

BUILDING BETTER CYCLING ARTERIES IN CITIES LESSONS FOR TORONTO



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Clean Air Partnership (CAP) is a registered charity that works in partnership to promote and coordinate actions to improve local air quality and reduce greenhouse gases for healthy communities. Our applied research on municipal policies strives to broaden and improve access to public policy debate on air pollution and climate change issues. Our social marketing programs focus on energy conservation activities that motivate individuals, government, schools, utilities, businesses and communities to take action to clean the air.

The Toronto Coalition for Active Transportation (TCAT) was formed in 2006 to give a unified voice to the many groups working for a better cycling and pedestrian environment in Toronto. TCAT has worked closely with CAP since its inception and became a project of CAP in 2008. TCAT guides the active transportation programming at CAP and has expanded its activities to other communities in Ontario.

Executive Summary

According to the City of Toronto's Road Classification system, arterial roads provide the major corridors for traffic movement (motor vehicles and public transit) "that are also important for pedestrians and cyclists." Since these streets carry a high volume of high-speed motor vehicles (major arterials are designed to carry in excess of 20,000 motor vehicles per day with posted speed limits of 50 to 60 km/hr), providing safe passage for cyclists is especially critical. From the perspective of deaths and injuries, arterials are the streets that most need to be changed (Toronto Streets Report 06 Hess & Milroy:21).

The best option to accommodate cyclists in a safe and convenient way on arterials is to install bike lanes directly on the street demarcated by a painted line or a curb. In some cases however, a separate artery for cyclists is installed. While a cycling artery (sometimes referred to as "bikeway", "bike route" or "bike boulevard") takes different forms depending on the context, generally the primary purpose is to provide a direct and fast route for cyclists. Cycling arteries can be effective in motivating bicycle commuting with all of its respective benefits. Commuter cycling can also relieve public transit systems, improving their operation and providing additional capacity.

In this research, we systematically review cycling policies and infrastructure in several leading urban cycling centres. Some of these cities encourage mass cycling to work and shopping destinations on wide, moderate-speed, moderate-volume arterial roads. This study examines innovations along such streets to increase cycling/public transport connectivity, the use of secure bicycle parking and bike boxes; cyclist overpasses, signalized intersections, snow removal and surface cleaning on cycling lanes, integration with public transit and other features of advanced cycling infrastructure that encourage commuter cycling, increase safety, and increase the speed of cycling trips. The study also investigates the extent to which cycling infrastructure frees up space on public transit systems. Options are explored for Toronto to improve its own bicycle infrastructure and policies.

A literature review using public documents, news articles, journal articles, reports and websites, was conducted to compile descriptions of bicycle innovations at intersections, road sections, and transit integration; and cycling policies. Case studies were then synthesized to understand policies and practices used to improve cycling arteries in Toronto, Vancouver, Montreal, Portland, New York City and Berlin. Further, east/west and north/south streets in Toronto were identified as potential cycling arteries and simulations of street improvements with bicycle facilities were created to illustrate potential changes.

Findings show that those cities with relatively higher number of cyclists and lower levels of bicycle fatalities and injuries have some things in common. They have many types of bicycle facilities suitable for all ages and cycling abilities, more bikeways that are spread throughout the city and policies that encourage cycling through planning and public programs. Cities that use a comprehensive approach that addresses cycling issues through infrastructure and policy increases cycling safety and accessibility.

Suitable bicycle facilities and sufficient bikeway networks along with policies that support cycling are important in creating safe and convenient cycling arteries in cities. Recommendations for the City of Toronto to improve cycling arteries in the city include:

- exploring the implementation of more bike facility pilot projects,
- investigating traffic calming treatments to convert residential signed routes into bicycle boulevards,
- considering on-street treatments on arterials such as separated bike lanes, and
- developing a Complete Streets Policy.

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1. INTRODUCTION

Cycling arteries (sometimes referred to as “bikeways,” “bike routes” or “bike boulevards”) take different forms depending on the context, but the primary purpose is generally to provide a direct and fast route that prioritizes cyclists. These types of facilities can be effective in motivating bicycle commuting, increasing safe passage for cyclists and providing additional capacity to public transit by encouraging transit riders to cycle for short trips. Although major roads in Toronto direct high volumes of motor vehicles to popular destinations in the city, not many cycling facilities are available to accommodate cyclists, especially along these roads. Indeed, Toronto has the fewest bike lanes per capita in Canada.¹ Therefore, more of the city’s streets need to be improved to accommodate cyclists.

While the City of Toronto defines a major arterial road as “subject to access controls, accommodates greater than 20,000 vehicles per day and greater than 5,000 bus passengers per day (with) speed limits along major arterials (...) from 50-60 km/h,²” it does not have a parallel definition for *cycling arteries*. In fact, there is not a commonly agreed upon definition. However, the general idea is that cycling arteries should function in a similar manner for cyclists as arterials do for cars. These pathways should accommodate high volumes of cyclists and move them quickly and directly to their destinations. Often they run along arterial roads but they can also run along residential streets parallel to arterial roads to meet these objectives. Traffic calmed routes along such local streets that prioritize cyclists over motorists are known as bike boulevards.

Through a review of cycling policies and infrastructure in leading cycling cities, this study examines innovations along arterial roads that encourage commuter cycling, increase safety and increase the speed of cycling trips. Case studies of six major urban centres in Canada, the United States and Europe are also presented in more detail to provide context for the success of cycling in each city. Lessons from different jurisdictions may support changes to Toronto’s arterial roads to enhance cycling across the city.

¹ The Pembina Institute (2010) *Canada’s Coolest Cities*. Report and TCAT (2010) Benchmarking Active Transportation in Canadian Cities.

² City of Toronto. *Road Classification*. Accessed June 2010:
http://www.toronto.ca/transportation/road_class/index.htm

2. Cycling in Toronto

Over 2.5 million residents live in Toronto, which is the largest city in Canada, at 630 sq km. With the amalgamation of the city in 1998, Toronto now includes the former cities of Etobicoke, Scarborough, North York, East York and York. Neighbourhoods further from the city centre tend to have amenities and residential areas further away from each other. This type of suburban development makes the implementation of bicycle infrastructure more difficult.

The City is focusing on increasing the use of public transit to reduce greenhouse gases. The Toronto Transit Commission's (TTC) Transit City plan and the Government of Ontario's Growth Plan for the Greater Golden Horseshoe, Greenbelt Plan and (Metrolinx) Big Move Regional Transportation Plan all work together with the aim of intensifying urban areas and providing transportation options to key areas for the growing population in the region. The City's plans to implement intensification with transit have the potential to increase cycling. With mixed-use development and denser development, cyclists can easily travel to their destinations. Plans to increase transit use present an opportunity for integrating cycling with transit. The Growth Plan, forecasting increasing transportation needs, promotes a range of transportation options, including cycling, to increase the transportation capacity of the Greater Golden Horseshoe.

Strengths

Toronto's Bike Plan (2001) is a "strategic plan for implementing cycling policies, programs and infrastructure improvements over the 10 year period 2002-2011 that creates a safe, comfortable and bicycle friendly environment that encourages people of all ages to cycle for everyday transportation and enjoyment." To this end, it aims to build bicycle friendly streets, expand the bikeway network, improve bicycle safety, promote cycling, provide secure bicycle parking and improve the links between cycling and transit. However, of the planned 1004km of bikeway network, currently only 425 km is completed.³

The City of Toronto is aiming to connect more residents from different neighbourhoods to more central parts of the city. The West Toronto Railpath route, a portion of which was recently unveiled, will link west side neighbourhoods through a recreational path to downtown. In addition, signed routes are already in place through residential neighbourhoods. Some of these routes have traffic calming measures including speed bumps and traffic operations for cyclists.

³ City of Toronto, Transportation Services *Bikeway Network project status*. Retrieved September 14, 2010: <http://www.toronto.ca/cycling/network/network-project-status.htm>



Left: Cyclist on bicycle actuated dots that activate traffic signal. (City of Toronto)

Right: Sign indicating one of Toronto's signed bike routes. (Spacing Toronto)

Innovative cycling infrastructure is present in some areas of the city but they are rare. For instance, there are bike crossing facilities along the Martin Goodman Trail along Lake Ontario but commuters going to school or work are not likely to use this recreational route on a daily basis.



Left: Bike Cross along Martin Goodman Trail (Ada Chan Russell)

Almost all Toronto Transit Commission (TTC) buses have bike racks (80%). The subway also accommodates passengers with bicycles during off-peak hours. Currently, streetcars cannot accommodate bikes on board but new light rail vehicles will have this option for cyclists. Toronto also recently opened Canada's first bike station, at Union Station, that is a secure indoor bicycle parking facility, including a change room, a mechanic stand, tools for users and a vending machine with emergency bike accessories.

Challenges

The Bike Plan has been slow to implement. Establishing a network across 44 wards requires approval from council members serving constituents with diverse interests. Some bicycle infrastructure proposals have been met with disapproval from community members who have concerns including the loss of parking or traffic lanes, both of which may result from new cycling infrastructure. In general, Toronto has the fewest bike lanes per capita of Canada's major cities.

Building east to west cycling connections is also a challenge because there are many disconnected east to west streets in Toronto.⁴ Most major east-west arterials have streetcar tracks and on-street parking and are not wide enough to add a bicycle lane while retaining those facilities.

According to the Toronto Bike Map, bicycle infrastructure is better in central parts of downtown than in more auto-oriented suburban areas of the city. In addition, bike facilities located further away from the city centre are made up of more recreational trails than on-street bike routes. Most signed routes on signed streets in Toronto are not bike boulevards (i.e. have no or minimal special treatments for bikes).

Future Plans

The City of Toronto recently approved a Public Bike Program to be implemented in 2011 (conditional upon several sponsorship and membership milestones being met by Nov 30 2010) and plans to expand the downtown bikeways to support it. Toronto's Public Bike Program is an extension of public transit and functions as a rental system. The service area is planned for the downtown area. In addition, plans for bicycling infrastructure are now focused on closing gaps in the on-street bikeways and off-street trails to "achieve continuous uninterrupted routes." The City also plans to accelerate construction of the Bikeway Network trails by adding another 600 km to the existing bikeway by 2015.

⁴ Old Toronto was composed of many subdivisions that did not directly connect streets between them.

