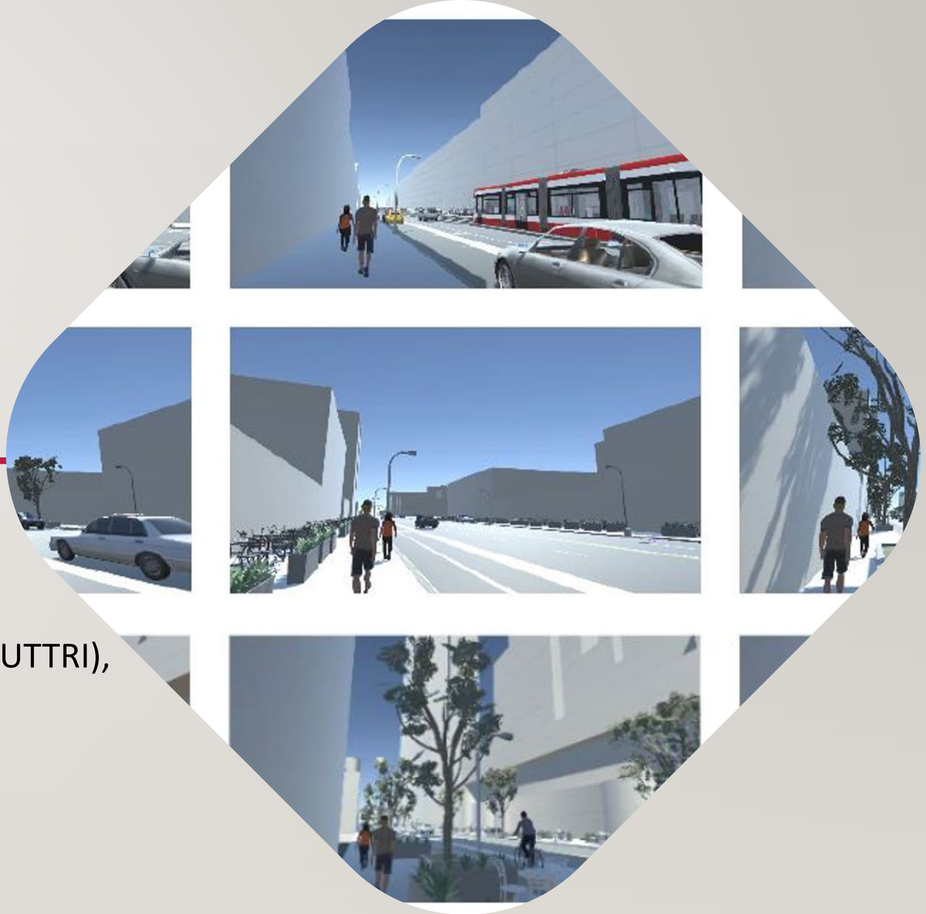
EVALUATING COMPLETE STREETS WITH A 3D STATED PREFERENCE SURVEY



A COLLABORATION BETWEEN UNIVERSITY OF TORONTO TRANSPORTATION RESEARCH INSTITUTE (UTTRI),

ESRI CANADA, OCAD UNIVERSITY & WATERFRONT TORONTO

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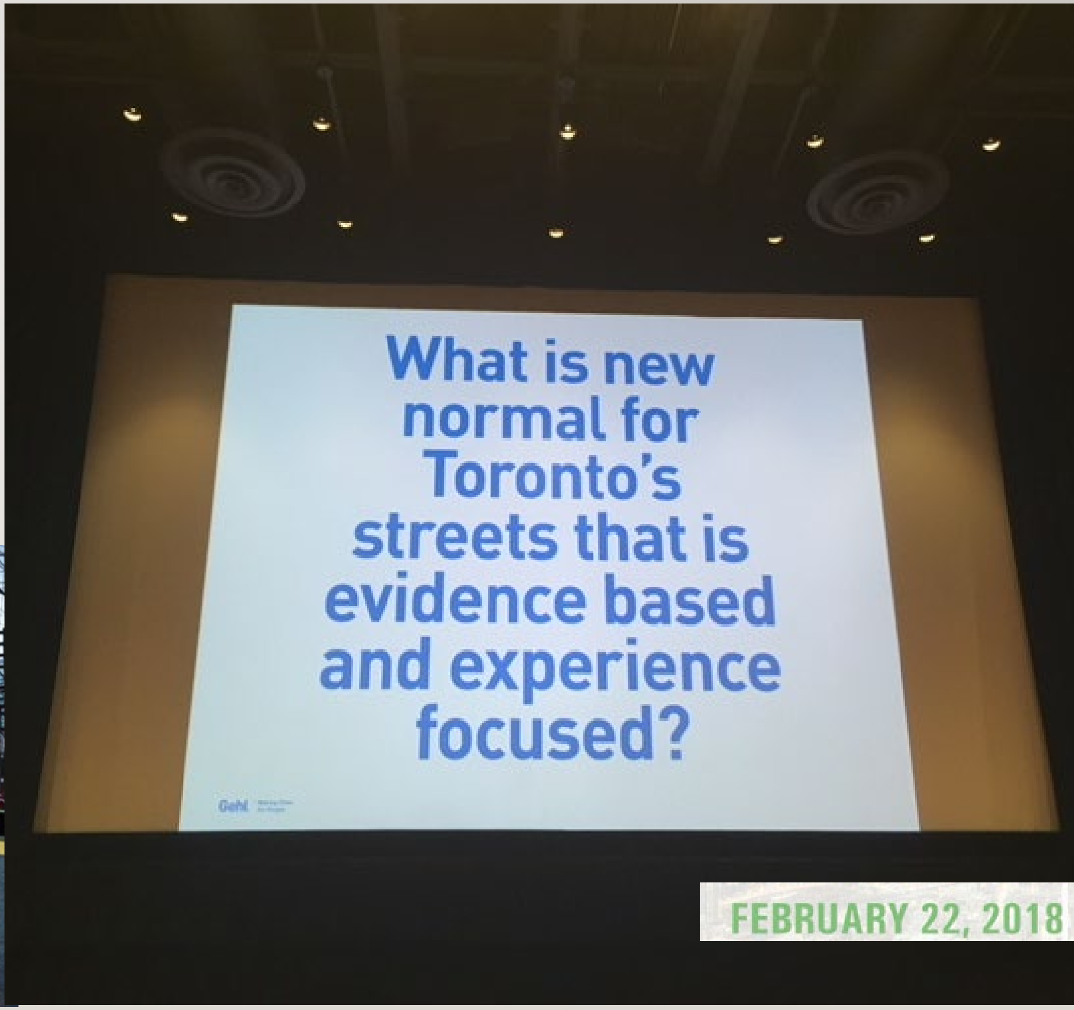
MOTIVATION

- Evidence-based design tools are needed to assess the **trade-offs** required between the many possible uses of roadway space.
- Most empirical evidence for street design focuses on functionality of streets for automobile and transit throughput.
- Design guidelines for complete streets are **rarely based on empirical evidence** of their relationship to behaviour or **user experience**.

Relevance



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DEVELOPING A COMPREHENSIVE EVIDENCE-BASED FOR EVALUATING COMPLETE STREETS

Well established empirically based methods for assessing traffic and transit level of service

Few methods exist for empirically evaluate the walkability of a street and the user experience

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Routledge
Taylor & Francis Group

Check for updates

Measuring the completeness of complete streets

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ABSTRACT

A tool for measuring the "completeness" of a complete street has applications in developing policy, prioritising areas for infrastructure investment for a network, and solving the right-of-way allocation problem for individual streets. A literature review was conducted on the state-of-art in the assessment complete street designs. Complete streets assessment requires a context-sensitive approach, thus context-sensitive standards of "completeness" must first be established by combining a street classification system with sets of priorities and target performance levels for the different types of streets. Performance standards should address a street's fulfilment of the movement, environmental, and place functions, and be flexible enough to account for the many ways that these functions of a street can be fulfilled. Most frameworks reviewed are unsuitable for evaluating complete streets because, with few exceptions, they guide street design by specifying the design elements for inclusion on the street. Secondly, the performance of a street can be assessed according to transportation, environmental, and place criteria, and compared to the target performance levels specified by the street's classification. As there are many different impacts to consider on a street, additional work is required to define the priorities and performance objectives for different types of streets.

