

A Canadian Perspective on Safe Signalized Intersections

Which Features are Beneficial to Operate Safe Signalized Intersections?

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Guidance and legal frameworks

Practice

Evidence

Perspectives

Types of cycling facilities in Quebec (North America?)

- Dedicated roads (shared-lane markings)
- Bike lanes
- Cycle track / path (physically separated)
- Cycle streets
- Off-road cycle path (generally shared use with pedestrians)

Guidance and legal frameworks

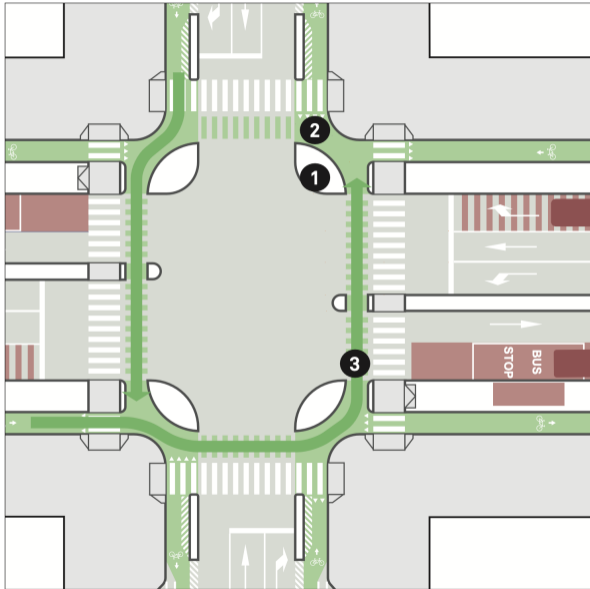
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Intersection design elements from the [Global Street Design Guide](#) [1]

- Advanced stop bars or cycle boxes
- Two-stage turn queue boxes
- Corner refuge islands
 - Protected cycle facilities at intersections
- Cycle signals
 - Partially or fully protected movement through leading interval or exclusive phase
- Filtered permeability: physical barriers at some intersections to divert motorized traffic



Protected cycle facilities at intersections

1. Corner refuge island
2. Forward stop line
3. Setback crossing by extending the curb

- Visibility and sight distance
At uncontrolled locations where volume or speed present safety concerns, add traffic controls or traffic calming devices on the intersection approach [1]
- Speed management
- Traffic calming, e.g., corner radii and diverters
- Signal progressions
When set to cycle- and transit-friendly speeds of 20–25 km/h, signal progressions can remove much of the incentive to speed [1]

Legal Framework in Canada



Legal Framework in Canada

- **Provinces** are responsible for transport, inc. road design and traffic control devices
 - rules of the road (law)
 - the Ministry of Transportation maintains the **norms** for road infrastructure that must be applied by road authorities, inc. cities
- **Complementary** implementation guides by cities, e.g., “guide de conception des feux en présence d’aménagements cyclables”

Legal Framework in Quebec

- The word cyclist appears **once** in the provincial norms on intersection design
- More in the cycling facility road design norm: emphasis on **visibility** (removing parking close to intersection), warning about contraflows, cycle tracks should be brought back along the roadway next to the intersection (need for safety study otherwise)
- Traffic lights
 - pedestrian and cyclist traffic is a justification for **3+ phases**
 - cyclist lights are “justified when an exclusive phase is necessary for cyclists”
 - adaptation of traffic light warrants for pedestrians to change control type (change to traffic light control)

Guidance and legal frameworks

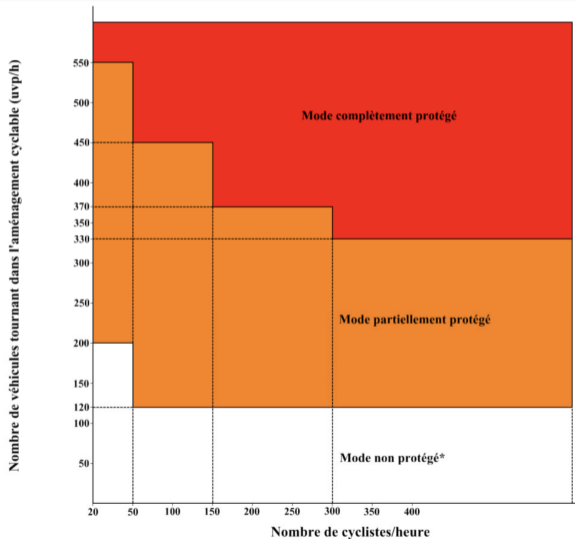
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- Minimum number of bike crashes with turning vehicles

Montreal Guide for Traffic Light Design (2016)



- Number of potential cyclist-vehicle conflicts based on conflict points and volumes

Other Adaptations

- Clearing time computed based on **cyclist speed**, esp. for large intersections (>20 m)
- **Adjusted warrants** from the ministry to change control type
 - bike crashes
 - cyclist volume and number of gaps in vehicular traffic
- Toronto: issues with **right turn on red**

