SAFETY MEASURES FOR CYCLISTS AND PEDESTRIANS AROUND HEAVY VEHICLES

SUMMARY REPORT

Canada

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June 2018

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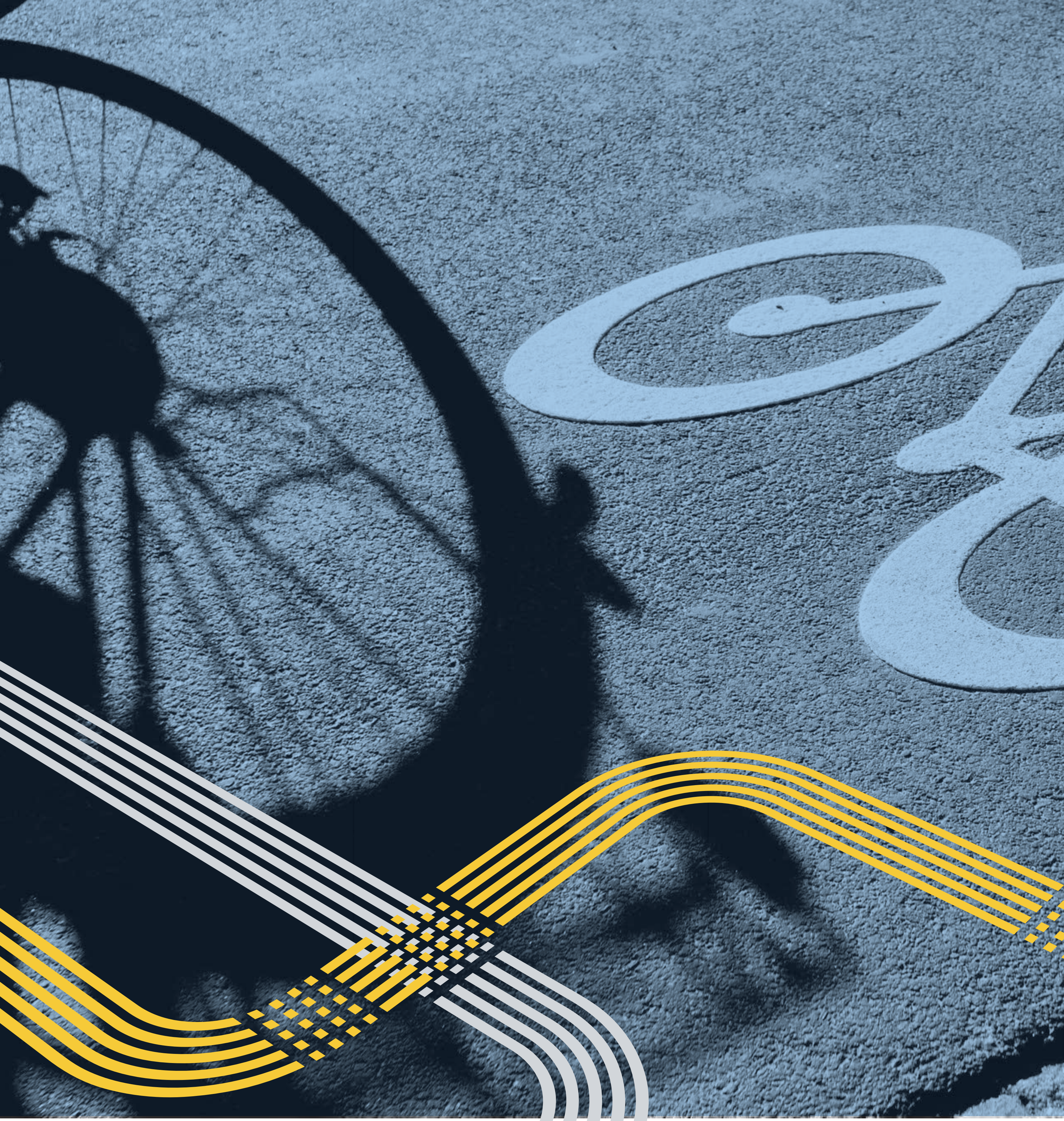

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FOREWORD

The way we live and move within our communities is changing how we look at mobility and road safety. While the focus of our interests may vary – from moving products and people to walking and cycling for pleasure – we all seek to live in communities that support our safety as pedestrians, cyclists and drivers. In addition, concerns about our environment means we are consistently seeing more pedestrians and cyclists on the road.

As a result, efforts to strengthen the safety of vulnerable road users (VRUs) are increasingly urgent. This is particularly true in urban settings where pedestrians and cyclists must share the road with heavy vehicles and buses.

In the fall of 2016, Canada's Ministers of Transportation mandated the creation of a task force to enable a collaborative process with provinces, territories and stakeholders to consider measures that could improve the safety of pedestrians and cyclists around heavy vehicles. The intent of this initiative was to create a springboard for action, spark ideas, and introduce discussion points to support jurisdictions as they effectively address safety challenges within their communities.

To support this process, the VRU Task Force worked with road safety experts and road user groups (drivers, cyclists and pedestrians), and consulted with communities across Canada in person and online.

The resulting summary report, *Safety Measures for Cyclists and Pedestrians around Heavy Vehicles*, captures findings that are presented as a series of safety measures and supporting evidence designed to protect both VRUs and heavy vehicle drivers. Of note, is the common thread that wove its way through our many discussions – *all* road users seek to operate in a safe space.

Since challenges differ across provinces and territories, this report has been designed as a reference tool and does not favour one safety measure over another. We anticipate its use by policy makers, infrastructure and/or program delivery managers, as well as planning authorities to consider what is most appropriate within their particular context or jurisdiction.

This report is an important first step in advancing further awareness while addressing the safety issues of vulnerable road users and heavy vehicles as they manoeuvre through our cities. We would like to take this opportunity to acknowledge the dedication and hard work of our expert Advisory Panel and Steering Committee members, as well as the advice and input provided by those who participated in Round Table Sessions and the Web Consultation Forum.

We look forward to the discussions, ideas, and potential pilot projects that may flow from this initial review process and to consider next steps as we all work together to strengthen road safety for all Canadians.

Shaun Hammond,
Steering Committee Co-Chair
Alberta Transportation

Michael DeJong,
Steering Committee Co-Chair
Transport Canada

ACKNOWLEDGEMENTS

The Steering Committee Co-Chairs, Shaun Hammond of Alberta Transportation and Michael DeJong of Transport Canada, would like to express their sincere appreciation and thanks to the following individuals for their hard work, insight, and unwavering commitment to this project.

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1.0 INTRODUCTION

PROJECT BACKGROUND, SCOPE AND GOVERNANCE

PROJECT BACKGROUND

Despite evolving technologies and infrastructure changes, heavy vehicles continue to pose a safety risk to vulnerable road users (VRUs). Consequently, in September 2016, a commitment to examine potential countermeasures to help protect the safety of cyclists and pedestrians was made during a *Council of Ministers of Transportation and Highway* Safety meeting.

While statistics do not indicate a large number of collisions between VRUs and heavy vehicles, the data do not show a reduction in these numbers from one year to the next. Although more jurisdictions promote complete transportation systems designed for all roads, there continues to be an increase in the number of users, including cyclists and pedestrians taking to the streets in all seasons thereby increasing the number of VRUs and additional conflicts with heavy vehicles. With this in mind, potential solutions are being examined in an attempt to address the increase in the number of conflicts and the resulting fatalities and injuries.

To encourage a collaborative and inclusive approach, Transport Canada and Alberta Transportation, working with the other provinces and territories, developed a project outline and invited a variety of representatives and stakeholders to participate. Since challenges facing VRUs and heavy vehicle drivers are broad and touch a diverse audience, including various levels of government, it was important to assemble participants with wide-ranging backgrounds and experience. This approach helped to ensure a balanced and enriched perspective.

SCOPE

For the purposes of this initiative, the ***scope of this project has been limited to cycling and pedestrian risks, defined as VRUs*** in and around large commercial vehicles, specifically buses or trucks over 4,500 kg.

This report addresses current and potential countermeasures that may reduce conflicts and the resulting fatalities and injuries among vulnerable road users (VRUs) (i.e., pedestrians and bicyclists) struck by heavy vehicles, including buses in urban areas. Urban rather than rural areas are the focus because statistically, the majority of VRU collisions with heavy vehicles take place within cities.

It is important to note that this report does not make any recommendations or favour one approach over another, as any such recommendation of one or more potential countermeasure(s) is outside the scope of this project.

GOVERNANCE STRUCTURE

The governance structure, designed to support project objectives and bring various stakeholders together, encompasses the following roles and responsibilities:

The **Steering Committee,** co-chaired by the Government of Alberta and Transport Canada, is comprised of individuals with decision-making authority with respect to the project, and assembled with representatives from Transport Canada, provincial/territorial governments and jurisdictions including the

Transportation Association of Canada (TAC) and the Federation of Canadian Municipalities (FCM). The Canadian Council of Motor Transport Administrators (CCMTA) has also agreed to participate. Although the Steering Committee itself reports to the Council of Deputy Ministers of Transportation and Highway Safety, the two co-chairs provide a centralized voice in overseeing and reporting on the project.

The role of the Committee is to manage the project schedule and provide strategic oversight. This oversight includes the exchange and review of advice and modal expertise provided by an Advisory Panel, overseeing and approving the public consultation process, and contributing to the development and presentation of reports to the *Council of Deputy Ministers* of *Transportation and Highway Safety*.

The **Advisory Panel** is made up of cycling, pedestrian and trucking advocates, functional experts in various areas related to heavy vehicles such as infrastructure and safety technology, experts in public awareness and educational groups, and representatives of federal/provincial/territorial/municipal jurisdictions.

The role of the Panel is to provide advice and expertise related to the safety of vulnerable road users when interacting with heavy vehicles. This group serves in an advisory capacity to the Steering Committee.

Under the direction and advice of the Steering Committee and Advisory Panel, a VRU team, composed of Transport Canada employees, provided secretariat support and assisted with the research, analyzed the comments and feedback, and consolidated supporting evidence, issues and barriers to create a comprehensive document for consideration by key stakeholders.

APPROACH AND METHODOLOGY

Following a review by the Advisory Panel, the methodology for this project was submitted to and approved by the Steering Committee. In addition, approval was obtained for the document list generated from an environmental scan and an Assessment Tool designed to capture the information on countermeasures during the research phase.

ENVIRONMENTAL SCAN

With the aid of the Advisory Panel, an environmental scan was conducted to determine the availability of reports and documentation addressing the interaction of heavy vehicles with pedestrians and cyclists, including the existence of supporting evidence. These documents were then compiled to produce a reading list of research literature.

DOCUMENT REVIEW AND DATA CAPTURE

The Advisory Panel was divided into three (3) sub-groups and assigned a number of documents from the reading list. Each sub-group reviewed the assigned literature, identified countermeasures and any evidence of their effectiveness. Given the number of documents on the reading list, the VRU Secretariat team also undertook part of the reading and followed the same methodology.

ASSESSMENT TOOL

An Assessment Tool (Annex I) was developed to capture data consistently, regardless of the countermeasure. The assessment tool included four sections to record the name of the countermeasure, the category and considerations, who the countermeasure was intended to affect, and the supporting evidence of its effectiveness, if available in the current list of documents. The resulting data were then consolidated into a list of countermeasures.

NOTE: *Every effort was made to obtain evidence on the effectiveness of countermeasures presented, with a focus on Canadian data. However, as many of the roadways and environmental factors in the U.S. can mirror Canadian conditions, U.S. evidence was also considered to be relevant for the purposes of this report. Furthermore, as Canada participates as a member of global road safety organizations, this report also references applicable international evidence.*

PROJECT PHASES

The first phase of the project involved identifying, compiling and organizing countermeasures found during the environmental scan. The first draft of the Summary Report presented those countermeasures for review and discussion by the Advisory Panel and Steering Committee.

Following their feedback and approval, attention was given to highlighting the evidence associated with each countermeasure based on the documentation reviewed to-date, and organizing countermeasures based on their relevance (Specific / vs Non-Specific) to the project's scope. (See Section 1.0 How this Report is Organized, below.)

Facilitated round table sessions, scheduled in Halifax, Montreal, Vancouver, and Toronto, provided local trucking, busing, cycling, pedestrian and other key stakeholders with an opportunity to offer input and feedback on the assembled countermeasures.

One-on-one targeted interviews were conducted to help ensure that the perspectives of under-represented stakeholder groups at the regional roundtable sessions were represented. These interviews helped to maintain the balance sought throughout the consultation process.

In addition**, public consultations** were conducted electronically via the internet, providing a mechanism for the general public to comment on the subject. News releases were used to promote the web site while individual e-mails targeted specific organizations inviting them to participate. The design allowed for easy navigation to review the report, respond to guided questions and interact with comments submitted by other participants earlier.

These various types of consultation sessions were designed to provide a forum for stakeholders across Canada to raise concerns and/or issues around countermeasures specific to them while ensuring a regional perspective was reflected in the project findings. They also helped to identify any gaps in the countermeasures listed, including any associated evidence, barriers and/or considerations.

Using the comments, the final Summary Report was adjusted and will be tabled in June 2018 for consideration by jurisdictions and key stakeholders. The co-chairs will continue to engage the Steering Committee and Advisory Panel on options to advance an evidence-based approach on VRU safety, which will be presented to jurisdictions in June 2018 and then to Deputy Ministers for consideration in September 2018.

HOW THIS REPORT IS ORGANIZED

This Summary Report has been organized to support the review and discussion of countermeasures. It has been divided into two key sections. In addition, the countermeasures listed are deliberately organized alphabetically to avoid any perception that one countermeasures is being prioritized or recommended over another.

Section 1.0 – Introduction

Section 2.0 – Road Safety Strategies, offers a summary of the overarching principles and philosophies associated with road safety. Typically, a variety of countermeasures are anchored in these strategies that can be applied to both heavy and other motor vehicles. The strategies are divided into two sub-sections:

- Global and National Road Safety Strategies
- Other Supporting Strategies

Section 3.0 – Countermeasures, is organized into eight sub-sections, based on their type, and further subdivided into two parts:

- **Part 1: Specific** includes those countermeasures that specifically address vulnerable road users and heavy vehicles;
- **Part II: Non-Specific** includes those countermeasures that address vulnerable road users and other motor vehicles, but the principles presented could also apply to heavy vehicles.

  Since most countermeasures can be applied to both heavy and other motor vehicles, you will notice that more countermeasures appear under Part II.

At the end of the report you will also find a List of References, along with the following Annexes:

- Annex I: Assessment Tool (used to gather data and information from documents reviewed)
- Annex II: List of Acronyms
- Annex III: List of Participating Organizations – Round Tables and Targeted Interviews
- Annex IV: Additional Resources
- Annex V: List of External Internet Links (provides the address, or url, to external internet pages where more information is available on an identified topic – look for this icon)

The report also includes an alphabetical Index to Countermeasures.

NOTE: *This report provides a listing of potential strategies and countermeasures that could be utilized to reduce serious injuries and fatalities when vulnerable road users come into conflict with heavy vehicles. However, it does not make any recommendations or favour one approach over another as the recommendation of any one or multiple potential countermeasures is outside the scope of this project.*

2.0 ROAD SAFETY STRATEGIES

Strategies can affect policies that are developed to promote the safety and health of VRUs. This section presents some examples of such road safety strategies.

Road safety strategies are designed to save lives and reduce injuries while promoting the mobility of people and merchandise. To achieve this objective, a successful road safety strategy will assess the situation; develop and implement evidence-based countermeasures drawing on best practices and emerging technologies; create and/or influence policy and education; build relationships among road safety participants; and monitor their impact. The latter includes forming partnerships with key stakeholders such as trucking organizations, safety advocacy groups, governments and other subject matter experts.

This holistic and integrated approach encourages the creation of a strategic framework that reflects a broad perspective encompassing the values of safety, quality of life and respect for the environment. For the purposes of this report, the identified strategies have been divided into three groups:

- Global and National Road Safety Strategies;
- Pedestrian and Bicyclist Safety Strategies;
- Other Supporting Strategies.

The first group of identified strategies have visions and principles that encompass road safety generally, while the second group are more specific to pedestrians and bicyclists. The third group lists supporting road safety strategies. Some strategies are well documented while others are only just emerging but each are addressed using the same format consisting of a description and links to additional references, as available.

SUSTAINABLE DEVELOPMENT GOALS

OVERVIEW

Sustainable Development Goals (SDGs); otherwise known as Global Goals, are a universal call to action by the United Nations to end poverty, protect the planet and ensure that all people enjoy peace and prosperity.

The 17 SDGs build on the successes of the Millennium Development Goals, while including new areas such as climate change, economic inequality, innovation, sustainable consumption, peace and justice, among other priorities. The SDGs highlight the need for safer roads and the creation of more sustainable and resilient communities. Goal 3, Target 3.6, specifically calls for a cut in road traffic deaths and injuries by half by 2020. Various other goals also strive to improve road safety by expanding public transportation, encouraging healthy transportation alternatives and paying closer attention to vulnerable demographic groups. The 17 goals are interconnected – often the key to success with respect to one will involve tackling issues more commonly associated with another.

The SDGs work in the spirit of partnership and pragmatism to make the right choices about how to improve life, in a sustainable way, for future generations. They provide clear guidelines and targets for all countries to adopt in accordance with their own priorities and the environmental challenges of the world at large.

ADDITIONAL REFERENCES

Sustainable Development Goals

Sustainable Development Knowledge Platform

OVERVIEW

The United Nations (UN) has developed a Global Plan for a Decade of Action for Road Safety from 2011 to 2020 with input from many global partners based on an extensive consultation process through meetings and the Internet. This Global Plan, which was approved by the UN General Assembly in 2010, provides an overall framework for activities that may take place in the context of the Decade. The categories or "pillars" of activities are:

- Building road safety management capacity;
- Improving the safety of road infrastructure and broader transport networks;
- Further developing the safety of vehicles, both in terms of crash avoidance and crashworthiness;
- Enhancing the behaviour of road users (e.g., speeding, impaired driving, distracted driving, vulnerable road users);
- Improving post-crash response (e.g., emergency measures).

Indicators have been developed to measure progress in each of these pillars. Periodic Global Status Reports on Road Safety have been published using these indicators to show where progress has been made in member countries. The Global Plan is led by the World Health Organization (WHO) in partnership with the UN Road Safety Collaboration, which includes governments, international agencies, non-governmental organizations, the private sector, and other stakeholders. Partners are invited to make use of the Plan as a guiding document for the events and activities that they will support as part of the Decade. In 2013, the WHO published the manual "Pedestrian safety: a road safety manual for decision-makers and practitioners" providing guidelines regarding how to improve the safety of pedestrians.

ADDITIONAL REFERENCES

Pedestrian Safety – A Road Safety Manual for Decision-Makers and Practitioners[1]

Global Status Report on Road Safety 2015

OVERVIEW

Vision Zero first appeared as a national traffic safety policy developed in Sweden. Launched in 1997, after being approved by Sweden's parliament, it adopts a radically different paradigm of traffic safety where the focus is on implementing failsafe roads and vehicles.[2] Rather than trying to change human behaviour to fit the system, *Vision Zero* changes the system to fit human behaviour. The "zero" refers to the target goal of zero deaths by 2020 in Sweden supporting the premise that "No loss of life is acceptable". However, some countries are seeking zero serious injuries as well (e.g., Canada). The policy itself is based on four elements: **ethics**, **responsibility**, a **philosophy of safety**, and **creating mechanisms for change**.

Working from the same premise, the Netherlands launched a similar initiative in 1998 called *Sustainable Safety*. The intent of this three-year program was to develop a safe and sustainable road traffic system with features that include an infrastructure adapted to take into account human limitations; use proper road designs; ensure vehicles are equipped with safety technology; and provide road users with adequate information and education so they will be deterred from engaging in undesirable or dangerous behaviour.

While other European countries have implemented this strategy during the late 1990s, Edmonton was the first Canadian city to officially adopt Vision Zero in 2015. Since then, other Canadian municipalities have joined the movement.

CONSIDERATIONS

Unlike other important *Vision Zero* strategies that require longer-term investments in infrastructure and culture change (both internally within city agencies and amongst the public), making relatively simple, inexpensive technology, policy, and training improvements with respect to large vehicles can be a quick and easy win for cities, including those in the early stages of implementing *Vision Zero*.
In most cases, cities, regional governments and transit providers have some degree of jurisdiction over their vehicles, whether in the form of contract agreements with vendors, procurement practices, or by operating and maintaining their own fleets. Early-adopter *Vision Zero* cities such as New York, Boston, Washington D.C., and San Francisco have experienced success in recent years, following cities in Europe, Asia, and Latin America that have documented safety improvements after implementing similar policies.[3]

ADDITIONAL REFERENCES

Vision Zero – Traffic Safety by Sweden

Vision Zero Canada

What is Vision Zero and How Can it Prevent Traffic Injuries and Fatalities

World Report on Road Traffic Injury Prevention

OVERVIEW

A *Safe System* Approach involves multiple strategies aimed at the road, the vehicle, and users involved. It provides a logical framework that examines these road safety elements and their interactions to enable practitioners to develop their thinking and understanding around risk and countermeasure possibilities. In short, this approach examines the whole road transportation system when seeking road safety improvements. It is often a companion strategy with Vision Zero or Sustainable Safety with the Safe System Approach providing the "How to" for achieving the goals of these strategies.

WHAT IS THE SAFE SYSTEM APPROACH?

The *Safe System* Approach is derived from the work of the Swedish Road Authority and road safety agencies in the Netherlands and has been adopted as the basis for road safety activity in Victoria, Australia, since 2003. It is also adopted across Australia in the current National Road Safety Action Plan.

As road users are human, crashes are always likely to happen even though there is a continuing focus on prevention. The Safe System Approach recognizes that there are limits to the capacity of the human body to survive collisions above certain speeds and impact types. It places a priority on systematically addressing major factors involved in specific crash types to achieve substantial road trauma reduction benefits over time.

The *Safe System* Approach aims to minimize the severity of injury and is based on the premise that road users should not die because of system failings. The basic premise for survivability is that when a five-star driver (obeying the law) is driving a five-star vehicle on a five-star road with a five-star speed limit for the crash risk on that section of road, then any road user in or outside the vehicle should not – if they or the driver make a simple mistake or error of judgement – be subjected to a crash of such severity that they lose their life or are seriously injured.

It assumes that:

- Crash analysis and ongoing development of better understanding of crash causes is a mainstream and continuing activity of road safety agencies;
- Adequate road rules to provide safe travel and the necessary enforcement of those rules in order to achieve high levels of road user compliance are in place;
- An adequate driver licensing system exists;
- An informed and aware community is very supportive of the measures required to achieve and maintain an increasingly safe road transport system.

It challenges "system designers" to achieve a balance in the 3 key factors of the physical network – the safety of the road infrastructure, road user behaviour (e.g., speeding, impaired driving, distraction, etc.), and the crash avoidance and crashworthiness safety features of vehicles in order to achieve safer conditions, which result in fewer fatalities and serious injuries.

However, it also anticipates that there are many other "system designers" – beyond the road and vehicle engineers – who impact the safe use of the network and who also carry a major responsibility for safer, survivable outcomes.

OVERVIEW

The *Complete Streets* movement emerged around 2005 in the United States. Although it is gaining technical, political and public importance in Canadian communities, to date it has received little attention at a national level.

Complete streets policies and practices integrate the needs of *all road users* (including those with disabilities) in right-of-way planning, design, construction, operation and maintenance. They are typically intended to ensure the appropriate consideration and accommodation of walking, bicycling and public transit, as well as the community environment.[4, 5]

CONSIDERATIONS

Transport Canada's *Complete Streets: Making Canada's roads safer for all* cites the experience of a variety of North American jurisdictions that have adopted, at least in part, a *Complete Streets* approach. The experience of these jurisdictions shows actual improvements related to reductions in fuel consumption, travel time, collisions and carbon monoxide emissions as a result of implementing the *Complete Streets* philosophy.

Municipalities may be concerned that adopting a *Complete Streets* approach will result in cost increases associated with infrastructure. Additionally, there may be opposition from various stakeholders expressing concern over the loss of parking, the ability to conveniently make deliveries, and other related issues.

A *Complete Streets* approach is not a "one size fits all" approach. Actual benefits will vary and could be affected by the skill, knowledge and experience of the team developing the plan.[6]

ADDITIONAL REFERENCES

Complete Streets: Making Canada's roads safer for all

Transportation Association of Canada Briefing

OVERVIEW

Shared space is an international philosophy of urban road design developed in the Netherlands that substantially improves the spatial quality of neighbourhoods. The concept replaces traffic regulations with informal social-minded rules. For example, the removal of traffic signs and traffic lights allow people to settle potential conflicts by eye contact. Traffic in these areas is regarded as a guest and the layout should clearly indicate that the primary function of the area is residential.[6]

This approach results in people and traffic not being clearly separated. For example, the shared space has a level, open surface without curbs or road crossing / traffic signals resulting in a space that is not designated for any particular user.

Such an approach is expected to result in lower driving speeds and improved road safety; the latter has not yet been conclusively proven for each example in real use.[6]

CONSIDERATIONS

Several cities have experimented with this concept and impact monitoring will be useful in fully assessing its benefits and possible undesired effects.[6] One consideration will be vehicle volumes on the roadway. For example, one model suggests that to facilitate cycling by persons of all ages and abilities, motor vehicle volumes should be 500 vehicles per day and 50 vehicles per peak hour or lower. Otherwise, separated cycling facilities should be provided.

Shared space environments with high volumes of motor vehicle traffic have also proved to be problematic for the visually impaired. Unless designs can resolve these types of issues, the *shared space* approach should only be used in low traffic areas.

ADDITIONAL REFERENCES

Pedestrian Safety, Urban Space and Health[6]

SHARING INTERESTS / COLLABORATION STRATEGY

OVERVIEW

The S*haring Interests* strategy is an approach that looks at the urban environment from a high-level community safety and amenity viewpoint. It targets two key objectives – keeping pedestrian mobility and pedestrian planning at the top of the political agenda – as core strategies informing any plan of action. This strategy places emphasis on the achievement of common goals within different policy settings through combining efforts and resources.(6)

CONSIDERATIONS

The collaboration of bicycle and freight interests in cities has resulted in joint planning of bicycle and truck facility networks to best serve both user groups.(7)

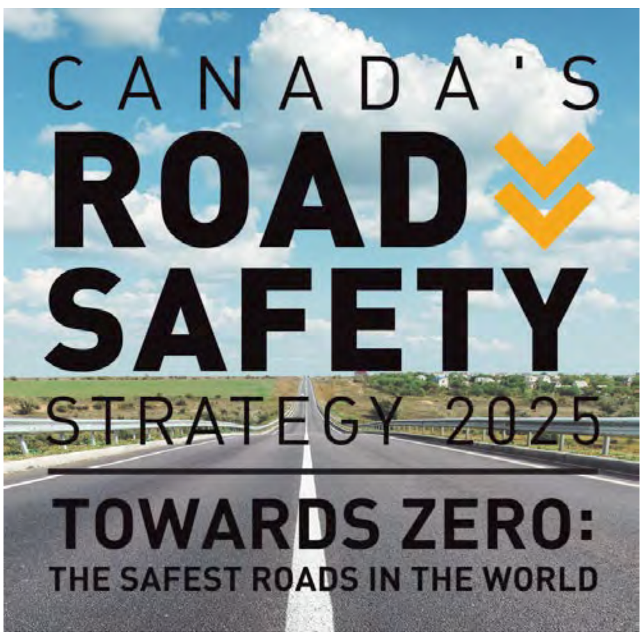
Research indicates that bicycles and trucks can exist successfully in the same city and travel corridors, if not on the same streets. Seattle has the framework in place to make this happen, such as a bicycle planning committee and a freight advisory board. However, collaboration between these groups has been minimal and somewhat contentious. Seattle can learn from other cities that have developed avenues for collaboration between the bicycle and freight communities so the needs of both are addressed and Seattle's city streets are optimized.(7)

A *sharing interests* strategy can help to gain financial support for the implementation of safety programs and packages of safety measures.(6)

While sound in concept, building relationships with multiple stakeholders governed by different agendas will require good coordination, communication and a willingness to collaborate. Inter-sectorial policies will deliver better results than separate policies within sectors.(6)

OVERVIEW

Canada's latest strategy is *Road Safety Strategy (RSS) 2025,* the vision of which is "Towards Zero – The Safest Roads in the World" and is based on the international best practice of Vision Zero. *RSS 2025* was created by the Canadian Council of Motor Transport Administrators (CCMTA), approved by the federal, provincial, and territorial Ministers of Transportation and Highway Safety in 2015 and launched in January 2016 This 10-year national road safety strategy is the fourth in a series of national strategies to have been implemented in Canada to-date, the earlier ones being Road Safety Vision 2001, Road Safety Vision 2010, and Road Safety Strategy 2015.



Canada's Road Safety Strategy 2025

The purpose of the RSS 2025 is to continue Canada's national effort in addressing important road safety issues by providing a framework for governments and other road safety stakeholders to establish their own road safety plans, objectives and interventions to eliminate road crashes that result in serious injuries or fatalities.

RSS 2025 provides an inventory of proven and promising best practices to address key high-risk groups and contributing factors. For each risk group and contributing factor, there may be more than one intervention for promoting safer road users, safer infrastructure and safer vehicles. A combination of interventions could result in even greater improvements to safety. It is a flexible approach allowing jurisdictions to implement road safety policies and programs that meet their own specific needs.[2]

CONSIDERATIONS

Although the strategy does not include hard quantitative safety targets but rather a continual downward trend in the number of fatalities and serious injuries, it does not preclude individual jurisdictions or organizations from establishing their own targets when there is government, law enforcement, and/or road safety stakeholder support for doing so. Furthermore, while some jurisdictions have launched road safety programs, others have passed road safety legislation or implemented specific road safety countermeasures.

ADDITIONAL REFERENCES

Canada's Road Safety Strategy 2025[2]

BICYCLE PLAN

OVERVIEW

A *Bicycle Plan* or strategy incorporates bike-friendly protocols and standards when building or reviewing any jurisdictionally-funded infrastructure initiatives. It is a consultatively written plan that is evidence-based and may result in the review of existing policies, guidelines and actions.[8] As such, it can include the design of bicycle infrastructure, such as Segregated Bicycle Lanes (see Section 3.4), to address the potential conflict between heavy vehicles and cyclists.[7]

Canada Bikes, an advocacy group, has proposed a National Bicycling Strategy to encourage and support more bicycling in Canada.[8]

CONSIDERATIONS

A *Bicycle Plan* requires leadership and collaboration with relevant stakeholders, strategic policy development and planning, and a need to examine capacity for research, program delivery and knowledge transfer. There is unclear authority as to what level of government would be the lead on such a strategy.

ADDITIONAL REFERENCES

Towards A Bike-Friendly Canada - A National Cycling Strategy Overview[8]

WALKING STRATEGY

OVERVIEW

A *Walking Strategy* builds a physical and cultural environment that supports and encourages walking by envisioning a city where high-quality walking environments are seamlessly integrated with public transit, cycling and other sustainable modes of travel. A *Walking Strategy* sets out a plan that produces tangible environmental, health and social benefits for city residents and visitors and promotes social inclusion. As the "International Charter for Walking" states, witnessing pedestrians on streets is a key indicator of a healthy, safe, efficient, socially inclusive and sustainable community.[6]

In 2015, the United States Department of Health and Human Services released "Step It Up! The Surgeon General's Call to Action Promoting Walking and Walkable Communities" which calls for making walking a national priority, designing communities that are safe and easy to walk in for people of all ages and abilities, promoting programs and policies to support walking where people live, learn, work and play, and providing information to encourage safe walking.

In 2016, the Federal Highway Administration published a Strategic Agenda for Pedestrian and Bicycle Transportation which is intended to achieve safe, accessible, comfortable, and connected multimodal networks in communities, improve safety for people walking and bicycling, promote equity among all transportation users throughout the planning, design, funding, implementation and evaluation process, and get more people walking and bicycling. It has the goal of an 80%

reduction in pedestrian and bicycle fatalities and serious injuries within 15 years and an increase in short trips by bicycling (5 miles or less) and walking (1 mile or less) by 30% by 2015.