ARTICLE HISTORY
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KEYWORDS
Complete streets; context-sensitive design; transportation; place; environment

DEVELOPING AN EVIDENCE BASE FOR WALKABILITY FOR COMPLETE STREETS PLANNING

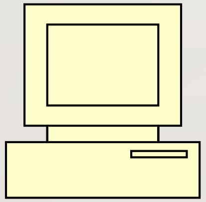
1	30	3	15	4
2	30	1	35	4
3	30	1	20	4
4	20	1	25	4
5	25	5	30	2
6	20	3	35	2
7	20	1	20	4
8	25	3	40	2
9	25	5	25	2
10	20	5	15	2
11	30	5	30	2
12	25	3	40	4

experimental design →

online survey respondents →

0 0 1 0
0 1 0 0
0 1 0 0
0 0 0 1
1 0 0 0
0 1 0 0
1 0 0 0

data →



estimation →

$\hat{\beta}$

$se(\hat{\beta})$

results →

evidence base →

informed planning →

Complete Streets

Partially adopted from Rose & Bliemer (2009)

METHOD

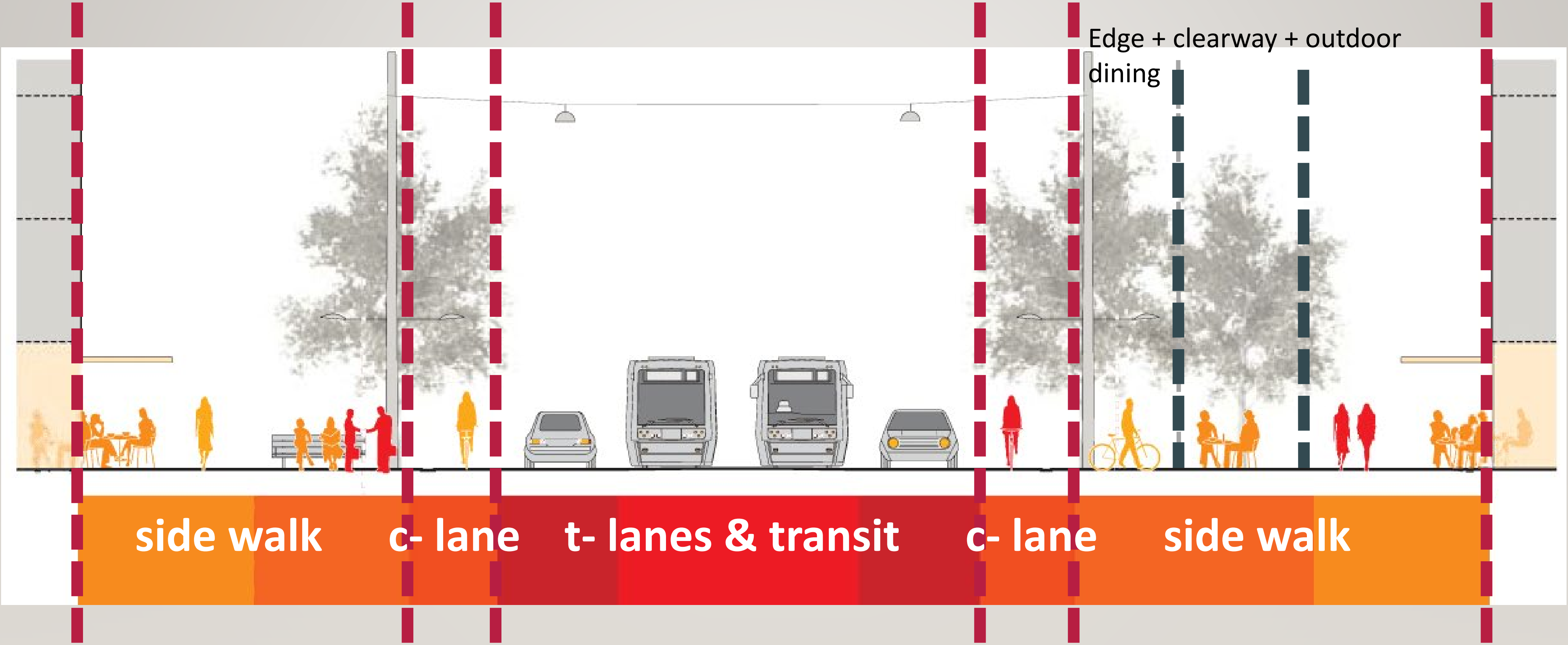
- Scope: Attributes at the **street segment level**, for the purpose of **recreational** walking

- **Web-based survey**: rate an existing street (revealed preference) + re-rate systematically manipulated options (stated preference).