⁵ City of Toronto, Transportation Services (2009) *Toronto Bike Plan – New Strategic Directions*.

3. The Importance of Cycling Arteries

Cycling arteries accommodate cyclists and in the process make cycling more attractive as a transportation mode. Studies show that cycling routes can greatly increase levels of bicycling commuting and use of these routes (Winters, Tesche, Grant, Setton and Brauer 2010, Dill 2009, Krizek, Barnes, Thompson 2009, Garrard, Rose, Lo 2008).

A study of Metro Vancouver (Winters et al 2010) reveals that cyclists deviate from the shortest route to use other routes with better bicycle facilities, including traffic calming measures and bicycle stencils. However, they need to be able to access designated routes quickly. Cyclists generally detour 400 m from the shortest route. Findings infer that a bicycle route network with designated facilities spaced a minimum of every 500 m should be ideal for urban areas that wish to increase cycling as a travel mode. Similar studies show cyclists travelling longer routes to their destinations to access bicycle facilities. Shafizadeh and Niemeier (1997) found that cyclists in Seattle increase their travel time to access off-road paths within a 0.5-0.75 mile radius after which they tend to choose more direct routes. In fact, about 40% of cyclists preferred using a longer route with a path to a shorter route consisting of a traffic lane shared with motor vehicles. Dill's (2009) research on cyclists in Portland also indicated while bike facilities made up only 8% of total street network, more than half of study participants use them. The extensive use of these bike routes shows that cyclists rely on them to travel around urban areas.

Further, Garrard, Rose and Lo (2008) found that improved cycling infrastructure in the form of bicycle paths and lanes that provide a high degree of separation from motor vehicle traffic is important for increasing transportation cycling, especially amongst women. Female commuters were more likely to use bicycle routes that provide separation from car traffic. The Australian survey results report that females are more likely to convey concerns about cycling in traffic and aggression from motorists. Such findings infer that cycling mode share can grow by increasing the sense of safety for both male and female cyclists.

Safer and Efficient Cycling Solutions

Making Toronto's Streets report (Hess and Milroy 2006) identified that arterials are the streets that most need to be changed to decrease traffic-related death and injury incidences. There are several different methods or treatments that can be made on busy and adjacent streets to enhance safety for cyclists.

The American Association of State Highway Transportation Officials Guide (1999) provides facility selection guidance centred on the skill level of cyclists defining three types of bicycle users. Advanced riders want convenience, speed and direct access to destination with minimum delays. They are comfortable riding with motor vehicles and need sufficient operating space to travel. Basic riders may use bicycles for

transportation purposes but prefer to avoid busy roads unless there is sufficient width to allow overtaking by faster vehicles. The third type of users are children who ride on their own or with parents and may not travel as fast as adults and require safe bikeways to destinations, such as schools and community centres. They would be most comfortable riding on streets with low motor vehicle speeds and volumes.⁶

Cycling arteries have a role to play in accommodating cyclists of different types and skill levels. A report on the bicycle boulevard planning and design (Walker, Tresidder, Birk 2009) states that “the establishment of a bicycle boulevard does not eliminate the need to properly accommodate bicyclists on nearby busy streets – typically with bicycle lanes, nor does the presence of bicycle lanes preclude the development of a parallel bicycle boulevard. (13)” When bike facilities on major arterials roads are not possible, bike boulevards on local streets could be used instead.

A study by Pucher and Buehler (2008) on cycling in the Netherlands, Denmark and Germany reveal that “the most important approach to making cycling safe and convenient in Dutch, Danish and German cities is the provision of separate cycling facilities, along heavily travelled roads and at intersections, combined with extensive traffic calming of residential neighbourhoods” (523). Traffic calmed roads in residential areas that run alongside arterial roads allow cyclists and motorists to travel at similar speeds and as a result may help avoid conflicts. Separated cycling facilities from traffic, also known as cycle tracks, provide a barrier for cyclists from fast moving cars that may move into a bike lane and from parked cars that may swing their doors into a lane. “Dooring” is one of the most common causes of collisions between motorists and cyclists, especially in Toronto’s downtown core (City of Toronto 2003). Danish research supports the finding that separated cycling facilities are successful. In Denmark, cycle tracks can increase bicycle ridership by 18-20% compared with 5-7% increase from bicycle lanes (Alta Planning + Design, 2009).

⁶ Federal Highway Administration. *Lesson 13: Selecting Bicycle Facility Types and Evaluating Roadways*. Retrieved August 8, 2010: <http://www.tfhrc.gov/safety/pedbike/pubs/05085/chapt13.htm>

4. Research Questions and Methodology

This study aims to examine successful cycling planning and policy practices used by different jurisdictions and to identify those that Toronto could adopt. The following questions are explored in this report:

- 1) What are cycling infrastructure and policies that are conducive to cycling arteries?
- 2) What are leading urban cycling centres practicing that encourage commuter cycling, increase safety and increase the speed of cycling trips?
- 3) From the innovations and case studies presented, what can the City of Toronto do to enhance cycling for residents?

A review of literature on bicycle infrastructure for cycling arteries included municipal documents, news articles, academic studies and reports. These sources generated a list of innovative infrastructure and policies detailed in the next section as well as provided information for the case studies on leading cycling centres. A total of six jurisdictions were selected as case studies: three Canadian (Toronto, Vancouver, Montreal), two American (New York, Portland) and one European (Berlin). The three Canadian cities have the largest populations in the country that are implementing cycling and transportation plans. The two US cities are known for their fast growth of cycling infrastructure. Portland is also known for its high cycling mode share. Berlin was chosen because it is a large city in Europe with a strong cycling culture. An evaluation of cycling infrastructure and policies used by leading cycling cities identifies successful elements that are conducive to cycling arteries. Further analysis of Toronto's cycling environment informs recommendations for effective bike facilities most suitable for its arterial roads.

Several limitations were encountered during the course of the research. First, without interviews with officials and staff from cities featured in the case studies, it is difficult to confirm whether the collected data is accurate or to obtain details of current projects. In addition, information that is available from municipal staff is insufficient. Although we were able to extract information from TCAT's Benchmarking Active Transportation in Canadian Cities survey (2010), most of the questions were not focused on arterial roads. Moreover, only five of the eight study cities responded to the survey. Finally, municipal documents and media in Montreal and Berlin are not readily available in English. Most of the information relevant to this research was only available in French for Montreal and in German for Berlin. TCAT does not have the capacity to research in these respective languages thus resulting in somewhat limited information for those municipalities.

5. Infrastructure and Policies for Cycling Arteries

Infrastructure and facilities for bicycles are improvements made to the environment to accommodate and encourage cycling, including cycling arteries. Bicycle facilities along arterial roads have been identified in TCAT's report "Benchmarking Active Transportation in Canadian Cities" as a key indicator to benchmark active transportation. These facilities help make cycling safer and more comfortable along arterial roads in different jurisdictions. Other bicycle facilities include connections to public transit, public bike systems and bicycle parking. In addition to facilities, various policies can accommodate and encourage cycling in cities. The following are selected infrastructure and policies that have been featured prominently in literature. Definitions for cycling infrastructure may vary from each city. Note that these innovations are not an exhaustive list – different municipalities are also implementing many other types.

5.1 INTERSECTIONS



New York City (<http://www.streetsblog.org>)

Bike boxes – A painted designated area is located before the crosswalk of the intersection for cyclists to wait for the traffic signal to change. When the traffic signal is red, only cyclists may enter this area. Cars are required to stop behind the bike box. It is used to increase visibility of cyclists for oncoming and turning traffic and grants cyclists priority for entering intersections, helping them make safer turns and crossings (City of Toronto Bike Map 2010)

Application - Bike boxes are suitable for intersections with a high volume of cyclists and motorists and frequent turning conflicts. They can be used with a cyclist-activated signal. Cyclists can position themselves to the left or the right of the bike box in preparation to turn left or right into the intersection. However, motorists are not able to turn right on a red light and may be unfamiliar with how bike boxes function. (City of Portland 2010).



Vancouver (www.bikeplanet.org)

Traffic Signal Operations for Bicycles – Several techniques can be used, including an advanced signal detection in the bike lane, shortened delay for bicycle boulevard crossing, and leading bicycle interval. Signal treatments reduce bicycle delay, provide bicyclists priority over other road users and increase bicycle safety by allowing cyclists a head start through the intersection (City of Portland 2010).

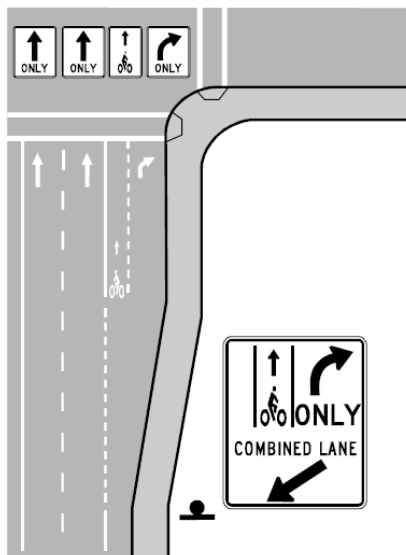
Application - Bicycle signal operations are best used at signalized intersections where bicyclists travel at high speeds, where intersection operation is confusing for signal crossing and where there is a high volume of bicycle trips. In Toronto, bicycle actuated signals are marked with three white dots on the pavement at intersections. Cyclists stop over the dots to activate traffic lights (City of Toronto Bike Map 2010).



Berlin
(<http://thecitycyclist.blogspot.com/>)

Forward Stop Bar – A stop bar for cyclists is placed closer to the centreline of the cross street than the stop bar for vehicles, increasing the visibility of cyclists waiting to cross the street. Cyclists will also have better visibility of cross-street traffic and shorter crossing distance. Bicyclists are permitted to bypass cars waiting to cross (City of Portland 2010).

Application - Forward Stop bars can be applied at low-volume, stop-controlled intersections, preferably with curb extension or unsignalized bicycle boulevard crossings.



Combined Right-turn Bike Lane – A right-turn lane for cars also functions as a through lane for bicycles (City of Portland 2010).

Application - This combined bike lane identifies bicyclists' location in a geometrically restricted intersection and allows dual use of a lane when there is not sufficient space for both a bike lane and a dedicated right-turn lane.