Canadians, among other jurisdictions from around the world, support adopting ambitious strategies for increased active transportation, cycling, walking, and active school travel. A national collaborative action plan will address real-world barriers and incentives. Solutions include infrastructure, community design, and high engagement community programs like travel to school planning designed to make active transportation safe, practical, and inviting, and to re-establish a culture of self-mobility.[9]

Unlike stand-alone promotional campaigns, a national walking strategy, generates lasting increases in walking rates and transforms behaviour.[9] Land use planning is the key to promoting pedestrian safety and accessibility – particularly for those with impaired mobility. "Design for all" or "universal design" is an important component of urban transport planning.[6]

CONSIDERATIONS

Countermeasures to address pedestrian safety are only as good as the overall vision of the pedestrian network and mobility. A study by the Organisation for Economic Co-operation and Development (OECD) indicates that "current knowledge points to the importance of an overarching vision, consisting of clear policies and targets, with communications tailored to specific user groups, supportive research and technical advice to effectively promote walking."[6]

A concern regarding such strategies is the cost of building and maintaining the infrastructure required to support road/transport systems and the urban sprawl it may engender. A study undertaken for the government of New South Wales in Australia has developed an approach for the economic appraisals of significant spending proposals to develop strategies for walking.[6]

Generally, the benefits identified and quantified within a cost-benefit appraisal framework for this study include savings in health and vehicle operating costs, among others. Further, it improves the level of road and pedestrian safety.[6]

ADDITIONAL REFERENCES

Let's Take Action to Make Canada a Great Place to Walk

Active Transportation for Canada. Now!

Toronto's Walking Strategy

Step It Up! The Surgeon General's Call to Action to Promote Walking and Walkable Communities[10]

Strategic Agenda for Pedestrian and Bicycle Transportation[11]

SPEED MANAGEMENT

OVERVIEW

Speed Management is an overarching, active approach that requires or persuades, drivers to adopt speeds that offer mobility without compromising safety. It is much more than setting and enforcing appropriate speed limits. It employs a range of measures with the aim of balancing safety and efficient vehicle speeds on the road network.[1] It aims to achieve a road transport system that anticipates and allows for human error, while minimizing the risk of death or serious injury.

In many countries, speed limits are set at levels too high for existing roadway conditions and the mix and volume of road users, particularly where there are many pedestrians and cyclists (e.g., school zones, parks, etc.). The management of speed involves a wide range of measures including setting and enforcing speed limits, engineering measures designed to reduce speeds, and public education and awareness campaigns.

CONSIDERATIONS

While *Speed Management* is an international strategy designed to promote the mobility of people and merchandise, at the same time, it recognizes the potentially negative effects with respect to road safety, quality of life and the environment.

Given the complexity of speed issues, it is not always easy to target the most effective intervention. Some solutions, such as roadway infrastructure, can represent significant investments. Conversely, the simplest solutions are not always effective. The mere reduction of speed limits, considering the redesign of roadways or traffic control devices, often does not have a significant effect on the speed of the drivers.

The Organization for Economic Cooperation and Development has developed a manual on speed management to assist practitioners in addressing speeding.[12]

Australian jurisdictions have adopted the use of an 'expert' computer system to assist with setting speed limits that considers a variety of factors including the nature and level of road user activity (pedestrians, cyclists and heavy vehicles), etc.

ADDITIONAL REFERENCES

Speed Management – A Road Safety Manual for Decision Makers and Practitioners[12]

Gestion de la vitesse sur le réseau routier municipal en milieu urbain[13]

OVERVIEW

An annual *Forensic Review* of all pedestrian (and cyclist) deaths (and injuries) occurring within each respective jurisdiction would identify collision-prone areas. Findings would be included as a component of capital planning for road reconstruction and resurfacing projects to proactively seek ways to improve pedestrian safety.(4)

CONSIDERATIONS

Targeted enforcement strategies require data on collision factors and frequencies to enable agencies to prioritize behaviours. Knowledge of the behaviour and traffic patterns of a community also help the police to develop countermeasures that address specific behaviours of both drivers, pedestrians and cyclists.(14)

Measuring, reporting, and monitoring pedestrian (and cyclist) mobility as well as injuries inform and support development of government policy and research strategies to better understand mobility trends and behaviours.(6)

Decision-makers rely on evidence regarding personal travel behaviour to formulate broader strategic transport policies and to improve the safety and efficiency of transport systems. Limited published data, however, results in its exclusion from analysis and policy discourse.(6)

The Ontario Ministry of Transportation suggests that an annual *Forensic Review* include full collision investigation / reconstruction reports to determine at-fault findings. Based on this data, more thoughtful evidence-based policies and considerations can be developed to target those typically at-fault collisions.

ADDITIONAL REFERENCES

Strategic Agenda for Pedestrian and Bicycle Transportation(11)

3.0 COUNTERMEASURES

Countermeasures are organized into a number of sub-sections, based on their type, and further subdivided into two parts:

- ***Part 1: Specific*** includes those countermeasures that specifically address vulnerable road users and heavy vehicles.
- ***Part II: Non-Specific*** includes those countermeasures that address vulnerable road users and other motor vehicles, but the principles presented could also apply to heavy vehicles.

Since most countermeasures can be applied to both heavy and motor vehicles, more countermeasures appear under Part II.

3.1 AUTOMATED ENFORCEMENT

Automated traffic enforcement technology, combined with other speed enforcement methods, including education and awareness, can help reduce the number and severity of collisions on our roads in all vehicles, including heavy vehicles.

PART I: SPECIFIC TO VRUs AND HEAVY VEHICLES

None Found

SPEED AND RED LIGHT CAMERAS

Groups Affected

- Drivers

Jurisdictions Studied

- Canada
- U.S.
- U.K.
- OECD (35+ countries)

Category: Policy/Legislation/Regulation; Enforcement; Communications/Awarenes

DESCRIPTION

Speed cameras, also called photo radar or automated speed enforcement devices, record a vehicle's speed using radar or other instrumentation. It captures the license plate information of vehicles that exceed the speed limit. Owners of these vehicles are automatically contacted and required to a pay a fine.[15]

Red light cameras are designed to prevent motorists from running red lights and are tied to the intersection's signalization. They can also be used as speed cameras at intersections; however, speed cameras cannot be used as red light cameras.

ISSUES / EVIDENCE

Seven out of ten drivers in Canada admit to speeding. There is an exponential increase in the risk of death for vulnerable road users as speed increases.[14] According to an Ontario Study, 42% of fatal crashes and 29% of injury crashes involved disobeying traffic signals.[16]

With respect to fixed or mobile speed cameras, a systematic international review based on 14 observational studies found that all but one showed effectiveness of cameras up to 3 years or less after their introduction. Another European study concluded that there are no reasons to doubt the effectiveness of speed cameras as a road safety measure. A further U.K. study also found consistency of reported positive reductions in speed and crash outcomes across all studies.[14]

An evaluation of Winnipeg's photo enforcement safety program between 1994 and 2008, using time series analyses, revealed that the installation of cameras was not associated with increases or decreases in crashes related to speeding. However, regarding red light running violations, analyses showed a positive impact of photo enforcement with significantly fewer violations after installation of cameras across all conditions studied. While the data suggest photo enforcement may be less effective in preventing serious speeding violations at intersections, overall, the analysis found that the program had a positive net effect on traffic safety.[16]
(See Section 2.0 Speed Management and Section 3.7 Speed Limit Reductions)

With respect to the safety effects of red-light running programs, a U.S. multi-jurisdictional study by the Federal Highway Administration (FHWA) shows a significant decrease in right-angle crashes, but a significant increase in rear end crashes.[79] An earlier Toronto study showed similar results with a 25.3% decrease in angle collisions, but a 4.9% increase in rear end collisions.[17]

The Winnipeg study[16] mentioned above (1994 to 2008 photo enforcement safety program) revealed a 46% decrease in right angle crashes but an initial 42% increase in rear end crashes related to red light running. This initial increase in rear end crashes was followed by a 19% decrease. Time series analyses suggest that decreases in the most severe crash types (i.e., right angle crashes) may remain consistent, but increases in less severe crash types (i.e., rear end crashes) over time, may shrink and eventually turn into decreases.

More recent research conducted by the Insurance Institute for Highway Safety (IIHS) in June 2017 found there were 21% fewer fatal red-light running crashes per capita in cities with cameras than would have occurred without cameras and 14% fewer fatal crashes of all types at signalized intersections.[18]

While most studies have found an overall reduction in speeding, red light running, and associated crashes, some studies have not found any significant improvement or found that photo enforcement is effective only at some locations or under certain conditions and that more research is needed to better understand the impact of photo enforcement and how this measure can best be employed.[16]

Note: *Right angle crashes have a higher injury and fatality rate than rear end crashes, so there is generally a net benefit in terms of lives saved and serious injuries prevented as well as a positive benefit to cost ratio.*[16]

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. Studies have focused on reductions in overall fatalities and serious injuries. They confirm that any countermeasure effective in reducing vehicle speeds and reducing running of red lights will improve injury outcomes.[14] Collisions between heavy vehicles and vulnerable road users generally take place at lower speeds, which may not be subject to speed violations. However, while reductions to running red lights by heavy vehicles may reduce right-angle crashes (with other vehicles and with pedestrians and cyclists), rear end crashes between a motor vehicle and a heavy vehicle may be more serious (e.g., heavy vehicle hits rear of light duty vehicle).

With respect to fixed or mobile speed cameras, only imposing speeding fines on the owner of the vehicle (not all heavy vehicle drivers are owners) may have little effect in changing driver behaviour, which is the ultimate outcome desired from this technology. The province of Quebec uses the principle of driver designation, which allows the owner of the vehicle to designate the driver of the vehicle at the time of the offense.

To overcome the high cost of installing and operating speed cameras at all high-risk sites, many countries use "dummy cameras". A dummy camera looks like the real camera box, but has no camera or film inside. Installation costs are about one-third of a real camera; operating costs are also very low. The idea behind dummy cameras is that drivers do not know whether the camera box actually contains a camera; therefore, they will adapt their speed "to be on the safe side". The effect can be strengthened by regularly rotating the operational cameras between the camera boxes as is done in many countries. In some countries (*e.g.*, France), dummy cameras are not used for policy reasons.[103]

With respect to running red lights, traditional police enforcement can help; however, there are not enough resources to station officers at every intersection. Cameras increase the odds that violators will get caught and well-publicized camera programs discourage would-be violators from taking those odds. It has been suggested that camera programs be organized so the public understands their value as a safety tool, not as a revenue generator. In France, a crucial element for the success of the speed camera program was to have a transparent communication on the allocation of the revenues which are mainly invested on road safety improvements. This approach was used in the United Kingdom as well.(18)

Photo enforcement may be more effective in preventing speeding violations in general but may perhaps be less effective in preventing serious speeding violations that are more commonly committed by high-risk drivers. Many traffic safety measures are less effective with such high-risk drivers because they are less likely to change their behaviour.(16)

Photo enforcement studies suggest that spill-over effects in surrounding non-camera intersections are a key advantage of automated speed enforcement that are not generally achieved by traditional police speed enforcement.(16)

Few photo enforcement programs have utilized photo enforcement cameras to detect "speed-on green" which is a type of photo enforcement that captures vehicles as they speed through intersections on green and amber lights. In Canada, only two jurisdictions, Alberta and Manitoba, have used speed cameras in this way and few evaluations have been conducted on the use of this technology. However, the City of Winnipeg was one of the first programs in North America to use the speed on green technology. Therefore, the Winnipeg study(16) was undertaken to evaluate the use of photo enforcement to detect speeding at intersections.

3.2 COMMUNICATIONS, AWARENESS AND EDUCATION

Changing behaviours and increasing road safety for vulnerable road users depends on effective communications and training that is equally supported by strong enforcement programs

PART I: SPECIFIC TO VRUs AND HEAVY VEHICLES

AN OVERVIEW – COMMUNICATIONS, AWARENESS AND EDUCATION PROGRAMS

Groups Affected
- Pedestrians
- Cyclists
- Drivers

Jurisdictions Studied
- Canada
- Italy
- Sweden
- Australia
- Global (WHO)

Category: Communications/Awareness

DESCRIPTION

Most Western countries have acknowledged that to achieve a substantial decrease in the number of fatal and serious injury collisions, there is need for greater education, awareness and advocacy programmes, along with improved legislation and policies to reduce injuries and fatalities to the minimum level. It has been argued that adopting a Vision Zero approach is necessary to help achieve these targets.[20] (See Section 2.0 Road Safety Strategies)

ISSUES / EVIDENCE

A 2007 study found that Public Service announcements are a relatively inexpensive way to deliver road safety messages, but they tend to be aired infrequently, miss target audiences, and have little or no effect on road safety. High-quality programs have had limited success in changing individual behaviour when used alone. Some characteristics of successful mass media campaigns include careful pre-testing, communicating previously unknown information, being long-term, having substantial funding, and being carried out in conjunction with other ongoing prevention activities such as law enforcement programs.[2]

A 2004 study concluded that road safety campaigns were able to influence behaviour when carried out in conjunction with legislation and law enforcement, but information and publicity generally did not result in tangible and sustained reductions in serious casualties when used in isolation. A further 2009 study undertook a meta-analysis, which showed the effects of mass media campaigns as being minimal when compared with the effects of campaigns that were combined with other measures. Mass media alone that focused on a specific targeted area would actually increase traffic collisions by 1%, whereas mass media + enforcement, mass media + enforcement + education, and local individualized campaigns would reduce collisions by an estimated 13%, 14%, and 39%, respectively.[2]

Ottawa's Strategic Road Safety Action Plan includes a variety of integrated countermeasures to combat pedestrian and cyclist fatalities and injuries. Communications, advocacy, and education have little impact on their own. When these are supported by enforcement vehicles, higher success ratios can be anticipated.[21] (See Section 3.5 Selective Traffic Enforcement Programs (STEP))

BARRIERS / CONSIDERATIONS

Awareness and safety campaigns used alone tend to have limited success in changing behaviour. There is a need for an integrated approach that also encompasses education and a strong enforcement component. Awareness programs need to be linked to the timing and location of pedestrian collisions.[4]

Changing the attitudes and behaviour of drivers and pedestrians is a complex, long-term undertaking, requiring a variety of interventions to be implemented. Practical training interventions and programs designed as a sequence of modules over a longer period of time is more effective than administering single interventions. To produce the desired effects, education should be viewed as a long-term strategy rather than a quick win.[6]

BEST PRACTICE GUIDANCE – PROTECTING VRUs FROM VEHICLE BLIND SPOTS

Groups Affected
- Drivers

Jurisdictions Studied
- U.K.

Category: Communications/Awareness

DESCRIPTION

Best Practice Guidance is a communications and awareness document prepared by the Brake Road Safety Charity group in the U.K. in response to the significant number of fatalities and crashes involving trucks and vulnerable road users. This document targeted drivers and fleet managers and outlined steps they can take to help mitigate these collisions. It also includes a one-page checklist for truck and bus drivers: *Protecting Vulnerable Road Users from Blind Spots*.[22]

ISSUES / EVIDENCE

The most common incident involving cyclists and heavy goods vehicles (HGVs) in London is where the vehicle is turning left (turning right in Canada) and the cyclist is beside the vehicle in a blind spot. In the five years from 1999-2004 CEMEX, a U.K. company, with a fleet of over 300 HGVs, was involved in several of these types of incidents, causing two deaths and four serious injuries.

From 2004 to 2012, following the initial awareness campaign involving fleet drivers, along with safety improvements, CEMEX achieved a significant reduction in collisions with vulnerable road users.[22] (See countermeasures under Section 3.8 Visibility and Conspicuity)

BARRIERS / CONSIDERATIONS

Fleet drivers should receive formal education and training – as a minimum – on recruitment, when a driver changes the type of vehicle they drive, if a driver is involved in a collision, or if he/she incurs points on their licence. Driver training should cover the importance of slower speeds when driving or manoeuvring and ensure that blind spot devices are never seen by drivers as a substitute for safe and careful driving (e.g., looking for VRUs).[22]

BUS DRIVER TRAINING – MITIGATING BLIND SPOTS

Groups Affected
- Drivers
- Vehicles

Jurisdictions Studied
- Canada
- U.S.

Category: Education / Training

DESCRIPTION

This training was developed and implemented in Montreal by the Société de Transport de Montréal (STM), in conjunction with a series of other measures in accordance with a Vision Zero approach.[(23)] (See Section 2.0 Road Safety Strategies)

ISSUES / EVIDENCE

The training is specific to the challenges associated with blind spots and offers techniques to counter them, such as reduced turning speed (15 km/h) and active checking of blind spots.[(23)] So far, the reaction from STM drivers has been positive.

The results of dynamic tests, conducted to better understand collision scenarios, have led to the development of the training/awareness exercise.

By reducing the bus' turning speed from 24 km/h to 13 km/h, the pedestrian remains visible to the driver 4 times longer; thus giving the driver time to react.[(23)]

Effectiveness is still unknown. Impact on the frequency and severity of collisions has not yet been demonstrated. Also, evidence of modified driver behaviour following the training is not yet available.

BARRIERS / CONSIDERATIONS

This training has been specifically designed for city buses; proposed techniques may be applicable to other heavy vehicles but have not been tested.

This type of countermeasure can be easily and immediately implemented by transit operators and is not dependent on the testing of new technologies or new bus designs.

Training must be given to all bus drivers (new and experienced); a three to four-year timeline is needed to reach all drivers.

The cost associated with the change in the training program remains a consideration. For Société de Transport de Montreal (STM), this was not an issue because they were in the process of updating their training program. However, this may not be the case for others looking to implement training of this nature. The approach to teaching the material may also have an economic impact. For example, driver training in the Metropolitan Transportation Authority (MTA) of New York City (NYC) includes a bus driving simulator, which can be very expensive. (View the Video of the Metropolitan Transportation Authority's (MTA) training for NYC bus drivers.)

More information about the MTA driver training program is also available in their Bus Safety Symposium White Paper – 2016.

MANDATORY TRAINING FOR COMMERCIAL VEHICLE DRIVERS

Groups Affected	Jurisdictions Studied
▪ Drivers	▪ Canada ▪ U.S. ▪ U.K.

Category: Policy / Legislation / Regulation; Education / Training

DESCRIPTION

In Canada, the province of Ontario is the only jurisdiction currently requiring completion of mandatory training before taking a road test and being issued a new Class A (commercial truck) driver's license. The Ministry of Transportation for Ontario (MTO), implemented this requirement effective July 1, 2017.[88] The Mandatory Entry Level Training (MELT) program, as well as the Official MTO Truck Handbook addresses sharing the road with cyclists and with pedestrians, monitoring of blind spots, and the effective use of mirrors.

The UK's Fleet Operator Recognition Scheme (FORS) is a similar accreditation program that was established in 2008. It is a publicly funded, three-level voluntary certification program for fleet operators in the U.K. measuring safety, environmental sustainability, efficiency and support for Vision Zero objectives (See Section 2.0 Road Safety Strategies). FORS-approved driver training courses for the mandatory Driver Certificate of Professional Competence (DCPC) – the safe London driving course and safe urban driving course – have been developed specifically to increase fleet drivers' awareness of vulnerable road users.[3, 25]

EVIDENCE

With respect to the UK program, FORS has provided training to 2,500 fleet managers and almost 7,500 drivers since 2012. FORS accredited companies have seen a reduction in collisions from 17 per 100,000 vehicle kilometres to eight. Ninety per cent of drivers attending intend to change their behaviour and give more consideration to vulnerable road users.[25]

BARRIERS / CONSIDERATIONS

A mandatory entry-level driver training program for the province of Saskatchewan is expected to be in place by 2019. Saskatchewan Government Insurance (SGI) will be working on the curriculum. Manitoba also announced that it will be looking at implementing an entry-level driver training program in the near future. Alberta has also indicated that it is looking at a similar measure.[87]

According to Alberta officials, mandatory training for commercial drivers needs to be effective, affordable and accessible. Any training program needs to enhance safety without creating insurmountable obstacles for industry.[86]

Regarding the UK's FORS program, as consumers and local governments began to prioritize working with operators who were members of FORS, more companies joined the program.[3]

In 2015, San Francisco initiated a policy to require any city-employed truck driver or bus driver, as well as commercial shuttle drivers to take a safety course emphasizing safe operations of large vehicle in urban areas.[3]

EXAMPLES OF COMMUNICATIONS AND AWARENESS PRODUCTS, CAMPAIGNS, AND TOPICS

Groups Affected
- Drivers
- Cyclists
- Pedestrians
- Pedestrians (School-aged children)

Category: Communications/Awareness

PRODUCTS AND ACTIVITIES

- City of Ottawa – Collaborate with Ottawa Police, RCMP, Public Health and Public Works[21]:
  - Distribution of information cards to offending drivers and cyclists by police;
  - Community presentations at public health forums;
  - Liaison with partners on cycling safety messages (e.g., proper use of bicycle helmets; evidence supporting the use of retro-reflective materials and flashing lights). (See countermeasures under Section 3.8 Visibility and Conspicuity)
- Bike Maryland – Partner with law enforcement officers and crown attorney (or designated jurisdictional legal office) to foster a safer cycling environment; partners with provincial transportation and other agencies on road safety messaging. (See Section 2.0 Sharing Interests / Collaboration Strategy).[24]
- Bike Maryland – Establish partnerships with existing programs to promote cycling to more diverse socio-economic groups.[24]
- U.K. – Use of ads, videos, posters, and leaflets are important; however, audio-visual channels (TV ads) and multi-media (internet-based on demand video) are increasingly used.[25]
- U.K. – Partner with school boards and other educational bodies to promote road safety education, e.g., interactive learning videos, interactive computer games, etc.
- U.K. – Develop educational resources for a range of road safety issues, divided into specific learning categories that cover the learning needs of pre-school aged children up to [Grade 8].[25]

EVENTS / CAMPAIGNS / PROGRAMS

- **Join the Campaign – Endorse the Vision:** A Canada-wide campaign to gather support for Canada's National Action Strategy for Walking. (See Section 2.0 Walking Strategy)[9]
- **Share the Road – Stay Safe – Stay Back:** A campaign emphasizing the importance of recognizing blind spots on large trucks, and the real dangers posed to cyclists if they are not easily seen by truck drivers. (View the Share the Road campaign video.) The campaign was launched on Bowen Island, B.C., in 2013 through a partnership with the Canadian Automobile Association (CAA) and partners in the municipal sector and the heavy trucking industry.[26]
- **Canada's First National Walking Summit:** Held in September 2017 to help local organizations promote walking and walkability in their own communities; facilitate information sharing and networking to facilitate a pan-national movement.[9]
- **Exchanging Places Program:** An award-winning British program which addresses the most common cause of serious injury and death to cyclists resulting from collisions involving a heavy goods vehicle (HGV). It gives cyclists the opportunity to sit in the driver's seat of an HGV to see for themselves how difficult it can be to see a cyclist riding close to the truck. Experienced traffic police

officers explain how this type of collision often happens and various ways to avoid them. (View the Exchanging Places video.) The number one cause of serious crashes involving cyclists in London, U.K. involve HGVs.[27]

- **A Decade of Action for Road Safety:** A United Nations (UN) / World Health Organization (WHO) recommendation. Literature states that a decade would allow for long-term and coordinated activities needed to support national and local road safety.[1]

- **Outreach – the School-Home Journey:** This is a point of considerable exposure and risk for children. An important question to consider is when – what time of the day, which day of the week, and which month of the year – are children most at risk?[1]

  Child pedestrians walking alongside or among vehicular traffic are at risk for many reasons; they often lack the ability to gauge vehicle speeds, don't know about safe crossing methods, or can't distinguish between safe and unsafe crossing gaps and sites, putting them at risk as they cross the road.[1]

- **Cycling 'roadshow':** Could incorporate bike-minded rodeos, commuter workshops, bike-friendly program, engineering advice to support cycling safety awareness and promoting any related educational programs.[24]

- **BikeMaps.org:** This University of Victoria (UVic) / Traffic Injury Research Foundation (TIRF) program, with funding from Public Health Agency of Canada (PHAC), focuses on many different aspects of awareness, education, infrastructure, etc. for bicycle safety (More information is available at Bikemaps.org)

- **Vehicle Safety Forum:** Organized events designed to bring together practitioners and stakeholders to exchange knowledge and share current industry developments. Examples of such events include:

  – Vision Zero Fleet Safety Forum, an annual event, sponsored by New York City (NYC) Fleet, brings together professionals representing private fleets, safety equipment suppliers, federal, state and city agencies and universities focusing on the collective goal of vehicle safety. The forum is used to exchange best practices, promote cutting edge vehicle safety technology and provide education to fleet managers about Vision Zero.[3]

  – SWANA Ontario Safety Summit (Solid Waste Association of North America), in partnership with the City of Toronto held a safety summit in 2018 to discuss safety issues and potential solutions including new technologies such as video cameras and sensors, strategies and training safety measures for the industry. Offering this event annually is under consideration given the positive reviews received.[97]

OTHER AWARENESS TOPICS

- Safety information regarding collision rates among various types of vehicles (e.g., cyclists and heavy vehicles) / understanding the risks.[4, 7]

- Truckers perceive themselves as being held to very high, rigid safety standards. Alternatively, they view cyclists as exhibiting unpredictable behaviour and not held to operational standards.[7]

- The safety concerns expressed by cyclists about sharing the road with a large truck seem to be greater than that shown by the data, suggesting that large trucks have an image problem that might not be entirely warranted. The fact that collision over-exposure rates are relatively low for large trucks, and for trucks in general, is an important piece of information for the non-motorized community to know, and can inform the dialogue in future discussions.[7] Nevertheless, when heavy vehicles and vulnerable road users interact, safety issues remain a concern.

- Public awareness campaigns targeted at truck drivers and pedestrians – What can each road user do to help?[5]

- Vulnerable road users and speed. (See countermeasures under Section 3.7 Speed).

- Informing drivers about care, prudence, kindness, consideration, speed, pedestrian right-of-way and traffic rules;[1]

- Pedestrian (and cyclist) safety at night / wearing reflective clothing.[4] (See Section 3.8 Increased Conspicuity and Visibility of Pedestrians / Cyclists)

PART II: NON-SPECIFIC TO VRUs AND HEAVY VEHICLES

EXAMPLES OF EDUCATION AND TRAINING PRODUCTS, PROGRAMS, AND TOPICS

Groups Affected

- Drivers
- Cyclists
- Pedestrians

Category: Education/Training

PRODUCTS AND ACTIVITIES

- **Safe Bicycling Guidelines Booklet:** Educate cyclists to the dangers of riding near trucks; other safety advice.[7, 28]

  Training can help to incorporate safe biking standards. (See countermeasures under Section 3.5 Rules of the Road and Section 3.8 Visibility and Conspicuity)

- ***CAN-BIKE Courses:*** A series of progressive courses that focus on skills such as basic bike handling, fundamentals of cycling, riding in traffic and rules of the road, and understanding forms of infrastructure.

- **Cycling Skills – Ontario's Guide to Safe Cycling**: Educates cyclists on basic safety procedures, recognizing obstacles and other hazards, observing road signs and traffic signals, and understanding the law and cycling.

- **National Pedestrian Guidance** (for local administrations): Guidelines to help local administrators give consideration to the impact of road planning projects on pedestrians and cyclists as part of project appraisals and environmental impact assessments.[6] (See Section 2.0 Walking Strategy)

- **Update the official Driver's Handbook:** Include a chapter clarifying those traffic scenarios when motorists are most likely to be involved in a collision with a pedestrian (or cyclist).[4]

- **Bicycle network guide:** Identifies gaps in the bicycle networks and suggests areas for connections; proposes new road and road extensions to separate trucks from cyclists and pedestrians and improved road designs to better accommodate trucks.[7] (See Section 3.4 Segregated Bicycle Lanes)

EDUCATIONAL PROGRAMS

- **Training program for [heavy vehicle] drivers:** This program would include topics such as watching for pedestrians at all times; yielding to pedestrians at crosswalks and when making turns; understanding the risks to pedestrians when travelling at higher speeds; parking and leaving parking locations; etc.[4] (See Section 3.2 Mandatory Training for Commercial Vehicle Drivers)

- **Educational body:** Some documents suggest that the creation of such a body would have, as its mandate, the identification and delivery of public education programs directed at preventing pedestrian deaths, including programs for senior citizens, children, adult pedestrians and drivers.[4]

- **Mandatory road and pedestrian safety education:** Specific for junior kindergarten through grade eight curricula (children 5 – 14 years of age) (collaboration between Ministry of Education and Ministry of Transportation).[4]

- **Develop high-quality education programs in schools / local community centres:** These should include adult re-training initiatives.[6]

- **School mobility plans:** These are aimed at producing a safe and supportive environment so children can walk to school.[6]

- **Urban bicycling and truck blind spots workshop.**[29]

- **Provide police officers with pedestrian-specific training and resource materials:** As police officers are first responders, they have a unique perspective on pedestrian and cycling injuries and deaths. This is why they are being engaged to get involved in providing training.[30]

- **Educational program for seniors and other adult pedestrians:** A program on understanding how to safely navigate arterial streets and high-risk corridors.[4]

OTHER EDUCATIONAL TOPICS

- Safety information regarding collision rates among various types of vehicles (e.g., cyclists and heavy vehicles) / understanding the risks.[4, 7]

- Reduce distracted driving.[14]

- Vulnerable road users and speed.[14]

- Watching out for cyclists.[7]

- Understanding the visual constraints of heavy vehicles.[7]

- Professionals (teachers of school-aged children) should receive continuous training about how pedestrians (and cyclists) can benefit from knowledge about pedestrian, cyclist and road infrastructure projects (new installations), understand their use and benefits along with any associated rules of the road.[6]

- Pedestrian (and cyclist) safety at night / wearing reflective clothing.[4] (See Section 3.8 Increased Conspicuity and Visibility of Pedestrians / Cyclists)

3.3 INTERSECTION DESIGN AND TRAFFIC CONTROL

The purpose of an intelligent city-wide traffic control system should be designed to limit dangerous interactions between vulnerable road users and road traffic.

PART I: SPECIFIC TO VRUs AND HEAVY VEHICLES

None Found

PART II: NON-SPECIFIC TO VRUs AND HEAVY VEHICLES

ADVANCED GREEN FOR PEDESTRIANS

Groups Affected	**Jurisdictions Studied**
▪ Drivers ▪ Pedestrians	▪ Canada ▪ U.S.

Category: Infrastructure

DESCRIPTION

This low-cost countermeasure, also referred to as a leading pedestrian interval (LPI), allows pedestrians to get a head start (3-6 seconds or more) before vehicles receive a green light. This puts pedestrians well into the crosswalk, increasing their visibility before drivers begin to turn. As pedestrians become accustomed to this advanced signal measure, many are able to move well into the crossing during this protected pedestrian period. The longer times are especially helpful in areas where there are multiple lanes to cross.[14] (See Section 3.3 Separate Left-Turn Phases for Cyclists)

There are different types of LPI signals. For example, in Montreal, one type of signal consists of a green straight arrow light, which prompts pedestrians to cross before cars are permitted to move into the intersection. In other cities, the pedestrian gets a walk signal several seconds before the vehicles are allowed to move into the intersection.

Specifications may vary between jurisdictions and may depend on types of roadways and other factors.