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Joint research with

- Luis Miranda-Moreno, McGill University
 - Sohail Zangenehpour, Joshua Stipancic, Bismarck Ledezma-Navarro, Paul St-Aubin
- Marie-Soleil Cloutier, INRS

Examples: guide for bike lights, conversion of 2-way stop control to all-way stop control (2021)

Bicycle Boxes (2014)

Without bicycle box (before) With bicycle box (after)



Bicycle Boxes (2014)

Explanatory variables	Violation			No Stop Before Crossing			Dangerous Violation		
	Coef.	p-val.	Elas. *	Coef.	p-val.	Elas. *	Coef.	p-val.	Elas. *
Constant	-0.987	0.00	-	-2.045	0.00	-	-3.941	0.00	-
Male	0.569	0.00	14 %	0.576	0.00	10 %	0.844	0.00	4 %
Young Adult	0.803	0.00	19 %	0.851	0.00	12 %	1.161	0.00	4 %
Wear Helmet	-0.343	0.00	-9 %	-0.290	0.01	-5 %	-0.560	0.01	-2 %
Group Arrival	-0.337	0.00	-8 %	-0.742	0.00	-12 %	-0.839	0.00	-4 %
Bicycle Box	0.211	0.01	5 %	0.273	0.01	5 %	-	-	-
Number of observations	2291			2291			2291		
Percentage of positive obs.	47 %			24 %			6 %		
Log-likelihood	-1530.32			-1198.82			-482.99		
Pseudo R²	0.034			0.046			0.054		

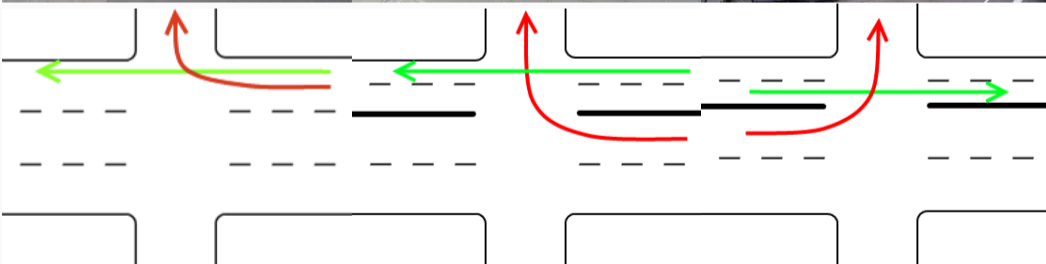
* Elasticity for discrete change of dummy variable from 0 to 1

Bicycle Boxes (2014)

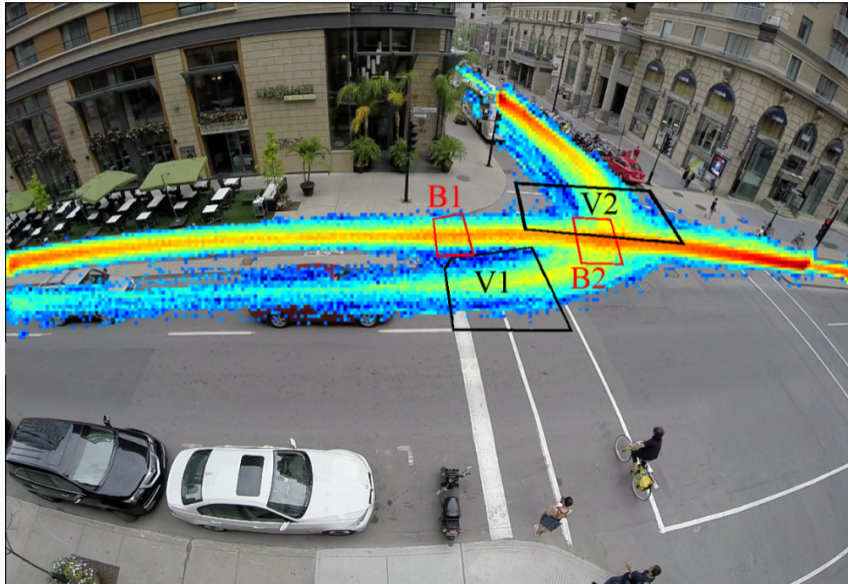
Explanatory variables	Interaction Type 1						Interaction Type 2					
	Interaction (PET < 5s)			Dangerous Interaction (PET < 1.5s)			Interaction (PET < 5s)			Dangerous Interaction (PET < 1.5s)		
	Coef.	p-val.	Elas.	Coef.	p-val.	Elas.	Coef.	p-val.	Elas.	Coef.	p-val.	Elas.
Constant	-0.559	0.00	-	-1.954	0.00	-	-2.994	0.00	-	-4.354	0.00	-
Bicycle Flow during 30s before	0.423	0.00	7.7 %	0.434	0.00	2.1 %	-	-	-	-	-	-
Vehicle Flow 1 during 30s before	0.091	0.00	1.6 %	0.040	0.04	0.2 %	0.063	0.00	0.4 %	-	-	-
Vehicle Flow 2 during 30s before	-0.086	0.00	-1.6 %	-0.082	0.01	-0.4 %	0.117	0.00	0.8 %	0.097	0.00	0.1 %
Presence of Bicycle Box	-0.739	0.00	-14 %*	-1.226	0.00	-7 %*	-0.726	0.00	-5 %*	-2.050	0.00	-2 %*
Observations	1054						1054					
Percentage of positive obs.	27.6 %			7.5 %			9.8 %			1.3 %		
Log-likelihood	-544.00			-251.48			-299.85			-66.44		
Pseudo R²	0.133			0.109			0.117			0.110		