U.S. Department of Transportation
(<http://www.tfhrc.gov>)



Crossbike Markings – Pavement markings alongside crosswalks indicate space for bicycles to cross major intersections. The markings increase the visibility of bicycles at intersections and encourage motorists to yield to bicyclists waiting to cross. They separate pedestrians and cyclists to reduce conflicts (City of Portland 2010).

Vancouver (<http://www.vancouver.ca>)

Application - Crossbike crossings can be used where main bicycle routes cross relatively minor collectors, and where cross traffic has to yield to crossing bicyclists. They are not appropriate where speeds exceed 50 km/h unless signalized. Markings can use colour to enhance visibility, should be skid resistant for bikes and should not be confused with crosswalks.



Green Wave – Cyclists activate coordinated traffic signals along bike paths to travel from intersection to intersection without stopping. Green wave signs notify cyclists the intended speed they should travel to benefit from activated signals, increasing efficiency of bike travel and addressing the demand of high volume bicycle corridors (City of Portland 2010).

Copenhagen (<http://www.streetfilms.org>)

Application – Green Waves should be applied on arterial and collector streets with groups of signalized intersections, high bicycle volumes and high percentage of through movements for bicyclists. However, they are more difficult to implement on two-way roadways.

5.2 ROAD SECTIONS



Vancouver
(<http://www.vancouver.ca>)

Bicycle Boulevards - Also known as bicycle preferred streets, local street bikeways (Vancouver) and Fahrradstraße (Germany), bicycle boulevards are shared streets typically within a residential area with low traffic volume and speeds “where the position of the car is subordinate to that of the bicycle.”⁷ Bike boulevards improve the public realm, and cyclist and pedestrian experience by restricting motor traffic. However, residential streets do not generally provide direct access to key destinations such as commercial or employment districts. Further, slower streets may increase cyclist travel time and residents may be wary of changes to their neighbourhood.

Application – Bike boulevards should run parallel to nearby arterials across residential areas but ensure that routes have direct access to key destinations. Traffic calming, traffic reduction, signage, pavement markings and intersection crossing treatments are implemented to facilitate direct, safe, and comfortable bicycle travel.



Toronto (Ben Smith Lea)

Bike lanes – Bike lanes are marked space along the length of roadways dedicated for cyclists where motorists are not allowed to park, stand or drive. Bike lanes create separation between cyclists and cars (City of Toronto Bike Map 2010).

Application - Lanes should be used on roads with high volume of traffic. Lane width should accommodate two cyclists riding side by side with sufficient space from the car lane and car parking. Bike symbols should be frequently visible on the lanes and door zone clearance should be considered when bike lanes are next to parked cars (City of Portland 2010).

⁷ City of Portland Bureau of Transportation (2010) *Bikeway Facility Design: Survey of Best Practices*.



New York City
(<http://www.nycbikemaps.com/>)



Toronto (<http://www.toronto.ca>)



New York City
(<http://www.nycbikemaps.com/>)

Coloured bike lanes – Colour is applied to bike lanes to distinguish the bike lane, alerting other road users at high conflict areas and providing the right of way to cyclists. Motorists should yield to cyclists in these areas. Coloured lanes provide safer merging of bicycles with cars and increase awareness and safety of both cyclists and motorists (City of Portland 2010).

Application - These lanes should be used in streets with high volume of vehicular traffic with bike lanes, and high conflict areas between cars and cyclists.

Contraflow bike lanes – Bike lanes allow cyclists to travel in the opposite direction of motorized traffic on one-way streets. Cyclists riding in the same direction as motorized traffic should not ride on this lane (City of Toronto Bike Map 2010).

Application - Contraflow lanes should be applied on narrow streets where on-street parking and bicycle accessibility are prioritized over car access.

Buffered bike lanes - Bike lanes with a spatial buffer separate the cycling lane from the car lane and/or parked cars. Buffered lanes provide space for cyclists to pass without entering the car lane and provide large vehicles greater distance from cyclists on the bike lanes. Parking side buffer also provides space to avoid the “door zone” of parked cars (City of Portland 2010).

Application - Buffered lanes are ideal on roads with high motor vehicle speeds and volumes.



Vancouver (<http://www.vancouver.ca>)

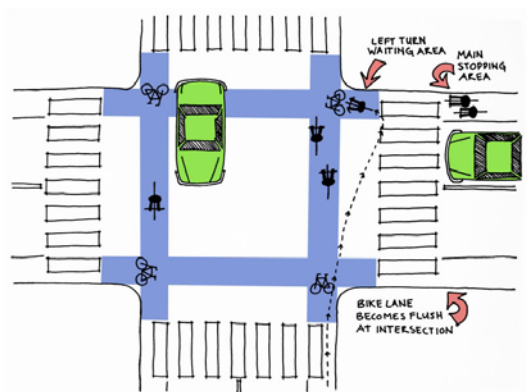
Cycle tracks – Bike lanes are separated along the length of a road by a physical barrier. Cycle tracks allow cyclists direct access to main commercial areas and provide significant separation from cars in the busiest parts of town. However, left turns for cyclists must be accommodated in an unconventional way.

Application - Cycle tracks work best on arterial roads with high car speeds and volumes, and roads with fewer cross-streets and longer blocks. A track can be a single one-way lane or two lanes, each going opposite directions.

Turns

An additional right-hand turn lane can be provided within the track for cyclists to either proceed forward in one lane or right on the right side lane. Cars should not be permitted to turn right on a red light.

Bicyclists should not be permitted to make a left hand turn directly from a cycle track. Instead, a two-stage left turn allows cyclists to turn left safely when there are physical or safety barriers, such as multiple vehicle lanes. Cyclists enter the roadway before the intersection, cross the street, reposition the bicycle to face left on the other side and cross the intersection again. It reduces conflicts between bicyclists and motorists and reduces complexity of left-turns for bicyclists.



Two-stage left turn
(<http://betweencyclists.com>)

Application - Cyclists cross straight through the intersection to the other side then wait in a designated area in front of the cross street traffic to proceed at the next light. The two-stage turn is most useful at intersections with a cycle track or bike lanes alongside multiple car lanes, and signalized intersections.

Separation

Separation should be channelized (elevated or at-grade), with a mountable curb, or bollards/markings. At driveways and low-volume streets, cyclists have the right of way. Sidewalks should be separated from cycle tracks so that pedestrians will not use the tracks.



Vancouver (<http://www.vancouver.ca>)



Cycle track to bike lane in Lucerne (<http://www.bugbog.com>)



Vancouver (<http://www.vancouver.ca>)

Cycle tracks require adequate space in order to remove the danger of car dooring. When there is on-street parking, cycle tracks should be placed between the parking and the sidewalk. Barriers can come in the form of lampposts, vegetation, fences or other physical barriers.

Intersections

At signalized intersections, cycle tracks can drop down to a bike lane, with a forward stop bar, crossbike markings, markings through the intersection or an exclusive bike signal phase. Bike specific signals are small and placed on the same side as the curb. Other forms of signals can be bike countdown signals and bicyclist-actuated signal button.

A cycle track can ramp down to the road before the intersection to reduce conflicts with right turning cars. Cyclists are then more visible at intersections. The truncated cycle tracks also mitigate "right hook" collisions with right turning cars.

Application - This treatment is best applied on cycle tracks behind on-street parking and at intersections with frequent right turning cars.

(City of Portland 2010)



New York City
(<http://www.nycbikemaps.com/>)

Sharrows – Short-form for “shared lane pavement marking”, sharrows are used to indicate the ideal cyclist position in shared lanes and to remind drivers to share the road (City of Toronto 2010).

Shared roadway – In Toronto, these roadways are designated by bikeway network signage indicating preferred routes for cycling and are shared by cyclists and cars. They raise awareness of bicycle traffic, but no physical changes are made to the roadway (City of Toronto 2010).

Application - Sharrows are best used on streets with moderate motor vehicle traffic and a constrained right of way, short gaps between bike lanes, and streets without space for bike lanes on both sides (City of Portland 2010). In Toronto, sharrows are used primarily on arterial and collector streets where a dedicated bike lane is not provided, while the shared roadway network is along smaller residential streets.

In summary, different types of roads require different treatment. For example, separated bike lanes are likely unnecessary in traffic calmed residential streets, whereas they might be needed on busy arterial roads. With a wide range of cyclists of different ages and abilities, it is important to consider facility types that would maximize the safety and comfort for all users. In Toronto, there is a growing demand for separated bicycle lanes to provide greater protection for cyclists of all ages and abilities.⁸

⁸ City of Toronto, Transportation Services (2009) *Toronto Bike Plan – New Strategic Directions*. Staff Report. May 25.

5.3 TRANSIT INTEGRATION

Cycling across long distances is not generally practical. In large urban areas in particular, multiple modes are often necessary for trips of varying distances. A distance of within 5 km is considered reasonable for cyclists to commute.⁹ Beyond this trip distance, cyclists may choose to take other transportation modes such as public transit. Connecting cyclists to public transit is vital in creating a city with integrated mobility.



Copenhagen

(<http://www.copenhagenize.com>)

Bicycle-Friendly Transit Stop Design – A boarding platform is placed at a public transit stop between the bicycle facility and the car lane so transit vehicles and bicycles will not merge into or across a bike lane. Bicyclists do not have to merge into a car lane or across rail tracks to overtake a stopped transit vehicle (City of Portland 2010).

Application - Marked or coloured pavement should be considered at conflict areas with cyclists and pedestrians, especially where pedestrians cross the bicycle facility.



Portland (<http://ridethisbike.com>)

Bikes on public transit – For cyclists, particularly those travelling distances further than 5km, having the option to take public transit for part of their journey is essential. Many municipalities permit transit riders to bring their bicycle on board, including bike racks on buses and dedicated sections in subways or light rail for passengers with bicycles. For example, Portland's light rail transit designates an area for passengers to mount their bikes upright throughout the duration of the transit ride.

⁹ Metrolinx (2008) *The Big Move*. Transportation Plan

With limited capacity for bicycles, many transit systems often do not allow passengers to bring bicycles on board transit vehicles during peak hours. For this reason, municipalities are starting to build bicycle parking facilities at main transit stations for cyclists to store bicycles before taking public transit.