ISSUES / EVIDENCE

At a typical intersection in Canada, the pedestrian signal works simultaneously with the traffic signal and many pedestrians are struck just after leaving the curb with a "WALK" signal in their favour, typically by a right-turning vehicle and, at other times, by a left-turning one.[14] A Transport Canada report noted that crossing the road at a signalized intersection when the "green signal for the pedestrian" is not showing, was the most frequent at-fault behaviour and accounted for about 13% of all pedestrian traffic deaths in Canada.[6] In Ontario, in the 15-year period between 1988 and 2002, pedestrians accounted for 14% of motor vehicle fatalities.[4] In Canada, between 2004 and 2006, approximately 16.9% of the pedestrian fatalities resulted from collisions where a heavy vehicle was turning right just before the collision occurred.[39]

A study, which examined a three-second leading pedestrian interval (LPI) whereby the *"WALK" signal comes on three seconds before vehicles can proceed*, found that this treatment reduced conflicts by 95% for pedestrians starting to cross at the beginning of the walk interval. The introduction of this LPI reduced the odds of a pedestrian having to yield to a vehicle by approximately 60%.[14]

Another study conducted in Anaheim, California, showed that the LPI resulted in an 18% increase of drivers yielding to pedestrians at one intersection and 9% at another, both statistically significant. However, yielding by drivers turning right did not change.[50]

A study carried out in St. Petersburg, Florida concluded that the implementation of a three-second LPI reduced conflicts between pedestrians and turning vehicles and reduced the incidence of pedestrians having to yield the right-of-way to turning vehicles. The study also concluded that the signal phasing made it easier for pedestrians to cross the street.[93]

A 2009 Federal Highway Administration (FHWA) report based on research conducted in San Francisco and Miami found a significant decrease in the number of motorists turning left in front of pedestrians in two out of the three intersections studied where LPIs were installed. It also found a significant increase in motorists yielding for pedestrians on left turns at both study intersections in Miami. The study indicated that LPIs reduced conflicts between pedestrians and left-turning motorists, but also determined that the increased yielding to pedestrians did not seem to be true for motorists turning right.[41]

Another American study found that for pedestrians leaving the curb during the beginning walk period, odds of conflict with turning vehicles were reduced by 95%; odds of pedestrians yielding to turning vehicles were reduced by 60%.[33]

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. Advanced Green for Pedestrians may mitigate the risks to pedestrians in intersections when heavy vehicles are turning and fail to see vulnerable road users that are in their blind spots. While this countermeasure could reduce the risks to pedestrians, it should be recognized that not all pedestrians (or cyclists) leave the intersection at the same time. For example, an incident in Montreal involved a truck driver who safely passed a group of pedestrians but then hit another late pedestrian who was running to cross the intersection as well. Further, especially in the case of heavy vehicles, this countermeasure does not address the main problem, that is, the driver's blind spot.

There is a need for an absolute minimum of three seconds for this LPI. This is underscored by the fact that older pedestrians delay for about 2.5 seconds before starting to cross. This would not only make it safer for pedestrians but may also give them an increased sense of comfort and safety. The distance traversed by pedestrians during the LPI would be sufficient for them to assert their right-of-way over vehicles.[14]

However, it may be necessary to lengthen the LPI when there is a higher proportion of slower pedestrians (e.g., elderly, children). (See Section 3.5 No Right Turn-on-Red (RTOR))

LPIs should be considered at intersections with a history of conflict between pedestrians and turning vehicles.[41]

Pedestrians permitted to enter the intersection prior to the release of traffic are more visible to motorists and drivers are less likely to initiate turns when pedestrians are already in the street. Several peer cities (e.g., Vancouver) have begun using this treatment.[41]

AUDITORY MESSAGES AT INTERSECTIONS

Groups Affected
- Pedestrians

Jurisdictions Studied
- U.S.

Category: Infrastructure

DESCRIPTION

Audio messages, such as "WAIT FOR THE WALK SIGNAL" or "WATCH FOR TURNING VEHICLES", provide specific instructions to pedestrians at signalised intersections. To indicate when it is safe for visually impaired pedestrians to cross, two audible tones are used to indicate the direction in which the pedestrian has the right of way; a "cuckoo" sound indicates the pedestrian has the right-of-way in the north/south direction or a "chirp" sound indicates the pedestrian has the right-of-way in the east/west direction.[14]

In addition to the "cuckoo" and "chirp" sounds, some signals are equipped with a continuous tone called a "locator tone". This tone is emitted from the pushbuttons to assist pedestrians, who are blind or visually impaired, in locating the pushbuttons. Some pushbuttons are equipped with a raised arrow that point in the direction of travel. This arrow vibrates when the Accessible Pedestrian Signals (APS) sounds are activated. These sounds and locator tones automatically adjust to ambient sound levels. Therefore, during peak traffic conditions, they may sound louder; overnight they drop to their lowest volume level. (More information is available at How do Accessible Pedestrian Signals (APS) Work?)

ISSUES / EVIDENCE

Pedestrians [or other vulnerable road users] often fail to scan the traffic environment and are, therefore, vulnerable to being struck by turning vehicles.[14]

A U.S. study examined the influence of verbal messages, spoken by either a woman or child just before the walk signal was illuminated, to determine if such an approach would reduce pedestrian / vehicle conflicts at intersections. During the baseline condition, 16.3% of pedestrians did not look for threats (vehicles) resulting in an average of one conflict per session. The auditory signal reduced the number of those not looking to 4.2% (74% reduction) and the conflicts to 0.25 (75% reduction) per session. The use of a child's voice was more effective than an adult's in promoting the search for threats.[14]

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. As many of the collisions between pedestrians and heavy vehicles occur at intersections, specific sounds that draw pedestrians' attention to WATCH FOR TURNING VEHICLES can help to increase their safety in these scenarios.

It is not always possible to hear these messages properly at a busy intersection due to ambient noise.[14] The "cuckoo-chirp" signals are no longer the recommended standard in the U.S. This is based on research completed since 1988. These signals resulted in incorrect decision about which street has the walk signal and people had difficulty remembering which tone was for which direction and often, didn't know what direction they were travelling. In addition, birds sometimes mimicked the chirp sound creating confusion. With the new system, the visual "WALK" sign is accompanied by a rapid ticking or beeping sound. However, it also might be a speech message saying the street name such as "PEACHTREE, WALK SIGN IS ON TO CROSS PEACHTREE." This auditory message usually will repeat for the entire time the visual "WALK" or "walking man" symbol is displayed. To use the speech message effectively, the name of the street being crossed must be known. (More information is available at Accessible Pedestrian Signals (APS))

AUTOMATIC PEDESTRIAN DETECTION

Groups Affected
- Pedestrians

Jurisdictions Studied
- Canada
- U.S.

Category: Policy/Legislation/Regulation; Infrastructure

DESCRIPTION

Automatic pedestrian detection can be used at traffic signals in lieu of pedestrian push buttons to automatically detect pedestrians and display a walk signal. This technology can also extend the crossing time to allow slower pedestrians to finish crossing.(32, 33)

ISSUES / EVIDENCE

Almost 9,000 pedestrians were killed and hundreds of thousands were injured in Canada in road collisions between 1989 and 2009. According to Transport Canada, an analysis of pedestrian collisions revealed that 60% of pedestrians killed in traffic crashes were trying to cross the road.(34)

Automatic pedestrian detection has been reported to significantly reduce conflicts. For example, at four urban intersections in Los Angeles, Phoenix, and Rochester, it helped to reduce the percentage of pedestrians who began to cross during the "DON'T WALK" signal. These reductions ranged from 52% to 88%; at 3 sites, reductions in the percentage of pedestrian–vehicle conflicts ranged from 40% to 90%.(33)

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. Drivers of heavy trucks and larger vehicles such as buses and SUVs that are higher than street level often find it difficult to see smaller pedestrians.(34)

Automatic pedestrian detection technology is promising but has been evaluated on a limited basis. In the case of many traffic engineering measures, more definitive research is needed to establish their effects on pedestrian–vehicle crash risks.(33) More recent research undertaken by the City of Ottawa shows that automatic detection technology is preferred to that of the push-button action as nearly 50% of pedestrians do not activate the push-button.(32)

Automatic detection systems are not widely used and there may be compatibility issues with coordinated signal systems.(32)

Given that this is a new technology, its reliability under various environmental conditions is not well documented.(32)

BICYCLE BOXES

Groups Affected	**Jurisdictions Studied**
▪ Cyclists ▪ Drivers	▪ Canada ▪ U.S.

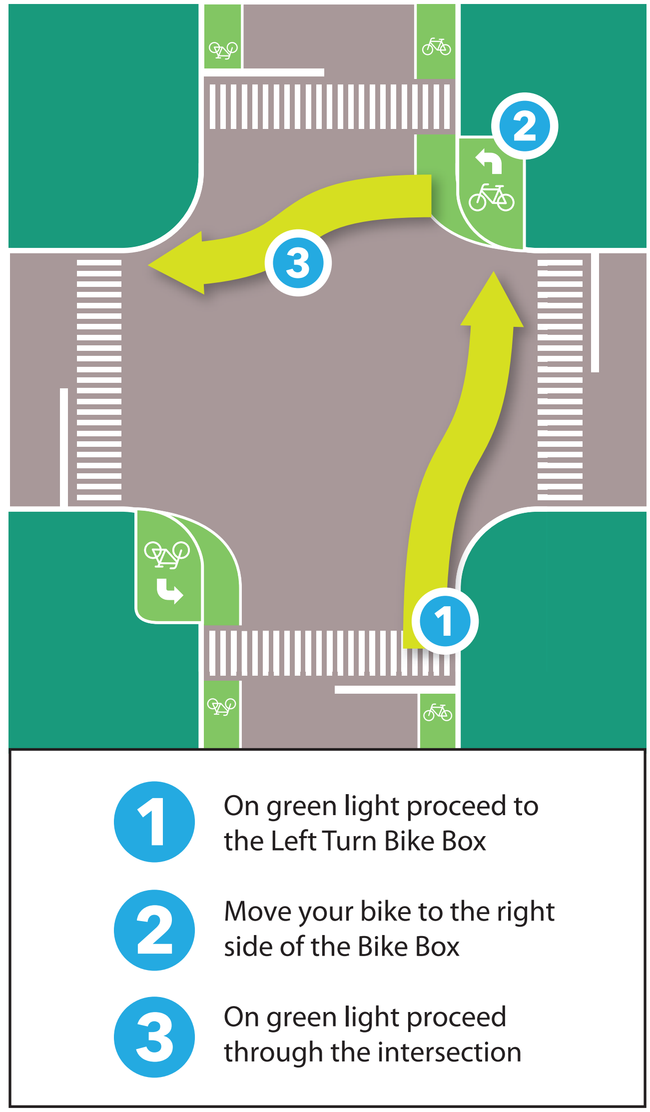
Category: Infrastructure

DESCRIPTION

A bicycle box is a right-angle extension of the bicycle lane positioned in front of motor vehicles at a signalized intersection. It is intended to improve the predictability of the bicyclists' stopping position at an intersection by allowing cyclists to move ahead of motor vehicle traffic when there is a red light. Giving them more space allows them to safely and more comfortably clear the intersection.[35, 36] Located in front of the traffic, cyclists are more visible and are provided with a head start once the lights turn green.[37] Bicycle box markings can either be a series of white painted lines with a white bicycle symbol inside (skeleton box) or they can include color, as shown in the illustration below.

Bicycle Box

There are also left-turn bicycle boxes that accommodate left-turning cyclists via a two-stage left-turn (also known as the "Copenhagen left"). These boxes are located on the inside edges of the intersection, but out of the path of drivers on the cross-street. At the first stage, left-turning cyclists move through the intersection to a bicycle box at the opposite-right end of the intersection, and then turn to face the desired direction of travel. At the second stage, cyclists pass through the intersection as part of the through-traffic and do not have to cross the path of oncoming through-traffic.[35]



Left-Turn Bike Box / Copenhagen Left

ISSUES / EVIDENCE

According to CAA, in Canada, 19% of bicyclists killed in traffic crashes were struck by a heavy truck. Approximately 16.9% of the pedestrian fatalities and 39.1% of the bicyclist fatalities resulted from collisions where the heavy vehicle was turning right just before the collision occurred.[39]

Studies conducted at ten signalized intersections in Portland, Oregon, observed a 31% decrease in conflicts between drivers of bicyclists after the installation of bike boxes. It also noted a 94% increase in bicycle volumes. Over 75% of surveyed cyclists thought bike boxes made the intersection safer.[38]

An Austin, Texas study further demonstrated how the design of bike boxes support changes in cyclist behaviour. Findings show that the percentage of bicyclists who approached the intersection in the bicycle lane remained about the same after the bicycle box skeleton (no color) was installed (that is, they did not enter the bicycle box). However, after color was added to the bicycle box, the percentage of bicyclists who approached the intersection using the bicycle lane and made use of the bicycle box increased from 77% to 93%. This may also suggest that the colored lane leading to the bicycle box encourages bicyclists to approach in the bicycle lane rather than the full (vehicle) lane.[36] In addition, there was an improvement in drivers yielding to cyclists at the newly installed bike box locations.[38]

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. The design of North American trucks compared to their European counterparts may preclude the effectiveness of this countermeasure. Even though a cyclist may be positioned in front of the truck and within the designated area, he/she may still fall within the truck's blind spot (e.g., front right), resulting in a high potential for collision. Other supporting countermeasures may be needed. (See Section 3.8 External Mirrors to Reduce Blind Spots and Visibility Detection Technologies

Conflicts have been shown to decrease when cyclists, using the bicycle box, and drivers are both stopped at a red light because they are visible to each other and observing the rules of the road. However, certain situations can still result in conflicts. Also, when traffic is moving, drivers may still not notice cyclists that may be approaching on their right.[36] (See Section 3.5 No Right Turn-on-Red (RTOR))

Bicycle boxes must be well designed; for example, the reservoir (the space between the cyclist's stop line and the stop line further back for drivers) should take into account all the manoeuvres cyclists need to make when entering and leaving the bike box, including the numbers of cyclists likely to be using it. From a practical design perspective, there is also the issue of paint being scraped off by snowplows in the winter, thus requiring repainting. (See Annex IV: Additional Resources, Transportation Association of Canada References – Best Practices and Guidelines)

CROSSING DISTANCES AND LOCATION OF MID-BLOCK CROSSWALKS

Groups Affected
- Pedestrians
- Drivers

Jurisdictions Studied
- OECD (35+ countries)
- ITF (50+ countries)

Category: Infrastructure

DESCRIPTION

To increase pedestrian safety, the widths of crossings can either be minimised or divided into sections. In this way, pedestrians have less oncoming traffic to consider making it easier to select an appropriate gap in traffic.

This can be accomplished using **curb extensions,** which significantly improve pedestrian crossings by reducing the crossing distance. They also visually and physically narrow the roadway and reduce the time pedestrians spend on the roadway.[6]

In addition, **crossing islands** consisting of a raised island in the centre of the road, may be used to shorten crossing sections on wider roads and provide a refuge for pedestrians. Central crossing islands allow pedestrians to deal with one direction of traffic at a time, enabling them to stop part-way across the street to wait for an adequate gap in traffic before completing their crossing.[6] (See also countermeasures listed under Section 3.3 Intersection Design and Traffic Control)

ISSUES / EVIDENCE

It has been demonstrated that crossing islands dramatically decrease pedestrian road crossing collisions due to fewer conflicts; they also help reduce vehicle speeds as they approach the island and offer improved crossing conspicuity and shorter exposure time for pedestrians.[6]

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. Curb extensions may make it more difficult for heavy vehicles to manoeuvre at intersections, impeding the ability of trucks to deliver in urban areas. This could have a negative impact on businesses that rely on trucks for the delivery of goods and services. Trucks are designed according to standard intersection schemes as outlined by the Transportation Association of Canada (TAC). Decreasing the turning radius can be problematic for heavy vehicles at intersections but mid-block crossings or islands may be an effective measure. (See Section 3.3 Marked Mid-Block Crossings)

An international study recommends that streets with a maximum speed of 50 km/h (or higher) and used by pedestrians should offer safe crossing opportunities for pedestrians every 100 metres at a minimum.[6] In Canada, the implementation of this type of intervention would be applicable to appropriate roadways, based on their functional classification.

In constrained environments with high vehicle volumes, the installation of raised medians, pedestrian refuges, redesigning intersections or increasing crossing times can have significant impacts on road capacity. A reduction in the number of lanes will provide more space for pedestrians, cyclists and parked cars, reducing crossing times and improving the social interaction and neighbourhood feel along the street. However, limiting the number of lanes may also require eliminating on-road parking space.[6]

Planning for any related infrastructure changes should take into consideration the need for the manoeuvrability of emergency vehicles.

FLASHING "EYES" TRAFFIC SIGNAL

Groups Affected
- Pedestrians

Jurisdictions Studied
- U.S.

Category: Infrastructure

DESCRIPTION

The flashing "EYES" pedestrian crossing signal is designed to remind pedestrians to be aware while waiting or crossing at an intersection. In one configuration (Florida), it consists of two blue LED "eyeballs" that scan left and right at a rate of one cycle/second. The position of the eyes are as follows: one set of eyes above the standard symbol of a hand (for wait), and one set of eyes above the walking person (for walk), which are also LED configurations.(14)

Flashing "EYES" Traffic Signal

ISSUES / EVIDENCE

Pedestrians [or other vulnerable road users] often fail to scan the traffic environment and are, therefore, vulnerable to being struck by turning vehicles.(14)

In a Florida study, the baseline condition used standard pedestrian signals. The experimental conditions included the "EYES" display either immediately before the "WALK" signal for 2.5 seconds, concurrent with the beginning of the "WALK" signal for 2.5 seconds or concurrent, then repeated every 9.5 seconds during the "WALK" signal. The percentage of pedestrians not looking for turning vehicles reduced dramatically under all conditions. Conflicts between pedestrians and turning vehicles were also greatly reduced by using the "EYES" display.(14)

A 2011 study evaluated three signal-based countermeasures in Las Vegas, Nevada, including a pedestrian countdown signal with animated blue eyes. There was a significant increase in the percentage of pedestrians who looked for vehicles before beginning to cross during the "WALK" phase. The researchers concluded that the pedestrian countdown signal with animated eyes improved overall pedestrian crossing behaviour at the intersection.(94)

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. As many of the collisions between pedestrians and heavy vehicles occur at intersections, these pedestrian signals may help to increase their safety.

When introducing such technology, it is important to educate VRUs about what they mean.

IMPROVED CROSSWALK DESIGN

Groups Affected
- Pedestrians
- Drivers

Jurisdictions Studied
- Canada
- U.S.
- OECD (35+ countries)
- ITF (50+ countries)

Category: Infrastructure

DESCRIPTION

The details of intersection crosswalk design constitute a highly technical and complex area. There are four main factors that influence collisions with pedestrians. These include: ensuring the visibility and conspicuity of the pedestrian; minimizing the crossing distance for pedestrians; considering the predictability of pedestrian behaviour at the crossing; and moderating vehicle travel speed.[6]

There are numerous crosswalk design details and countermeasures that address these areas; many of which are listed in this section.

ISSUES / EVIDENCE

In Canada, the majority of pedestrian and cyclist fatalities and injuries occur at intersections, with significant incidents involving heavy vehicles moving straight ahead and turning right manoeuvres.[39] The majority (75%) of pedestrian fatalities occur on urban roads and pedestrian collisions more often occur on urban roads with speeds of 70 km/h or less, and near intersections when pedestrians are crossing a roadway.[34]

A U.S. study found that installing raised medians and redesigning intersections and sidewalks reduced pedestrian risk by 28%.[6]

Further evidence supporting specific crosswalk design features are handled under each respective countermeasure.

(See countermeasures under Section 3.3 Intersection Design and Traffic Control and Section 3.8 Visibility and Conspicuity)

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. While crosswalk design features address the safety of vulnerable road users and their interaction with all motor vehicles, consideration of how any existing or future designs can increase the safety of pedestrians and cyclists when heavy vehicles enter the intersection warrants attention.

The general knowledge required to improve pedestrian crossings is well documented; however, there are specific measures or situations that require more study or 'fine tuning'.

Implementing measures to improve pedestrian safety often has an impact on the road's capacity and on levels of congestion. This can have an economic impact due to the lengthened time required to reach a destination (people and merchandise). (See Annex IV: Additional Resources, Transportation Association of Canada References – Best Practices and Guidelines)

To encourage walking, people must feel safe and comfortable. To promote this, jurisdictions must ensure and provide safe infrastructure. (See Section 2.0 Walking Strategy)

Other identified considerations include costs, resources, political will and jurisdictional differences.

INCREASED CROSSING TIME AT INTERSECTIONS

Groups Affected
- Pedestrians

Jurisdictions Studied
- Canada
- U.S.
- Sweden
- OECD (35+ countries)
- ITF (50+ countries)

Category: Policy/Legislation/Regulation; Infrastructure

DESCRIPTION

Crossing times at intersections may either be programmed into the traffic signals or be initiated by pedestrians using push-buttons. Careful consideration is given to the time allocated for pedestrians to cross an intersection. These signals are most often designed assuming a walking speed of 1.2 metres per second, which can be challenging for some pedestrians. A walking speed of 1 metre per second or less is preferred, as it allows pedestrians walking more slowly to cross at their own pace (e.g., young children, older adults or people with mobility impairments).[6, 32] (See Section 3.3 Crossing Distances and Location of Mid-Block Crosswalks)

ISSUES / EVIDENCE

Between 33 and 50% of collisions with pedestrians occur at intersections.[6] Sixty-three percent (63%) of pedestrians killed at intersections were 65 or older.[4]

A recent evaluation of walking speed carried out in Winnipeg looked at age, gender, and seasonal differences. Walking speeds for both young and older pedestrians were slower in winter than in summer. It was concluded that nearly 40 percent of older pedestrians and approximately 10 percent of children would not be accommodated using a design value for speed of 1.2 m/s.[14]

A further U.S. study recommended crossings be designed to accommodate a walking speed of 1.0 m/s at crossings used by large numbers of seniors, based on their observations of the walking speeds of older pedestrians at three types of crossings. Speeds were greater at un-signalized intersections than where there were signals. Older people in the study reported difficulty negotiating curbs and judging the speeds of oncoming vehicles, as well as confusion with pedestrian walk signal indications. A further report suggests a design speed exceeding 1.0 m/s may be too high for older pedestrians.[14]

A study in Sweden found pedestrians aged 70 or older, considered crossing an intersection "fast" to be less than 1.2m/s. The comfortable speed was .67 m/s for 15 percent, well below the standard often used.[14]

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. It has been found that fatal pedestrian collisions involving large trucks were more likely to occur at signalized intersections during daylight hours and to involve older pedestrians.[40]

Walking speeds reported in studies vary; however, it is clear a significant proportion of pedestrians will find it difficult or impossible to cross streets at the 1.2 m/s expected at most signalized intersections.[14]

Pedestrians who would normally walk at an average speed for their age can be slowed down through being encumbered with bags of groceries, luggage, etc., as well as by snow and ice on the road.[14]

Increased crossing time at a signalized intersection may be warranted if there is an increase in pedestrians that are children, teenagers, the elderly, or those with special needs.[32]

Increasing crossing times and the resulting redesigning of intersection signals can have important impacts on road capacity. Pedestrian needs and limitations vary – children, older adults, disabled persons.

Each have behavioural and psychological drivers that affect road crossing decision-making and judgment.[14]

(See Section 3.7 Speed Limit Reductions and Annex IV: Additional Resources, Transportation Association of Canada References – Best Practices and Guidelines, Pedestrian Crossing Control Guide)

LIGHTING AT INTERSECTIONS

Groups Affected
- Pedestrians
- Drivers

Jurisdictions Studied
- Canada
- U.S.

Category: Policy/Legislation/Regulation; Infrastructure

DESCRIPTION

Street lighting is essential in areas where there are many pedestrians walking at night including lighting at intersections and crosswalk lights. Lighting not only makes pedestrians more visible to drivers, but creates a safer environment for walking at night.[14]

ISSUES / EVIDENCE

In Canada, pedestrians accounted for 14% of all road users killed and 7% of victims injured between 2008 and 2011. A Transport Canada study of fatally injured vulnerable road users found that 59% of pedestrians killed in crashes in Canada between 2004 and 2006 were struck in dim lighting conditions (dawn or dusk) or darkness. An Ontario study on pedestrian fatalities indicated that twilight or darkness conditions existed for 57% of fatal pedestrian crashes in the province in 2010.[4, 5]

Documents reviewed identified several studies that examined the effect of lighting and vulnerable road user casualties and injuries. In addition, *Pedestrian Casualties in Ontario*: *a 15-year Review* found that 25% of pedestrian fatalities occurred between 3 - 7 p.m. Potential reasons cited included high traffic levels, darkness and alcohol use. Furthermore, the City of Toronto's *Pedestrian Collision Study* found that collisions occur more frequently between 3 - 8 p.m. and most pedestrian fatalities occur in January. (See Section 3.3 Marked Mid-Block Crossings and Section 3.8 Increased Conspicuity and Visibility of Pedestrians / Cyclists)

A U.S. report analyzing the effectiveness of street lighting in Florida, indicated that compared to dark conditions without street lighting, daylight lowers the odds of a fatal injury by 75% at mid-block locations and 83% at intersections, while street lighting reduces these by 42 and 54% respectively at mid-block and intersection locations.[14]

Note: *Collisions examined with respect to lighting conditions did not differentiate between types of vehicles. Therefore, it is unknown if any of these incidents involved heavy vehicles. However, the vast majority of collisions between vulnerable road users and heavy vehicles occurred during clear weather (92%) and in daylight conditions (81%).(Transport Canada)*

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. The majority of collisions between heavy vehicles and vulnerable road users take place in urban areas during daylight hours. Some jurisdictions (e.g., the U.K.) are studying the experiences of cities (Dublin and Paris) where heavy vehicles over a certain size are restricted from certain parts of the city, or at certain times of the day.[25] New York City is conducting a pilot study of an after-hours delivery program.[7] Any jurisdiction considering similar strategies, may want to consider how the issue of lighting at intersections could impact interactions between vulnerable road users and heavy vehicles.

Pedestrians often assume that drivers can see them at night and may be deceived by their own ability to see the oncoming headlights. Without sufficient overhead lighting (both in the crosswalk and at refuge areas), motorists may not be able to see pedestrians in time to stop.[32]

The need for lighting on one or both sides of the street are subject to jurisdictional standards, including permitted crossings at intersections.

The location of an intersection and the type of collision may preclude any benefits that result from infrastructure changes. For example, one U.S. study indicated that while a lighted intersection and pedestrian crossing lights were possible countermeasures, such changes may be difficult to justify at a particular intersection where the collision took place and where a pedestrian was hit (at the front of a truck that was turning left). [80]

(See Annex IV: Additional Resources, Transportation Association of Canada References – Best Practices and Guidelines)

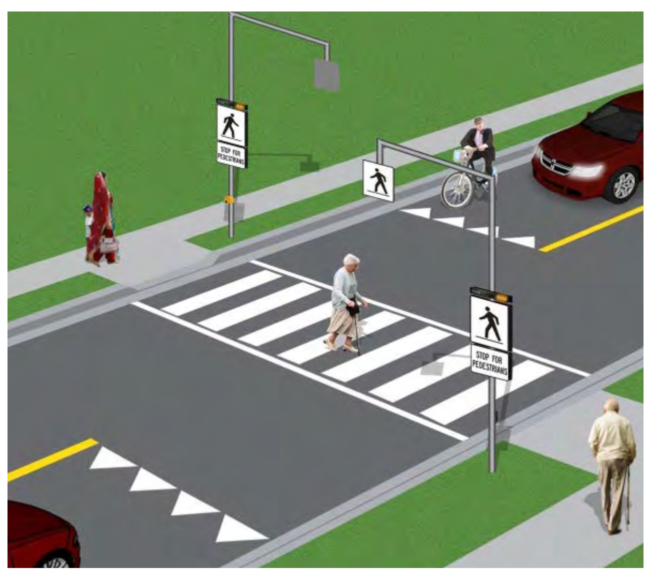
MARKED MID-BLOCK CROSSINGS

Groups Affected	Jurisdictions Studied
▪ Pedestrians	▪ Canada ▪ U.S.

Category: Policy/Legislation/Regulation; Infrastructure

DESCRIPTION

Midblock crossings are marked crosswalks located between intersections that offer safe and convenient locations for pedestrians to cross in areas where there may be long stretches with limited intersection crossings. They should be located where there is heavy pedestrian traffic and major destinations, such as schools, shopping centers, or transit stops. There are a variety of design treatments associated with mid-block crosswalks that include traditional and advanced yield markings; they can also be enhanced with medians, refuge islands, signals, signs, lighting and curb extensions.[43] (See Section 3.3 Crossing Distances and Location of Mid-Block Crosswalks)



Marked Mid-Block Crossing with Advanced Yield Markings

ISSUES / EVIDENCE

Review of pedestrian fatalities in Ontario found that more fatalities occurred at mid-block locations (31%) than elsewhere. The City of Toronto Pedestrian Collision Study reported that this accounted for 22% of all collisions.[4] In the United States, 69,000 pedestrians were injured in motor vehicle crashes in 2008. Approximately 4,400 pedestrians were killed in motor vehicle crashes in the United States that year. Seventy-six percent of pedestrian fatalities occurred at non-intersection crossings.[44]

In a Massachusetts, U.S. study, driver eye fixations and yielding behaviour (that is, their likeliness to stop) at marked mid-block crosswalks were examined as drivers approached the intersection. Subjects in the control group encountered traditional road markings with stop bars 3 metres before the intersection, while subjects in the experimental group experienced advance yield markings and prompt signs. Subjects in the experimental group looked for pedestrians 69% of the time and began to look sooner, while those in the control group looked 47% of the time. 61% of the advanced yield group yielded or stopped when a pedestrian emerged behind the stopped vehicle while none of the control group drivers yielded or stopped.[14, 44]

Advance yield markings and prompt signs in sight-limited, multi-threat scenarios can lead to changes in drivers' behaviour such as increasing the likelihood of glances towards the pedestrian, increasing the distance at which the first glance is taken, and increasing the likelihood of yielding which are likely to reduce pedestrian–vehicle conflicts.[44]

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. Based on study results of the advance yield group, it seems likely that this countermeasure would benefit drivers of heavy vehicles, as well.

Drivers do not expect to see pedestrians crossing at midblock locations. Therefore, adequate lighting, signage, signalization and/or markings help ensure drivers have the necessary time to stop.[43]

Midblock crossings that span multiple lanes may be challenging for many pedestrians, so consideration should be given to appropriate design features (e.g., medians, refuge islands, curb extensions) to help reduce the number of lanes that pedestrians must cross at once and/or reduce the distance a pedestrian must walk to cross the street.[43]

Midblock crosswalks can be difficult to use safely for those who are visually impaired.[43]

The requirements for the design and implementation of mid-block crossings within different jurisdictions needs to be taken into consideration. (See Annex IV: Additional Resources, Transportation Association of Canada References – Best Practices and Guidelines, Pedestrian Crossing Control Guide).

As of January 2016, drivers – including cyclists must stop and yield the whole roadway at pedestrian crossovers (mid-block crossings, school crossing and other locations where there is a crossing guard). These new rules do not apply to pedestrian crosswalks at intersections with stop signs or traffic signals, unless a school crossing guard is present. Only when pedestrians and school crossing guards have crossed and are safely on the sidewalk can drivers and cyclists proceed. (More information is available at MTO – Safety)

PEDESTRIAN COUNTDOWN SIGNALS

Groups Affected
- Pedestrians

Jurisdictions Studied
- Canada
- U.S.

Category: Infrastructure

DESCRIPTION

This signal is a timer that provides a numeric countdown displaying the number of seconds remaining for a pedestrian to complete the crossing. The timer starts counting at the beginning of the pedestrian flashing "DON'T WALK" display and finishes counting (i.e., a "zero" display is shown) until the end of the pedestrian flashing "DON'T WALK" display. There is no countdown display during the pedestrian "WALK" or solid "DON'T WALK" displays. The practice of starting the countdown at the beginning of the FDW (Flashing Don't Walk) is recommended by the Transportation Association of Canada (TAC). (More information is available at City of Toronto)

The initial countdown display value is dependent on the length of the crosswalk. Consequently, the display value can vary depending on the crossing and intersection type. In Canada, countdown timers are governed by the provincial/territorial jurisdictions and may vary accordingly.

ISSUES / EVIDENCE

Nearly half (47%) of pedestrian fatalities and severe injuries occurred at signalized intersections; surprisingly, most (57%) of these crashes occurred while the pedestrian was crossing with the signal. Crossing-against-the-signal, pedestrian KSI (killed or severely injured) crashes are 56% more deadly than crossing-with-the-signal crashes. [15]

Statistics suggest that both driver failure to yield to pedestrians in the crosswalk, as well as pedestrian failure to follow traffic signals, are both significant factors leading to KSI crashes at intersections.[15] Countdown signals have been shown to reduce pedestrian injury crashes in some cases and are strongly preferred by pedestrians, who find them easier to understand than other signal types.[15]

In San Francisco, researchers examined pedestrian injuries during the twenty-one months leading up to the installation of nine pilot countdown signals and for the twenty-one months following the installation of the signals. They compared treatment location statistics with those for 1,266 intersections, about half of which were scheduled to receive countdown timers in the future, while half were not. Analysis of the results showed that the number of pedestrian collisions declined by a statistically significant 52% following the introduction of these signals. However, the authors caution that some of the effect may have been due to regression to the mean, given that the pilot intersections were selected based on pedestrian safety-related criteria.[45]

A large study in Toronto compared the rate of pedestrian-motor vehicle collisions at 1,965 Toronto intersections before and after the installation of pedestrian countdown signals. A total of 9,262 pedestrian-vehicle collisions took place during the ten-year study period. Analysis of the results indicated that the pedestrian countdown signals had no statistically significant effect on the number of pedestrian-motor vehicle collisions at the intersections where they were installed. The authors concluded that pedestrian countdown signals should not be considered to offer significant safety benefits when used in the absence of other safety measures, such as education about how they work.[46] Therefore, the evidence on the effectiveness of these countdown signals is mixed.