- **Visualization**: ESRI's CityEngine + Unity

  Locations: A number of streets at Toronto waterfront & down town

side walk + curb lane + through lanes & transit + curb lane + side walk ☑



Adjacent buildings and land uses ☒

QUESTIONS

- Are pedestrians willing to trade sidewalk width for trees/outdoor dining?
- What design features are likely to make broader streets with more lanes more favourable for pedestrians?
- Which are preferred by the pedestrians for the curb-side use: on street parking, one or two-way bicycle lanes or transit?

METHOD

- Formalized stated preference design
- Visualized 3D Animated environment
- Statistical analysis of using mixed logit model with panel effects

Experimental design

Attributes

Through lane	Curb lane	Side walk
car+car	none	narrow edge + wide clearway
transit+transit	one-way cycle path	medium edge + normal clearway
car+car+car+car	two-way cycle path	medium edge + wide clearway
car+transit+transit+car	on-street parking + cycle path	outdoor dining + normal clearway
transit+car+car+transit	cycle path + on-street parking	narrow edge + normal clearway + outdoor dining

Attribute levels

Attributes

Experimental design

Through lane	Curb lane	Side walk
• car+car	• none	• narrow edge + wide clearway
• transit+transit (3.5 m + 3.5 m)	• one-way cycle path 2*(0.8 m + 1.5 m)	• medium edge + normal clearway 2*(1.6 m + 1.6 m)
• car+car+car+car	• two-way cycle path	• medium edge + wide clearway
• car+transit+transit+car	• on-street parking + cycle path	• outdoor dining + normal clearway
• transit+car+car+transit	• cycle path + on-street parking	• narrow edge + normal clearway + outdoor dining

Street width: 18 m

Experimental design: orthogonal design

Scenario	through lane	curb lane	sidewalk	tlane_width	clane_width	sidewalk_width	street_width
King street							
1	transit+car+car+transit	none	medium edge+wide clearway	13	0	9,6	22,6
2	car+car	cycle path+on street parking	medium edge+normal clearway	6	9,4	6,4	21,8
3	car+car	cycle path_one way	narrow edge+normal clearway+outdoor dining	6	4,6	11,2	21,8
4	transit+transit	cycle path_one way	medium edge+wide clearway	7	4,6	9,6	21,2
5	car+car	cycle path_two way	outdoor dining+normal clearway	6	3,8	9,6	19,4
6	car+car+car+car	none	medium edge+normal clearway	12	0	6,4	18,4
7	transit+transit	cycle path_two way	medium edge+normal clearway	7	3,8	6,4	17,2
8	transit+transit	none	outdoor dining+normal clearway	7	0	9,6	16,6
9	car+car	none	narrow edge+wide clearway	6	0	8	14
Queens Quay between Lower Jarvis & Lower Sherbourne							
1	car+transit+transit+car	on street parking+cycle path	medium edge+normal clearway	13	9,4	6,4	28,8
2	car+transit+transit+car	cycle path_one way	outdoor dining+normal clearway	13	4,6	9,6	27,2
3	car+car+car+car	cycle path_two way	narrow edge+normal clearway+outdoor dining	12	3,8	11,2	27
4	car+transit+transit+car	cycle path_two way	medium edge+wide clearway	13	3,8	9,6	26,4
5	car+car	on street parking+cycle path	medium edge+wide clearway	6	9,4	9,6	25
6	transit+car+car+transit	cycle path_two way	narrow edge+wide clearway	13	3,8	8	24,8
Queens Quay between Yonge & Freeland							
1	car+transit+transit+car	cycle path_two way	medium edge+wide clearway	13	3,8	9,6	26,4
2	car+car	on street parking+cycle path	medium edge+wide clearway	6	9,4	9,6	25
3	transit+car+car+transit	cycle path_two way	narrow edge+wide clearway	13	3,8	8	24,8
4	car+car+car+car	cycle path_one way	narrow edge+wide clearway	12	4,6	8	24,6
5	car+transit+transit+car	none	narrow edge+normal clearway+outdoor dining	13	0	11,2	24,2
6	transit+car+car+transit	cycle path_one way	medium edge+normal clearway	13	4,6	6,4	24
Villiers Street Don to Cherry							
1	transit+car+car+transit	on street parking+cycle path	narrow edge+normal clearway+outdoor dining	13	9,4	11,2	33,6
2	transit+car+car+transit	cycle path+on street parking	outdoor dining+normal clearway	13	9,4	9,6	32
3	car+car+car+car	on street parking+cycle path	outdoor dining+normal clearway	12	9,4	9,6	31
4	car+car+car+car	cycle path+on street parking	medium edge+wide clearway	12	9,4	9,6	31
5	car+transit+transit+car	cycle path+on street parking	narrow edge+wide clearway	13	9,4	8	30,4
6	car+transit+transit+car	on street parking+cycle path	medium edge+normal clearway	13	9,4	6,4	28,8