Toronto's Bike Station at Union Station
(<http://www.thewashcycle.com>)



Toronto sheltered bike parking
(<http://www.Biking Toronto.com>)



Montreal Bixi bike share program
(<http://www.cbc.ca>)

Bike parking at transit points – Transit users who ride their bicycles to public transit require adequate bicycle parking. Many municipalities provide bicycle parking facilities for commuters at transit stations, such as bike racks, bike lockers, and bike stations (which may include amenities like showers and/or a tune-up centre in addition to parking).

By offering bike parking at transit stations, municipalities can encourage the use of bicycles for both the first and final miles of a trip. In the Netherlands, it has been found that although many passengers ride bicycles from their location of origin to transit stations, after the transit journey, they do not cycle to their destination.¹⁰ Although passengers with two bicycles can store one at each station and cycle at both ends of the journey, many cyclists do not have this option. Public bike systems are gradually being made available in jurisdictions across the world to make bicycles available in key locations such as transit stations.

Bike Sharing – Bicycles are available for the public to rent to encourage cycling in cities. Users can subscribe to the system and have access to bicycles location at rental locations throughout the city. Passengers who store their bicycles at their origin station can rent a bicycle at their last transit stop and cycle to their final destination.

In the Netherlands, users can rent and return bikes with the same smartcard they use on public transit, using on-line billing and payment. A survey by the Dutch Railway's OV-Fiets (Public Transport Bike) reveals that 50% of customers

¹⁰ TCAT (2010) *Complete Streets Forum Summary Report*

travel more often by train because of the bike sharing system.¹¹ In Montreal, users do not need to be subscribers – day users pay by credit card at an automated station and return the bike at any station in the network.

5.4 LANE MAINTENANCE



Copenhagen (<http://www.copenhagenize.com>)

In cities where there is snow, lanes need to be cleared regularly so cyclists can use them throughout the year. In addition, when debris obstructs bicycle lanes, they need to be removed immediately for safe cycling. In the case of raised cycle tracks, special methods of lane maintenance may be required. When construction occurs around bicycle facilities, efforts should also be made to ensure that cyclists are able to proceed safely by means of a temporary bike route around the work area.

5.5 POLICIES

Cities can implement policies and plans that increase cycling infrastructure and encourage cycling. This may include measures such as requiring all new road construction or maintenance to include facilities that accommodates cyclists. Street design guidelines and complete streets policies can also encourage creative solutions to increase safe and direct cycling routes.

Complete Streets provide safe access for all road users - including pedestrians, cyclists, public transit users and motorists - through careful street design and operation. People of different ages and abilities should feel comfortable using every street. An effective Complete Streets policy development and implementation plan restructures procedures (e.g. zoning by-laws, building codes, design guidelines), rewrites design manuals, trains staff from different departments, links policies to funding criteria that plan for Complete Streets and include performance measures showing the results of before-and-after studies. The U.S. has been supportive of Complete Streets with 152 American jurisdictions that have adopted policies or have made written commitment to do so as of September 2010¹². These jurisdictions are changing policy through laws and ordinances, resolutions, tax ordinances, internal policies or executive orders and plans, and design manuals or guides.

¹¹ TCAT (2010) *Complete Streets Forum*

¹² National Complete Streets Coalition website (<http://www.completestreets.org/complete-streets-fundamentals/complete-streets-faq/>)

Overall, treatment and maintenance of road and intersections, connections with transit, and policies help to ensure safer conditions for cyclists and connect them directly to destinations.

6. Case Studies

To better understand the context of cycling arteries being used in leading cycling cities, five case studies are presented below: Vancouver, Montreal, Portland, New York and Berlin.¹³ Each section will provide an overview of the cycling policies in the city, cycling infrastructure strengths, challenges, as well as future plans for cycling arteries.

6.1 Vancouver

Background

Compared with other cities presented here, Vancouver is a relatively small urban centre at 115sq km in size with just under 600,000 residents. Since Mayor Gregor Robertson started his term in 2008, many cycling improvements have been made. Approval of these changes can be partly attributed to an at-large council system¹⁴ with a sustainable focus. Documents that support cycling arterials in the city include its Bicycle Plan (1999), the Downtown Transportation Plan (2003) and the Community Climate Change Action Plan (2005). Vancouver's Downtown Transportation Plan aims to create downtown access, livability, and a balanced transportation system including bike lanes; while the Community Climate Change Action Plan encourages and supports active transportation to meet greenhouse gas reduction targets. The City is currently working on a new Bicycle Master Plan.

The City of Vancouver's Greenest City Plan aims to reduce greenhouse gases as a priority. Currently, emissions levels are equal to 1990 levels. One of the focuses is to reduce trips by cars, ensuring that the majority (greater than 50%) of transportation trips will be made on foot, bicycle and transit by 2020. Transportation and land use planners are also working closely to encourage more sustainable modes of transportation by not increasing vehicle capacity on roads.

Strengths

Pilot projects, diverse bike options for cyclists, growing facilities across the city and links to transit help to create a well-connected bike network to encourage cycling in Vancouver. The hierarchy of transportation modes of pedestrians, cyclists, transit, commercial vehicles and person vehicles also help to create a cultural shift of relying less on cars. Vancouver has the largest percentage of commuters travelling by walking and cyclists out of Canada's major cities (16%).

Many new bicycle pilot projects have been implemented to show residents treatments and technologies that are possible, including bikecross markings, bike boxes and coloured lanes within the past two years.

¹³ Four of the five cities (Vancouver, Montreal, New York and Berlin) were also study cities in TCAT's companion report: Benchmarking Active Transportation in Canadian Cities.

¹⁴ Ten council members make decisions on behalf of the entire City of Vancouver, not separate ward areas.



Cyclists waiting at a coloured bike box (www.vancouver.ca)

Notable examples include bike lanes on the Burrard Bridge, and separated bike lanes on Dunsmuir St., which connect to separated bike lanes on the Georgia Viaduct. Both Burrard St. and Dunsmuir St. are busy arterial roads in downtown. Components of the Dunsmuir pilot separated lanes include planters, barriers beside parked cars, bicycle parking, and a bus stop on a refuge median (transit riders need to cross through the tracks).



Diagram of the Dunsmuir separated lanes (www.vancouver.ca)

The development of new bike facilities in Vancouver is a good example of how safe and effective bicycle infrastructure can increase cycling rates. Monitoring of the Burrard Bridge shows that accident rates on the bridge have decreased. Although travel time for motor vehicles crossing the bridge increased by 30 seconds to 3 minutes during peak hours, cycling volumes increased by 26%, with 23% more men and 31% more women using this route.

Vancouver's bike network is mostly comprised of local street bikeways that run on residential streets parallel to arterial roads. Another option for pedestrians and cyclists are Greenways, pathways that connect parks, nature reserves, cultural features, historic sites, neighbourhoods and retail areas. Local street bikeways and Greenways ensure

that cyclists using local street routes are able to reach popular destinations as easily as motorists or cyclists travelling on arterial roads. With newer bike lanes on arterials, more options are available for cyclists. In general, bike routes are spread relatively evenly across Vancouver. The development of new bicycle routes connects cyclists to even more destinations.



Cyclist crossing an intersection from a bike boulevard (www.vancouver.ca)

All of Vancouver's buses are equipped with bus racks and its Skytrain and light rail lines allow passengers with bicycles to ride during off-peak hours.

Challenges

Although there has been much progress in cycling infrastructure, a gap remains between high-level goals set by the Vancouver Greenest City Plan and the actions currently being taken. Greenhouse gas emissions from light-duty vehicles in the city increased by 16% between 1990 and 2008.¹⁵

Pilot projects have caused conflicts with different stakeholders, especially those in the downtown area. With the implementation of the Dunsmuir separated bike lane, hotel owners along Dunsmuir can no longer allow taxis to park in front of their building to pick up or drop off guests. The City received significant backlash with the opening of bike lanes on the Burrard Street Bridge, particularly from motorists concerned about long delays in traffic and merchants concerned about losing business due to decreased car access to their storefronts.

Future Plans

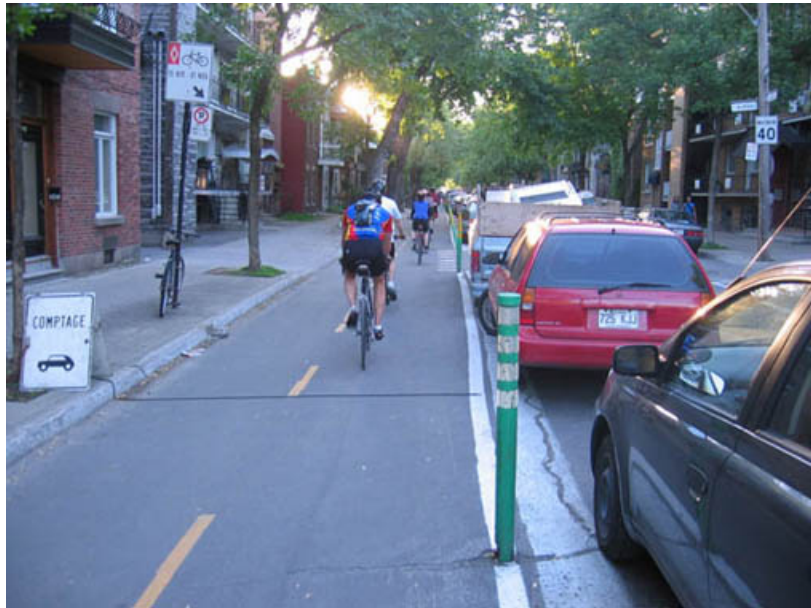
¹⁵ Pembina Institute (2010)

City Council recently approved \$25 million to implement the Vancouver Bike Plan and expand the existing bike network to 524 km by 2011. The City aims to increase cycling in parts of the city that have lower cycling mode share with targeted informational and awareness programs.