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. As many of the collisions between pedestrians and heavy vehicles occur at intersections, these pedestrian countdown signals may help to increase their safety. However, this countermeasure does not address the issue of blind spots, which is a key concern.

Some pedestrians may start to cross the intersection during the countdown phase assuming they have sufficient time to cross the street. The countdown signals are meant to inform pedestrians with how much time they have left once they start crossing. Also, some drivers, seeing there are only a few seconds left in the countdown, may speed up to go through an intersection to avoid a red light raising the risk of a collision with VRUs or other vehicles.

Countdown signals need to be customized by adding more time at those intersections where there are higher populations of slower walking pedestrians such as school zones and near seniors' residences.

Road users can usually be guided towards making safe decisions by informative street design and traffic engineering. This can be further supported by education on their proper use and interpretation, and awareness of how road conditions may affect the time it takes to cross the intersection. However, some problems can only be addressed with the deterrence that comes from strong enforcement of traffic law.(15)

PEDESTRIAN HYBRID BEACON (PHB)

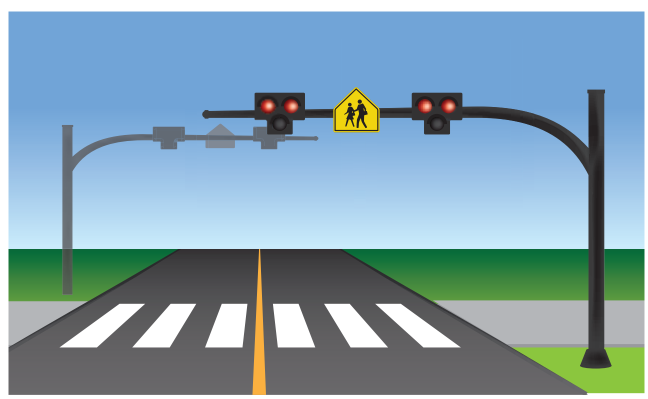
Groups Affected
- Pedestrians

Jurisdictions Studied
- U.S.

Category: Policy / Legislation / Regulation

DESCRIPTION

The pedestrian hybrid beacon (PHB), also known as High-Intensity Activated Crosswalks (HAWK), is a traffic control device designed to help pedestrians safely cross busy or higher-speed roadways at midblock crossings and uncontrolled intersections. The PHB head consists of two red lenses above a single yellow lens. The lenses remain "dark" until a pedestrian desiring to cross the street pushes the call button to activate the beacon. The signal then initiates a yellow to red lighting sequence consisting of steady and flashing lights that directs motorists to slow down and come to a stop. The pedestrian signal then flashes a "WALK" display to the pedestrian. Once the pedestrian has safely crossed, the hybrid beacon again goes dark. The PHBs are included in the U.S. (More information is available at Manual on Uniform Traffic Control Devices)



Pedestrian Hybrid Beacon (PHB)

EVIDENCE

More than 75 percent of pedestrian fatalities occur at non-intersection locations and vehicle speeds are often a major contributing factor. Drivers don't always stop for pedestrians who want to cross at crosswalks resulting in them being hit or having to retreat to the curb.

A 2010 report evaluated the safety effectiveness of the PHB at 21 sites in Tucson, Arizona. The researchers used collision data for the 3 years pre-treatment and for 3 years following the installation of PHBs, as well as nearby untreated comparison sites. Results of the analysis showed a statistically significant reduction in total crashes of 29% as well as a statistically significant 69% reduction in pedestrian crashes at treated sites compared to untreated sites.[89, 90]

Three sites in Charlotte, North Carolina were treated with PHBs with researchers collecting data from pedestrian crossings during weekday mornings and evening peak times over several months. An analysis of the results showed an increase in the percentage of yielding motorists, a decrease in the percentage of trapped pedestrians, and a decrease in pedestrian-vehicle conflicts at all three sites. However, these results were significant at only one of the three sites. The results also indicated that changes in pedestrian and motor vehicle actions were more consistent after the PHBs had been in place for three months or more.[91]

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. The installation of PHBs can be expensive and there is no guarantee that drivers will be fully aware of what is expected of them. They may also give pedestrians a false sense of security by assuming drivers will stop because the lights are flashing; consequently agencies should consider an education and outreach effort when implementing a PHB within a community. The Charlotte N.C. study suggests that some time is required for drivers and pedestrians to get used to PHBs.[91]

PEDESTRIAN SCRAMBLE OPERATIONS (PSOS)

Groups Affected

- Pedestrians
- Drivers

Jurisdictions Studied

- Canada
- U.S.
- U.K.

Category: Infrastructure

DESCRIPTION

Also referred to as "all exclusive pedestrian phasing", the Pedestrian Scramble Operation (PSO) is an exclusive pedestrian signal phase in which traffic in all four directions is stopped and pedestrians are allowed to make diagonal as well as lateral crossings. During the pedestrian walk phase, drivers cannot turn right or left, eliminating common points of conflict with pedestrians.[14] The PSO design chosen will depend on several factors including sidewalk space, pedestrian circulation, traffic congestion, evidence of high conflict with turning vehicles, pedestrian wait times, concerns of visually impaired pedestrians, etc.

Pedestrian Scramble – Courtesy of LADOT (Los Angeles Department of Transport)

ISSUES / EVIDENCE

In Canada, 44.6% of all pedestrian fatalities and the majority of pedestrian injuries (53%) occurred at intersections on public roads.[39] Further, many pedestrian collisions at intersections involve a left or right-hand turning vehicle. A Pedestrian Scramble Operations, or PSO, is one recommended solution to this conflict.[14]

The U.S. Department of Transport (DoT) has reported a 34% decrease in pedestrian collisions where intersections have been converted into PSOs.[14]

Alberta conducted a pilot test in Calgary on the effects of implementing PSOs at two intersections in the downtown area and found they significantly reduced the number of pedestrian / vehicle conflicts. Of the total pedestrian violations, 13% were "safe side" crossings (i.e., going in the same direction as the vehicle movement), and about 40% of the violations were at the beginning of the "FLASHING DON'T WALK" phase.[14] Because of the longer wait times for pedestrians before they can cross, some intersections experience higher incidents of pedestrians not observing the new traffic signals.[47]

More recently, Toronto completed a pilot project implementing PSOs at three intersections with very high volumes of pedestrian traffic. Overall findings revealed an alleviation of corner crowding (on sidewalks), an aggregate time savings for pedestrians, and increased use of the diagonal crossing intersections. At the same time, however, there was a significant increase in delays to mixed traffic in Toronto; from a policy implementation perspective, this trade-off was acceptable given that there are over 50,000 pedestrians at these Toronto intersections in a typical 24-hour period compared to 36,000 vehicles.[47]

The increase in delay to transit vehicles is a concern. While a better level of service is being provided to pedestrians at the Toronto intersections, these same pedestrians are subject to additional delays when they ride on the streetcars. Similarly, in Calgary, the expected increase in vehicle delay was considered acceptable given the safety and operational benefits for pedestrians that scramble control provides.[47]

A "Diagonal Crossing Scheme" was implemented on Oxford Street in London, England. It allows users to cross diagonally and to almost double free pavement space, radically cutting pedestrian congestion. Preliminary findings showed positive results, including reduced pedestrian congestion, collision rates and public transit journey time.[6]

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. Considering the high probability of collisions between heavy vehicles and vulnerable road users at intersections, this countermeasure is likely to offer positive outcomes in such circumstances. However, as indicated below, its success depends on all parties fully understanding what is expected of them when using PSOs.

PSOs could interfere with the flow of traffic and oblige pedestrians to wait longer for the all vehicle stop phase.

Successful outcomes depend on taking measures to ensure that the public is informed of the new operations in the days leading up to implementation. These include a good communications strategy, collaboration with stakeholders, and effective signage.[47]

Pedestrians crossing illegally using this new operation places pedestrians at risk of being struck by turning motorists. Based on field observations, it appeared that most pedestrians who cross on green for vehicles are those who are not familiar with the new traffic light operation. Considering that a location could have a high concentration of tourists who would not be familiar with pedestrian scramble phasing, this may be a chronic problem at both Calgary and Toronto locations.[47]

Pedestrian scramble control is not appropriate at all locations. It should be reserved for locations where there are a large number of pedestrians crossing in all directions at all times of day. Also, consideration should be given to maintaining consistency of operations in a City. It would be confusing to pedestrians and motorists to implement different types of pedestrian scramble phasing or to operate some by time of day and others on a 24/7 basis.[47]

PROTECTED LEFT-TURN PHASING

Groups Affected
- Pedestrians
- Drivers

Jurisdictions Studied
- U.S.

Category: Infrastructure

DESCRIPTION

Protected left-turn phasing is a traffic signal sequence that holds the pedestrian at the curb by a "DO NOT WALK" phase while through traffic is held by a red light. The driver is able to make a left turn without conflicting with pedestrians. Some jurisdictions have increased the number of intersections with protected left-turn phasing and where drivers are prohibited from turning right on a red light.[14] (See Section 3.3 Advanced Green for Pedestrians and Section 3.5 No Right Turn-on-Red (RTOR))

ISSUES / EVIDENCE

Most intersections make it difficult for drivers to make safe turning choices.[14]

In New York City, left-turn only phases for vehicles were introduced at 95 intersections, which resulted in a 45% decrease in vehicle/pedestrian crashes compared to an 11% decrease where there were no left-turn only phases.[48]

A study in Austin, Texas found that the best phasing measure was a split phase where the left-turning drivers had a green phase holding the pedestrians and then the pedestrians would have a green phase while the left-turning vehicles were held by the light. The vehicle/pedestrian conflict rate was reduced from .25 to .01 using the split phases, which was statistically significant.[95]

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. This countermeasure separates the movement of vulnerable road users and heavy vehicles (and other motor vehicles) at intersections. However, it can result in longer waiting times for both vehicles and pedestrians.

Groups Affected
- Pedestrians
- Cyclists
- Drivers

Jurisdictions Studied
- Canada
- U.S.
- Sweden
- Netherlands
- Denmark
- Belgium
- Germany

Category: Policy/Legislation/Regulation; Infrastructure

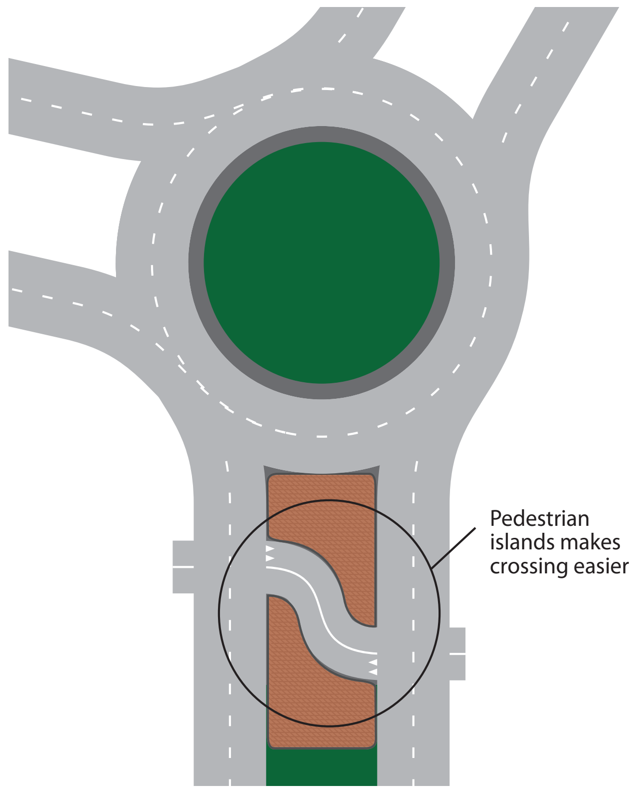
DESCRIPTION

A roundabout is a type of circular intersection where road traffic flows almost continuously in one direction around a central island; in North America the direction is always counter clockwise. Merging traffic gives way to vehicles already in the circle, then proceeds into the roundabout and exits at their desired street. There are no traffic signals or stop signs. This design should not be confused with traffic circles or rotaries, which are much larger than a modern roundabout and often have traffic signals or stop signs within the circular intersection. The Arc de Triomphe in Paris is a good example of these older-style traffic circles.

Although there are a variety of designs, they all share a common element by allowing traffic to move in a circular direction. The raised central island is a main feature. They may have single or multiple lanes and may or may not contain a segregated bicycle lane located on the outer edge of the circle, next to the outer edge or recessed from the roundabout itself. There is even a roundabout uniquely designed in the Netherlands for the use of cyclists only. (See Section 3.4 Segregated Bicycle Lanes)

Due to the dangers presented by roundabouts to cyclists specifically, there are features within the roundabout itself where the bike lane is raised a few centimetres above the normal road surface. Entering or exiting vehicles must pass over the "hump" when they cross the bicycle lane. This helps to reduce speed and signals the potential presence of cyclists.

The image below shows a roundabout with a two way-lane for the cyclist and a brick walkway for the pedestrian, and the 90-degree angle, which provides longer sight lines for everyone. The jog in the lane forces cyclists to reduce their speed and the yield sign indicates that cyclists must give way to motor vehicles.



Roundabout – with 90 Degree Angle

ISSUES / EVIDENCE

In Canada, the majority of pedestrian and cyclist fatalities and injuries occur at intersections, with significant incidents involving heavy vehicles moving in straight ahead and turning right manoeuvres.[39] Between 33 and 50% of collisions with pedestrians occur at intersections.[6] Twenty-eight percent (28%) of fatal truck crashes occur in urban environments and more than half of truck crashes involving cyclists and pedestrians in urban areas occur at relatively low speeds.[63]

Since the majority of collisions occur at intersections, studies conclude that replacing intersections controlled by traffic lights or stop signs with roundabouts, where conditions permit, has considerable potential for reducing lateral collisions. Above all, roundabouts can potentially reduce injuries and deaths due to lower speeds. Statistics collected showed collisions were reduced by: 61% when a single lane roundabout replaced stop signs; 5% when a multi-lane roundabout replaced stop signs; 35% when a single-lane roundabout replaced traffic lights.(49)

However, the design of roundabouts can result in safety issues such as, amongst others, reduced visibility and manoeuverability of heavy vehicles.(50)

Recent Belgian, German and American studies indicate that bicycle lanes in the roundabout present the worst scenario for cycling safety. A recent Danish study also indicates that the number of bicycle collisions is associated with the speed of the motor vehicles in the roundabout.(51)

During 2007 and 2012, a study on the safety record of roundabouts located in Assen, Holland was conducted. During this five-year period, two cyclist injuries occurred at all 21 roundabouts combined. This impressive safety record is attributed to the design – specifically, the 90-degree crossing point for both cyclists and pedestrians, providing longer sight lines for everyone, and thus allowing more reaction time. Cyclists are not required to go all the way around the roundabout as the crossing points provide two-way cycling lanes.(52)

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. Although roundabouts encourage lower speeds, certain designs may place cyclists closer to heavy vehicles and place them in the driver's blind spot which, in turn, may put cyclists in a more precarious position. Further, maneuvering through intersections can be challenging for heavy vehicles, which become even more pronounced when the load is exceptionally large or heavy.

Due to the circular design motorists are obliged to slow their speed when entering a roundabout, which allows visual engagement between motorists and pedestrians specifically. Crosswalks at each entry/exit may be located one full car length outside the roundabout providing extra space for a vehicle exiting to stop. These crosswalks may or may not use signalized crossing technology.

Although roundabouts can play an important role in limiting the number of casualties at intersections and have been employed by many jurisdictions, research studies from a variety of countries seem to indicate that roundabouts do not reduce the number of collisions involving cyclists.(51) A number of attempts have been made to find the differences in the level of safety for cyclists when employing various designs. To date, findings have been unclear on this front with the exception that multi-lane roundabouts have a higher incidence of bicycle collisions, and the 90-degree crossing point is safer for cyclists.

For a single lane roundabout, pedestrians cross one lane of traffic at once instead of multiple lanes, thereby minimizing the number of things to look for. Further, studies have shown a pedestrian's risk of severe collision is lower at roundabouts due to the slower vehicle speeds.

The relatively free-flowing traffic patterns of roundabouts result in a lack of the more predictable traffic movement found at signalized intersections. This makes it more difficult for the visually impaired pedestrian who may be relying on audible cues alone. Visually-impaired pedestrians face multiple risks at roundabouts. These can include longer delays because of the higher volumes typical of roundabouts, difficulty locating the crosswalk and difficulty in detecting yielding drivers.[50]

Maintenance of the road surface within the roundabout is also an important consideration when bicycle lanes are created within the circle. Pot holes and other irregularities must be repaired quickly as failure to do so may result in collisions when cyclists swerve to avoid debris or irregularities on the road.[51]

Roundabouts do not necessarily require more space than traditional intersections, but it could be a consideration. Geometric design details vary from site to site and must take into account traffic volumes, land use, topography, and other factors. Since they can process traffic more efficiently than traffic signals and stop signs, roundabouts typically require fewer traffic lands to accommodate the same amount of traffic. In some cases, roundabouts can require more space than stop signs or traffic signals at the actual intersection to accommodate the central island and circulation lanes, but approaches to roundabouts typically require fewer traffic lanes and less right-of-way than those at traditional intersections. (More information is available at Roundabout Facts)

Oversize / overweight (OSOW) vehicles are particularly sensitive to how intersections are designed. Therefore, the geometry of roundabouts must be carefully considered to achieve a good balance between safety for all users and the basic ability of freight to flow through the intersection. Truck aprons, which are part of the roundabout infrastructure, are concrete surrounds that encircle the outer portion of the roundabout and edge the roadway. The apron is lower than a curb but slightly higher than the roadway. This provides a more forgiving edge and helps heavy vehicles navigate the roundabout safely.

SEPARATE LEFT-TURN PHASES FOR CYCLISTS

Groups Affected
- Cyclists
- Drivers

Jurisdictions Studied
- OECD (35+ countries)

Category: Infrastructure

DESCRIPTION

Separate left-turn phases for cyclists introduce a phase at signalized intersections providing cyclists advanced time to turn left. There are other measures commonly used in some countries to reduce the number of nearside turn crashes at signalized intersections, such as pre-green stages for cyclists and separate phases for nearside turning cars against bicycles.

ISSUES / EVIDENCE

In the U.S. (between 2005 and 2010), 36% of all fatal bicycle crashes occurred at intersections.[53]

Traffic signals and different ways of upgrading existing signalized intersections have been subject to a fairly high number of evaluations and research studies. However, only a few studies have presented quantified results for reductions of bicycle crashes.

An international study found that separate left-turn phases reduce the number of left-turn crashes involving bicyclists at signalised intersections by 58%. This effect is also likely to apply to crashes with bicycles (especially collisions where bicycles are hit by left-turning cars from the opposite direction).[53]

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. This measure is equivalent to Advanced Green for Pedestrians (see Section 3.3) and may mitigate the risks to cyclists in intersections when heavy vehicles are turning and fail to see vulnerable road users that are in their blind spots.

It should be mentioned that separate left-turn phases are likely to cause a minor increase in other types of crashes, including crashes involving bicycles. If separate left-turn phases are introduced at an intersection where left-turn crashes only account for a minor share of overall crashes, there is a risk that the decrease in left-turn crashes may be outnumbered by an increase in the number of other types of crashes.[53]

YELLOW OR RED SIGNAL DURATION

Groups Affected
- Pedestrians
- Cyclists

Jurisdictions Studied
- Canada
- U.S.

Category: Policy/Legislation/Regulation; Infrastructure

DESCRIPTION

The yellow light display duration, or yellow change interval, can vary depending on the speed of the roadway, its grade (i.e., steep downgrade) and other factors. The all-red signal duration is provided after every yellow display. The all-red duration allows traffic to clear through the intersection before an opposing green is displayed. (More information is available at City of Toronto)

ISSUES / EVIDENCE

According to Transport Canada (2015), the majority (75%) of pedestrian fatalities occur on urban roads; pedestrian collisions more often occur on urban roads with speeds of 70 km/h or less, and near intersections when pedestrians are crossing a roadway.

Adequately timed yellow and all-red clearance signals are necessary at traffic signals to ensure drivers have sufficient time to clear the intersection before the pedestrian walk signals are displayed. A U.S. study showed that combined changes in the duration of yellow and all-red signal timing reduced the risk of pedestrian and bicycle crashes at intersections by 37% compared to control sites.[33]

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. Arguments have been made to consider larger vehicles in the timing calculations, such as single-unit trucks (30 feet) or intermediate semitrailers (55 feet). Considering larger vehicles would increase the duration of the red clearance interval to accommodate the additional length prior to conflicting traffic being released. However, conflicting vehicular traffic is obliged to yield the right-of-way to other vehicles legally in the intersection, which would include truck trailers. Therefore, it was considered that the length of the vehicle is irrelevant to this requirement.[54]

Traffic signal interval timing practices, procedures, and considerations vary widely. Methods include the approach speed of traffic upstream of the intersection, speed at entry into the intersection, speed during the left-turn manoeuvre, trajectory of the left-turn path, percent of trucks, and other factors.[54]

The duration of the yellow change and red clearance intervals has an impact on driver behaviour and intersection safety.[54]

WARNING SIGNS / PAVEMENT MARKINGS AT INTERSECTIONS

Groups Affected
- Pedestrians
- Cyclists
- Drivers

Jurisdictions Studied
- Canada
- U.S.
- Netherlands

Category: Infrastructure

DESCRIPTION

Warning signs provide instructions and/or warnings of potential danger ahead and are designed to reduce the potential of conflicts. Placed at intersections, they generally appear as a pictograph and/or pavement markings with directions for both drivers, pedestrians and cyclists. (See Section 3.3 Bicycle Boxes)

Some examples of warning signs include: “TURNING TRAFFIC MUST YIELD TO PEDESTRIANS”, “LOOK FOR TURNING VEHICLES”, “WATCH TURNING VEHICLES”, “YIELD HERE TO PEDESTRIANS”, “BLIND SPOT, TAKE CARE”, or “WARNING, YOU MAY BE IN A BLIND SPOT”[14]

Blind Spot Warning Signs

Also, pavement markings can indicate the locations of crosswalks and guide pedestrians along a safe path for crossing the road to help eliminate vehicle-pedestrian conflicts.[14] For example, zebra crosswalks tend to reduce motor vehicle speeds and, as a consequence, the severity of pedestrian injuries.[55] There are also signs and/or pavement markings that include speed limits, hidden laneways, and those that guide cyclists to safe driving zones. (See Section 3.3 Bicycle Boxes and Section 3.4 Segregated Bicycle Lanes)

ISSUES / EVIDENCE

Right-turn collisions between heavy vehicles and cyclists have been identified as a specific collision risk. They were identified as particularly severe in the Netherlands, where an estimated 30 to 40 fatalities and 100 serious injuries happened in one year, where right-turning trucks collided with cyclists at intersections. These collisions can, in part, occur because cyclists can approach alongside a heavy vehicle and are riding in the driver’s blind spot.[40]

A study published in the Institute of Transportation Engineers Journal (ITE) involved analyzing the effects of special signage on pedestrian-vehicle conflicts at signalised intersections. A “LOOK FOR TURNING VEHICLES” with an accompanying pictograph of the crosswalk along with pavement marking which read “WATCH TURNING VEHICLES”, were installed at three signalized intersections. Both pedestrian behaviour and pedestrian-vehicle conflicts were recorded before, immediately after and one year after these prompts were introduced. The results showed a dramatic decrease from the before period to the after period. The one year follow-up showed no conflicts, as compared to the earlier 2.7% baseline condition.(14)

A similar University of Nebraska study looked at the impact of a sign to remind drivers to yield to pedestrians at 12 marked crosswalks. The before-and-after study showed that conflicts between pedestrians and turning drivers were reduced by 20 to 65% for left turns and by 15 to 30% for right turns. In spite of these improvements, occurrence of conflicts remained relatively high after sign installation – 35% for left turns and 38% for right turns.(14)

Research indicates that other advance pavement markings are effective in increasing yielding distance at crosswalks. The multiple-threat collision occurs (in a multiple lane scenario) when one vehicle stops to allow a pedestrian to cross while another vehicle travelling in the same direction, fails to stop and strikes the pedestrian. This condition can also occur when a vehicle stops too close to the crosswalk thereby obscuring the visibility of the crossing pedestrian. The effects of “YIELD HERE TO PEDESTRIANS” signage and advance yield pavement markings were studied to determine their influence on vehicle-pedestrian conflicts at multi-lane crosswalks at T-intersections. The advanced pavement markings were a combination known as “shark’s teeth” or “saw-tooth markings”. The study found the sign alone reduced conflicts and increased the distance at which drivers yielded to pedestrians. The addition of pavement markings further increased yielding distances and reduced conflicts.(14)

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. The Ministry of Transportation of Ontario Trucks Handbook and Bus Handbook each includes a brief chapter on pavement markings. Any such warning signs (whether actual signage or pavement markings) would be applicable to heavy vehicles, as well as any resulting safety gains.

The relation of driver age and different perceptions of right-of-way, particularly in left-hand turn situations, may impact compliance.(14)

Certain pavement markings are best suited for multi-lane roads because, with the extra distance, visibility is improved for both pedestrians and drivers.(14) High conflict points can benefit from warning signs and pavement markings, for example, the use of reflective paint. However, the potential for distraction can lead to confusion.

Traffic control devices (TCDs) are not all equally effective because different types of warnings or pavement markings will lead to different rates of compliance by drivers.(14)

3.4 ROADWAY AND CYCLING INFRASTRUCTURE

The manner in which the public road network is designed, built and managed can have a significant effect on the utility of roadways and the safety of vulnerable road users.

PART I: SPECIFIC TO VRUs AND HEAVY VEHICLES

SEPARATE TRUCK AND BIKE ROUTES

Groups Affected	**Jurisdictions Studied**
▪ Cyclists ▪ Pedestrians ▪ Drivers	▪ Canada ▪ U.S. ▪ OECD (35+ countries)

Category: Policy/Legislation/Regulation; Infrastructure

DESCRIPTION

"Truck route" means the network of roads or streets that has been formally designated for certain trucks to use when traveling through or within that jurisdiction. (See Section 3.5 Restrict Movement of Heavy Vehicles)

A "bike route" is an overarching term that includes a bike lane or path specifically designed for bicycle travel. These routes are completely separated from motor vehicle traffic and offer an off-street alternative typically located in parks, alongside waterways or in quiet areas. Some transportation plans (e.g., Portland, Oregon; San Francisco, Vancouver) advocate for or manage the routing of trucks and bicycles to separate streets, where possible. This reflects Vision Zero and Complete Streets, to mention two such strategies.[7] (See Section 2.0 Road Safety Strategies)

Other strategies include diverting motor vehicle traffic to prevent drivers on major roads from entering local, mainly residential roads. This can be achieved by installing barriers and raised refuge islands that allow only pedestrians and cyclists to cross the major road.[56]

ISSUES / EVIDENCE

Based on studies conducted between 2011 and 2012 in Berkeley, California as well as in Toronto and Vancouver, separating cyclists from motor vehicle traffic can have beneficial results. It was found that traffic diversion can reduce motor vehicle crashes by as much as 29%. Bicycle boulevards that include traffic diversion can reduce vehicle-cyclist crashes by as much as 63 to 70%. In addition, traffic diversion from residential streets is even more effective than traffic circles or speed humps in reducing crashes for people who cycle.[35] (See Section 3.3 Roundabouts)

A Seattle study found that, in total, there were sixty-one collisions between trucks and bicycles in Seattle over the roughly ten year period between 2002 and 2012, and only sixteen of these involved large trucks. In comparison there were 3,721 total incidents between vehicles and bicycles. Based on this summary, it is reasonable to conclude that there are relatively few incidents with large trucks. However, the small number of truck related bicycle incidents does not entirely address the question of safety on routes shared by trucks and bicycles. The research team hypothesized that safety issues might exist on streets commonly shared by bicycles and trucks, regardless of whether the incidents actually involved trucks. To that end, a comparison was made between the number of total incidents on truck and bicycle routes and the streets common to both.[(7)]

Incident rates on roads common to both were 30 percent higher than incident rates on roads that did not overlap. Although this does not attempt to assign causality, especially since the analysis did not control for relative traffic volume, it is notable that the rate per lane mile of incidents is higher on streets shared by heavy vehicles and bicycles.[(7)]

New York City's *Truck Route Management and Community Impact Reduction Study* was undertaken and published in May 2007. Through this study, the City performed an extensive analysis of the roadway network and developed a set of recommendations to improve efficiency of goods movement through its five boroughs. Recommendations included routing modifications, among others.[(57)]

By the time NYCDOT's report was completed, two route changes had been made: a portion of the truck route network in the Bronx and one in Brooklyn had been realigned. The realigned truck routes improved the efficiency of goods movement and removed truck traffic from residential neighborhoods.[(57)]

BARRIERS / CONSIDERATIONS

Safety concerns expressed by cyclists regarding sharing the road with large trucks seem to be greater than the data shows, suggesting that large trucks may have an image problem that might not be entirely warranted. The fact incident rates are relatively low for large trucks, and for trucks in general, is an important piece of information for the non-motorized community to know and can inform future discussions.[(7)] Nevertheless, when heavy vehicles and vulnerable road users interact, safety issues remain a concern. (See countermeasures under Section 3.2 Communications, Awareness and Education)

While today's central approach is to integrate road users, this has grown out of the realisation that separation, despite the guidelines being quite clear, has led to more resources being dedicated to allocating space for cars, rather than to pedestrian (and cycling) facilities. The strict separation of road user categories has resulted in increased numbers of high-risk crossing points where different road user groups may conflict. While the Buchanan report addresses these problems, its perspective continues to support the concept of modal separation where vehicle circulation is high.[(6)]

Other considerations include: constrained street widths, limited budgets, topography, and road patterns. Separation of bikes / trucks and the design of road modifications to improve traffic flow would depend on lane width, vehicle speed, availability of alternative routes, proximity to destinations, and importance of route to each user group. Studies also indicate that separation of bikes and trucks can potentially reinvigorate a business area.[(7)]

SEGREGATED BICYCLE LANES

Groups Affected
- Cyclists

Jurisdictions Studied
- Canada
- U.S.
- Denmark

Category: Policy/Legislation/Regulation; Infrastructure

DESCRIPTION

A segregated bicycle lane, also known as a protected bicycle lane or cycle track, runs alongside a road but is physically separated from motorized traffic and distinct from the sidewalk. Although there are different designs, all share common elements. They may be one- or two-ways and provide space for the exclusive or primary use of bicycles, although they may be used by skateboarders, inline skaters and, possibly, other non-motorized devices. The main feature of a segregated bike lane is the physical barrier that defines the cyclist's dedicated space. The barrier could be a curb, bollards, plantings, or parking lanes; it could also take the form of white lines on the pavement that clearly delineate the space between the bike lane and traffic (see image below).

