds and volumes • Where road width permits • Buffer should be at least 0.6 metres in width[i]	• Can provide an increased sense of comfort • Offers more space for cyclists to manoeuver around other road users and parked vehicles • Provide space for bicyclists to pass other cyclists • Increase comfort for bicyclists of all ages and abilities	Low	Moderate
Painted Bicycle Lane		A space designated by a painted line and a bicycle symbol indicates that the space is designated for bicycles. Can be located on the left or right side of the lane.	• Considered on streets with moderate traffic volumes and speeds • On streets with transit vehicles • Ideal width >1.5 metres • Markings denoting that space is used for bicycles (bicycle symbol and arrow markings) • Marked by a solid white line [ii]	• Indicate that the space is designated for cyclist use • Increase rider comfort and confidence • Increase cyclist visibility	Low	Moderate

Treatment	Photo	Description	Application Guidance	Benefits	Cost	Relative Effectiveness for Cyclist Safety
Separated Bicycle and Pedestrian Pathways		Off street pathways that provide separation between pedestrians and cyclists.	• Install on pathways that are used heavily by pedestrians and cyclists • Where space is available to provide facilities to accommodate both modes separately • If there is adequate space, for two direction use or one way only facilities	• Separated from the street and moving vehicles • Provide separated and designated spaces for pedestrians and cyclists • Safer for both pedestrians and cyclists, reduces conflict and interaction between the two modes • Is the facility that makes cyclists feel the most comfortable	High	High
Multi-Use Pathway		Off-street pathway where pedestrians and cyclists and other users use a shared travel space.	• Install where space is provided to allow for adequate two direction use or one way only facilities	• Separated from the street and moving vehicles • Provide separated and designated spaces for pedestrians and cyclists without interaction with motorized vehicles	High	Medium
Local Street Bikeways		Located on local streets with lower traffic volumes designated as routes for cyclists. Often have been traffic calmed and are located parallel to a major arterial route providing an alternative route for cyclists.	• Should still provide direct access to destinations • Easy to locate follow (signage) • Incorporate design features to slow vehicle speed and volumes • Provide safe and convenient crossings at intersections	• Traffic calming on local street bikeways reduces vehicle speeds, which allows vehicles more time to notice cyclists and reduces injury severity when crashes do occur. • Traffic calming and diversion reduces vehicle volumes on local street bikeways, reducing potential conflicts between motorists and cyclists.	Moderate	Moderate
Shared Use Lanes		Often denoted by the use of sharrow markings to indicate that this is a shared space. Bicycles and motorists have to share the lane.	• Often located on roads too narrow for bicycle lanes • Requires signage and street markings • Ideally located on streets with low traffic volumes and speeds	• Reinforce the legitimacy and position of cyclists on the street and within the lane • Makes motorists more aware of the presence of cyclists • Provides more guidance for cyclists to pass parked cars • Requires no additional street space	Low	Low

Treatment	Photo	Description	Application Guidance	Benefits	Cost	Relative Effectiveness for Cyclist Safety
Full Traffic Signal		Install a full traffic signal at high collision intersections and intersections with high cyclist volumes.	• Install at intersections with high volumes of vehicle travel • Where collisions are frequent with existing intersection control	• Provides better control of all vehicle movements	High	High
Dedicated Bicycle Signal		Bicycle signals provide cyclists with their own signal to indicate when it is safe to enter an intersection without conflict from other vehicles attempting to make movements in the intersection.	• Locate at intersections with high turning volumes where cyclist demand is high • Split signal phases at intersections where a frequent bicycle movement conflicts with a common vehicle movement • Use at complex intersections	• Separates bicycle movements from conflicting motor vehicles and pedestrians • Provides priority bicycle and bicycle only movements • Protects cyclists in intersections	Moderate	High
Cyclist and Pedestrian Activated Signals		Cyclist activated signals are used to assist cyclists in crossing major streets in areas where there is high cyclist demand, but where a full traffic signal is not warranted.	• Higher speed/volume roadways at mid-block locations or at unsignalized intersections where cyclist crossing demand is high and distant from an existing signalized crossing	• Provides a signal-protected cyclist crossing phase. • Possibly reduces the delay for vehicles travelling on the minor streets compared to a full signal • Improves cyclist safety	Moderate	High
Signal Timing		Adjusting the timing of signals for cyclists can reduce wait times for cyclists at intersections.	• Install at intersections with high volumes of vehicle travel	• Reduces cyclists from being tempted to cross against the signal due to long wait times • Allows for better trip flow for cyclists	Moderate	Moderate