DEMONSTRATION OF THE WALKABLE STREET 3D SURVEY

SAMPLE

- Pre-test on approx. 100 students, staff & planning contacts

- 600 Torontonians (representative sample by age, gender& residence location in Toronto)

Figure 4: Place of residence of respondents within City of Toronto districts

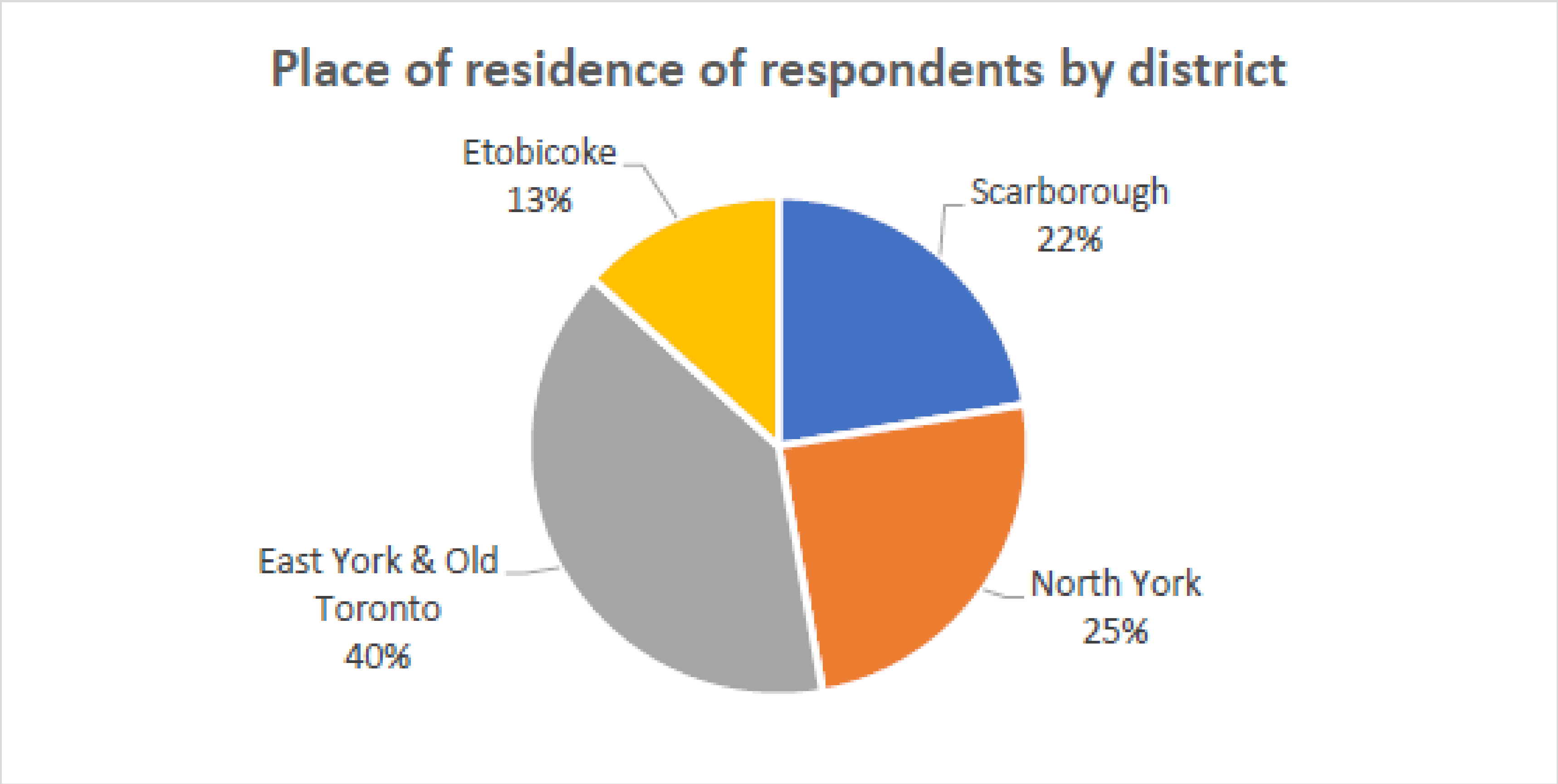


Table 6: Census profile vs survey profile based on age and gender

Age group	2016 census profile		Survey profile	
	% male	% female	% male	% female
20-29 years	49	51	47	53
30-39 years	48	52	44	56
40-49 years	48	52	45	55
50-64 years	48	52	48	52
65 years and over	43	57	42	58

Table 7: Census profile vs survey profile based on geography

Place of residence	2016 census profile (%)	Survey profile (%)
East York & Old Toronto	37	40
Etobicoke	15	13
North York	25	25
Scarborough	23	22