Providing a defined, designated space that separates cyclists from motorized traffic offers a higher level of security and subsequently, tends to be more attractive to a wider spectrum of the public. (Adapted from NACTO definition)

Segregated Bicycle Lane

ISSUES / EVIDENCE

A study found that in about half of the single bicycle crashes the road design, layout and maintenance play a role in the origin of the crash. Common causes for the crashes that occurred on bicycle paths were steering off the road (against the curb), cycling into a bollard, and a slippery road surface.[99]

A literature review reveals that the creation of well-marked bicycle-specific facilities significantly reduces the risks of bicycle crashes and injury.[7] Cycling injury risk can be reduced by 30 to 90%, compared to on-street riding with no cycling infrastructure.[35]

One study found that of fourteen types of bicycle routes in Toronto and Vancouver, segregated bicycle lanes that included physical barriers limiting motorists' ability to enter the space, had the lowest risk of bicyclist injury.[7] According to a Montreal study, these segregated bicycle lanes along roadways reduced the potential contact with heavy vehicles.[58] Further, a recent study focused on bicycle safety findings for Ottawa's first segregated bike lane saw the collision rate for people on bikes decrease by 32% while the volume of cyclists increased by 330%. The new design of the road increased safety for pedestrians, as well, with a reported 50% decrease in bicyclist/pedestrian collision frequency.[59]

A U.S. study analyzing 23 papers on transportation infrastructure and bicyclist safety found that clearly marked, bicycle-specific facilities are safer for cyclists when compared to on-road cycling with traffic. Statistics show that these facilities reduce injury or crash rates by about half when compared to unmodified roadways.[7]

In 2009, New York City's Allen and Pike Streets safety improvement pilot project, included the installation of separate bike lanes as one of several safety initiatives. Post-implementation evaluation along the corridor showed significant reductions in injuries. The project rectified frequent turning conflicts between cars, buses, delivery trucks, bicyclists, and pedestrians. Data compiled following the installation of the protected bike paths and pedestrian improvements showed a 35% decrease in both motor vehicle and bike crashes involving injuries, and 12% decrease in injuries for pedestrian, cyclists, and motorists from Houston Street to South Street. Bike ridership increased by 43% northbound and 23% for southbound traffic. While project outcomes resulted from multiple design interventions, the installation of segregated or protected bike paths contributed to improved safety for all road users.(60)

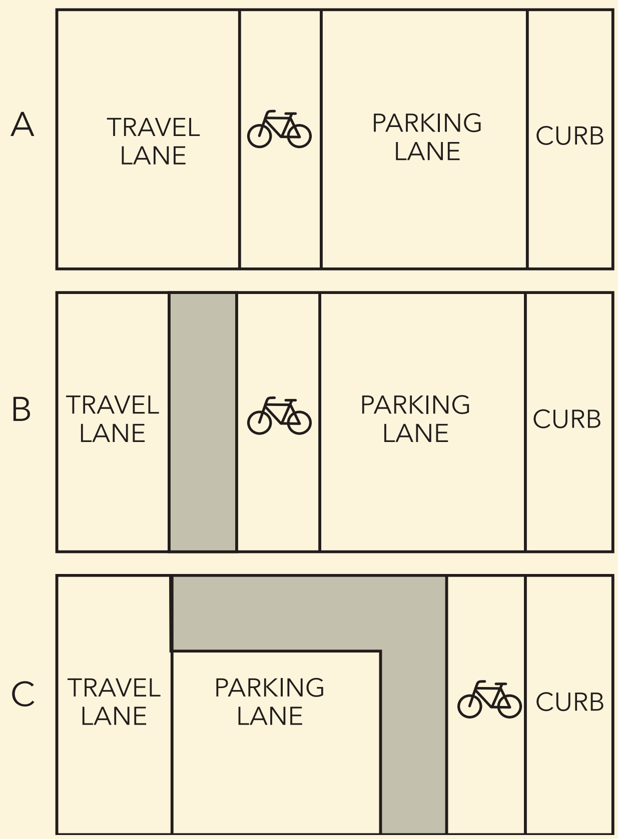
Further, studies in Denmark indicate that providing segregated bicycle tracks or lanes alongside urban roads reduced deaths among cyclists by 35%.(5)

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. While studies show that segregated bike lanes reduce the risk of collisions with cyclists, conflicts can be caused by heavy vehicles parking in the bicycle lanes and by trucks crossing the bike lane to park or turn. Other conflicts have occurred when the trucks were located outside of the bicycle lane resulting in cyclists moving to avoid close proximity to the trucks or potential "dooring" events. Bicycle lane configuration can significantly affect the likelihood of bicycle lane obstruction.(7)

There are reasons for paying particular attention to the design of segregated bicycle lanes. Studies have shown one-way bicycle lanes on both sides of the street are "significantly safer"(35) than a single two-way lane on only one side of the street particularly when they cross intersections or driveways because such designs do not always seem well understood by drivers. Furthermore, additional facilities are necessary at intersections in order to reduce the speed differences between cyclists and other traffic as much as possible. Priority regulations, speed humps, and raised intersections are suitable to achieve this.(61)

Segregated bicycle lanes adjacent to the curb and separated from traffic lanes by a buffer strip and parking lane yield the lowest number of conflicts between commercial vehicles and bicycles and yield the lowest number of conflicts when trucks need to park for delivery or pick-up of goods. (See Configuration C in illustration below.) In New York City, when commercial vehicles are allowed to double-park, it is against regulations to block a bicycle lane when doing so. If a bike lane is blocked, a fine may be issued.(7)



Bicycle Lane Configurations(7)

Barriers to implementation include constrained street widths, limited budgets, and perceived impact on businesses due to reduced parking space. However, studies indicate that segregated bicycle lanes can potentially reinvigorate a business area.[7] One implementation delivery model is to give priority to intersections being rebuilt or to new intersections to better accommodate segregated bicycle lanes.

A Transport and Energy project, sponsored by the European Commission, reviewed the scientific studies on the magnitude and nature of the safety problem of pedestrians and cyclists, contributing accident factors, and the effectiveness of countermeasures. It found that although bike lanes have been found to be a good safety measure on road sections – provided the width of the track is sufficient and measures have been taken to prevent crashes with vehicles parking – there is evidence that they tend to create safety problems at intersections.[61] (See Section 3.3 Bicycle Boxes)

The effectiveness of safety-improving infrastructure treatments such as segregated bike lanes relies on ensuring they operate as they should. In order to do so, maintenance of the bicycle infrastructure must be conducted so pot holes and other irregularities are repaired quickly. Debris should be swept away and the removal of ice, snow and standing water should be removed. Failure to do so might provoke crashes as cyclists hit or swerve to avoid obstacles.[51]

3.5 RULES OF THE ROAD

Ignoring or breaking of the "rules of the road" is the major cause of collisions.

PART I: SPECIFIC TO VRUs AND HEAVY VEHICLES

RESTRICT MOVEMENT OF HEAVY VEHICLES

Groups Affected
- Vehicles
- Drivers
- Cyclers
- Pedestrians

Jurisdictions Studied
- Canada
- U.S.
- U.K.

Category: Policy/Legislation/Regulation; Vehicle Technology/Equipment; Enforcement

DESCRIPTION

Road safety measures that support Vision Zero suggest the restriction of heavy vehicle movement in urban areas, based on their size, use, and level of blind spots, will promote the safety of vulnerable road users. A recommendation is to place restrictions on certain truck configurations or time periods in specific urban zones and encourage the use of smaller trucks for local deliveries in areas where there is a higher concentration of vulnerable road users.[62] (See Section 3.8 External Mirrors to Reduce Blind Spots)

ISSUES / EVIDENCE

In Ontario, 18 of 100 fatal cyclist collisions and 11 of 95 fatal pedestrian collisions with a motor vehicle involved a heavy truck.[4, 5] Twenty-eight percent (28%) of fatal truck crashes occur in urban environments and more than half of truck crashes involving cyclists and pedestrians in urban areas occur at relatively low speeds.[63]

The road capacity during the 2010 Olympics was reduced by 50% to and from the downtown core. (Transport Canada) As a result, during the Vancouver Olympic Games, TransLink reported a large increase in transit ridership: bus ridership increased by 34%, and ridership for the SeaBus and Canada Line doubled, while ridership on the Expo and Millennium Lines SkyTrain increased by 54%, and West Coast Express by 78%.[64]

After the Games, the City of Vancouver highlighted the success of the Plan with the following figures that further demonstrated the willingness of Vancouverites to use alternate modes of transportation rather than private vehicles:

- The transportation network accommodated 44% more person trips to and from downtown;
- Walking, cycling and transit to downtown more than doubled over 24 hours;
- Vehicle trips to and from the downtown core decreased by 29%;
- Average vehicle occupancy to and from the downtown core increased by 14% over 24 hours;
- Almost 80% of spectators at downtown venues walked, cycled or took transit;
- More than 350,000 people used the downtown pedestrian corridors during business days.[64]

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. The County of Brant updated By-law 182-05 to restrict heavy vehicle traffic from travelling through the community of Paris, Ontario, south of Silver Street and north of King Edward Street/Dundas Street East, excluding heavy trucks with an origin or destination in the community of Paris as defined by the urban settlement boundary. This by-law also defines vehicle criteria to which the restriction applies.[92]

New York's pilot program for providing after-hours delivery services (on a voluntary basis) cites reduced time drivers spend stuck in traffic and increased number of deliveries per unit of time as some incentives of this changed approach.[7]

The Ontario Ministry of Transportation conducted an Off-Peak Deliveries (OPD) Pilot in 2014 and 2015. Its objectives were to test the concept of OPD within the downtown core of the City of Toronto, where there is a high concentration of both deliveries and traffic, and help address future Games-time transportation challenges (e.g., 2015 Pan/Parapan American Game). Productivity and environmental impacts were also considered. For example, if trucks are limited in size but the demand for the goods is maintained, it will take more trucks to deliver the same amount of goods. This could, in-fact, increase exposure rates, increase emissions, and increase congestion unless delivered off-peak.

Results from such initiatives may facilitate addressing concerns associated with limiting the movement of heavy vehicles within urban areas, in particular its impact on the delivery of merchandise to businesses.

PART II: NON-SPECIFIC TO VRUs AND HEAVY VEHICLES

BICYCLE HELMETS AND USE

Groups Affected	Jurisdictions Studied
▪ Cyclists	▪ Canada ▪ Australia

Category: Policy/Legislation/Regulation; Enforcement

DESCRIPTION

A bicycle helmet is designed to manage the energy of a single, hard blow to the head but does not prevent the skull being crushed by a huge weight. Additionally, the shape of a bike helmet may help to convert a rollover to an "almost rollover" by allowing the wheel [of the vehicle] to be deflected. (More information is available at Helmets.org.)

The wearing of bicycle helmets and attitudes towards their use vary around the world. In Canada, helmet legislation varies between provinces / territories. Compulsory use of helmets has often been proposed and is the subject of much dispute, based largely on considerations of overall public health. (More information is available at Bicycle Helmet Laws by Country)

ISSUES / EVIDENCE

In Ontario between 2006 and 2010, only 34 of 129 cyclists (26%) sustaining a fatal injury were wearing a helmet. In 71 of the 129 cases (55%), the cyclist sustained a head injury which caused or contributed to their death. In 43 of those 71 cases (60%), a head injury alone (with no other significant injuries) caused their death. Those whose cause of death included a head injury were three times less likely to be wearing a helmet as those who died from other types of injuries.[(5)]

In Ontario, helmet use is optional for cyclists aged 18 and older. Helmets are mandated under the Highway Traffic Act below the age of 18; parents are responsible for ensuring helmets are used by their children below the age of 16.[(5)] By contrast, British Columbia has legislation that makes the wearing of an approved bicycle safety helmet mandatory for everyone when operating a bicycle. (More information is available at British Columbia Helmet Law)

In the state of Victoria, Australia, a law requiring helmets in 1990 increased the use of helmets from 31% to 75% within one year and was associated with a 51% reduction in head injuries to cyclists.[(5)]

Despite existing legislation, in Ontario only 1 of 16 cyclists (6.25%) under the age of 18 who died were wearing a helmet, suggesting the need for cycling safety education in schools. Cyclists do not undergo any formal evaluation of their knowledge of necessary rules and safe practices before they begin to use the road.[(5)]

The Ontario Coroner's review did not look at all cycling injuries (both fatal and non-fatal); consequently, it cannot be stated with certainty the degree to which wearing a helmet decreases the likelihood of a head injury.[(5)]

Some stakeholders felt the mandatory helmet legislation sent the message that the responsibility for safety rests with the cyclist alone, rather than a shared responsibility of all road users.[(5)]

The introduction of mandatory helmet legislation in some jurisdictions has been associated with a drop in cycling activity. Some research suggests that the safety benefits of helmets may be outweighed by the detrimental effects on overall health of the population through the decrease in cycling activity.[(5)]

(See Section 3.4 Separate Truck and Bike Routes and Segregated Bicycle Lanes)

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. The outcome of a collision between a heavy vehicle and a cyclist who is wearing a bicycle helmet will depend on the location of the impact, the manoeuvre the heavy vehicle is undertaking, and the speed at which the vehicle is travelling. If the truck and the cyclist are both travelling straight (in the same direction) and the cyclist hits the side of the truck, the outcome would also depend on whether the cyclist falls beneath the truck, or is deflected into parked cars, onto a sidewalk or, conversely, into traffic.

ENFORCE TRAFFIC LAWS FOR ALL ROAD USERS

Groups Affected
- Pedestrians
- Cyclists
- Drivers

Jurisdictions Studied
- Canada
- U.S.
- U.K.

Category: Enforcement

DESCRIPTION

Enforcing traffic laws involves imposing sanctions that can range from a warning to a fine of varying amounts, demerit points, suspension or loss of a driver's license, an impounded vehicle, and even jail.

ISSUES / EVIDENCE

In 71% of deaths, some modifiable action on the part of the cyclist was identified which contributed to the fatal collision. The three most common contributory cyclist actions identified were inattention (23%), failure to yield right of way (19%) and disregarding traffic signals (8%).[5] From the driver perspective, the leading cause of collisions with pedestrians is drivers failing to yield to pedestrians. The resulting injuries are often life-altering – loss of limbs, brain damage, extensive hospitalization, etc.[15]

With respect to pedestrians, studies from Australia indicate that issuing warnings for minor offences rather than monetary penalties may have a larger impact. Conversely, some experts suggest that if the level of risk associated with unsafe behaviour is not correlated with penalties, these pedestrian behaviours will continue.[2]

In San Francisco, the most common cause of collisions is cyclists disobeying traffic laws.[7] Since 2008, there has been a decrease in illegal sidewalk bicycle riding, with 94% of cyclists now riding legally. This could be due in part, to the city's decision to cite cyclists for their riding behaviour. The police have been issuing "fix-it" tickets requiring traffic school for infractions. The city's plan has a stated goal to increase citations for the violations related to behaviours that pose the greatest safety threat.[7]

A 2004 *Journal of Applied Behavior Analysis* article evaluated the effects of a 2-week saturation enforcement program carried out in Miami Beach. The program used decoy pedestrians, feedback flyers, verbal and written warnings, and enforcement to catch drivers who failed to yield to pedestrians at crosswalks and remind them of the law that required them to do so. The researchers used a multiple baseline design, measuring yielding behaviour and driver-pedestrian conflicts at baseline (pre-enforcement), following the launch of an enforcement program in one corridor (the west corridor), following the launch of a second enforcement program in another corridor (the east corridor), and once a month at the eight sites for one year following the introduction of the treatment program. At baseline, 3.3 percent (west corridor) and 18.2 percent (east corridor) of drivers yielded for pedestrians at each of the four sites in each of the study corridors. At one week following the introduction of the enforcement program in the west corridor, driver yielding increased to 27.6 percent, while no increase was observed in the untreated east corridor. Driver yielding increased to 33.1 percent in the east corridor following the introduction of enforcement. Following the reduction in enforcement, yielding rates were maintained at the treated crosswalks in the course of the year that followed. The researchers also observed increases in motorist yielding at ten of twelve control sites which received no treatment, demonstrating spillover effects. The researchers concluded that enforcement programs produce pedestrian safety benefits, especially when coupled with engineering enhancements.[5]

More study is required to determine if assigning penalties alters the behaviour of drivers. [14] Literature shows that a visible police presence on the roads is an effective modifier of driver behaviour. When police are on the road, people become ultra-cautious because of their fear of being penalised and the high likelihood of it happening when a police car is around. General deterrence is created among drivers who have not been punished for a law violation but believe they might be punished while specific deterrence occurs among drivers who have been punished and want to avoid being punished again.[65]

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. Safety concerns expressed by cyclists regarding sharing the road with large trucks seem to be greater than the data shows, suggesting that large trucks have an image problem that might not be entirely warranted. The fact that incident rates are relatively low for large trucks, and for trucks in general, is an important piece of information for the non-motorized community to know, and can inform future discussions.[7] Nevertheless, when heavy vehicles and vulnerable road users interact, safety issues remain a concern. (See countermeasures under Section 3.2 Communications, Awareness and Education)

The concept of citing cyclists for disrespecting the rules of the road warrants further research. These may include, for example, bicyclists running red lights and not stopping at stop signs. Determination of how this practice affects the overall dialogue between the user groups (truck drivers, pedestrians and cyclists) may be useful as has been done in San Francisco. Issuing citations for cycling behaviours that pose the greatest safety risk may soften the rough edges of the discussion (between cyclists and trucks).[7]

Combining awareness, education and enforcement (with respect to heavy vehicles) with clear legislation would increase the confidence of police officers in their ability to enforce the laws.[4, 14]

Pedestrian needs and limitations vary – children, older adults, and disabled persons each have behavioural and psychological drivers that affect road crossing, decision-making and judgment.[14]

MODEL VULNERABLE ROAD USER LAW

Groups Affected	Jurisdictions Studied
▪ Drivers	▪ U.S.

Category: Policy/Legislation/Regulation

DESCRIPTION

Vulnerable road user (VRU) laws provide important legal protection to cyclists and other persons who are not protected by their vehicles. VRU laws operate on the principle of general deterrence and reflect a Vision Zero approach to road safety. By providing an increased penalty for identified road behaviours that lead to the serious injury or death of certain road users, people will be deterred from exercising those behaviours. The model law includes very strong punishments for people who seriously injure or kill cyclists and other VRUs. Nine U.S. states have laws defining a vulnerable road user and provide particular penalties when such laws are broken – Connecticut, Delaware, Florida, Hawaii, Maine, Oregon, Utah, Vermont, and

Washington.[66] See Section 3.4 Separate Truck and Bike Routes and Section 3.5 Restrict Movement of Heavy Vehicles

An example of this type of law in Canada is the One-Metre Passing Law. For example, as of July 2016, Ontario implemented a law requiring drivers of motor vehicles to maintain a minimum distance of one metre, where practical, between the vehicle and the cyclist when passing a cyclist. Failure to do so may result in a fine in the range of $60 to $500 and an addition of two demerit points on the driver's record. (More information is available at MTO Driver's Handbook) A number of other provinces have implemented the same legislation with similar penalties while others are considering the possibility.

ISSUES / EVIDENCE

Some American jurisdictions have indicated that there is lenient treatment of careless drivers who receive merely a fine and are not even required to make a court appearance after a horrific collision.[66]

A 2013 report by the Center for Investigative Reporting showed that in 238 pedestrian fatalities in the Bay Area, California, 60% of motorists found to be at fault or suspected of a crime faced no criminal charges.[66]

Legislation in Oregon changed in 2008 to include a non-criminal alternative of a $12,500 fine (up from $750.00) and a one-year license suspension. Previously, there had been no license suspension included in Careless Driving convictions. To induce careless drivers to improve their driving skill and pay the community back for their actions, a requirement to attend a traffic safety course and complete 100-200 hours of community service were included as an alternative to the fine and suspension. In situations where the program was successfully completed, the suspension and fine would be lifted.[66]

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. Heavy vehicle drivers perceive themselves as being held to very high and rigid safety standards. While their compliance is also based on ensuring the safety of vulnerable road users, they (along with other motorists) view bicyclists exhibiting unpredictable behaviour and not being held to operations / safety standards as part of the issue.[7] Nevertheless, when heavy vehicles and vulnerable road users interact, safety issues remain a concern. (See countermeasures under Section 3.2 Communications, Awareness and Education)

A variety of studies have shown that perceptions exist showing that vulnerable road users can expect bad things to happen because the roadways are so dangerous. This attitude can adversely affect motorists taking proper safety precautions.[66]

Observing and trusting traffic regulations especially by children and the elderly, due to their lower physical ability and related fear and anxiety, may result in a sense of a false feeling of security and increase the risks for collisions. Even the use of marked crosswalks may induce more pedestrians to cross there and may give them a false sense of security and reduce vigilance.[14, 67]

Any potential legislative change is subject to jurisdictional needs, decisions, and related legal frameworks.

NO RIGHT TURN-ON-RED (RTOR)

Groups Affected
- Drivers
- Cyclists

Jurisdictions Studied
- Canada
- Netherlands

Category: Policy/Legislation/Regulation; Infrastructure

DESCRIPTION

One of the conditions leading to motor vehicles hitting pedestrians is created when vehicles turn right at an intersection, especially when their traffic light is red and pedestrians have the right of way. The right turn on a red light manoeuvre is a major source of concern for pedestrian safety. Drivers are supposed to stop and yield to crossing pedestrians in this situation but often fail to do so.(14) (See Section 3.3 Auditory Messages at Intersections, Pedestrian Scramble Operations, Protected Left-Turn Phasing, Warning Signs / Pavement Markings at Intersections and Section 3.8 Increased Conspicuity and Visibility of Pedestrians / Cyclists)

ISSUES / EVIDENCE

Right-turn collisions between large trucks and cyclists were identified as particularly severe in the Netherlands, where an estimated 30 to 40 fatalities and 100 serious injuries took place per year.

A Canadian study found that after the implementation of RTOR at signalized intersections, there was a significant increase in pedestrian and cyclist trauma. These increases of pedestrian collisions in four jurisdictions ranged from 43 to 107%. Analysis of police reports suggested that drivers stop for a red light, look left for a gap in the traffic and fail to see pedestrians and cyclists coming from their right as they turn.(14)

Prohibiting right turns on red effectively removes a potential for conflict between drivers and pedestrians, as long as drivers comply with the rule.(14) Turning right on a red light is already prohibited on the island of Montreal.(62)

Review is currently underway to assess how the no RTOR has affected collisions with pedestrians and cyclists.

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. A prohibition of right-on-red may mitigate the risks to pedestrians in intersections when heavy vehicles are turning and fail to see vulnerable road users in their blind spots.

Collisions continue to exist when trucks turn on a green light and pedestrians do not observe the “DO NOT WALK” indicator or when the pedestrian is in the truck’s blind spot zone. (See Section 3.3 Warning Signs / Pavement Markings at Intersections and Section 3.8 Increased Conspicuity and Visibility of Pedestrians / Cyclists)

SELECTIVE TRAFFIC ENFORCEMENT PROGRAMS (STEP)

Groups Affected
- Drivers
- Pedestrians

Jurisdictions Studied
- Canada
- U.S.

Category: Enforcement; Communications/Awareness; Education/Training

DESCRIPTION

Selective Traffic Enforcement Programs (STEP) combine intensive enforcement of a specific (or targeted) traffic safety law with extensive communication, education, and outreach to inform the public about a targeted enforcement activity. Examples of targeted enforcement campaigns include use of seatbelts, distracted or impaired driving, speeding, or other identified safety risks.[14]

Effective enforcement measures require skillful planning and resource allocation to maximize the effect of a particular strategy. The objective of using a targeted approach is to address certain behavioural issues related to road safety and to increase compliance for all target groups through various channels. As communications and education programs have been shown to have limited effectiveness on their own, such programs have the greatest potential for success when combined with targeted enforcement programs.[14] (See Section 3.2 An Overview – Communications, Awareness and Education Programs)

ISSUES / EVIDENCE

In Ontario, approximately 20% of pedestrian casualties may be a result of some form of distraction on their part (e.g., cell phone or other mobile device, pushing a shopping cart, walking a dog, riding a skateboard). Alcohol and/or drugs were positive in 28% of pedestrian casualties. While 2% of pedestrians struck by a motor vehicle will die, this rises to 48% for intoxicated pedestrians.[4] The three most common contributory cyclist actions identified were inattention (23%), failure to yield right of way (19%) and disregarding traffic signals (8%).[5] A driver's failure to yield was identified as a factor in approximately 21% of pedestrian deaths. Vehicle speed was responsible for 67% of deaths on roads with posted speeds higher than 50 km/h and only 5% on roads below 50 km/h.[4, 14]

Targeted enforcement has been used to deter failure to yield right-of-way to pedestrians and cyclists. In coordination with the Department of Transportation's education and marketing efforts, the New York Police Department (NYPD) targets failure-to-yield to pedestrians at intersections, identified through previous crash data, as being prone to collisions.[14]

Prior research from many countries over the past three decades has investigated the effects of road safety enforcement campaigns. While individual evaluations have focused on different road safety issues, and different measures of behaviour change (e.g., crash data, observational data, self-reported changes in behaviour, perceptions and attitudes), overall many have shown a range of positive outcomes and demonstrated that road safety campaigns can change perceptions and reduce crashes. One of the most prominent studies involves a European meta-analysis of 437 effects extracted from 228 international studies conducted in 14 countries during the past 30 years. It revealed that road safety campaigns generally:

- reduced the number of road incidents by approximately 9%;
- increased seatbelt use by 25%;
- reduced speeding by 16%;
- increased yielding behaviour by 37%; and,
- increased risk comprehension by about 16%.(68)

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. Since this type of enforcement program targets the behaviour of drivers and pedestrians (and, by extension, that of cyclists), it may also address the concerns of both heavy vehicle drivers and vulnerable road users when it comes to safety and the need for all groups to respect the rules of the road.

Theories with respect to various safety campaigns suggest that a clear understanding of factors that shape the behaviour is essential, whether it is attitudes, intentions, social norms, perceived vulnerability, perceived barriers or consequences, or sources of social control, in order to identify how to effectively change it. Further, their success relies on effective enforcement strategies.(68)

Targeted enforcement strategies require data on collision factors and frequencies to enable agencies to prioritize behaviours. Knowledge of the behaviour and traffic patterns of a community also helps police to develop countermeasures to address specific behaviours. Working in partnerships enables collective problem solving to address pedestrian [and cyclist] safety issues from a variety of angles.(14) (See Section 2.0 Monitoring Strategy – Forensic Review of Collision Data)

According to saskatoonpolice.ca/traffic, a successful STEP strategy also relies on highly trained police officers, as well as the use of available technology (e.g., radar, laser speed detection technology, etc.).

3.6 SIDE GUARDS AND SIDE SKIRTS

Side guards are designed to prevent exposed vulnerable road users from being caught under the sides of trucks and getting crushed by the back wheels.

PART I: SPECIFIC TO VRUs AND HEAVY VEHICLES

TRUCK SIDE GUARDS

Groups Affected
- Vehicles
- Drivers

Jurisdictions Studied
- U.S.
- UK
- Australia
- Japan

Category: Vehicle Technology/Equipment

NYFD Truck Installation
TAKLER USA SIDEGUARDS (Rail Type)

DESCRIPTION

Truck side guards (also called "lateral protection" or "side underrun protection devices") are designed to aid in the prevention of vulnerable road users, or VRUs (pedestrians and cyclists) against the risk of being pulled under the sides of a heavy vehicle and being caught under the wheels.[39]

Currently, designs include rail or smooth (flush mount) side guards. The types of devices used vary among jurisdictions. Typically, side guards are designed, built and installed by vehicle manufacturers or third-party parts suppliers.

NYC Private Garbage Truck Installation
TAKLER USA SIDEGUARDS (Rail Type)

ISSUES / EVIDENCE

The most recent collision data from the 2015 National Collision Data Base (NCDB) revealed that three-quarters of Canadian fatal collisions between heavy trucks and pedestrians and cyclists happen at the front of the vehicle (front, right front and left), while only 22% of the fatal collisions occurred at the side. An earlier study by the National Research Council found that in 43% of bicycle-truck crashes and in 46% of pedestrian-truck crashes, the VRU was hit by the front of the truck.[39]

According to a 2005 U.K. report using collision data, side guards were effective for collisions involving cyclists and pedestrians moving in the same direction as the heavy vehicle where the initial point of impact occurs on the "nearside (i.e., curbside) of the HGV". For such "going ahead" collisions, the introduction of side guards resulted in a 61% reduction of fatally injured bicyclists and a 20% reduction of fatally injured pedestrians; the study does not address their effectiveness for other types of collisions.[39]

A further report stated that in the U.K., with the introduction of side guards, fatalities and injuries among cyclists was reduced by 5.7% and 13.2% respectively.[5] However, the U.K.'s Transport Research Laboratory (TRL) computer simulation showed that although integrated side guards have the potential to offer substantial benefits to pedestrians, an analysis of fatal collisions estimated that fitting such integrated side guards could prevent up to 3% of pedestrian fatalities.[69]

Other U.K. studies provided conflicting evidence regarding the effects of side guards when cyclists collide with heavy vehicles turning left (or turning right in North America). For example, previous collision data has shown that side guards have been effective at preventing the type of collision for which they were designed – where a heavy vehicle overtakes a cyclist or pedestrian and they fall sideways into the side of the vehicle between the front and rear axles (straight ahead manoeuvres). They were not designed to protect a cyclist that gets knocked to the ground by the heavy vehicle's cab and then gets run over as the vehicle turns left (turns right in North America.).[42]

An analysis of vehicles that are exempt from applying side guard technology suggests that side guards have a significant effect both on reducing the frequency of such collisions and on reducing the severity of injuries sustained when these collisions do occur. Which analysis is correct cannot be proven with the data available in this study.[42]

In the European Union, bicyclist deaths and serious injuries have been reduced by 6% and 13%, respectively with the introduction of side guards. However, it is not clear if this reduction is entirely related to side guards or if side guards are but one of the factors contributing to the reduction.[39]

A further study reports that when considering the influence and effectiveness of a single countermeasure, fitting current side guards is cited as a possible influence in a relatively large number of cases with respect to heavy vehicles and cyclist fatalities; but it is usually considered to have a great deal of uncertainty.[42]

In addition, when considering sole countermeasures most likely to reduce cyclist fatalities in collisions with heavy vehicles based on the vehicle's manoeuvre, fitting current side guards was not among the top measures for either manoeuvre (Turning Left; Going Ahead; Overtaking). For turning left (turning right in North America) collisions, side guards were considered to have a possible influence in a substantial number of collisions. [42]

The U.K.'s Heavy Vehicle Crash Injury Study (HVCIS) database suggests alternative measures may be more effective in left-turn (right-turn in North America) collisions, in particular, "improve side vision." In time, benefits may be achieved by a properly developed electronic warning system capable of alerting drivers to the presence of vulnerable road users. A 2010 study ranked such a VRU warning system as one of the top 5 commercial vehicle safety priorities, based on the assumption it would work all around the vehicle, not just at the side.[42] (See Section 3.8 Visibility Detection Technologies)

Currently, there is no way to accurately quantify the potential reduction in VRU deaths or serious injuries as a result of side guard installation based on the available evidence.[39]

BARRIERS AND CONSIDERATIONS

It is not clear if side guards will reduce deaths and serious injury or if the side guards will simply alter the mode of death and serious injury. For example, VRUs may strike the side guards and be deflected into another lane of traffic to suffer a serious injury as part of secondary event with another vehicle or with the road/sidewalk surface.[39]

Side guards can also inhibit rescue efforts of first responders in the event of a collision with a vulnerable road user or may make maintenance and mechanical inspections more difficult.

City buses have built-in side skirting that are lower than side guards found on most trailers; yet, there are still incidences of pedestrians being killed as they slip and fall under the wheels of moving city buses.[39]

What other jurisdictions are doing with respect to side guards:

As of 2016, all City of Montreal-owned trucks have side guards installed. The requirement to install side guards on other trucks or to include this requirement in tenders is being evaluated.

While there are no U.S. federal regulations governing the use of side guards, at least three U.S. cities – Boston, New York and Seattle – mandate side guards on city-owned and/or contracted trucks as part of Vision Zero initiatives to eliminate crash deaths and injuries, particularly among pedestrians and bicyclists.[70] (See Section 2.0 Road Safety Strategies) In addition, Boston, New York City, Portland, Oregon, Washington D.C. and Cambridge, Massachusetts are some of the cities that have created policies (all quite recently) requiring side guards on trucks in certain circumstances.[3] However, there are no data available on whether these policies have been effective in reducing VRU deaths and injuries.

TRUCK SIDE SKIRTS

Groups Affected	Jurisdictions Studied
▪ Vehicles ▪ Drivers	▪ Canada ▪ U.K.

Category: Vehicle Technology/Equipment

DESCRIPTION

Aerodynamic side skirts, or belly fairings, are devices fitted to the longitudinal edges of a trailer on a heavy vehicle and are intended to allow the air flow to pass alongside the trailer rather than underneath it.[71] The addition of side skirts to highway trailers tends to smooth airflow and reduce cross-flow along and below the bottom edges of the trailer resulting with the air moving more efficiently around the trailer and keeping crosswinds from causing turbulence beneath it. The secondary effects, such as brake cooling and the ability to prevent intrusion by a vulnerable road user are not as well documented.