Treatment	Photo	Description	Application Guidance	Benefits	Cost	Relative Effectiveness for Cyclist Safety

Protected Intersections		A combination of bicycle signal phases and design elements and space allocation that help protect cyclists from turning cars	• There are four main elements to protected intersection design
			  ○ A corner refuge island
			  ○ A forward stop bar for bicyclists
			  ○ A setback bike and pedestrian crossing
			• Bicycle friendly phasing
				• Makes cyclist more visible to turning vehicles
				• Provides protected space for cyclists at intersections
				• Changes to signal timing provide cyclists with the time to clear the intersection
					High	High

Launch Pad/ Two-Stage Left Turn		Allows cyclists to make a left turn from by continuing through the intersection to a location that sets them up to safely wait to cross the intersection.	• Use to ease left hand turns from separated bicycle lanes • Areas where there is heavy bicycle traffic and high volumes of left turn movements by cyclists	• Allows for efficient left turns from separated bicycle facilities as opposed to having to get off their bike and cross via a crosswalk • Provides safer options for cyclists • Reduces conflict between cyclists and pedestrians and motorists	Low	Moderate
Coloured Conflict Zone Markings		In the City of Vancouver Green marking have been used to designate conflict zones and areas where cyclists are travelling. They provide visual reminder of the presence of cyclists.	• Different types of material available including paint, Durable Liquid Pavement Markings (DLPM), Thermoplastic and coloured asphalt • Thermoplastic recommended by NACTO for spot improvements, DLPM for corridors	• Are used to identify conflict areas including intersections, driveways, and other areas where interaction between road users is high and conflict has or is likely to occur • Improve cyclist safety and driver awareness • Increase visibility of cyclists on the road	Low	Moderate
Bike Box and Advance Stop Lines		Provide a space for cyclists to wait to cross the intersection. They are often located in advance of the automobile stop line and provide the cyclists a "head start".	• Install at signalized intersections with high volumes of bicycle and motor vehicles • Where there are right or left hand turning conflicts • Where there are a lot of cyclists turning left • Pavement markings and signage required	• Helps reduce right hook conflicts • Facilitates transition from right side to left side of the bike lane • Often provide cyclists with a head start into the intersection • Allow the cyclist to make turning movements more obvious to other road users	Low	Low

Treatment	Photo	Description	Application Guidance	Benefits	Cost	Relative Effectiveness for Cyclist Safety
Median Refuge		Provides a space in the middle of the road (median) for cyclists to cross one direction of traffic and wait until there is a clearing to cross the intersection.	• Use on high speed and volume arterial routes where there is high cyclist crossing demand • Often used on roads with four or more lanes • Used near bus stops, schools, and other key destinations • Where local street bikeways cross arterial roads	• Cyclists can cross one direction of traffic at a time • Shortens the crossing distance	Moderate	Low
Grade Separated Crossing		Allows cyclists to cross major streets and intersections separated from other road users. Often via an underpass or overpass.	• Recommended over major roadways including highways and major arterials routes • Midblock crossings	• Provide a crossing of a major street or intersection • Cyclist and pedestrian crossings will have no delay on vehicle movements • Less wait times for cyclists	High	High
Median Barriers		Prevent vehicles from making certain movements, often used to limit turning and through movements of motorized vehicles. Median barriers are a form of traffic diversion.	• Install at intersections where an arterial and local road intersect • Use to lower traffic volumes on a local road • Often used at intersections where the local road is adjacent to a school, or other recreational facilities	• Limit turning movements of vehicles can increase the safety of cyclists traveling in the opposite direction • Reduces traffic volumes on certain local streets, such as those with a local street bikeway or destinations that encourage cycling	Moderate	Moderate
Diverters		Similar to median barriers noted above diverters prevent motorized vehicles from entering certain streets or restrict certain movements while permitting cyclists.	• Install on roads that are designated as bicycle routes, particularly local street bikeways • Use to lower traffic volumes on a local road	• Reduces vehicle volumes while still permitting cyclists to travel through • Reduces traffic volumes on certain local streets, such as those with a local street bikeway or destinations that encourage cycling	Moderate	Moderate