Figure 9: Survey respondents' auto-vehicle access

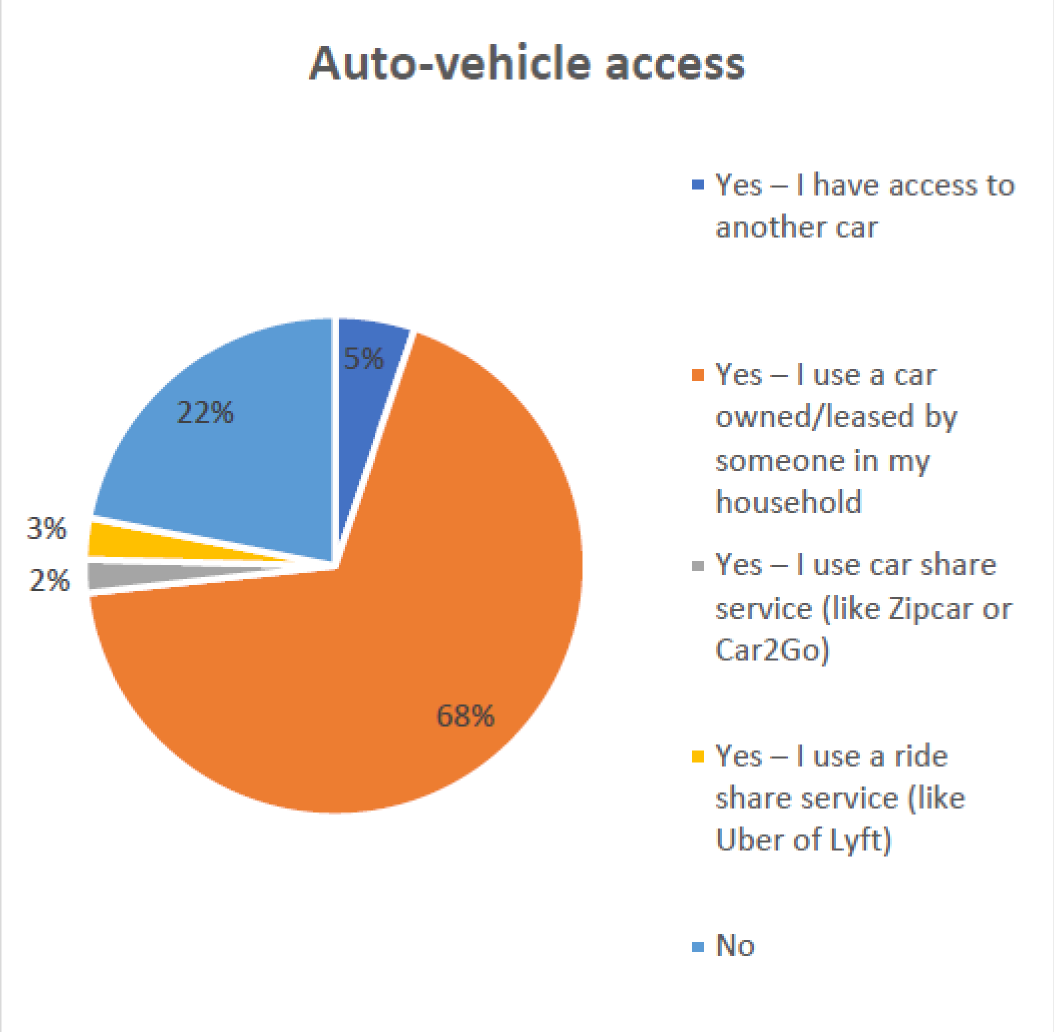