6.2 Montreal

Background

Just over half the size of Toronto, at 365sq km, Montreal has over 1.6 million inhabitants. The growth of cycling infrastructure in Montreal has facilitated an increase in cycling mode share. Between 2000 and 2005, the number of cyclists increased by 72%. Many streets in the city accommodate cyclists with various types of bicycle facilities, including bike lanes and sharrows. In fact, 50.2% of cycling in Montreal is on separate bike paths and lanes. This means that cycle tracks that make up much of the bicycle network are frequently used. In 2005, around 600,000 cyclists used the cycle track on the downtown arterial road Rue Bréboeuf¹⁶. With new bicycle infrastructure on road sections and the BIXI Public Bike System, the number of cyclists is expected to increase significantly when Velo Quebec's¹⁷ "Etat du Velo 2010" report is published next year.¹⁸



Two-way cycle track with bollards by parked cars (<http://streetsblog.org>)

The City adopted greenhouse gas targets to achieve 30% reduction from all sources by 2020 by focusing on improving low-carbon modes of transportation. Its Master Plan (2004) proposes increasing land use density and diverse uses to increase public transit ridership. The 2008 Transportation plan aims to improve the quality and safety of existing planned transportation systems, particularly low-carbon transportation. The City is

¹⁶ Cycling Vision Ottawa (<http://cycling-vision.ca/resources/research/cycling-lanes.html>)

¹⁷ Quebec's bicycle advocacy organization

¹⁸ Lalonde, M (2010) The key to cycling safety? More cyclists: Traffic-calming measures and bike lanes increase the number of cyclists and decrease the risk of collisions: study. *Montreal Gazette*. August 1, 2010 (<http://www.montrealgazette.com/news/cycling+safety+More+cyclists/3349544/story.html>)

implementing the Plan d'accessibilité et de mobilité à vélo au centre-ville (Plan for Bicycle Access and Mobility in Downtown Montreal) which was adopted in 2005 to create 26 km of bicycle paths – 16km was created in 2008. Montreal plans to create a bicycle plan in the near future.¹⁹

Strengths

In 2009, Montreal became the first North American city to implement BIXI, a Public Bike System. The network comprises over 5000 bicycles at 400 stations. The City is also implementing diverse cycling facilities types, access to facilities year round and connects cyclists to transit through bicycle parking and bringing bicycle on-board the subway.

The current bike path network is comprised of the Perimeter Bikeway surrounding Montreal Island and the provincial Route Verte cycling route, connected to denser areas of the city using local bike paths. Different types of bicycle facilities are used, from off-street paths, on-street separated lanes, on-street painted lanes, to shared roadway markings. With a mix of cycling facilities, most of the network is concentrated around the downtown area and university campuses. In 2007, the City of Montreal created 30 km of new year-round winter paths with regular snow clearance. This *White Network* will expand to other bike routes (63 km planned kilometers) to enable cyclists to travel to more areas in the city during the winter. Further, bicycles are permitted on the Metro subway system except during rush hour and special events.



Shared roadways on Montreal streets (Spacing Montreal)

¹⁹ Ville de Montreal (2008) *Transportation Plan*

Challenges

Although Montreal has a high percentage of sustainable travel modes, they experienced the lowest increase in commuters choosing to walk, cycle and take public transit out of Canada's major cities between 2001 and 2006.²⁰ Rates are below the population growth of the city. The City of Montreal will need to examine causes for such low rates to increase sustainable transportation use in the city.

More bikeway connections are needed in residential areas further away from downtown that are under-served by cycling infrastructure to get to popular destinations. Safer bicycle infrastructure is needed in Montreal's lower income neighbourhoods, where a high number of children cycle and have to cross busy arterials. Most injuries to cyclists occur at intersections and injury rates increase with traffic volumes at intersections.²¹

Currently, there are no bicycle racks on public buses. However, bike racks will be installed on some buses as a pilot project in Fall 2010.

Future Plans

Earlier this year, the city approved a \$10 million plan to add 51km to the city's 502 km path network in over 20 projects by fall 2010. This plan will keep Montreal on track to reach their goal of installing a total of 800 km of cycling routes by 2015.

²⁰ Pembina Institute (2010)

²¹ Lalonde, M (2010) *The key to cycling safety?*

6.3 Portland

Background

In 2008, the League of American Bicyclists granted Portland a platinum-level status as a Bicycle Friendly Community. A city of 377sq km with 540,000 inhabitants, Portland had zero bicycle fatalities in 2008 for the fourth time since 2000 and bicycle crashes dropped 8% since 2007. Cycling ridership also increased by 28% compared to 2007. According to the Alliance for Biking and Walking (2010) Portland has a high percentage of work trips by bicycle because of “strong policies, investment in bicycling infrastructure, active education and encouragement programs, and support of residents (142).”

Portland’s progressive Complete Streets Policy helped to increase its cycling arteries as well as its numbers of cyclists. In 1971, Oregon’s Bike Bill made it necessary to spend one percent of statewide transportation revenue on pedestrian and bicycle facilities. New road constructions and rebuilds are also required to have cycling facilities. Since the 1990s, cycling in Portland increased by 74% and transportation-related carbon dioxide was reduced by 12.5%. Six percent of workers commute by bicycle.

Strengths

A leader in the implementation of different types of bike facilities, Portland uses more innovative treatments than any other major US city, including shared lane markings, bicycle boulevards, coloured bike lanes and bicycle traffic lights.



Portland’s green bike lanes
(<http://www.portlandize.com>)

Portland is focusing its efforts around promoting education, encouragement, and community outreach, including activities with active adult and youth bicycle

education courses, Bike to Work Days and ciclovía (car-free) events, and city-sponsored bike rides.²²

Like Vancouver, there are many bike boulevards in Portland in addition to bike routes on arterial roads. Portland's Green Streets, providing park characteristics to bike routes, are also similar to Vancouver's Greenways. Bike infrastructure is effective because of supporting land use and street network structure. In more suburban areas, the design and implementation of cycling facilities have been adapted to its characteristic winding streets so that cyclists are able to travel between different parts of the city.

Transit integration is another key factor in creating a bicycle friendly city. Stations of both MAX and WES streetcar lines have first-come, first served bike racks. Cyclists can bring bicycles aboard streetcars and bike hooks are available on light rail vehicles. Portland's transit authority TriMet has a Bike & Ride facility that offers secure enclosed daytime or overnight parking in a group access bicycle parking area for a small fee and lockers can be rented. Although public transit accommodates bicycles throughout the day, travelling during non-peak hours is recommended, as trains are crowded and bike spaces fill up quickly during peak times.



[\(http://www.reconnectingamerica.org/\)](http://www.reconnectingamerica.org/)

Photo by Zach Behr

Portland, OR, clearly marks where bicyclists should store their wheels.

Challenges

Portland's ambitious bike plan requires substantial expansion of the current bike network and provision of sufficient infrastructure for all bike trips less than 20 minutes long. Although there is a growing critical mass of cyclists, the City will have to achieve a lot of milestones to reach their goals.

²² Alliance for Biking & Walking (2010) *Bicycling and Walking in the United States 2010 Benchmarking Report*. p.141

Future Plans

With nearly 500 km of bicycle facilities in Portland, the city aims to install 1090 km more by 2030 and significantly increase cycling trips.



Buffered bike lanes in Portland
(<http://www.streetsblog.org>)

6.4 New York

Background

At 786 sq km and with over 8.2 million residents, New York is the largest city in the United States. Despite its high density, many short trips and flat topography, New York City has one of the country's lowest rates of cycling. However, cycling is on the rise. Since Mayor Bloomberg appointed Janette Sadik-Khan as the Commissioner of the New York City Department of Transportation in 2007, she has been instrumental in increasing sustainable and active transportation in the city, including the installation of 320 km new bike lanes in various forms in the past few years. Bike share of work trips in NYC has also doubled since 2000 and increased by 26% between 2008 and 2009 alone.

In 2007, the City released PlaNYC 2030, a long-range strategic plan to ensure a higher quality of life for residents and to contribute to a 30% reduction global warming emissions. The Plan focuses on five key dimensions of the city's environment: land, air, water, energy, and transportation. Although the NYC Master Bike Plan (1997) needs updating, the Transportation Plan of PlaNYC promotes cycling by creating safe and comfortable cycling facilities including the expansion of bikeways and bicycle parking.

Strengths

The quick expansion of innovative bicycle infrastructure and techniques since 2007 has brought forth great change, including green-coloured bike lanes, cycle tracks, bike boxes and shared lane marking on some streets.



Cycle tracks behind parked cars
(<http://www.nycbikemaps.com/>)

The city also has a Complete Streets Policy, which resulted in street projects like the Ninth Avenue Complete Street project. This entailed retrofitting road sections in an

active and mixed-use central business district with high quality traffic, bicycle and pedestrian operations, and streetscape improvements.



Many of New York City's streets were transformed to accommodate cyclists and pedestrians. (<http://www.streetfilms.org>)

Bicycles are allowed on subway at all times although passengers are recommended to bring their bicycles outside of rush hours. However, stations are not designed to accommodate bicycles and passengers have to carry their bicycles up and down the stairs at stations. Only folding bicycles are allowed on buses. Bicycles are also permitted on the local commuter rail services (Long Island Rail Road and Metro-North Railroad) and Staten Island's rapid transit line (Staten Island Railway) outside of rush hours and holidays. Bicycle parking is available at most subway stations.

Challenges

Many innovative treatments have been used for bike facilities since 2007, but most of this is in the busy Manhattan downtown core. Bike lanes also link across bridges, but further from the peninsula cycling infrastructure is sparse. Staten Island, for example, only has a couple of bicycle routes along the length of the island.

The rate of men cycling has doubled but there has been no increase in women cyclists. According to Pucher et al (2010), only 5% of women cycle several times a month compared to 13% of men. Further, the average percentage of women cyclists on paths are three times greater than the percentage of women using on-street facilities such as bike lanes or shared lanes. The on-street facilities with the highest proportion of women cyclists are wide bike lanes with striped buffer zones between bike lane and traffic lanes.²³ New York City may need to concentrate more of its efforts in reaching out to non-cycling residents to increase cycling mode share and introduce more suitable infrastructure to encourage more women to cycle.

²³ Pucher, J; Thorwaldson, L; Buehler, R.; Klein, N (2010) Cycling in New York: Innovative Policies at the Urban Frontier. *World Transport Policy and Practice*, Vol. 16, Summer, forthcoming

Furthermore, cycling fatalities in New York City are high, with almost 22 incidences per year.²⁴ Most cycling fatalities (53%) occur on arterials, although they make up only 10% of roads. Eighty-nine per cent of fatalities and 70% of serious injuries occurred at or near intersections. While most incidents occurred in mixed traffic, only one fatality occurred in a marked bike lane, demonstrating the benefits of separated lanes.²⁵ Similar to Montreal, these trends show that arterials and intersections require more separated facilities to create safer environments for cyclists.