Treatment	Photo	Description	Application Guidance	Benefits	Cost	Relative Effectiveness for Cyclist Safety
Curb Extensions		Curb extensions are an extension of the curb into the parking lane at intersections to reduce speeds and increase the visibility of road users and shorten crossing distances.	• Where there is a full-time on-street parking lane • Where bicycles will travel outside of the curb edge for the length of the streets • Design should ensure adequate drainage	• Reduces speed of turning vehicles • Makes road users more visible	Moderate	Low
Traffic Circles		Often referred to as a roundabout, there is a raised island located in the centre of an intersection. Vehicles travel around the circle to complete turning movements.	• Use on local streets to help reduce vehicle speeds • Use in place of stops to give cyclists unimpeded travel •	• Can be used to slow traffic while allowing for better flow and traffic movement • Reduces possible conflict at intersections • Right of way is given to vehicles in the traffic circle	Moderate	Low
Road Closures		Closing a road to motorized vehicles can create routes that are designed specifically for cyclists and pedestrians. Can be a temporary or permanent option.	• Use on roads where there is a focus on increasing active transportation modes • Local or special roads with high pedestrian and cyclist volumes	• Reduces all conflict between cyclists and motorized vehicles • Creates a shared space with pedestrians	High	High
2-Way Stop		Two way stops at intersections give one road the right of way at all times and travelers on the other road must stop and wait for a break in traffic before they are able to cross.	• Use when one road that crosses the intersection has significantly higher traffic volumes (including cyclists) •	• Vehicles travelling on the street without the stop sign do not have to stop as frequently.	Low	Low
Parking Removal		Limit or remove on-street parking on streets with bicycle facilities or high volumes of bicycle travel.	• Consider removing parking on streets with high volumes of vehicle and bicycle traffic • Use on routes with a high occurrence of doorings	• Promotes cyclist safety by decreasing the chances of doorings and vehicles entering and exiting on street parking spaces	Low	High

Treatment	Photo	Description	Application Guidance	Benefits	Cost	Relative Effectiveness for Cyclist Safety
Separated vs. Mixed Modes		Roadways that mix modes allow for the shared use of space by motor vehicles, pedestrians, and bicyclists, without lane assignment. There generally are no sidewalks or other features to separate modes and these roadways usually have lower posted speed limits.	• Special consideration should be given to ensure there are cues that demarcate the travel way for visually impaired pedestrians. • Cyclists need to recognize that the space is shared and extra care should be taken to watch of other road users	• Reduces motor vehicle travel speeds and volumes. • Increases bicycle/pedestrian activity. • Improves attractiveness of street. • Increases social activity amongst neighbours and children.	Moderate to High	Moderate
New or Upgraded Intersection Lighting		Increases the visibility of the intersection for motorists to see Vulnerable Road Users	▪ All signalized intersections. ▪ Intersections where cyclist volumes are high, especially during the night time.	• Increases visibility of cyclists.	Moderate	High

[i] National Association of Transportation Official Guidelines. (NACTO). NACTO Urban Bikeway Design Guide. http://nacto.org/cities-for-cycling/design-guide/ . (accessed 2014)

[ii] National Association of Transportation Official Guidelines. (NACTO). NACTO Urban Bikeway Design Guide. http://nacto.org/cities-for-cycling/design-guide/ . (accessed 2014)