* Elasticity for discrete change of dummy variable from 0 to 1

Cycle Tracks: Turning Vehicles and Cyclists (2015)



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	Model I. Cycle track on the right vs. no cycle track			Model II. Cycle track on the left vs. no cycle track			Model III. Cycle track on the right vs. cycle track on the left		
	Coef.	Std. Err.	Sig.	Coef.	Std. Err.	Sig.	Coef.	Std. Err.	Sig.
Cycle Track on Right	0.395	0.181	0.03	-	-	-	-	-	-
Cycle Track on Left	-	-	-	Not Significant			-0.513	0.131	0.00
Bicycle Flow for 5s before to 5s after	Not Significant			0.088	0.038	0.02	0.066	0.034	0.05
Turning-Vehicle Flow for 5s before to 5s after	-2.771	0.132	0.00	-3.265	0.090	0.00	-3.131	0.080	0.00
Number of Lanes on the Main Road	-0.151	0.078	0.05	Not Significant			Not Significant		
Number of Lanes on the Turning Road	Not Significant			0.324	0.146	0.03	0.457	0.178	0.01
Cut-off 1	-6.599	0.353	0.00	-7.372	0.301	0.00	-7.621	0.323	0.00
Cut-off 2	-4.233	0.273	0.00	-3.807	0.223	0.00	-4.125	0.265	0.00
Cut-off 3	-3.150	0.256	0.00	-2.102	0.211	0.00	-2.479	0.258	0.00
Number of Observations	2880			4803			6567		
Log likelihood	-804			-1876			-2330		

Association of Gender with Interaction Safety (2016)

Explanatory variables	β_1			β_2		
	Parameter	z stat	p value	Parameter	z stat	p value
	$y^* = \beta_1 X + \beta_2 wX + \beta_3 w + \varepsilon$					
Bike Speed	-	-	-	0.0272	2.31	0.021
Helmet	-	-	-	-	-	-
Vehicle Speed	-	-	-	0.0250	2.38	0.017
Truck/Van	-	-	-	-	-	-
Platoon Leader	-	-	-	0.2395	1.63	0.104
Red	-0.7713	-4.99	0.000	-	-	-
Bike First	-	-	-	-	-	-
Pedestrian	-	-	-	-	-	-
Stanley	-0.3774	-2.56	0.010	-	-	-
Peel	-	-	-	-	-	-
Mackay	-	-	-	-0.4946	-2.41	0.016
Metcalfe	-0.2384	-1.75	0.080	-	-	-
Denis	-	-	-	-	-	-
Union	-0.8953	-2.21	0.027	0.6657	1.35	0.178
	β_3			β_3		
Male	-1.1703	-3.79	0.000	-1.1703	-3.79	0.000
Tau 1			-0.2007			
Tau 2			1.0455			
Number of cases			1514			
Log likelihood at convergence			-1488.69			
Log likelihood for constants- only model			-1522.09			
Pseudo R ²			0.0219			

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- There is a **convergence**: good design is easy to find and rather obvious, e.g., based on the Global Street Design Guide [1]
- There is a **lack of evidence** on specific treatments in different contexts
- What to do if there is **not enough space**?

There is a **philosophical question** with lights and other traffic control devices: are they needed? Are spaces with little to no traffic control devices (naked streets) safer? How to encourage **awareness and safe interacting behavior**?

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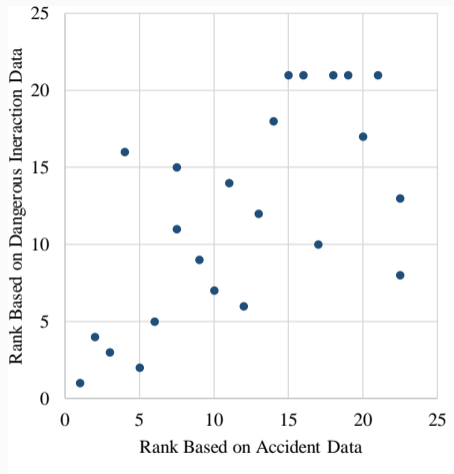


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Questions?

Correlation with Accidents



Spearman Rank Correlation of 0.64



Global Designing Cities Initiative and National Association of City Transportation Officials.

Global street design guide.

Island Press, 2016.