Future Plans

The Transportation Plan of PlaNYC aims to build 2880 km of bike lanes and mixed-use greenway paths by 2030 and to increase cycling levels considerably.



Bike lane on one-way street
(<http://www.nycbikemaps.com/>
)

²⁴ Alliance for Biking & Walking (2010)

²⁵ Pucher, J; Thorwaldson, L; Buehler, R.; Klein, N (2010) Cycling in New York: Innovative Policies at the Urban Frontier. *World Transport Policy and Practice*, Vol. 16, Summer, forthcoming

6.5 Berlin

Background

The largest city in this study is Berlin at 892 km sq with over 3.4 million inhabitants. Cycling mode share more than doubled in the last decade, representing 12% of total trips in 2007. There have been improvements to connections between train stations and bike paths and many types of bicycle infrastructure added across the city. Germany has implemented policy changes using both carrot and stick initiatives to increase cycling and to reduce car share. German children received training in safe and effective cycling techniques as part of their school curriculum. These changes along with the demand for better cycling infrastructure from cyclists have created a strong bicycle culture in Berlin.

Berlin's Public Transport Law requires provisions for sufficient bicycle parking and allowing bikes on trains. The Local Transport Plan (2006-2009) identifies a rivalry relationship between bikes and public transport for short distance journeys.²⁶ The City is working on the integration of cycling and public transit to address this.

Strengths

Berlin has a well-connected network from the city centre to its suburbs. Different types of cycling facilities take advantage of wide streets inherited from Communist town planning after World War II. The cycling network covers bicycle paths, bicycle lanes, shared bus lanes, non-exclusive bicycle lanes and bicycle priority streets. Separated bike lanes in Berlin separate cyclists from both motor traffic and pedestrians.

²⁶ Senate Department for Urban Development (2009) Berlin. *Bicycle and Public Transportation - Dream Team of Rivals: A Berlin Experience*. PowerPoint Presentation. March



Cycle track in Berlin transitioning into a coloured bike lane at an intersection (<http://www.planetizen.com>)



Cycle track onto curb level between parked cars and pedestrians (<http://www.streetsblog.org/>)

Newly opened routes run through parks, woods, and alongside waterways to the public. The network originates from the city centre “Schlossplatz” with twelve bicycle routes that span out into the suburbs in a star-shaped network “radial” linked up by eight circular routes. In addition to Berlin’s bicycle routes, four supra-regional long-distance routes pass through Berlin: The European Bicycle Route R1, the Berlin-Copenhagen Route and Bicycle Path Berlin-Usedom and the Havel-Radweg. Berlin-Leipzig Route and Spree-Radweg are being planned.

Berlin is attempting to increase cycling levels to focus on interlinking bicycle and public transport and promote sustainable transportation over car usage. Transit riders can bring bicycles on bicycle compartments of the city’s U- and S-Bahn subway trains all day, but they need to pay a bicycle fee. Bike and parking facilities are available at S-

Bahn and U-Bahn train stations. In addition, nearly all public bus lanes are open for bicycle use.

In 2008, German Rail started to offer a Public Bikes System called "Call-A-Bike" in Berlin. By calling the hotline, users rent a bicycle using a credit card at any of the public bike stations throughout the city 24 hours a day. A code unlocks the bike for users. Bicycles can be returned at any "Call a Bike" stations and users call the hotline to end the bike rental.²⁷ Like other Public Bike Systems in North America, Call A Bike presents an opportunity to increase cycling rates as well as link first and last miles of a transit journey.

Of the total streets in Berlin, 72% are traffic calmed with speed limits of 30 km/h or less. This reduced speed is ideal for on street cycling without lanes or paths.

Challenges

Although cycle paths are extensive throughout West Berlin, the Eastern half needs to catch up.

Future Plans

Berlin plans to expand its existing "Call a Bike" service to be located near public transport stations and other popular destination and to integrate the public bikes as part of its public transport system. The objectives of this expansion are to relieve public rail systems from exceeding the capacity of its on-board bicycle carriage and to increase bicycle use at the end of public transit journeys.²⁸ The National Bicycle transportation Plan's (2002) main goal is to increase bicycle use from its current 10% to 25% in 2020.

²⁷ Jorg&Olif (2010) *Cool Cycling: Call a Bike Berlin*. March 9. (<http://jorgandolif.com/2010/03/09/cool-cycling-call-a-bike-berlin/>)

²⁸ Senate Department for Urban Development (2009) Berlin. *Bicycle and Public Transportation - Dream Team of Rivals: A Berlin Experience*.



Bicycle traffic activation leading to a coloured cycle track
(<http://www.matthiasliffers.com>)

7. Implications for Cycling in Cities

The cities presented in the case studies implement a range of cycling infrastructure and policies resulting in varying levels of cycling and types of cycling arteries. Bike facility types, length of bikeways and cycling policies have been identified as factors that influence the implementation and success of cycling arteries in cities.

7.1 Various bike facilities

Cities with a higher share of cycling and decreased incidents of collisions involving cyclists and motorists offer a wide range of bicycle facilities. Different facility types ensure that roads with different motor vehicle speeds and volumes can be equipped with suitable bike infrastructure to accommodate cyclists. For example, the separated treatment of the Burrard Bridge in Vancouver resulted in higher numbers of cyclists as well as decreased visits to hospital emergency wards. Cycling infrastructure provides different options for cyclists, catering to the needs of different cyclists. Some prefer to use lanes along major arterials while others choose to remain on residential roads. Innovations for intersection and road section treatments should enhance safety and provide direct connections for cyclists.

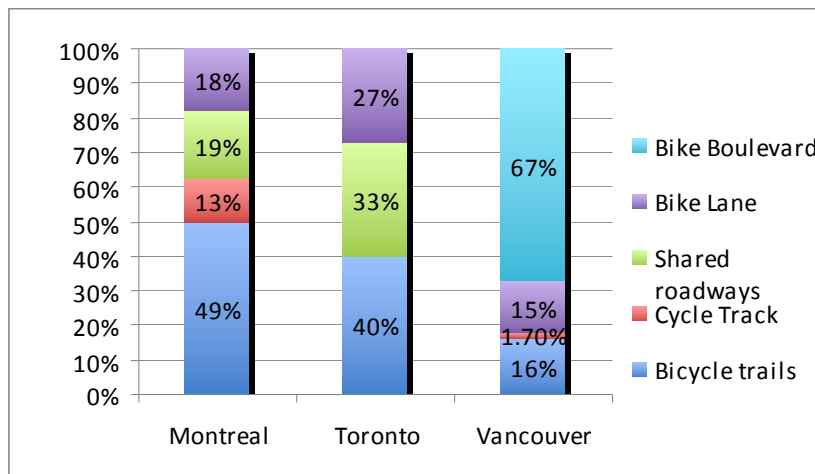
If suitable bicycle infrastructure can increase safety, the availability of different types of cycling facilities may affect both injury and fatality rates for cyclists. With high bicycle conflict areas at intersections and along arterials as reported in Montreal and New York, treating these road sections is essential. In Portland, 22 of 25 cyclist fatalities (1995-2007) occurred where no bike lane existed (City of Portland 2010). With more bike facilities in high-risk areas, fatality and injury rates should decrease (Figure 1).

The willingness to diversify and try new treatments is an effective means to bring cycling options to cyclists. The surge of bicycle-friendly treatments on streets in New York City allows cyclists to travel quickly and safely through downtown. Similarly, facilities that began as pilot projects in Vancouver became more permanent with heavy use by cyclists, overcoming initial skepticism. Please refer to Table 1 and Figure 2 on the following page for a comparison of bike facilities (introduced in Section 5) in different cities as of August 2010.

Table 1: Comparing facilities in municipalities

	Montreal	Toronto	Vancouver	Portland	New York	Berlin
INTERSECTIONS						
Bike Boxes	x		x	x	x	x
Traffic Signal Operations for Bicycles		x	x	x		x
Truncated Cycle Track - to Bike Lane			x	x		x
Cycle Track Two-Stage Left Turn				x		
Forward Stop Bar				x		x
Combine Right Turn Bike Lane		x		x		
Crossbike Markings		x	x			
ROAD SECTIONS						
Bicycle Boulevards			x	x		x
Bike Lanes	x	x	x	x	x	x
Coloured Bike Lanes	x		x	x	x	x
Contraflow Bike Lanes	x	x	x	x		
Cycle Tracks	x		x	x	x	x
Shared Roadway Markings	x	x			x	x
TRANSIT INTEGRATION						
Bicycle-friendly transit stop			x			
Bikes on Transit	Subway only	80% buses	x	x	folding bikes on subway	x
Bike parking at Transit points	x	x	x	x	x	x
FACILITIES MAINTENANCE						
	Winter bike lanes	Pilot lane maintenance for Martin Goodman Trail (2009)				
POLICIES						
	Transportation Plan (2008)	Bike Plan (2001)	Bike Plan (1999)	Bicycle Plan for 2030 (2010)	PlaNYC (2007)	National Bicycle Transportation Plan (2002)

Figure 1: Breakdown of Facility Type in Bicycle Network²⁹



Integrating cycling with public transit provides more options for cyclists and has the potential to increase cycling in cities. The availability of bike parking, storage and space for bicycles on transit vehicles has allowed passengers to get to and from transit stations by bike. Cyclists are then able to travel longer distances using both bicycle and transit as part of their journey. All cities featured in the case studies accommodate cyclists as part of their public transit system to some extent. Public bike systems can also increase convenience and accessibility for cyclists. Of the cases featured, only Montreal and Berlin have a public bike system. However, Toronto plans to launch its system next year while Vancouver, Portland and New York City are conducting feasibility studies.

7.2 Length of cycling arteries

The length of a bicycle network that is comparative to the size of the city is important. Longer kilometers of bikeways are necessary for larger cities to ensure that residents are able to easily access it. More specifically, the network should be well connected and directly link cyclists from origin to destination points. As studies indicate, cyclists are more likely to use cycling infrastructure if they are located within a 500 m detour from direct routes. For the cycling arteries to be effective, there should be a good variation of facilities for different skill level of cyclists to feel safe.