Side skirt panels are primarily available in three materials: aluminum, thermoplastic olefin (TPO) and fiberglass reinforced plastic (FRP). TPO and FRP, are flexible, durable, lightweight, temperature resistant, ultraviolet (UV)-stabilized and often recyclable. In comparison, aluminum, a metal known for its relative light weight, is less elastic than plastic, and tends to be heavier than TPO or FRP.[71]

It is important to note that these skirts were designed to improve the aerodynamics of trailers and not to prevent pedestrians and bicyclists from falling under the wheels of the trailer.

Side Skirt

ISSUES / EVIDENCE

It is yet to be determined how, under realistic conditions, a human cyclist's body would behave once it strikes a side skirt and assessing any potential safety benefits of aerodynamic side skirts in preventing cyclist under-run. Testing in Canada has been focused mainly on the strength of various types of aerodynamic side skirts in the event of a perpendicular impact on a stationary vehicle with a weighted bicycle. An anthropomorphic dummy, one that resembles a human form, was not used and so no testing was conducted on what effects an impact might have on a cyclist. Under specific test conditions, all three of the tested skirt types prevented the bicycles from entering under the trailer. Furthermore, the bicycles did not become wedged underneath the skirts. In all tests, the bicycles were ejected rearward along their original path and away from the trailer and became tangled in the test device.[71]

In the U.K., survey and strength testing work has shown that current examples of side skirts are stronger and typically have lower ground clearances than current rail-type side-guards. In general, they also fill far more of the space between the wheels. They have the added advantage that they present a smooth uninterrupted surface to the crash victim and are usually flush with the outer edge of the vehicle. All of these differences from rail side-guards are to enhance aerodynamic performance but test work has shown that they are all good features for improved safety.[42]

In addition to the benefits of stronger and lower side skirts, where a cyclist or pedestrian has fallen against the side of a passing heavy vehicle fitted with side skirts and not been run over, this has occurred because the smooth surface helps to prevent severe impacts between the cyclist's head and projections such as load hooks, top edges of guards or supports. This helps to prevent heavy contact between the chest and the outer edge of the rear tire. An added benefit is that clothing and limbs are less likely to be caught in the structure of the side skirt resulting in the cyclist being dragged along by the vehicle. Tests also suggest the cyclist is typically thrown to the ground with less force. In theory, young, healthy adults wearing cycle helmets should not be killed when involved as a cyclist falling against the side of a passing HGV if this type of protection [side skirt] is fitted.[42]

BARRIERS / CONSIDERATIONS

Aerodynamic trailer side skirts offer an average fuel savings potential of 4.0% to 7.5%.[71]

Given that three-quarters of Canadian fatal collisions between heavy trucks and pedestrians and cyclists happen at the front of the vehicle[39] rather than its side, side skirts will not be effective for all collisions involving heavy trucks. In particular, if the front right corner of a truck hits a bicyclist or pedestrian while turning right, the VRU may be knocked to the ground and then be run over by the wheels of the trailer.

PART II: NON-SPECIFIC TO VRUs AND HEAVY VEHICLES

None Found

3.7 SPEED

Controlling vehicle speed can prevent crashes happening and can reduce the impact when they do occur, lessening the severity of injuries sustained by the victims.

PART I: SPECIFIC TO VRUs AND HEAVY VEHICLES

None Found

PART II: NON-SPECIFIC TO VRUs AND HEAVY VEHICLES

SPEED LIMIT REDUCTIONS

Groups Affected
- Pedestrians
- Cyclists
- Drivers

Jurisdictions Studied
- Canada
- OECD (35+ countries)

Category: Policy/Legislation/Regulation; Infrastructure; Enforcement; Education; Communications

DESCRIPTION

Maximum speed limits vary depending on the type of roadway and its intended use. These limits are determined by each jurisdiction. A number of jurisdictions are considering reducing speeds in urban areas from 50 km/h to 40 km/h, and from 40 km/hr to 30 km/hr in residential areas. (This measure has already been adopted by many municipalities such as Ottawa, Montreal, and Toronto.)

A little over 50% of Canadian roads are owned and operated by municipalities; a larger portion of the remainder fall under provincial/territorial jurisdictions. As a result, variances in posted speed limits across the country are the norm rather than the exception.

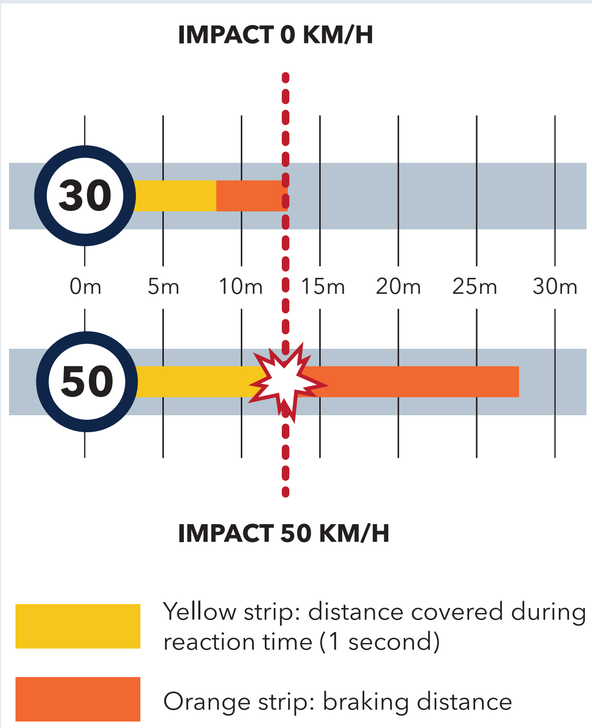
ISSUES / EVIDENCE

A Montreal study revealed that 73% of collisions with injuries occur on streets where the speed limit is 60 km/h and less; 81% of the collisions observed on the municipal road network involving pedestrians and cyclists occur in urban areas; 74% of collisions occur on arteries and collector roads, even though these represent only 31% of the length of the municipal road network.(13)

A Montreal bus driver training and testing exercise revealed that by reducing a bus' turning speed from 24 km/h to 13 km/hr, a pedestrian would remain visible to the driver four times longer; thus giving the driver additional time to react. (See Section 3.2 Bus Driver Training – Mitigating Blind Spots)

According to the Ministère des transports du Québec, speed limits lower than 50 km/h where there is a prevalence of pedestrians, cyclists and persons using motorized mobility aids, contribute to improved road safety, if they are compatible with the environment and respected by drivers.(13)

A U.S. study found that the proportion of pedestrians who were severely injured or killed increased as impact speed increased across all examined categories of impact speed.[72] The consensus of recent (global) studies indicates that reducing the impact speed from 50 km/h to 30 km/h reduces the pedestrian fatality risk by a factor of 80%. Speed moderation in urban areas not only reduces the likelihood of a collision but, moreover, the severity of the injuries, which is a main goal of a Safe System approach.[6] (See Section 2.0 Road Safety Strategies)



Stopping Distances at Different Travel Speeds

A U.K. report suggests that each decrease of 1.6 km/h in an urban speed limit results in a 3 to 6% decrease in collisions, depending on the type of road (e.g., a major road) being considered.[49]

Based on a Swedish study, a change in average speed of 1 km/h will result in a change of collision numbers ranging between 2% for a 120 km/h road and 4% for a 50 km/h road. This result has been confirmed by many before and after studies of different speed reduction measures. This relationship is used by other Scandinavian countries and by Australian and Dutch safety engineers.[61]

An Australian study, which included input from U.S. and Danish researchers, found the majority of all traffic crashes occur in an urban setting, where there is a more complex traffic environment and a higher predominance of road users that are more susceptible to injury and fatality in the event of a collision. Research shows that reduced speed is likely to bring about a reduction in average travel speed and have a positive impact on both the number of collisions and resulting outcome severity.[73]

A 2009 study in the U.K. used 20 years of police-reported pedestrian collisions to examine the effect of implementing 20 mph (32 km/hr) zones throughout London. Injury counts were compared in the before- and after-intervention periods, as well as between streets with and without the intervention. Results of the analysis indicated that the number of pedestrians who were killed or seriously injured decreased by 34.8 %. Decreases were even more pronounced for children (pedestrians age 0-15), with a decrease of 44% for collisions leading to fatalities or serious injuries. All reductions were statistically significant. An analysis of roadways in areas adjacent to the speed zones indicated that injuries were not being displaced to nearby roads. The researchers concluded that the 20 mph speed zones were effective in reducing pedestrians' risk of injury or death, with the greatest benefits observed for children under age 15.[19]

The data also shows that although fatal collisions are rare below 40 km/h and severe injuries are rare below 25 km/h, over 30% of severe injury collisions occur in speed environments below 35 km/h. This indicates that 30 km/h speed limits might not be as safe as previously believed.[74]

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. While studies have focused on reductions in overall fatalities and injuries, and confirm that any countermeasure effective in reducing vehicle speeds will improve pedestrian injury outcomes[14], collisions between heavy vehicles and vulnerable road users generally take place at lower speeds, which may not be subject to speed violations. While speed is not typically a factor in turning manoeuvres at intersections, when most collisions between vulnerable road users and heavy vehicles occur, slower speeds may allow vulnerable road users to remain visible to drivers for a longer period of time.

Not only does excessive speed increase the risk of injury and deaths for pedestrians and cyclists, it also reduces their sense of safety and comfort, particularly in children, the elderly and people with disabilities. A survey conducted in 2011 reveals that the feeling of safety of pedestrians and cyclists is closely related to the speed of vehicles.[13]

The severity of risks when there is a collision vary significantly by age. For example, the average risk of severe injury or death for a 70-year-old pedestrian struck by a car travelling at 25 mph is similar to the risk for a 30-year-old pedestrian struck at 35 mph.[72] While minor and severe injuries occur in similar speed environments, the age of the victims will significantly affect whether the injury outcome will be minor or severe.[74]

Pedestrian injury severity is directly linked to vehicle impact speed. The faster a vehicle approaches, the longer the distance required to stop, and so avoid a collision. Clearly, in the event of a collision, the risk of a severe injury to a pedestrian [or cyclist] is dependent upon the energy involved in the collision, which is a direct function of the vehicle speed at impact.[6]

Decreases in the posted maximum speeds on roadways may not always lead to tangible changes in the behaviour of motorists (e.g., truly reducing operating speeds). This is consistent with what was noted in study findings state that the implementation of speed reduction initiatives should act simultaneously on the road infrastructure, the road user and the vehicle.[6]

Due to the complexity of the issues regarding speeding, it is not always easy to identify the most appropriate measure. Some solutions, like redesigning a street's geometry, often requires important investments. On the other hand, simple solutions are not always efficient. For example, the simple reduction of the speed limit without modifying the street infrastructure, or implementing the appropriate traffic controls, does not always have a significant effect on speeds; and yet, this measure (speed reduction) is often adopted.[13]

The regulation of speed is one of many to be considered in a portfolio of measures designed to increase the safety of VRUs. In some collisions, speed may not be a factor; hence, there is a need to combine this countermeasure with others, as required in a Complete Streets and Safe System Approach. (See Section 2.0 Road Safety Strategies)

Evidence pointing to the reduction and severity of crashes occurring at lower speeds should be shared with all parties to build and maintain support towards lowering maximum speeds.[6] (See Section 2.0 Monitoring Strategy – Forensic Review of Collision Data)

TRAFFIC CALMING STRATEGIES AND DEVICES

Groups Affected
- Drivers

Jurisdictions Studied
- U.S.
- New Delhi

Category: Infrastructure

DESCRIPTION

Traffic calming can encompass a number of strategies, including reduced number and width of travel lanes; wide parking lanes and the introduction of cycling lanes, road diets (another name for reducing travel lanes), speed humps, raised intersections, bulb outs (also called curb extensions or blisters), chicanes (an artificial narrowing or turn of a road), cross walks, traffic signals, automated traffic enforcement systems (scientifically validated and strategically located) and reduced speed limits on residential streets from 40 to 30 km/hr.[4]. This is not an exhaustive list. (See Section 3.7 Speed Limit Reductions, as well as countermeasures under Section 3.3 Intersection Design and Traffic Control)

ISSUES / EVIDENCE

New York City's Department of Transport (DoT) installs about 75 speed reducers (speed humps) per year; the Department's before and after studies found an average of 19% reduction in speeds where speed reducers were in place.[15] An ongoing DoT study has found that speed reducers decrease injury crashes by approximately 40%.[15]

A World Health Organization (WHO) study found that the speed of buses in New Delhi was lowered after installing rumble strips (in December 2008). As a result, pedestrian incidents involving speeding buses have been reduced. It also found that, in general, lower speed streets experienced lower rates of vehicle-pedestrian crashes, while downtown areas with wide travel lanes and higher operating speeds experienced higher rates. Further, a 60–90% reduction in pedestrian fatalities was observed in 10 high-risk locations after installing traffic signals and rumble strips in 2011.[1]

There are theoretical advantages of area-wide traffic calming strategies over strategies that intervene at specific points or on specific segments of the road network. An analysis of 33 studies evaluating the effectiveness of area-wide traffic calming strategies on both local and main roads concludes that there were significant reductions in collisions with and without injury on local streets and main roads, as well as throughout the area. The reductions observed on local streets were significantly greater than those on main roads. However, when retaining only the studies with the most robust designs ("before-after" with control sites) for the purpose of evaluating the effect on personal injury collisions, only the reduction of 12% for the entire calmed area remains statistically significant.[49]

The results of 50 walking and 35 child pedestrian injury studies were reviewed in 2014 to calculate the effect of different built environment characteristics on child pedestrian injury. This review indicated that only traffic calming and the presence of playgrounds / recreation areas were consistently associated with more walking and less pedestrian injury. Several built environment features were associated with more walking, but with increased injury. Many features had inconsistent results or had not been investigated for either outcome. The findings emphasize the importance of incorporating safety and monitoring into the conversation about creating more walkable cities.[50]

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. Certain traffic calming interventions, such as chicanes (road narrowings) or horizontal deflection, such as chokers or curb extensions, can negatively affect the manoeuverability of heavy vehicles and the perceived safety of vulnerable road users. Cyclists perceive narrowings as dangerous because of the greater proximity of moving vehicles, especially heavy vehicles. Speed cushions, vertical deflections designed to act on cars in the same way as speed humps, have a minimal effect on heavy vehicles, such as emergency vehicles.[49]

Chicanes are not necessarily effective if there is a key centreline trajectory as speeders tend to find that line in order to maintain their speed.

Traffic calming interventions alone may not improve conditions for pedestrians. Other issues need to be addressed, such as law enforcement, adequate street lighting, etc.[1]

Interventions targeting the physical environment, such as traffic-calming strategies, have the advantage of not depending on the presence of the police force to be effective. In addition, they have the potential to improve the safety of all road users.[49]

3.8 VISIBILITY AND CONSPICUITY

To be noticed is to be safe.

PART I: SPECIFIC TO VRUs AND HEAVY VEHICLES

AUDIBLE SENSORS ON VEHICLES

Groups Affected
- Vehicles
- Pedestrians
- Cyclists

Jurisdictions Studied
- Canada

Category: Vehicle Technology/Equipment

DESCRIPTION

A variety of technologies exist that audibly alert vulnerable road users that they need to move further away from a heavy vehicle's blind spot. These might include Turn Warning Systems and Directional LED Headlight Systems, among others. Some of these systems may simply be activated when the vehicle turns; other, more intelligent systems rely on vision, radar, ultrasonic and lidar* sensors. (See Section 3.8 Turn Assist Systems for Heavy Vehicles)
Similar equipment works for reversing beepers on various trucks that alert of an approaching 'danger area'.

***Lidar** stands for Light Detection and Ranging; it is a detection system that works on the principle of radar, but uses light from a laser.*

ISSUES / EVIDENCE

Audible sensor devices are in the process of being tested in Montreal and the York region of Ontario. There are also field tests that have been conducted in the U.S. Results are pending.

BARRIERS / CONSIDERATIONS

Although this technology is becoming available, it is yet unproven.

Emerging intelligent systems can be expensive. Also, the noise that they generate may cause a negative reaction within the community. Additionally, exterior cameras and sensors can be damaged in environments such as construction sites.

An important consideration for vulnerable road users is that ongoing noise tends to be ignored and becomes less effective as time goes on. In addition, if they are wearing headphones, they will not hear the warning.

The type of equipment and the manner in which it functions must comply with jurisdictional regulations. This could be supported by educational pamphlets for cyclists / pedestrians, and commercial drivers.

AUXILIARY TURN SIGNALS

Groups Affected
- Vehicles

Jurisdictions Studied
- Canada

Category: Vehicle Technology/Equipment

DESCRIPTION

Auxiliary turn signals on heavy vehicles provide notice to cyclists positioned along the vehicle's passenger side providing another cue of the driver's intention to turn. This allows the cyclist to re-position themselves away from the vehicle and avoid danger.(75)

ISSUES / EVIDENCE

Due to the length of most commercial vehicles, when a cyclist is positioned along the passenger side of the vehicle on the road, ahead of the bumper, the cyclist is often unable to see the activated turn signal of the truck.(75)

Many fatalities occur when cyclists are positioned at the mid-point of the truck's passenger side, while stopped at an intersection. Since the cyclist is unable to see the truck's turn signal, coupled with the driver's difficulty detecting the cyclist, the driver enters into a right turn without knowledge that a cyclist is located in a danger zone.(75)

The documentation reviewed did not provide evidence supporting the successful implementation of this countermeasure.

BARRIERS / CONSIDERATIONS

Auxiliary turn signals could also be used in conjunction with Audible Sensors on Vehicles (See Section 3.8).

Lafarge Canada has committed to installing auxiliary turn signals on all their owned commercial vehicles operating across Eastern Canada by the end of 2017.(75)

EXTERNAL MIRRORS TO REDUCE BLIND SPOTS

Groups Affected
- Vehicles

Jurisdictions Studied
- Canada
- U.S.
- U.K.
- Netherlands
- E.U.?

Category: Vehicle Technology/Equipment

DESCRIPTION

Heavy vehicles can be equipped with multiple exterior mirrors to improve the driver's field of view. In Canada, these include rear view planar mirrors on each side of the vehicle, as specified in the Canada Motor Vehicle Safety Standard (CMVSS)*. They could also include additional mirrors such as circular convex mirrors near the planar mirrors, fender or hood-mounted circular convex mirrors, a look-down rectangular convex mirror over the passenger door window, and cross-over mirrors installed in front of the cab to eliminate a truck driver's front "blind spot".

External Mirrors

** The Canada Motor Vehicle Safety Standards (CMVSS) outline minimum requirements for heavy vehicles, such as rear and side view mirrors.*

ISSUES / EVIDENCE

Based on a preliminary analysis of a sample of large trucks involved in crashes resulting in injuries or deaths, a 2007 U.S. study reported that large trucks lacking right fender mirrors were over-involved in crashes resulting in deaths and injuries compared with large trucks with right fender mirrors designed to mitigate the large blind spot on the right side.(76)

In the Netherlands, blind spot mirrors have been mandatory on all Dutch trucks since the end of 2003. No studies evaluating the safety effect of blind spot mirrors have been found. Crash statistics from the Netherlands show that for a short period of time (2002-2003), the number of related fatal collisions decreased, but from 2004 the numbers were back up to the same level as before.(53)

In the E.U., the number of vulnerable road users killed in collisions with a heavy goods vehicle (HGV) has fallen substantially; in 2009 the number was less than expected based on the predicted effects of Directive 2007/38/EC. This would suggest that retro-fitting side view blind spot mirrors had been successful. However, the overall number of fatalities also fell more sharply in the same time period and the specific data available are limited. It is not, therefore, possible to quantify the extent to which the overall fall in HGV-VRU fatalities was the result of the mirrors being installed.(77)

BARRIERS / CONSIDERATIONS

School buses in Canada have been required to have additional mirrors so that the drivers can see children crossing in front of the bus.

Crossover convex mirrors are currently required by state law on large trucks operating in New York City; the European Union also has requirements for enhanced mirrors on large trucks to reduce the size of blind spots.[7, 77]

Vehicle size and design can affect direct and indirect vision (i.e., the driver's field of view), either reducing or increasing a truck's blind spots. Design issues include the height of the cab above the ground, window apertures (openings), position of the A and B pillars, as well as the position and height of the driver's seat. Even vehicles with the same cab height may have other design differences and, therefore, have different blind spots. Trucks will have greater blind spots than passenger vehicles.[37] (See Section 3.8 Field of View Standards for Heavy Vehicles)

External mirrors are only useful if they are properly adjusted and *used* by heavy vehicle drivers.[77] However, there is some indication that multiple mirrors may, in fact, be a distraction to drivers and thus limit their effectiveness (U.K.).[53]

While external mirrors help drivers see pedestrians and cyclists that are beside the vehicle (outside of blind spots), external blind spot mirrors may not be a sufficient countermeasure for reducing fatalities when trucks or buses are making turns into intersections. The mirrors themselves can create blind spots for the driver, along with the vehicle's hood, and the A and B pillars.[23] (See Section 3.8 Turn Assist Systems for Heavy Vehicles)

Note: *The City of Montreal is testing a tool that helps to evaluate blind spots on heavy vehicles. Based on the assigned blind spot rating, these vehicles would have limited access to [specific areas] in cities.*

FIELD OF VIEW STANDARDS FOR HEAVY VEHICLES

Groups Affected
- Vehicles

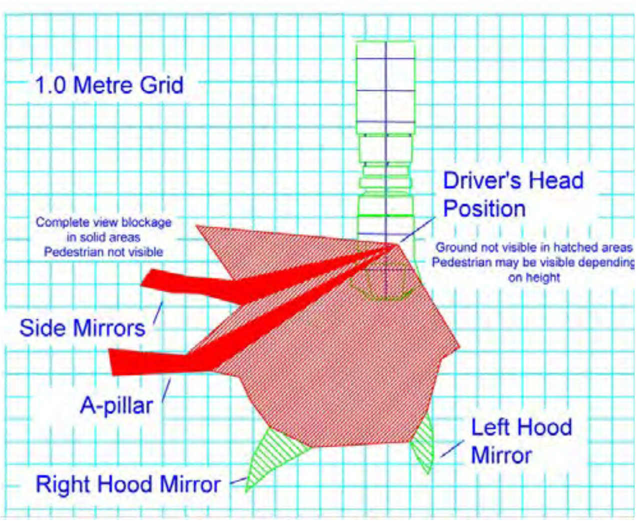
Jurisdictions Studied
- U.K.
- E.U.

Category: Policy/Legislation/Regulation; Enforcement

DESCRIPTION

Field of view standards (also referred to as direct vision standards) define the ability of a driver to see someone directly through their windows. Direct vision standards for trucks, which reflect a Vision Zero approach to road safety, mandate at least best-in-class performance for different heavy vehicle categories. In the U.K., Direct Vision Standards use a star rating system (from 0 to 5).[(3)] (See Section 2.0 Road Safety Strategies)

For heavy vehicles, better field of view usually means lowering the position of the driver. This increases what the driver can see, and puts the driver closer to the level of other road users in (urban) traffic.[(63)] (See Section 3.8 External Mirrors to Reduce Blind Spots and Visibility Detection Technologies)



Field of View – Blind Spot Areas from a Heavy Vehicle

EVIDENCE

Truck design is a major contributor to fatalities involving trucks and VRU's. Blind spot mitigation using mirrors has been attempted but is proving ineffective. The European Union (EU) is exploring solutions for direct vision between truck drivers and VRUs. Implementation models are to be considered.[(63)]

With direct vision, problems of distorted images or poorly adjusted mirrors are eliminated. Secondly, seeing something directly also reduces the time needed to "scan" a traffic situation. Thirdly, it is likely direct vision also has a number of 'cognitive' benefits over indirect vision. This means people react differently to something they see directly.[(63)]

In 2015, the U.K.'s Transport Research Laboratory (TRL) estimated the lifesaving potential of better direct vision to be up to 553 lives saved per year in the EU.[(63)]

BARRIERS / CONSIDERATIONS

There is a major difference between North American trucks (conventional cabs that experience many blind spots that make it difficult to improve line-of-sight) and European trucks (almost exclusively advanced cab design with good visibility). An adequate standard of line-of-sight would require a change in vehicle type and would further require a profound change in the North American trucking culture.

The E.U. study recommended that differentiated direct vision standards be introduced for different truck categories. Construction vehicles, long haul and urban vehicles have different characteristics and potentials for improvement. Urban trucks clearly have the biggest potential, whereas construction vehicles with off-road capability are more challenging. The exact classification needs to be further researched but it is clear that a one-size-fits-all approach would deliver suboptimal results … and would end up having little impact as it would likely be tailored to the lowest common denominator.[63]

This study also indicated that implementation of the Direct Vision Standard could be a lengthy process.[63] Vehicles cannot be retrofitted; implementation would be applied to the design of new vehicles moving forward.

Direct Vision Standards reflects a Vision Zero approach to road safety and the protection of vulnerable road users sharing the road with heavy vehicles. As Vision Zero has as its goal the elimination of traffic deaths and serious injuries, prioritizing large vehicle safety measures within jurisdictional plans will enable increased safety on their streets. (See Section 2.0 Road Safety Strategies)

PARKING RESTRICTIONS / BUS STOP PLACEMENT NEAR INTERSECTIONS

Groups Affected

- Pedestrians
- Cyclists
- Drivers

Jurisdictions Studied

- Canada
- U.S.
- E.U.

Category: Policy/Legislation/Regulation; Enforcement

DESCRIPTION

Parking restrictions near intersections, also referred to as "daylighting", involves the prohibition of parking any vehicle within a specified distance of an intersection or crosswalk as they can obscure the visibility of a crossing pedestrian[14] or cyclist. This also applies to bus stop locations.

ISSUES / EVIDENCE

Unsafe parking by heavy vehicles or the placement of bus stops near intersections can affect the safety of pedestrians. When a bus is stopped and passengers are disembarking, some drivers may attempt to overtake the bus. The bus obstructs the vision of other drivers to see pedestrians crossing in front of the bus; likewise, pedestrians cannot see the passing vehicle. Parking of heavy trucks at intersections can also hinder vulnerable road users' ability to see oncoming traffic.[14, 62]

To reduce the potential for collisions, many jurisdictions have prohibited parking near intersections and crosswalks and moved bus stops from these locations.

For example, in line with Vision Zero principles, a law is being proposed in Quebec that will enforce the prohibition of parking a vehicle within 5 meters of an intersection.[62] European Transport Ministers have passed resolutions banning parking near crosswalks in school zones.[14] (See Section 2.0 Road Safety Strategies) It was noted in the U.S. Department of Transportation's Toolbox of Countermeasures that moving a bus stop location away from crosswalks deterred pedestrians from crossing in front of the bus.[14]

The documentation reviewed did not provide detailed evidence supporting the successful implementation of this countermeasure. (See Section 3.5 Restrict Movement of Heavy Vehicles)

BARRIERS / CONSIDERATIONS

Moving bus stops to mid-block locations (in order to move them away from intersections), may require the creation of more mid-block crossings to ensure "protected" VRU spaces.

TURN ASSIST SYSTEMS FOR HEAVY VEHICLES

Groups Affected
- Vehicles
- Drivers

Jurisdictions Studied
- Canada
- Germany

Category: Vehicle Technology / Equipment

DESCRIPTION

Turn assist systems provide a targeted warning to the driver when performing a turning manoeuvre where a cyclist could be overlooked.[82] Assists could be either in the form of low-intensity information or a high-intensity warning.[81] (See Section 3.8 Visibility Detection Technologies)

EVIDENCE

In Ontario, over a 15-year period between 1988 and 2002, pedestrians accounted for 14% of motor vehicle fatalities.[4] In Canada, between 2004 and 2006, approximately 16.9% of the pedestrian fatalities and 39.1% of the cyclist fatalities resulted from collisions where a heavy vehicle was turning right.[39]

Research conducted by insurers in Germany has estimated that a generic, optimally functioning turn assist system (installed in an entire fleet) – using sensor technology to monitor the zones in front of and to the right of the heavy vehicle warning the driver and, if necessary, preventing the vehicle from moving – could prevent around 40% of collisions involving pedestrians and cyclists.[82]

The safety potential of a "turning assistant system" and an intelligent rear view camera accounts for 6% of prevented crashes in relation to all truck collisions. Detailed analysis reveals that this covers 55% of all truck collisions involving vulnerable road users (VRUs). Compared to current rear-view mirror technology, these assistance systems are much more effective.[100]

***Note**: Based on documentation reviewed, this countermeasure is still undergoing testing; no formal implementation has been made.*

BARRIERS / CONSIDERATIONS

Low intensity information is suggested for implementation of the Turn Assist System as there is likely to be a lower risk of driver deactivation and will be less likely to distract the driver. Warnings that are high intensity can become annoying if issued too often, resulting in the risk of driver deactivation.(83)

As yet, there are no requirements regarding the performance or effectiveness of this technology. However, such requirements would be a prerequisite for the possible funding of systems and/or the basis for lawmakers to make their installation mandatory.(82)

Generally, drivers are not likely to react to information (with a high or low intensity) until after a response time ("moment of shock") has expired. In many situations, this response time is significantly longer than the amount of time required to avoid the collision – which can then not be avoided despite the warning.(82)

For reasons of vehicle dynamics, only early but low-intensity information to the driver can be an effective assistance function for preventing collisions.(82)

VISIBILITY DETECTION TECHNOLOGIES

Groups Affected

- Vehicles

Jurisdictions Studied

- U.S.

Category: Vehicle Technology/Equipment

DESCRIPTION

Specific technologies to alert tractor-trailer drivers of other vehicles traveling in their blind spots are already on the market. The side view assistance system has sensors to monitor the blind spot in the adjacent lane and provides an audio warning if there is a vehicle in the blind spot after the driver signals an intention to change lanes. In addition, rear vision assistance systems, consisting of cameras and monitors, allow drivers to see pedestrians (and passenger vehicles) present in the rear blind spot while drivers are backing their vehicles.(76) (See Section 3.8 External Mirrors to Reduce Blind Spots, Field of View Standards for Heavy Vehicles, and Turn Assist Systems for Heavy Vehicles)

ISSUES / EVIDENCE

The U.S. National Transportation Safety Board (NTSB) concluded in 2014 that onboard systems and equipment can allow tractor-trailer drivers to better detect passenger vehicles, motorcyclists, pedestrians and cyclists. Such systems are available and their use could prevent fatalities and injuries that occur in collisions involving tractor-trailers. The NTSB recommends that the National Highway Traffic Safety Administration (NHTSA) require newly manufactured truck-tractors with Gross Vehicle Weight Ratings (GVWRs) over 26,000 lbs (approx. 11,793 kg) to be equipped with visibility enhancement systems to improve the ability of drivers to detect passenger vehicles and vulnerable road users.(76)

A NTSB multidisciplinary case review team reviewed 11 single-unit truck cases involving impacts to the front, side, and rear of the single-unit truck and identified whether there were countermeasures that could have mitigated the effects of the crashes.[80]

In the case of an incapacitating injury involving pedestrian impact at the front of the truck, when the truck was travelling straight:

- Pedestrian detection technology may have limited effectiveness if there was traffic on the two adjacent travel lanes.[80]

In the case of a fatality involving pedestrian impact at the front of the truck when the truck was turning left:

- Pedestrian detection technology should focus on a crash scenario where the truck is turning left across traffic and the pedestrian is legally crossing the adjacent crosswalk.[80]

In the case of a fatality involving pedestrian impact at the back of the truck when the truck backing up:

- This is a classic example of the benefits of a backup camera system.[80]

NTSB concludes that onboard systems and equipment that compensate for blind spots and allow drivers of single-unit trucks to detect VRUs could prevent fatalities and injuries.[80]

Specific technologies to alert tractor-trailer drivers of other road users traveling in their blind spots are already on the market. The side view assistance system has sensors to monitor the blind spot in the adjacent lane and provides an audio warning if there is a vehicle in the blind spot after the driver signals an intention to change lanes. In addition, rear vision assistance systems, consisting of cameras and monitors, allow drivers to see pedestrians (and passenger vehicles) present in the rear blind spot while drivers are backing their vehicles.[41]

European regulations refer to more encompassing "devices for indirect vision", which allows for technology other than enhanced mirrors. The regulation states that these are "devices to observe the traffic area adjacent to the vehicle which cannot be observed by direct vision. These can be conventional mirror, camera monitors or other devices able to present information about the indirect field of vision to the driver.[101]

One such device is an ultrasonic proximity sensor which reduces blind spots and improves driver visibility in order to minimise collisions with pedestrians, cyclists or objects. The detection system alerts the driver of obstacles close to the vehicle, whether moving or stationary. An audible and/or visual in-cab warning informs the driver of the distance to the person/ object while an optional external speaking alarm can be added to alert cyclists and pedestrians that the vehicle is turning.