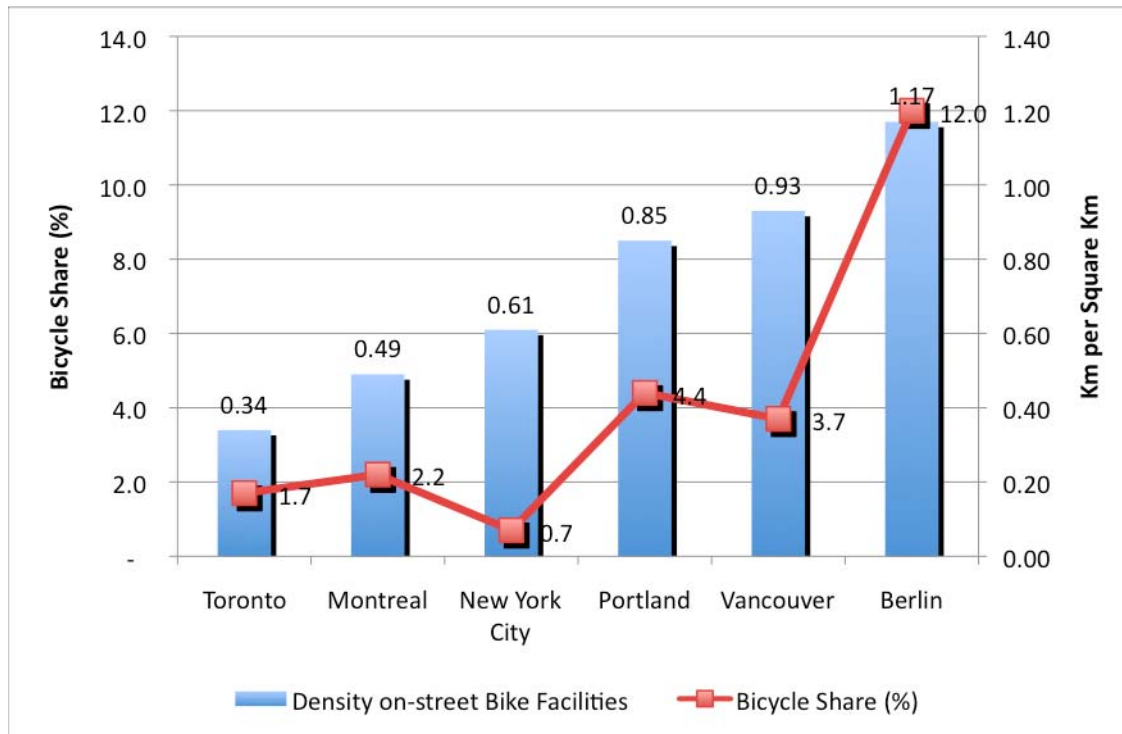
Research shows that cities with more miles of cycling facilities per square mile generally have higher levels of cycling.³⁰ Figure 3 shows the density of on-street bike facilities (km of network per sq km of city area) and the percentage of bicycle to work share in the six cities featured in the case studies. Bikeway density and bicycle share are generally correlated.

²⁹ Riga, A. (2010) Breaking down Montreal's 502 km cycling network. *The Gazette*. May 27

TCAT (2010) *Benchmarking Active Transportation in Canadian Cities*. Survey results

³⁰ Toronto Coalition for Active Transportation (2010) *Benchmarking Active Transportation in Canadian Cities*. Report

Figure 2: On-Street Bikeway Density and Bicycle Share (2007)³¹



Toronto's current bicycle mode share is low compared to other cities and has the fewest bike lanes per capita in Canada. Increased density of its bikeway network has the potential to also increase bicycle share in the city.

Further, findings from TCAT's Benchmarking Report on Active Transportation in Canada (2010) also show that in "cities with high mode share, the percentage of cyclists and pedestrians injured and killed is lower than in cities with low mode shares." This theory is proven to be accurate for the six cities (Figure 3). Fatality and injury rates are calculated by the total reported incidents of bicycle injuries and fatalities per year (2007) divided by the total population times the bicycle to work share.

³¹ TCAT (2010) Benchmarking Active Transportation in Canadian Cities and TCAT (2008) *Benchmarking Toronto's Bicycle Environment: Comparing Toronto to other world Cities*.

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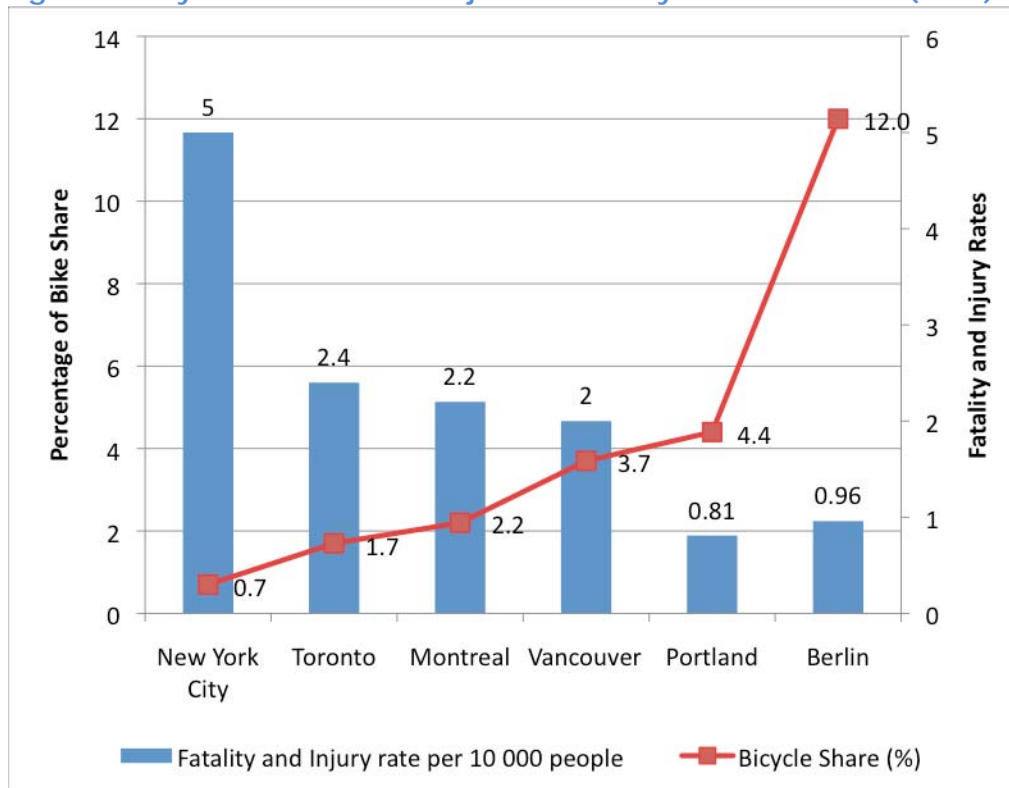
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Senate Department for Urban Development (2009) Berlin. *Bicycle and Public Transportation - Dream Team of Rivals: A Berlin Experience*. PowerPoint Presentation. (Using 2005 statistics) March

Figure 3: Bicycle Fatalities and Injuries and Bicycle Mode Share (2007)³²



In European cities such as Berlin, there are higher levels in cycling especially among women, children and the elderly compared to North America and the UK. Both fatality and injury rates are also much higher for cyclists in North America and the UK.³³ In Germany, for example, cycling is perceived as a mainstream form of transportation. Motorists tend to be more cautious on the road as they are used to sharing space with cyclists. In many instances, motorists are also cyclists. With cycling education in German, Dutch and Danish schools, cyclists are also made aware of rules and risks on the road. As a result, there are fewer collisions involving cyclists and motorists. In Toronto, cycling is a more marginal mode of transportation. Cyclists face more conflicts with motorists, making cycling more unsafe and discouraging many people from cycling. Therefore cycling mode share remains low and risks for traffic related fatality and injuries remains high.

If bikeway density is correlated with an increase in bicycle share, and bicycle share is correlated with a decrease in cycling fatalities and injuries, an increase in bicycle density may also be correlated with bicycle fatality and injury rates. Bikeway densities and bicycle fatality and injury rates in the six cities is presented in Figure 4 demonstrating that this is generally true (following page).

³² TCAT (2010) *Benchmarking Active Transportation in Canadian Cities*.

City of Portland (2009) *Portland Bicycle Count Report*

Insurance Corporation of British Columbia (2010) *Cyclists injured in motor vehicle crashes. 1996-2009*

³³ Pucher and Buehler (2008) *Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany*

Figure 4: Bicycle Network Density and Bicycle Fatalities and Injuries (2007)



If a bikeway network is dense, cyclists are more able to access cycling facilities for the majority of their trips. Particularly if facilities of the bikeway are separated from motorists or if the cyclists' positions are emphasized for motorists, collisions between cyclists and motorists are less likely to occur. Findings from Toronto's Cycling Study (2010) reveal that "safety on roads remains the public's principal concern about cycling (...) only one-third of cyclists say they are comfortable biking on major roads without bike lanes (...) improvements in safety-related infrastructure such as more bike lanes, paths and safer road conditions (11)" can increase cycling mode share in the city.

Cycling infrastructure, mode share and safety are connected to each other. Functional cycling arteries that are dense and offer different types of facilities for users can increase bicycle mode share and safety for cyclists. Motorists may become more accustomed with sharing the roads with cyclists to further increase bicycle safety.

7.3 Cycling policies

The goals and policies of cities influence the quality and quantity of cycling arteries in cities. Those with strong support of cycling and environmental goals tend to be more progressive in innovation and bike network size. Commitment to reduce carbon emissions through investing in sustainable and active transportation, and reducing car use provides opportunities for cities to build cycling arteries. Complete Streets Policies provide guidelines and support to accommodate all users in road infrastructure

including cycling arteries. For instance, Portland's policy requiring the installation of bike facilities on new roads or on roads that are being maintained normalizes these facilities.

Governance structure also influences the decision-making function of cities. Stronger mayoral cities such as New York City allow the city to quickly implement cycling initiatives within a small time frame to meet its sustainability goals in PlaNYC. When NYC started painting bike lanes on streets, they were able to increase awareness of cyclists for motorists. Vancouver's at-large council are able to make quicker decisions to meet the objectives of its Greenest City Plan while Toronto's many ward councillors may delay decision-making.

Further, comprehensive strategies to increase cycling are able to improve cycling arteries. In the case of Portland, its multi-pronged approach has successfully increased awareness and popularity of cycling in the city. Policies, promotional programs and education events can help create a cycling culture, increasing the cycling mode share and a greater demand for more bike facilities (Figure 4).

8. Improving Cycling Arteries in Toronto

To improve cycling arteries in Toronto, the bikeway network should grow extensively to connect all residents to cycling routes; facilities should be available to accommodate cyclists of all ages and abilities; and policies should encourage the inclusion of bicycle infrastructure in street design. Road clearing and maintenance is also needed during snowy months. Plans for sustainable transportation in the city should be implemented with the integration of cycling through the provision of bicycle parking and storage at transit stations and space for passengers to carry bicycles on board transit vehicles. If its public bike system launches next year, residents will have more opportunities to cycle across downtown Toronto.

8.1 Diverse Bicycle Facilities

Different facilities to accommodate everyone

Compared to German cities and other leading cycling cities in North America, Toronto lacks a broad range of cycling facilities. Compared with Montreal and Vancouver, Toronto offers fewer facility options for cyclists, mainly bike lanes, recreational trails and shared roadways. In Toronto, shared roadways are mostly signed routes in residential areas that do not have traffic calming measures and are not designed to prioritize bicycles. If these signed routes were configured to accommodate cyclists, they could function more like bicycle boulevards in Portland and Vancouver, bringing cyclists safely and directly to key destinations in the city.

Although there are some places that have different cycling facilities from the three main categories, these examples are few and not significant enough to benefit most

cyclists. For example, a few residential streets in downtown Toronto have contraflow lanes and the Martin Goodman Trail has a few bike crossing facilities. Most cyclists in Toronto would not cycle past these areas to reach their destinations.

Other Canadian cities such as Vancouver and Montreal are following the footsteps of European design by installing separated bike lanes from vehicle lanes. These lanes are slowly expanding across Montreal and Vancouver has just begun a pilot separate lane in downtown. So far, there has been an increase of cyclists using the facility. Like the Burrard Bridge reconfiguration, trial projects can become permanent infrastructure that increase cycling and safety. Toronto can also start adopting facilities such as separated lanes on a trial basis. Pilot projects are a good way to introduce new facilities to cyclists as the bikeway network expands.

Toronto Case: Cycling Treatment on Yonge St. and Bloor St.

Suitable intersections that require bicycle facilities can be identified as those with a close proximity to prime destinations in the city, with intersecting streets that have high motor vehicle speeds and volumes. For instance, a potential north/south arterial that would be suitable as a cycling artery is Yonge Street. Like Bloor Street, Yonge Street is mostly a commercial corridor in Toronto's downtown. This makes it a prime destination for many people. It is then not surprising that where the two arterials meet the subway system is heavily used during peak hours. The TTC has been focusing efforts to improve peak-hour flow at the Bloor and Yonge subway station. The station is used by close to 200,000 people each day. If people chose to cycle for shorter trips, the capacity at major transit hub may be alleviated.

Different street modifications can improve cycling conditions in the intersection of Yonge and Bloor. Figure 5 shows the intersection as it appears today.



Figure 5:
Yonge
Street at
Bloor Street
looking
south (Ada
Chan
Russell)

Both Yonge and Bloor are major arterials that can accommodate high volumes of motor vehicles (approximately 20 000, according to the City of Toronto) and speeds (50-60 km/h). With cycling arteries along these streets, cyclists will also be able to travel direct routes at relatively high speeds. In this case, separated facilities would be an appropriate treatment to implement along Yonge Street. For example, New York City and Montreal use cycle tracks with bollards or raised tracks on major arterials. A less expensive option for the City of Toronto is to use painted buffers to separate the bicycle lanes from the traffic lane. We now present potential treatments to this intersection.

Option 1: Modifications can be made to accommodate a two-way bicycle lane on one side of the road on either side of Yonge Street. At the intersection of Yonge and Bloor, the position of cyclists should be indicated to motorists and pedestrians. This can be made with the extension of the coloured bicycle lane through the intersection or sharrow stencils painted in the space where the bicycle lane would be. With bicycle facilities on one side of the road, there would be space for either three travelling lanes or two travelling lanes with the widening of sidewalks on both sides of the street. If there are three travelling lanes, the middle lane can be made into a reversible lane that changed direction depending on car volumes throughout the day.



Two-way Bicycle lane on one side of the road in Montreal (<http://www.streetsblog.org>).



One-way Bicycle Lane on each side of side with reversible centre lane in Portland (<http://www.bikeportland.org>)

Option 2: Modifications can also be made to accommodate one-way buffered bicycle lanes on both sides of the road. Again, treatment at the intersection should include either extended coloured bike lanes or sharrow markings to indicate travel space for cyclists. Sidewalks on both sides of the street may be widened to accommodate pedestrians, reducing four lanes of motor traffic to two.

Many other bicycle facilities can be built across the city, depending on the type, width and location of streets, as well as available budget.

8.2 Denser Bikeway Network

Bicycle maps in different cities show that bicycle routes can be developed densely throughout a city, as in the example of Portland's street grid and Berlin's spiral routes, or sparsely in suburban areas, as in the example of Toronto. For cyclists to access functional cycling arteries, bike systems need to be dense and connected. The layout of streets in each city may affect the suitability of cycling artery locations. Toronto should take into account the lack of east west connections when identifying cycling arteries to ensure that its bikeway network is connected across the city.

Identifying Cycling Arteries in Toronto

Cycling arteries can be incorporated on most streets. In Toronto, there are more north/south arterials than east/west ones. In fact, many already serve as cycling arteries, including St. George/Beverly, Sherbourne, and Jarvis. East/west streets are more challenging because aside from arterials, many local east-west streets do not extend for long stretches. Instead, users of these streets often have to navigate a bit north or a bit south before turning onto other streets to reach east or west. This creates more conflict points on east/west arterials for both cyclists and motors vehicles and results in more collisions. In contrast, there are many residential streets parallel to north/south arterials for cyclists to travel. Although east/west signed bicycle routes on

residential streets are few and far between and increase travel distance and time, some cyclists prefer them to arterial roads. To ensure that these routes are safe enough for cyclists, traffic calming treatments should be incorporated in their design. For cyclists who prefer shorter travel distance, more east/west cycling arteries should be built on arterial roads, with safe and effective bicycle facilities to ensure direct routes.

Many arterial roads in Toronto can accommodate cycling arteries. Potential streets are wide enough for both cyclists and motor vehicles and are along or adjacent to popular destinations such as commercial districts. In suburban areas, there are many wide and busy arterial roads without cycling infrastructure. With modifications to the number of motor vehicle lanes and parking spaces, and/or vehicle lane widths, cycling arteries may run along these streets. To use a downtown example from the Clean Air Partnership's *Bike Lanes, On-Street Parking and Business reports of Bloor Street in Toronto's Bloor West Village* (2009) and *Annex Neighbourhood* (2008), Bloor Street has been identified as a suitable arterial to accommodate cycling arteries.

8.3 Policies that support cycling arteries

The State of Oregon's Bill spends one percent of statewide transportation revenue on pedestrian and cycling infrastructure while the City of Portland's Complete Streets policy ensures that any road construction or rebuilds considers all road users, resulting in significant progress in cycling infrastructure. The commitment from both the city and the state to invest in sustainable transportation ensures the safety of its residents and encourages planners, designers and landscape architects to incorporate effective cycling facility design into their work.

9. Recommendations and Conclusion

From information about cycling artery treatments and case studies of leading cycling centres, the following are key recommendations for the City of Toronto to consider in improving its cycling arteries.

- 1- *Explore the possibility of implementing different bike facility pilot projects across the city.*

Pilot projects provide an opportunity for residents to discover and become familiarized with new cycling treatments. Residents opposed to bike infrastructure would also gain awareness of cycling and understanding of their importance. Further pilot projects may become permanent facilities that can help increase the level of cycling. Media promotions and public events can help raise awareness of new facilities across the city.

- 2 -*Examine current residential signed bike routes and investigate traffic calming treatments to convert them into bicycle boulevards.*

Many local streets in Toronto are signed bike routes. However, without much traffic calming, direct connections to popular destinations or prioritization of cyclists, they are not being used fully as cycling arteries. Improvements to current signed routes should help accommodate cyclists for long distances to key destinations, reduce detours from main routes and provide prioritization over motor vehicles.

- 3- *Consider on-street treatments, such as separated bike lanes, on arterials.*

The success of separated bike lanes in other jurisdictions shows that they can be easily applied in North American cities like Toronto. Their implementation has the potential of facilitating an increase in safe and direct cycling as well as cycling levels overall on busy arterials with high motor vehicle speeds and volumes. The proposal of transforming University Avenue into separated bike lanes was not passed by City Council in Spring 2010, but there are other north/south and east/west arterial roads that would accommodate separated bike lanes. Downtown streets such as Yonge and Bloor may accommodate separated bike lanes as well as major arterials on wider streets outside downtown.

- 4- *Develop a Complete Streets Policy.*

Portland and New York City's Complete Streets Policies help to increase the length and quality of cycling arteries. Not only does the Complete Streets policy have the ability to

influence the inclusion of bike facilities with street construction or repair; planners, developers and the public will be more aware of accessibility issues for all street users. The City of Toronto can help encourage and develop a safer and convenient public realm and right for way for cyclists in addition to pedestrians, transit users and drivers.

The City of Toronto's expansion of its bikeway network and implementation of its Bike Plan is behind schedule and the network is not accessible for all cyclists across the city. Yet findings from various major jurisdictions show that there are many ways for the city to create safe and convenient cycling arteries for its residents. Modified treatment of intersections and road sections and integration of cycling with transit can better accommodate cyclists. Cycling arteries with a variety of cycling facilities should be made available in different neighbourhoods and gaps in the network should be connected. Using this connected network allows people to travel to key destinations, increasing accessibility for Torontonians, while suiting the needs of cyclists of all ages and abilities. Further, to support the success of cycling arteries, promotions, events and education should be implemented as part of a comprehensive approach to increase the safety and proportions of cyclists in Toronto.

Modifications to increase functional cycling arteries in Toronto complement its objectives to provide sustainable transportation options to increase transportation capacity across the region. A complete streets policy can further push the objectives for safer, accessible and convenient bicycle travel.

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