A Florida study examining the results of an integrated camera-mirror system in transit buses showed that that drivers were able to make a 96-98% correct identification when using the integrated camera system, versus only 70-78% with mirror only. Drivers were also faster in identifying objects using the camera system, despite there being more search locations because of the mirrors.[81]

Another type of device is the Mobileye+ Shield Pedestrian and Bicyclist Detection device which detects VRUs in the driver's blind spot using cameras and alerts the driver. The following video shows how the device works on transit buses: (View Mobileye Video)

A study at a university in Texas found that this device resulted in the bus driver never having to make a corrective driving maneuver to avoid a collision with pedestrians.[85]

The Mobileye Shield+ Collision Avoidance Warning System (CAWS) was also the subject of a pilot test in the state of

Washington, U.S., which was specifically designed for transit buses. The system provides alerts and warnings that could lead to a collision: 1) changing lanes without activating a turn signal (lane departure warning was disabled for this pilot), 2) exceeding posted speed limit, 3) monitoring headway with the vehicle leading the bus, 4) forward vehicle collision warning, and 5) pedestrian or cyclist collision warning in front of, or alongside the bus. Alerts and warnings are displayed to the driver by visual indicators located on the windshield and front pillars. Audible warnings are issued when collisions are imminent.(84)

The pilot test met all test objectives. Thirty-eight (38) buses equipped with Shield+ systems logged 352,129 miles and 23,798 operating hours during the official pilot data collection period from April 1, 2016 through June 30, 2016. No Shield+ equipped buses were involved in any collisions with bicyclists or pedestrians. The pilot test showed that although driver acceptance was mixed, there were large reductions in near-miss events for CAWS-equipped buses.(84)

A study conducted by the U.S. Department of Transportation's VOLPE Centre analyzed the potential safety benefits of pedestrian crash avoidance / mitigation (PCAM) system (funded by NHTSA the National Highway Traffic Safety Administration). The researchers used a quantitative measure to determine the effectiveness of PCAM systems. They devised a method using test data, real-world driver behaviour data, and historical crash data to assess safety impact. Volpe found that PCAM systems can potentially reduce up to 5,000 vehicle-pedestrian crashes and 810 fatal vehicle-pedestrian crashes per year. These crashes account for 8% of crashes where cars strike a pedestrian and 24% of same crash types where fatalities were involved. If a crash is unavoidable, PCAM systems could reduce the resulting number of injured pedestrians through impact speed reduction.(98)

BARRIERS / CONSIDERATIONS

There is significant evidence highlighting the issues of blind spots. There have already been developments of vehicle technologies to mitigate these issues. Evidence presented strongly supports the use of visibility enhancement systems.

However, there are risks associated with multiple systems designed to increase visibility. Acceptance by drivers and drivers' behaviour are important considerations, especially with drivers who are unfamiliar with new or advanced systems. In addition, there is a risk of increasing distractions, overloading the drivers' tasks, and dealing with false alarms which, ultimately, may undermine confidence in the detection system.

One of the reported problems of the integrated camera mirror system was during nighttime driving, the headlights of passing vehicles tend to be distracting. This particular issue was not investigated further, even though the cameras were chosen because they reduce blooming and light bleed-through, and they recover relatively fast from this effect. Further research might shed light on this problem, because if it is not addressed, the system can become potentially hazardous in extreme cases.(81)

At this time, the reliability and effectiveness of such systems are unknown; in particular, those designed to detect vulnerable road users in all manoeuvres (front, side and at the back of heavy vehicles).

Pedestrian technology may be limited based on location of collision (with truck) and where there is existing traffic in adjacent lanes.(101)

The NTSB study also recommends the development of performance standards for visibility enhancement systems to compensate for blind spots. Once developed, newly manufactured single-unit trucks over 10,000 lbs should be equipped with such systems.[80]

Factors in achieving industry acceptance include the need to demonstrate incentives as well as the business case for CAWS in order to stimulate and support research and development. Although the pilot project produced encouraging results, collisions, injuries and fatalities can be considered "rare events." A much larger in-service test will be needed to demonstrate actual cost-savings.[84]

The City of Montreal is testing a tool that helps to evaluate blind spots on heavy vehicles. Based on the blind spot rating assigned, these vehicles would have limited access to [specific areas] in cities. (See Section 3.5 Restrict Movement of Heavy Vehicles)

ONGOING STUDIES OF VISIBILITY DETECTION TECHNOLOGIES BY TRANSPORT CANADA

Transport Canada (TC) has been testing advanced technologies for improving the safety of vulnerable road users around heavy vehicles. These advanced technologies warn the operator with visual and audio warnings when pedestrians and cyclists are at risk. This research is aimed at preventing cyclist and pedestrian collision with heavy vehicles in many collision scenarios.

Testing has been conducted at TC's Motor Vehicle Test Centre in a controlled environment exploring various technologies such as radar, ultrasound, camera, as well as a combination of these tools. With the collaboration of several cities across Canada, the performance of these systems will be further evaluated in real world settings. The intent is to evaluate their operation for a full year and gather data on their performance across different conditions, e.g., Canadian weather, driving conditions and driver acceptance.

WARNING SIGNS / DECALS AT REAR OF HEAVY VEHICLES

Groups Affected
- Vehicles

Jurisdictions Studied
- Canada

Category: Other

DESCRIPTION

Warning signs (decals) at the rear of vehicles could advise cyclists and other vulnerable road users to avoid riding and/or passing trucks along the passenger side. As most designated bike lanes / tracks are installed along the right curb of the roadway, this design invariably funnels cyclists along the passenger side of vehicles, where they are at greater risk of becoming involved in a collision, especially with a right-turning vehicle.[(75)] (See Section 3.3 Bicycle Boxes and Section 3.4 Segregated Bicycle Lanes)

ISSUES / EVIDENCE

The documentation reviewed did not provide evidence supporting the successful implementation of this countermeasure.

BARRIERS / CONSIDERATIONS

Lafarge Canada Inc. had committed to installing cyclist warning signs on all its owned commercial vehicles across Eastern Canada by the end of 2015.[(75)]

Signage identifying the blind-spots of a truck and placed in and around bike lanes in urban centres, on buses, streetcars, subways, and stations, as well as any signage placed ahead of the hood and on the front right side of the vehicle, where VRUs might put themselves in precarious situations, may encourage VRUs to move to where they know the truck driver can see them.

DAYTIME RUNNING LIGHTS ON BICYCLES

Groups Affected
- Vehicles (Bicycles)

Jurisdictions Studied
- OECD (35+ countries)

Category: Vehicle Technology/Equipment

DESCRIPTION

These are new types of bicycle lights that are permanently affixed to the bike and powered by magnetic induction from magnets fixed to the spokes.[53]

A daytime running light is an automotive lighting and bicycle lighting device on the front of a road-going motor vehicle or bicycle that automatically switches on when the vehicle is moving forward. The lights emit white, yellow, or amber light to increase the visibility of the vehicle during daylight conditions. (Definition taken from Wikipedia)

ISSUES / EVIDENCE

In a Danish study in 2005, nearly 2,000 cyclists in the town of Odense used the new induction (running) lights (flashing type) for one year, while 2,000 others continued with ordinary bike lights, which were only turned on during dark hours. The crash frequencies (based on self-reported collisions) were then compared and analyzed. The use of daytime running lights were associated with a reduction in the number of crashes by more than 30%. The number of related crashes (crashes in daylight and with a counterpart) decreased by approximately 50%. Both results are statistically significant. There are indications that the study may have not controlled for all factors – for instance, it is unclear to what extent the control group's crashes included single vehicle crashes (this type of crash is hardly influenced by the use of induction lights). Also, the study makes no findings as to the safety effect of flashing versus steady lights.[53]

BARRIERS / CONSIDERATIONS

Relevance to heavy vehicles. While most collisions occur during daylight (when there is likely to be more cycling), a significant share occur in unlit or low light conditions, especially in the U.S. where these crashes account for nearly half of all fatal crashes.[53]

INCREASED CONSPICUITY AND VISIBILITY OF PEDESTRIANS / CYCLISTS

Groups Affected
- Pedestrians
- Cyclists
- Drivers

Jurisdictions Studied
- U.S.
- OECD (35+ countries)
- ITF (50+ countries)

Category: Policy/Legislation/Regulation; Enforcement; Education; Communications

DESCRIPTION

Driving on a typical major road is a complex activity, involving processing large amounts of visual information, which continuously changes, and making decisions at speed. The amount of visual information in road environments is increasing. This results in a road environment that is increasingly prone to 'visual clutter', that is, visual information presented in road environments in the forms of advertisements, billboards, road signs, vehicle traffic, buildings and other infrastructure, etc.(102)

While crashes are usually complex events with a mix of causal factors, it is clear that crashes between vehicles and pedestrians are overrepresented at night and there is strong evidence that visibility issues are a key factor.(78)

Pedestrians and cyclists can take measures to increase their visibility to drivers and thus, in some cases, decrease their risk of being hit by a motor vehicle. Visibility aids include reflective clothing and flashing lights for both pedestrians and cyclists(21) and help to ensure visibility of pedestrians wanting to cross [*the road*].(6)

In addition, there are conspicuity treatments for large vehicles, such as lamps, reflective devices, and associated equipment.

ISSUES / EVIDENCE

Analyses of crash databases have determined that the increased incidence of crashes involving pedestrians at night is primarily a consequence of lower illumination rather than other factors that vary between day and night, such as driver fatigue and the use of alcohol.(78) While driver age affects accuracy in identifying pedestrians, actual pedestrian motion significantly affected their recognition (or conspicuity). However, the main effect of clutter was not significant.

Research has repeatedly demonstrated that pedestrians are even more conspicuous to drivers at night when reflective material is attached to the pedestrian's major moveable joints rather than to their torso. The conspicuity benefit associated with these limb markings has been attributed to our perceptual sensitivity to the distinctive patterns of "biological motion" that are associated with normal human gait.(78)

In contrast to the widely reported conspicuity benefits that biological motion configurations provide, one previous study failed to find a conspicuity advantage associated with biological motion. Those authors suggested that biological motion configurations may not be effective when the pedestrian is surrounded by visual clutter. The present study addressed this issue explicitly. Three patterns in the present data confirm that clothing configurations that include reflective markings on the limbs offer conspicuity advantages that are both significant and substantial, even in the presence of visual clutter.(78)

About 5% of pedestrians and 3% of cyclists involved in a collision had used alcohol or drugs at the time of the collision. If a pedestrian or cyclist involved in a collision consumed drugs or alcohol, they had a greater likelihood of being severely injured or killed than a pedestrian or cyclist who hadn't consumed drugs or alcohol (pedestrians were about 2.5 times as likely to be severely injured or killed, and cyclists were more than 2 times as likely to be severely injured or killed).[103]

BARRIERS / CONSIDERATIONS

Caution should be taken when promoting the use of reflective clothing with respect to increasing the visibility of pedestrians around heavy vehicles. Studies on the impact of retro-reflective clothing have typically been performed with automobiles. The effectiveness of reflective materials will be less with heavy vehicles due to the greater distance between the driver's eyes and the headlights. There is also evidence *that* people overestimate the effectiveness of safety equipment such as reflective clothing, resulting in them potentially taking more risk.

Education campaigns sufficient to reach and change the behaviour of a significant portion of the population are costly. Before undertaking a campaign to encourage people to improve their visibility, the costs and benefits of other measures including infrastructure improvements should be considered.

LIST OF REFERENCES

1 World Health Organization. (2013). *Pedestrian Safety - A Road Safety Manual for Decision Makers and Practitioners.* Retrieved from www.grsproadsafety.org: https://www.grsproadsafety.org/wp-content/uploads/PedestrianSafety_eng.pdf?x96695

2 CCMTA. (n.d.). Canada's *Road Safety Strategy 2025*. Retrieved from strategiesecuriteroutiere.ca: http://strategiesecuriteroutiere.ca/en/strategy

3 Vision Zero Network. (n.d.). *How can cities increase the safety of large vehicles in urban areas.* Retrieved from visionzeronetwork.org: http://visionzeronetwork.org/wp-content/uploads/2016/10/CaseStudy_LargeVehicle_Final.pdf

4 Office of the Chief Coroner for Ontario. (2010). *Pedestrian Death Review.* Retrieved from mcscs.jus.gov.on.ca: http://www.mcscs.jus.gov.on.ca/sites/default/files/content/mcscs/docs/ec161058.pdf

5 Office of the Chief Coroner of Ontario (2012, June). *Cycling Death Review: A Review of All Accidental Cycling Deaths in Ontario from January 1st, 2006 to December 31st, 2010.* Retrieved from mcscs.jus.gov.on.ca: http://www.mcscs.jus.gov.on.ca/sites/default/files/content/mcscs/docs/ec159773.pdf

6 International Transport Forum. (2012). *Pedestrian Safety, Urban Space and Health, OEDC Publishing*. Retrieved from oecd-ilibrary.org: http://www.oecd.org/publications/pedestrian-safety-urban-space-and-health-9789282103654-en.htm

7 University of Washington, Department of Urban Design and Planning . (2012, December 7). *Why Can't We Be Friends? Reducing Conflicts Between Bicycles and Trucks* . Retrieved from faculty.washington.edu: http://faculty.washington.edu/abassok/studio/reducing_conflicts_between_bicycles_and_trucks.pdf

8 Canada Bikes. (n.d.). *Towards a Bike-Friendly Canada, A National Cycling Strategy Overview.* Retrieved from canadabikes.org: http://www.canadabikes.org/wp-content/uploads/2016/04/TowardsABike-FriendlyCanadaForWeb2.pdf

9 Canada Walks. (2015). *Canada's National Active Transportation Strategy* . Retrieved from canadawalks.ca: http://canadawalks.ca/take-action/national-action-strategy/

10 Office of the Surgeon General, U.S. Department of Health and Human Services. (2015). *Step It Up! The Surgeon General's Call to Action to Promote Walking and Walkable Communities* . Retrieved from https://www.surgeongeneral.gov/library/calls/walking-and-walkable-communities/index.html

11 Federal Highway Administration, U.S. Department of Transportation. (2016, September). *Strategic Agenda for Pedestrian and Bicycle Transportation.* Retrieved from https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/strategic_agenda/

12 World Health Organization. (2008). *Speed Management - A Road Safety Manual for Decision Makers and Practitioners* . Retrieved from http://www.who.int/roadsafety/projects/manuals/speed_manual/speedmanual.pdf

13 Ministère des Transports du Québec. (2015). *Guide à l'intention des municipalités*, *Gestion de la vitesse sur le réseau routier municipal en milieu urbain.* Retrieved from: https://www.transports.gouv.qc.ca/fr/securite-signalisation/securite/moderation-vitesse/Documents/A6898_guide_vitesse_EPAC_web.pdf

14 CCMTA. (2013, August). *Countermeasures to Improve Pedestrian Safety in Canada.* Retrieved from ccmta.ca: http://ccmta.ca/images/publications/pdf/CCMTA_Pedestrian_Report_Eng_FINAL.pdf

15 New York City Department of Transportation. (2010, August). *The New York City Pedestrian Safety Study and Action Plan* . Retrieved from nyc.gov: http://www.nyc.gov/html/dot/downloads/pdf/nyc_ped_safety_study_action_plan.pdf

16 Vanlaar, W., Robertson, R., & Marcoux, K. (2014). *Accident Analysis and Prevention: An Evaluation of Winnipeg's Photo Enforcement Safety Program: Results of Time Series Analyses and an Intersection Camera Experiment.* Elsevier.

17 Ministry of Transportation Ontario. (2003, December). *Evaluation of the Red Light Camera Enforcement Pilot Project - Final Technical Report* . Retrieved from www.motorists.org: https://www.motorists.org/wp-content/themes/nma/pk/lib/pdf/web/viewer.html?file=https://www.motorists.org/wp-content/uploads/2015/05/2003-ontario.pdf

18 Insurance Institute for Highway Safety. (2016, July 28). *Turning Off Red LIght Cameras Costs Lives, New Research Shows.* Retrieved from www.iihs.org: http://www.iihs.org/iihs/news/desktopnews/turning-off-red-light-cameras-costs-lives-new-research-shows

19 Grundy, C; Steinback, R; Edwards, P; Green, J; Armstrong, B; Wilkinson, P. (2009). *Effect of 20 mph Traffic Speed Zones on Road Injuries in London, 1986-2006: Controlled Interrupted Time Series Analysis.* Retrieved from https://www.bmj.com/content/339/bmj.b4469

20 Monash University Accident Research Centre, Automobile Club of Italy, Vectura Consulting. (n.d.). *Vulnerable Road User Safety: Italy, Sweden, and Australia.* Retrieved from sietitalia.org: http://www.sietitalia.org/siet2010/28-Fildes_Pennisi_Rizzi_paper.pdf

21 Public Health, Public Works Department. (n.d.). *Ottawa's Stretegic Road Safety Action Plan, 2012 – Beyond.* Retrieved from ottawa.ca: http://ottawa.ca/calendar/ottawa/citycouncil/occ/2011/12-14/cpsc/02%20-%20Safe%20Roads%20Document%201%20-%20Action%20Plan%20-%20English.pdf

22 Brake – The Road Safety Charity. (2014). *Protecting Vulnerable Road Users From Vehicle Blind Spots*. Retrieved from tfpschemes.co.uk: http://www.tfpschemes.co.uk/media/10264/brake-best-practice-guidance-vru.pdf

23 Société de transport de Montréal. (2016). *Présentation Ingénierie Bus STM*

24 Bike Maryland. (2015). *Strategic Plan 2015 - 2020*. Retrieved from bikemaryland.org: https://www.bikemaryland.org/resources/riding/strategic-plan/

25 Mayor of London. *Safe Streets for London - The Road Safety Action Plan for London 2020*. (2013, June). Retrieved from content.tfl.gov.uk: http://content.tfl.gov.uk/safe-streets-for-london.pdf

26 Share the Road Cycling Coalition. (n.d.). Retrieved from sharetheroad.ca: http://www.sharetheroad.ca

27 Crossrail UK. (n.d.). *Exchanging Places.* Retrieved from crossrail.co.uk: http://www.crossrail.co.uk/construction/road-safety-information/exchanging-places

28 Vélo Quebec. (2015). *Cycling in Quebec.* Retrieved from velo.qc.ca: http://www.velo.qc.ca/documents/?mag=l%C3%A9tat-du-v%C3%A9lo-au-qu%C3%A9bec-cycling-in-qu%C3%A9bec-in-2015/0548836001464362483

29 San Francisco Bicycle Coalition. (2017). *Intro to Urban Bicycling and Truck Blind Spots Workshop.* Retrieved from sfbike.org: http://www.sfbike.org/event/intro-to-urban-bicycling-and-truck-blind-spots-workshop/

30 Sandt, L., Cohn, J., West, A., Johnson, S., Moose, W., & LaJeunesse, S. (2017). *The Role of Law Enforcement in Supporting Pedestrian and Bicycle Safety: An Idea Book*.

31 Federal Highway Administration, U.S. Department of Transportation. (2009). *Pedestrian Safety Engineering and ITS-Based Countermeasures Program for Reducing Pedestrian Fatalities, Injury Conflicts, and Other Surrogate Measures Final System Impact Report*.

32 City of Ottawa. (2010). *Pedestrian Intersection Safety Countermeasure Handbook*.

33 American Journal of Public Health. (2003, September). *A Review of Evidence-Based Traffic Engineering Measures Designed to Reduce Pedestrian–Motor Vehicle Crashes*.

34 Traffic Injury Research Foundation . (n.d.). *Road Safety Issues - Pedestrians: What Do We Know?* Retrieved from tirf.ca: http://tirf.ca/wp-content/uploads/2017/01/TIRF_Toolkit_Factsheets_Pedestrian-Issue.pdf

35 British Columia. (n.d). *B.C. Community Road Safety Tool Kit, Module 1 – Protecting people who walk and cycle*. Retrieved from: https://www2.gov.bc.ca/assets/gov/driving-and-transportation/driving/publications/community_road_safety_toolkit_module1.pdf

36 CIty of Austin; Centre for Transportation Research, University of Texas at Austin . (2010, August 2). *Effects of Bicycle Boxes on Bicyclist and Motorist Behavior at Intersections.* Retrieved from nacto.org: https://nacto.org/wp-content/uploads/2011/02/Effects-of-Bicycle-Boxes-on-Bicyclist-and-Motorist-Behavior-at-Intersections.pdf

37 The Royal Society for the Prevention of Accidents (ROSPA). (n.d.). *HGVs and Vulnerable Road Users.* Retrieved from rospa.com: http://www.rospa.com/rospaweb/docs/advice-services/road-safety/cyclists/hgvs-and-vulnerable-road-users.pdf

38 Jennifer Dill; Christopher M. Monsere; Nathan McNeil. (2012). *Evaluation of Bike Boxes at Signalized Intersections.* Elsevier.

39 National Research Council Canada. (2010, March 1). *Side Guards for Trucks and Trailers, Phase 1: Background Investigation.* Retrieved from safetrucks.ca: http://www.safetrucks.ca/resources/National_Research_Council_Truck_Side_Guard_Study_2010-03-01.pdf

40 Transportation Association of Canada (TAC). (2009, June 12). *Study on Safe Accommodation of Vulnerable Road Users and Large Commercial Vehicles in Urban Areas.* Retrieved from ville.montreal.qc.ca: http://ville.montreal.qc.ca/pls/portal/docs/PAGE/COMMISSIONS_PERM_V2_FR/MEDIA/DOCUMENTS/REF_TAC_20190612.PDF

41 City of Vancouver. (2012). *Pedestrian Safety Study.*

42 Transport Research Library, Cookson & Knight. (2010). *Sideguards on heavy goods vehicles: assessing the effects on pedal cyclists injured by trucks overtaking or turning left.*

43 Broek, N. V., & Agencies, K. L. (2011). *The When, Where and How of Mid-Block Crosswalks.* Retrieved from www2.ku.edu: http://www2.ku.edu/~kutc/pdffiles/LTAPFS11-Mid-Block.pdf

44 Department of Mechanical and Industrial Engineering and Department of Civil and Environmental Engineering, Univerity of Massachusetts. (2010, December 28). *Advance Yield Markings and Drivers' Performance in Response to Multiple-Threat Scenarios at Mid-Block Crosswalks.* Retrieved from www.ncbi.nlm.nih.gov: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3482473/

45 Markowitz, F., Sciortino, S., Fleck, J. L., & Yee, B. (2006). *Pedestrian Countdown Signals: Experience with an Extensive Pilot Installation.* Retrieved from http://www.popcenter.org/problems/pedestrian_injuries/PDFs/Markowitz_etal_2006.pdf

46 Camden, A., Buliung, R., Rothman, L., Macarthur, C., & Howard, A. (2011, December 10). *The Impact of Pedestrian Countdown Signals on Pedestrian-Motor Vehicle Collisions: A Quasi-Experimental Study.* Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3406612/

47 City of Toronto, City of Calgary. (2011). *Pedestrian Scramble Crossings - Tale of Two Cities.*

48 Chen, L., Chen, C., & Ewing, R. (2012). *The Relative Effectiveness of Pedestrian Safety Countermeasures at Urban Intersections - Lessons from a New York City Experience* . Retrieved from https://nacto.org/docs/usdg/relative_effectiveness_of_pedestrian_safety_counter_measures_chen.pdf

49 Institut nationale de santé publique, Quebec. (2011). *Urban Traffic Calming and Health - Literature Review.*

50 Federal Highway Administration. (2014). *Evaluation of Pedestrian-Related Roadway Measures: A Summary of Available Research on Pedestrian Safety.*

51 ITF (2013), *Cycling, Health and Safety*, ITF Research Reports, OECD Publishing, Paris, https://www.oecd-ilibrary.org/transport/cycling-health-and-safety_9789282105955-en.

52 Hembrow, D. (2014, May 23). *The Best Roundabout Design for Cyclists.* Retrieved from http://www.aviewfromthecyclepath.com/2014/05/the-best-roundabout-design-for-cyclists.html

53 International Transport Forum OECD. (2013). *Cycling, Health and Safety - Research Report.* Retrieved from oecd.org: http://www.oecd.org/greengrowth/cycling-health-and-safety-9789282105955-en.htm

54 Transportation Research Board, National Cooperative Highway Research Program. (2012). *Guidelines for Timing Yellow and All-Red Intervals at Signalized Intersections.* Retrieved from redlightrobber.com: http://redlightrobber.com/red/links_pdf/NCHRP-Guidelines-for-Timing-RPT-731.pdf

55 PLOS ONE. (2014, March 3). *Injury Severity and Mortality of Adult Zebra Crosswalk and Non-Zebra Crosswalk Road Crossing Accidents: A Cross-Sectional Analysis*. Retrieved from plosone.org: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0090835#pone-0090835-t001

56 Safe Roads and Communities Working Committee. (2015). *B.C. Community's Road Safety Toolkit - Module 1: Protecting People Walking and Cycling.*

57 U.S. Department of Transportation; Federal Highway Administration. (2017, February). *Urban Freight Case Studies - New York City.* Retrieved from ops.fhwa.dot.gov: https://ops.fhwa.dot.gov/publications/fhwahop10019/truckrtmgmt.htm#9b

58 Coalition Vélo de Montréal. (2017). *Consultation publique - Concilier déplacements sécuritaires à vélo et présence de véhicules lourds, UN ENJEU DE POIDS!* Retrieved from coalitionvelomontreal.org: https://coalitionvelomontreal.org/site/assets/files/2940/mem_poidslourds.pdf

59 Jamie Stuckless, Share the Road Coalition. (2018, January 30). *On Bike Lanes & Safety: Our Response to the Financial Post.* Retrieved from medium.com: https://medium.com/share-the-road-cycling-coalition/on-bike-lanes-safety-our-response-to-the-financial-post-22ad7159d468

60 National Association of City Transportation Officials . (n.d.). *Allen and Pike Streets Pedestrian and Bicycle Improvement Project, New York, NY - Case Study.* Retrieved from nacto.org: https://nacto.org/case-study/left-side-bike-lanes-on-allen-pike-st-new-york-ny/

61 European Commission. (n.d.). *Mobility and Transport Road Safety - Pedestrians and Cyclists.* Retrieved from ec.europa.eu: https://ec.europa.eu/transport/road_safety/specialist/knowledge/pedestrians_en

62 Commission Sur le Transport et Les Travaux Publics, VIlle de Montréal . (2017). *RAPPORT ET RECOMMANDATIONS - Examen public - Cohabitation sécuritaire entre les usagers vulnérables et les véhicules lourds en milieu urbain, dans l'optique de la « Vision zéro » en matière de sécurité routière.* Retrieved from ville.montreal.qc.ca: http://ville.montreal.qc.ca/pls/portal/docs/PAGE/COMMISSIONS_PERM_V2_FR/MEDIA/DOCUMENTS/RAPPORT_CM_20170515_0.PDF

63 European Federation for Transport and Evnironment. (2016). *Eliminating Truck Blind Spots – A Matter of Direct Vision.* Retrieved from transportenvironment.org: https://www.transportenvironment.org/sites/te/files/publications/2016_07_Trucks_direct_vision_briefing_FINAL_0.pdf

64 Transport Canada. (2011). *Annual Report, Transportation in Canada 2011, Road Transportation*. Retrieved from: https://www.tc.gc.ca/eng/policy/anre-menu-3021.htm

65 University of Michigan. (1980). *Police Enforcement Procedures for Unsafe Driving Actions*.

66 The League of American Bicyclists. (n.d.). *Model Vulnerable Road User Law*. Retrieved from bikeleague.org: http://bikeleague.org/content/model-vulnerable-road-user-law

67 Organization for Economic Cooperation and Development. (1998). *Safety of Vulnerable Road Users*.

68 Traffic Injury Research Foundation. (2015). *TIRF Road Safety Campaigns - What the Research Tells Us.* Retrieved from tirf.ca: http://tirf.ca/wp-content/uploads/2017/01/TIRF_Toolkit_Factsheets_Road-SafetyCampaignEffectiveness.pdf

69 U.S. Department of Transportation / Volpe. (2014). *Truck Side Guards for Vision Zero*. Retrieved from ntl.bts.gov: http://ntl.bts.gov/lib/54000/54700/54711/Truck_Sideguards_NYC.pdf

70 Insurance Institute for Highway Safety. (2017, May 10). *IIHS tests show benefits of side underride guards for semitrailers.* Retrieved from iihs.org: http://www.iihs.org/iihs/news/desktopnews/iihs-tests-show-benefits-of-side-underride-guards-for-semitrailers

71 National Research Council Canada. (2012, April 5). *Test Report - Effects of Side Skirts and Wheel Covers on Heavy Trailers.*

72 AAA Foundation for Traffic Safety (U.S.). (2011, September). *Impact Speed and a Pedestrian's Risk of Severe Injury or Death.*

73 Monash University, Accident Research Centre; Transport Accident Commission. (2008, January). *The Impact of Lowered Speed Limits in Urban and Metropolitan Areas.* Retrieved from www.monash.edu: https://www.monash.edu/__data/assets/pdf_file/0007/216736/muarc276.pdf

74 International Association of Traffic Safety Sciences (IATSSS). (2017, July). *Is 30 km/h a 'Safe' Speed? Injury severity of pedestrians struck by a vehicle and the relation to travel speed and age*. Retrieved from: https://www.sciencedirect.com/science/article/pii/S0386111214000235#bb0020

75 LaFarge Canada. (2017). *Our Fleet Drives Innovation in Cyclist Safety.* Retrieved from www.lafarge.ca: https://www.lafarge.ca/en/vehicle-safety

76 National Transportation Safety Board. (2014, April 3). *Safety Recommendations, Letter to National Highway Traffic Safety Administration Regarding Side Guards.* Retrieved from ntsb.gov: https://www.ntsb.gov/safety/safety-recs/RecLetters/H-14-001-007.pdf

77 Transport Research Laboratory. (2011). *A study of the implementation of Directive 2007/38/EC on the retrofitting of blind spot mirrors to HGVs.* Retrieved from ec.europa.eu: https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/pdf/retrofitting_mirrors.pdf

78 Department of Psychology, Clemson University, USA; School of Optometry, Institute of Health and Biomedical Innovation, Queensland University of Technology, Australia; Department of Psychology, Wichita State University, USA. (2009). *Seeing Pedestrians at Night: Visual Clutter Does Not Mask Biological Motion.* Retrieved from QUT Digital Repository: https://eprints.qut.edu.au/29994/1/c29994.pdf

79 U.S. Department of Transportation, Federal Highway Administration. (April 2005). Safety Evaluation of Red-Light Cameras - Executive Summary. This summary report is an archived publication and may contain dated technical, contact and link information.

80 National Transportation Safety Board. (2013, June 17). *Safety Study – Crashes Involving Single-Unit Trucks that Resulted in Injuries and Deaths*. Retrieved from www.ntsb.gov: https://www.ntsb.gov/safety/safety-studies/Documents/SS1301.pdf

81 Florida Department of Transportation. Pei-Sung Lin, Ph.D., P.E., PTOE, FITE, Achilleas Kourtellis, Ph.D., Matthew Wills, E.I.T. (2012, December). *Evaluation of Camera-Based Systems to Reduce Transit Bus Side Collisions-Phase II*. Retrieved from: nctr.usf.edu https://www.nctr.usf.edu/wp-content/uploads/2013/01/77940.pdf

82 Federal Highway Research Institute. Benjamin Schreck and Dr Patrick Seiniger. (2014, December 1). *Turn assist system for goods vehicles - Bases for a testing procedure*.

83 Federal Highway Research Institute Germany. Patrick Seiniger. (n.d.) Draft Regulation on Driver Assist Systems to Avoid Blind Spot Accidents - Development of Test Procedure and First Verification Tests. Retrieved from unece.org: http://www.unece.org/fileadmin/DAM/trans/doc/2016/wp29grsg/GRSG-110-18e.pdf

84 Transportation Research Board. (2017, May). *Active Safety-Collision Warning Pilot in Washington State*. Retrieved from onlinepubs.trb.org: http://onlinepubs.trb.org/onlinepubs/IDEA/FinalReports/Transit/Transit82.pdf

85 Texas A&M Transportation Institute, Koeneman, P. Turner, S. and Turnbull, K. (2017). *Follow-up Assessment of the Mobileye Shield+ Evaluation*. Retrieved from: https://static.tti.tamu.edu/tti.tamu.edu/documents/165610-1.pdf

86 The Canadian Press. Canada's Occupational Health & Safety Magazine. (2018, April 29). *Changes to truck driver training gaining traction: industry group*. Retrieved from ohscanada.com: https://www.ohscanada.com/changes-truck-driver-training-gaining-traction-industry-group/

87 Trucknews.com. (2018, April 30). *Mandatory commercial driver training coming to Saskatchewan*. Retrieved from trucknews.com: https://www.trucknews.com/regulations/mandatory-commercial-driver-training-coming-saskatchewan/1003085463/

88 Province of Ontario. (2017, July 21). *New Mandatory Training for Class A (Commercial Truck) Drivers in Ontario*. Retrieved from ontario.ca: https://www.ontario.ca/page/new-mandatory-training-class-drivers-licence-applicants

89 U.S. Department of Transportation, Federal Highway Administration. Kay Fitzpatrick and Eun Sug Park. (2010, June). *Safety Effectiveness of the HAWK Pedestrian Crossing Treatment*. Retrieved from fhwa.dot.gov: https://www.fhwa.dot.gov/publications/research/safety/10042/10042.pdf

90 U.S. Department of Transportation, Federal Highway Administration. Kay Fitzpatrick, Susan T. Chrysler, Ron Van Houten, William W. Hunter, and Shawn Turner. (2011, April). *Evaluation of Pedestrian and Bicycle Engineering Countermeasures: Rectangular Rapid-Flashing Beacons, HAWKs, Sharrows, Crosswalk Markings, and the Development of an Evaluation Methods Report*. Retrieved from fhwa.dot.gov: https://www.fhwa.dot.gov/publications/research/safety/pedbike/11039/11039.pdf

91 International Journal of Injury Control and Safety Promotion. Volume 22, 2015 – Issue 2. (2015). Srinivas S. Pulugurtha and Debbie R. Self. *Pedestrian and motorists' actions at pedestrian hybrid beacon sites: findings from a pilot study*. Retrieved from tandfonline.com: https://www.tandfonline.com/doi/full/10.1080/17457300.2013.857694?scroll=top&needAccess=true

92 County of Brant (Ontario). (n.d.) *By-Law 182-05: Community of Paris - Heavy Truck Restriction*. Retrieved from: https://www.brant.ca/en/index.aspx

93 Van Houten, Ron, Richard Retting, Charles Farmer, & Joy Van Houten. Journal of the Transportation Research Board, No. 1734, Transportation Research Board of the National Academies. (2000). *Field Evaluation of a Leading Pedestrian Interval Signal Phase at Three Urban Intersections*. Retrieved from trrjournalonline.trb.org: https://trrjournalonline.trb.org/doi/abs/10.3141/1734-13?journalCode=trr

94 Vinod Vasudevan, Srinivas Pulugurtha, Shashi Nambisan, Mukund Dangeti, Journal of the Transportation Research Board, No. 2264, Transportation Research Board of the National Academies. (2011). Effectiveness of Signal-Based Countermeasures on Pedestrian Safety: Findings from a Pilot Study. Retrieved from: https://trrjournalonline.trb.org/doi/abs/10.3141/2264-06

95 Pratt, M., P. Songchitruska and J. Bonneson. Presented at 91st Annual Meeting of the Transportation Research Board, Washington, D.C. (2012). *Pedestrians and Left-Turning Vehicles: An Evaluation of Safety Treatments*.

96 Insurance Corporation of British Columbia. (2017). Quick Statistics. Retrieved from icbc.com: http://www.icbc.com/about-icbc/newsroom/Documents/quick-statistics.pdf

97 Ontario Waste Management Association. Web Site. (2018, March). *SWANA Ontario Safety Summit*. Retrieved from owma.org: https://www.owma.org/articles/swana-ontario-safety-summit

98 U.S. Department of Transportation. Volpe Centre. (2017, August). *Researchers Study Benefits of Pedestrian Detection Systems on Vehicles*. Retrieved from volpe.dot.gov: https://www.volpe.dot.gov/news/how-effective-are-pedestrian-detection-systems-in-cars

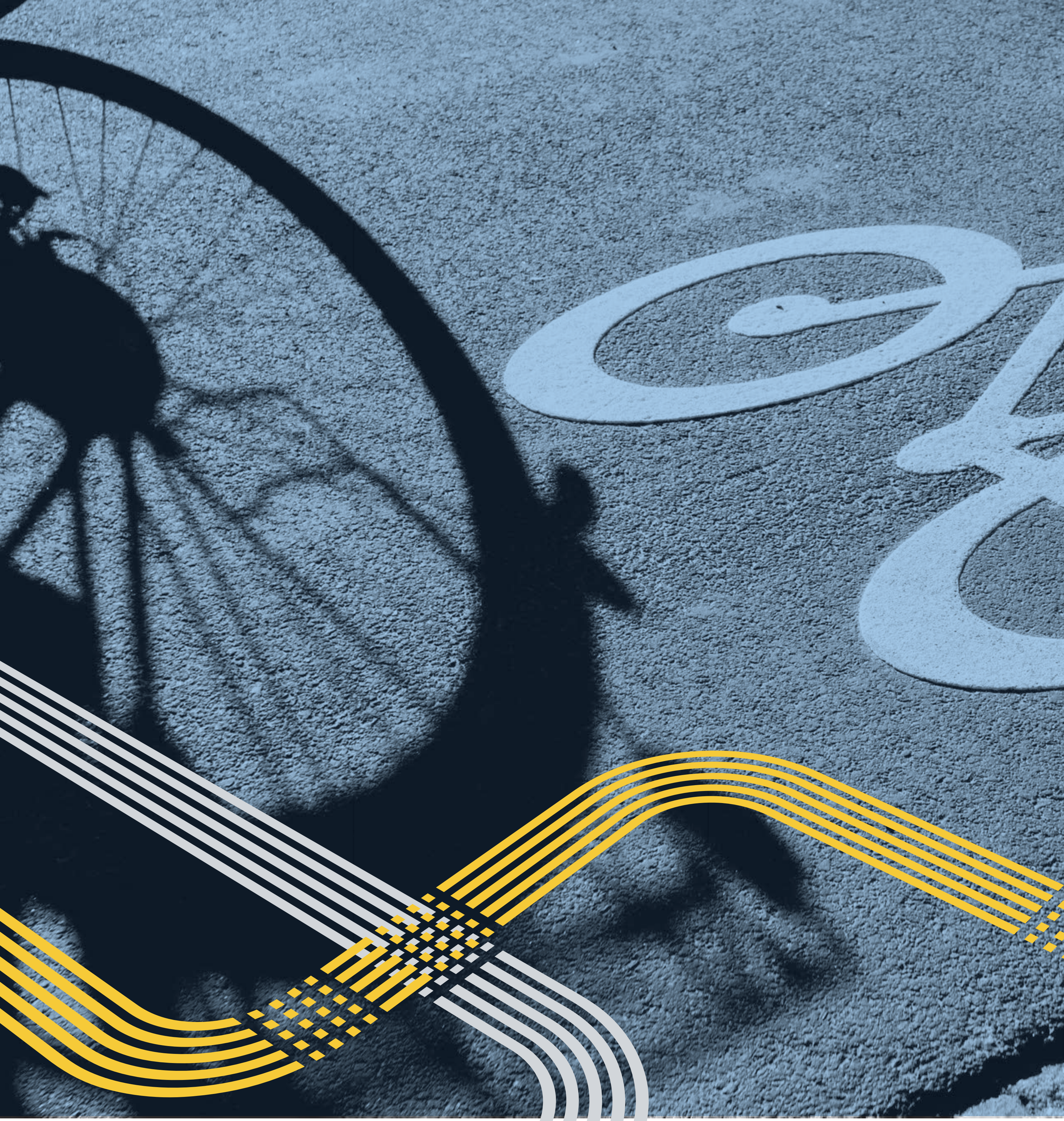
99 Institute for Road Safety Research. SWOV Leidschendam, the Netherlands. SWOV Fact Sheet. (2012, July). *Vulnerable Road Users*.

100 German Insurers Accident Research. Kuehn, M., Hummel, T., Bende, J. Paper Number 11-0153. (n.d). *Advanced Driver Assistance Systems for Trucks – Benefit Estimation from Real-Life Accidents*. Retrieved from esv.nhtsa.dot.gov: https://www-esv.nhtsa.dot.gov/Proceedings/22/files/Session%2013%20Oral.pdf

101 Transport for London. Loughborough Design School, Loughborough University. Summerskill, S. Dr., Marshall, R., Dr., Lenard, J. (2014, August). *The Design of Category N3 Vehicles for Improved Driver Direct Vision*. Retrieved from transportenvironment.org: https://www.transportenvironment.org/sites/te/files/Loughborough%20Design%20School%20and%20T%26E-Report_The%20design%20of%20category%20N3%20vehicles%20for%20improved%20driver%20direct%20vision-FINAL_5_09_2014.compressed.pdf

102 Monash University Accident Research Centre. Edquist, J., Johnston, I. (2008, November). *Visual Clutter in Road Environments – What it Does, and What to Do About it.* Retrieved from casr.adelaide.edu.au: http://casr.adelaide.edu.au/rsr/RSR2008/EdquistJ.pdf

103 Organization for Economic Co-operation and Development (OECD). (2006). *Speed Management*.



ANNEXES

ANNEX I: ASSESSMENT TOOL

VULNERABLE ROAD USERS COUNTERMEASURES PROJECT

VRU COUNTERMEASURES ASSESSMENT TOOL

ANCHOR QUESTION

What countermeasures can be implemented to encourage/foster an increasingly safer environment for Vulnerable Road Users (VRUs) – that is, pedestrians and cyclists – as they manoeuver city streets and share space with heavy vehicles?

SECTION ONE: COUNTERMEASURE

Countermeasure name:

Countermeasure Category (check all that apply):

- ☐ Policy/Legislation/Regulation
- ☐ Infrastructure
- ☐ Vehicle Technology/Equipment
- ☐ Enforcement
- ☐ Education/Training*
- ☐ Communications/Awareness*
- ☐ Other: ______________________________

* Communications/awareness countermeasures will apply to a broader audience; education/training countermeasures will be more effective if they are targeted at a particular audience.

Considerations * (check all that apply):

- ☐ Social
- ☐ Technological
- ☐ Economic
- ☐ Environmental
- ☐ Political
- ☐ Legal
- ☐ Demographic
- ☐ Jurisdictional
- ☐ Future Consideration

Comments: ______________________________

____

* Education / Training countermeasures may have demographic considerations. For example, attention will need to be given to the differing delivery channels and needs that could be targeted to adults / parents, young drivers, seniors, etc.

Countermeasure intended to affect: (check all that apply)

☐ Pedestrians	☐ Cyclists	☐ Vehicles	☐ Drivers
☐ Children	☐ Youth	☐ Adults	☐ Seniors

Jurisdictions where work (study) completed: ______________________

Number of jurisdictions, if applicable: ______________________

SECTION TWO: PERFORMANCE MEASURES	Yes	No
1. Were any evaluations, cost/benefit analyses, or cost effectiveness analyses conducted? 2. If no, what evidence supports the inclusion of the countermeasure?	☐	☐
3. If yes, please indicate the author, title, source, and/or web-link where the cost-benefit, statistical, or other evidence-based analyses can be located. (Include evidence such as real-life experience, field or lab tests, etc.)	**Works Cited** **Scope of the Problem** **Evidence**	

SECTION THREE: EVIDENCE AND EVALUATION

Barriers and considerations for implementation. Please identify any barriers or concerns that may hinder the implementation of this countermeasure.

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SECTION FOUR: GENERAL COMMENTS AND OBSERVATIONS

ANNEX II: LIST OF ACRONYMS

APS	Accessible Pedestrian Signals
ASL	Advanced Stop Lines
CAA	Canadian Automobile Association
CAWS	Collision Avoidance Warning System
CCMTA	Canadian Council of Motor Transportation Administrators
CMVSS	Canada Motor Vehicle Safety Standard
FHWA	Federal Highway Administration
FDW	Flashing Don't Walk
FORS	Fleet Operator Recognition Scheme
GVWRs	Gross Vehicle Weight Rating
HGV	Heavy Goods Vehicle
HPB	Hybrid Pedestrian Beacon
HTA	Highway Traffic Act
ITF	International Transport Forum
KSI	Killed and Seriously Injured
LPI	Leading Pedestrian Interval
MPA	Mineral Products Association
MTA	Metropolitan Transportation Authority
MTO	Ministry of Transportation Ontario
NACTO	National Association of City Transportation Officials
NHTSA	National Highway Traffic Safety Administration
NRC	National Research Council Canada
NTSB	National Transportation Safety Board
OECD	Organization for Economic Cooperation and Development
OTM	Ontario Traffic Manual
PCAM	Pedestrian Crash Avoidance / Mitigation
PHAC	Public Health Agency of Canada
PSO	Pedestrian Scramble Operations
ROSPA	The Royal Society for the Prevention of Accidents (ROSPA)
ROW	Right of Way
RTOR	Right Turn-on-Red
STEP	Selective Traffic Enforcement Program
STM	Société de Transport de Montréal
TAC	Transportation Association of Canada
TCD	Traffic Control Device
TIRF	Traffic Injury Research Foundation
TfL	Transport for London
TRL	Transport Research Laboratory
TTMA	Truck Trailers Manufacturers Association
UN	United Nations
UVic	University of Victoria
WHO	World Health Organization

ANNEX III: LIST OF PARTICIPATING ORGANIZATIONS – ROUND TABLES / TARGETED INTERVIEWS

PARTICIPANTS – ROUND TABLE SESSIONS

MONTREAL

NAME	ORGANIZATION
Jurisdictions	
Guillaume Jean	Gouvernement du Québec, Direction régionale de la Montérégie et de l'Ouest-du-Québec
Emanuelle Bérube	Gouvernement du Québec, Conseillère en sécurité routière
Jonathan Labonté	Gouvernement du Québec, Société de l'assurance automobile du Québec
Paul-André Perron	Gouvernement du Québec, Bureau du coroner
Sébastien Bedard	Gouvernement du Québec, Ministère des Transports,
Pierrette Vaillancourt	Gouvernement du Québec, Ministère des Transports, de la Mobilité durable et de l'Électrification des transports
Serge Nadeau	Gouvernement du Québec, Direction de la santé publique
Eve Arcand	Ville de Montréal, Transport et mobilité
Injury Prevention	
Samuel Laverdiere	Via Prévention, Transport et entreposage de santé et sécurité au travail
Sylvanie Godillon	INRS, Université de recherche
Valérie Leclerc	INRS, Université de recherche
Heavy Vehicles	
Dominic Lefebvre	Praxair Canada Inc.
Olivier Dufour	Association des propriétaires de machinerie lourde du Québec
Axel Rioux	Association du camionnage du Québec
Dave Beaulieu	Centre de formation en transport de Charlesbourg
Stephane Trudeau	Centre de formation en transport de Charlesbourg
Enforcement	
Julie Boisvert	Service de police de la Ville de Montréal
Vulnerable Road Users	
Geneviève Guérin	Pietons Québec
Magalie Bebronne	Vélo Québec

VANCOUVER

Jurisdictions	
Steven Haywood	Government of BC, Ministry of Transportation and Infrastructure
Philip Bellefontaine	City of Surrey, Transportation Planning
Sam Macleod	Road Safety BC
Aileen Shebata	ICBC – Insurance Corporation of British Columbia
Michael Egilson	Government of BC, BC Coroners Service Child Death Review Unit
Vulnerable Road Users	
Richard Campbell	BCCC, British Columbia Cycling Coalition
Peter Stary	British Columbia Cycling Coalition (BCCC)
Fiona Walsh	British Columbia Cycling Coalition (BCCC)
Moreno Zanotta	Bike Maps
Jack Becker	British Columbia Cycling Coalition (BCCC)
Heavy Vehicles	
Ron Richings	Lafarge – Cement Truck Safety
Mark Donnelly	Trucking Safety Council of BC
Tammy Sampson	BC Road Safe / BC Flagging Association
Lindsay Sampson	British Colombia Trucking
Steven Wong	Translink
Solomon Kenno	Translink
Injury Prevention	
Tobin Copely	Fraser Health, Population and Public Health
Marie-Soleil Cloutier	Institute national de la recherche scientifique
Trina Pollard	Work Safe BC
Raheen Dilgir	TranSafe Transportation Safety Consultants
Law Enforcement	
Ken Usipiuk	Delta Police
Technology	
Steven Chan	Transoft Solutions Inc.

TORONTO

Jurisdictions	
Kelly Marrin	Ministry of Transportation
Ashlee Babcock	City of Toronto
Tanya Waugh	Ministry of Transportation
Tony Di Lorenzo	Ministry of Transportation
David Allen	City of Toronto
Vukadin Lalovic	City of Toronto
David Kuperman	City of Toronto
Roger Browne	City of Toronto
Robert Monster	Ministry of Transportation
Sarah Plonka	Road Safety Research Office
Marco D'Angelo	Ontario Traffic Council

Vulnerable Road Users	
Albert Koehl	Lawyer
Jeannette Holman-Price	The Jessica Campaign

Law Enforcement	
Gary Carty	Peel Regional Police
Greg Amoroso	Peel Regional Police

Injury Prevention	
Linda Rothman	Sick Kids, Program in Child Health Evaluative Sciences
Gayle Bursey	Toronto Public Health
Sarah Richmond	Public Health Ontario
Gina Ing	Chronic Disease and Injury Prevention

Technology	
James Tubbs	Data Collection – Collisions of Pedestrians and Cyclists

Heavy Vehicles	
Marco Beghetto	Canadian Trucking Alliance

HALIFAX

Jurisdictions	
Taso Koutroulakis	City of Halifax, Traffic Management
Dylan Hayne	City of Halifax, Project Planning
Injury Prevention	
Sandra Newton	Child Safety Link
Natasha Warren	Nova Scotia Health Authority
Sean Margueratt	Halifax Medical Examiner's Office
Emily Schleihauf	Halifax Medical Examiner's Office
Shirley Burdock	Injury Free Nova Scotia
Jennifer Russell	Atlantic Collaborative on Injury Prevention
Amber Walker	Nova Scotia Health Authority
Amelia Johnston	Child Safety Link
Other	
Mana Wareham	Department of Energy, Sustainable Transport
Wayne Browne	Researcher
Vulnerable Road Users	
Kelsey Lane	Halifax Cycling Coalition
Eliza Jackson	Ecology Action Centre
Ben Buckwold	Bicycle Nova Scotia
Heavy Vehicles	
David Skater	Earsons Transport Ltd

PARTICIPATING ORGANIZATIONS – TARGETED INTERVIEWS

Atlantic Provinces Trucking Association

Bike Feats Bicycle Consulting

Motor Coach Canada

Ottawa Walk

ANNEX IV: ADDITIONAL RESOURCES

TRANSPORTATION ASSOCIATION OF CANADA REFERENCES – BEST PRACTICES AND GUIDELINES

Citizens for Safe Cycling. (2017). *2017 Ottawa Report on Bicycling.*

IBI Group. (2010). *Active Transportation - Making It Work in Canadian Communities.*

Institute of Transportation (ITE). (2004). *Promoting Sustainable Transportation Through Site Design: A Proposed ITE Recommended Practice.*

National Association of City Transportation Officials (NACTO). (n.d.). *NACTO Urban Bikeway Design Guide - Intersection Treatments.*

Transport Association of Canada. (2016). *Speed Management Guide: Canadian Road Safety Engineering Handbook (CRaSH).*

Transportation Association of Canada. (2006). *Guide for the Design of Roadway Lighting.*

Transportation Association of Canada. (2008). *Guidelines for Understanding Use and Implementation of Accessible Pedestrian Signals.*

Transportation Association of Canada. (2008). *Manual of Uniform Traffic Control Devices for Canada - Pedestrian Countdown Signal Project Steering Committee.*

Transportation Association of Canada. (2009). *Canadian Guidelines for Establishing Posted Speed Limits.*

Transportation Association of Canada. (2012). *Bikeway Traffic Control Guidelines for Canada, 2nd Edition.*

Transportation Association of Canada. (2012). *Pedestrian Crossing Control Guide.*

Transportation Association of Canada. (2014). *Manual of Uniform Traffic Control Devices for Canada, Fifth Edition.*

Transportation Association of Canada. (2014). *Traffic Signal Guidelines for Bicycles.*

Transportation Association of Canada. (2014). *Truck Lanes in Canadian Urban Areas: Resource Document.*

Transportation Association of Canada. (2017). *Geometric Design Guide for Canadian Roads: Chapter 5 - Bicycle Integrated Design.*

Transportation Association of Canada. (2017). *Geometric Design Guide for Canadian Roads: Chapter 6 - Pedestrian Integrated Design.*

Transportation Association of Canada. (2018). *TAC Traffic Calming Guide (forthcoming).*

RECENTLY SUBMITTED RESOURCES

Note: *These resources represent additional information recently submitted to the VRU Secretariat Team, but which have not been reviewed.*

Toronto Centre for Active Transportation. Anders Whitney, R. (2013, August). *Complete Streets Gap Analysis: Opportunities and Barriers In Ontario*. Retrieved from: tcat.ca: http://www.tcat.ca/knowledge-centre/complete-streets-gap-analysis-opportunities-and-barriers-in-ontario/

Urban Systems, in association with the Cycling in Cities Research Program at the University of British Columbia and Simon Fraser University, City of Vancouver. (2015). *Cycling Safety Study*.

Presentation to the 87th Annual Meeting of the Transportation Research Board. Schrock, S.D., and B. Bundy. (2008). *Pedestrian countdown timers: Do drivers use them to increase safety or increase risk taking?*

German Insurers Accident Research. (2014, May). *Turning Assistant for Trucks*. Retrieved from udv.de/en: https://udv.de/en/commercial-vehicles/trucks/turning-assistant-trucks

German Insurance Association. Hummel T., Kuhn, M., Bende, J., Lang, Antje. (2011, August). *Advanced Driver Assistance Systems. An investigation of their potential safety benefits based on an analysis of insurance claims in Germany*. Retrieved from udv.de: https://udv.de/sites/default/files/tx_udvpublications/RR_12__fas.pdf

Child Safety Link. Russell, J. (2014, April). *Pedestrian Safety in Nova Scotia A Scan of Stakeholders and Initiatives Focusing on Children and Youth*. Retrieved from childsafetylink.ca: http://childsafetylink.ca/wp-content/uploads/2014/11/CSL-pedestrian-safety-final-lo-res.pdf

The XCycle Project. Web Site. (n.d.). Retrieved from: http://www.xcycle-h2020.eu/

Navistar Truck Group. Presentation to Virginia Tech Transportation Institute. Krum, A. (2009). *Visibility Modeling from a Heavy-Vehicle OEM's Perspective*. Retrieved from vtti.vt.edu: https://www.vtti.vt.edu/PDFs/TRBVS_presentations/Krum_Hvy_OEM_Visibility_Modeling_12may09.pdf

Cavacuiti, Dr. C. (n.d.). *An Overview of Cycling Research: Selected Facts, Statistics, Citations and Quotations*. Retrieved from sharetheroad.ca: http://www.sharetheroad.ca/files/Cycling_Safety_Overview___2012_12_05.pdf

Toronto Public Health. (2014, October). *Healthy Streets. Evidence Review*. Retrieved from Toronto.ca: https://www.toronto.ca/wp-content/uploads/2017/10/963b-TPH-Healthy-Streets-Evidence-Review.pdf

Institute of Transportation Engineers (ITE). Unsignalized Intersection Improvement Guide. Treatment ID No. 031. (n.d.). *Install a Pedestrian Hybrid Beacon*. Retrieved from ite.org: http://www.ite.org/uiig/treatments/31%20Pedestrian%20Hybrid%20Beacon.pdf?pass=22

Antcil, G., Deschamps, A., Deslauriers, L., Lefranc, H. (2018, avril). *Protection des piétons et cyclistes : avec un grand poids viennent de grandes responsabilités*. Retrieved from gabrielleanctil.com: http://www.gabrielleanctil.com/wp-content/uploads/2018/04/Me%CC%81moire-Ve%CC%81lo-Fanto%CC%82me-pour-Transport-Canada.pdf

MMM Group. McLaughlin, D. Presentation to Bicycle Facilities and Municipal Liability Workshop, Region of Peel. (2105, February). *New Cycling Design Guidelines for Ontario*.

Transport for NSW. (2017, June). *Safety Technologies for Heavy Vehicles and Combinations*. Retrieved from roadsafety.transport.nsw.gov.au: http://roadsafety.transport.nsw.gov.au/downloads/safety-technologies-heavy-vehicles.pdf

Toronto Public Health. Kate Bassil, Heather Rilkoff, Marco Belmont, Anna Banaszewska, Monica Campbell. (2015, June). *Pedestrian and Cycling Safety in Toronto*. Retrieved from toronto.ca: https://www.toronto.ca/legdocs/mmis/2015/hl/bgrd/backgroundfile-81601.pdf

Ontario Ministry of Transportation. (2012-2018). The Official Ministry of Transportation (MTO) Driver's Handbook. Safe and Responsible Driving, Sharing the road with other road users.

World Resources Institute | Global Road Safety Facility. (2018). *Sustainable & Safe, A Vision and Guidance for Zero Road Deaths*.

ANNEX V: LIST OF EXTERNAL INTERNET LINKS

Section	Topic / Title	Name of External Link	Address / URL
2.0	Sustainable Development Goals	Millennium Development Goals	http://www.undp.org/content/undp/en/home/sustainable-development-goals/background.html
2.0	Sustainable Development Goals	Sustainable Development Goals	http://www.undp.org/content/undp/en/home/sustainable-development-goals/background.html
2.0	Sustainable Development Goals	Sustainable Development Knowledge Platform	https://sustainabledevelopment.un.org/?menu=1300
2.0	United Nations' Decade of Action for Road Safety	Global Status Report on Road Safety 2015	http://www.ansr.pt/SegurancaRodoviaria/Internacional/Documents/Global%20Status%20Report%20On%20Road%20Safety%202015.pdf
2.0	Vision Zero / Sustainable Safety	Vision Zero – Traffic Safety by Sweden	http://www.visionzeroinitiative.com/
2.0	Vision Zero / Sustainable Safety	Vision Zero Canada	https://visionzero.ca/
2.0	Vision Zero / Sustainable Safety	What is Vision Zero and How Can it Prevent Traffic Injuries and Fatalities	http://www.vandykelaw.ca/2017/02/what-is-vision-zero-and-how-can-it-prevent-traffic-injuries-and-fatalities/?gclid=CJzgzIO0ytYCFVy4wAodtBMKvw
2.0	Vision Zero / Sustainable Safety	World Report on Road Traffic Injury Prevention	http://apps.who.int/iris/bitstream/10665/42871/1/9241562609.pdf
2.0	Complete Streets	Complete Streets: Making Canada's roads safer for all	http://data.tc.gc.ca/archive/eng/programs/environment-utsp-casestudy-cs72e-completestreets-812.htm
2.0	Complete Streets	Transportation Association of Canada Briefing	http://www.tac-atc.ca/sites/tac-atc.ca/files/site/doc/Bookstore/briefing-final-e-jan2015.pdf
2.0	Walking Strategy	Let's Take Action to Make Canada a Great Place to Walk	http://canadawalks.ca/take-action/
2.0	Walking Strategy	Active Transportation for Canada. Now!	http://activetransportationcanada.weebly.com/
2.0	Walking Strategy	Toronto's Walking Strategy	https://www1.toronto.ca/wps/portal/contentonly?vgnextoid=380f7e5921f02410VgnVCM10000071d60f89RCRD
3.2	Bus Driver Training – Mitigating Blind Spots	Video of Metropolitan Transportation Authority's training for NYC bus drivers	https://www.youtube.com/watch?v=3nCD0g0-rJ8
3.2	Bus Driver Training – Mitigating Blind Spots	Bus Safety Symposium White Paper – 2016	http://web.mta.info/safety/pdf/MTA%20Bus%20Safety%20Symposium%20White%20Paper%20-%202016.pdf

Section	Topic / Title	Name of External Link	Address / URL
3.2	Mandatory Training for Commercial Vehicle Drivers	Official MTO Truck Handbook	http://www.mto.gov.on.ca/english/trucks/handbook/index.shtml
3.2	Examples of Communications and Awareness Products, Campaigns, and Topics	Video Share the Road campaign	https://vimeo.com/74886075
3.2	Examples of Communications and Awareness Products, Campaigns, and Topics	Video Exchanging Places	http://www.crossrail.co.uk/construction/road-safety-information/exchanging-places
3.2	Examples of Communications and Awareness Products, Campaigns, and Topics	Bikemaps.org	https://bikemaps.org/
3.2	Examples of Communications and Awareness Products, Campaigns, and Topics	Vision Zero Fleet Safety Forum	http://www.nyc.gov/html/dcas/html/employees/vision_zero_fleet_safety_forum.shtml
3.2	Examples of Communications and Awareness Products, Campaigns, and Topics	SWANA Ontario Safety Summit	https://www.owma.org/articles/swana-ontario-safety-summit
3.2	Examples of Education and Training Products, Programs and Topics	CAN-BIKE Courses	http://canbikecanada.ca/courses/
3.2	Examples of Education and Training Products, Programs and Topics	Cycling Skills – Ontario's Guide to Safe Cycling	http://www.mto.gov.on.ca/english/safety/pdfs/cycling-skills.pdf
3.3	Auditory Messages at Intersections	How do Accessible Pedestrian Signals (APS) Work?	https://www.toronto.ca/services-payments/streets-parking-transportation/traffic-management/traffic-signals-street-signs/types-of-traffic-signals/accessible-pedestrian-signals/
3.3	Auditory Messages at Intersections	Accessible Pedestrian Signals (APS)	http://acb.org/content/accessible-pedestrian-signals-aps
3.3	Marked Mid-Block Crossings	MTO – Safety	http://www.mto.gov.on.ca/english/safety/pedestrian-safety.shtml
3.3	Pedestrian Countdown Signals	City of Toronto	https://www.toronto.ca/services-payments/streets-parking-transportation/traffic-management/traffic-signals-street-signs/types-of-traffic-signals/pedestrian-countdown-timers/
3.3	Pedestrian Hybrid Beacon (PHB)	Manual on Uniform Traffic Control Devices	https://mutcd.fhwa.dot.gov/
3.3	Roundabouts	Roundabout Facts	http://www.virginiadot.org/info/resources/Roundabout_Facts_-_Week_7.pdf
3.3	Yellow or Red Signal Duration	City of Toronto	https://www.toronto.ca/311/knowledgebase/kb/docs/articles/transportation-services/traffic-management-centre/urban-traffic-control-systems/traffic-signals-operation-timing.html

Section	Topic / Title	Name of External Link	Address / URL
3.4	Separate Truck and Bike Routes	Buchanan report	https://www.ncbi.nlm.nih.gov/pubmed/22400427
3.4	Segregated Bicycle Lanes	NACTO definition	https://nacto.org/publication/urban-bikeway-design-guide/cycle-tracks/
3.5	Restrict Movement of Heavy Vehicles	Transport Canada	https://www.tc.gc.ca/eng/policy/anre-menu-3021.htm
3.5	Bicycle Helmets and Use	Helmets.org.	https://www.helmets.org/truck.htm
3.5	Bicycle Helmets and Use	Bicycle Helmet Laws by Country	https://en.wikipedia.org/wiki/Bicycle_helmet_laws_by_country
3.5	Bicycle Helmets and Use	British Columbia Helmet Law	https://helmets.org/bc_law.htm
3.5	Model Vulnerable Road User Law	MTO Driver's Handbook	https://www.ontario.ca/document/official-mto-drivers-handbook/sharing-road-other-road-users
3.8	Visibility Detection Technologies	Mobileye Video	https://www.youtube.com/watch?v=QkatmZyL3Vc
3.8	Daytime Running Lights on Bicycles	Wikipedia Definition	https://en.wikipedia.org/wiki/Daytime_running_lamp

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