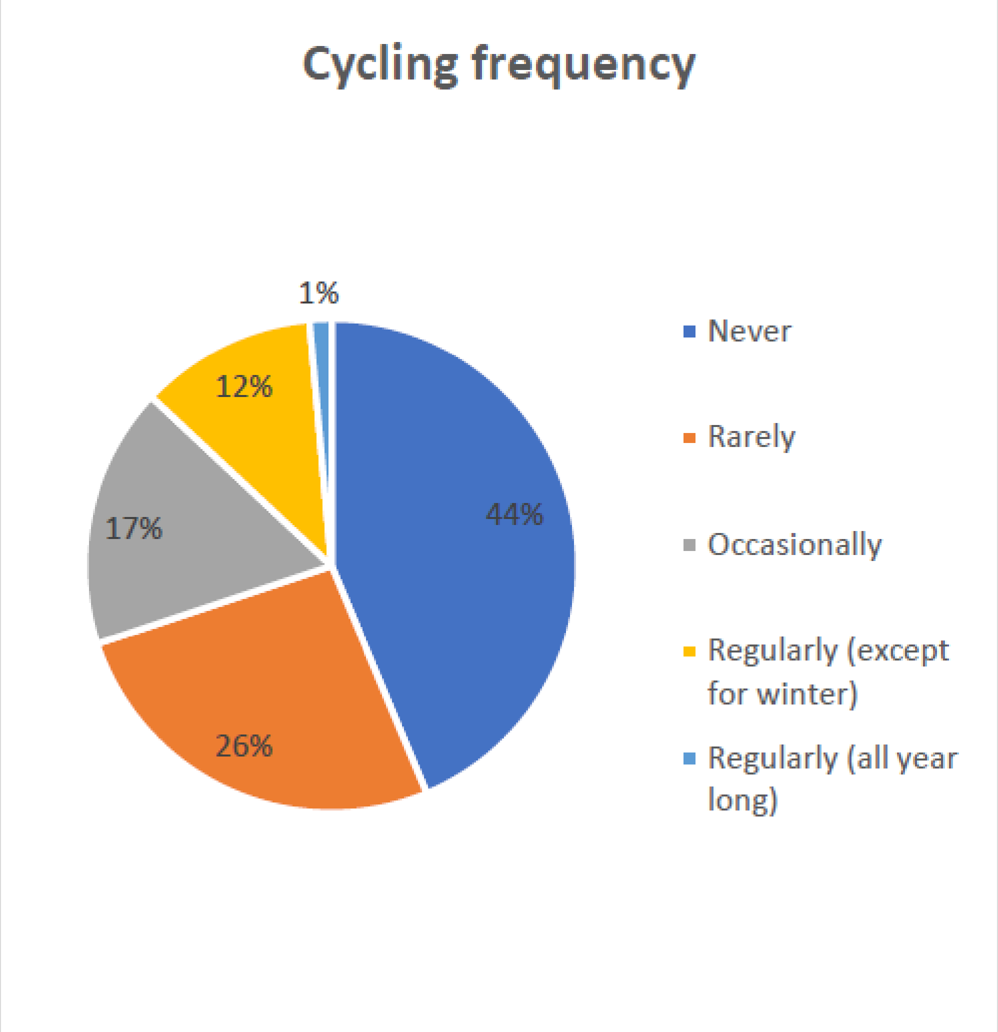


Figure 8: Survey respondent's cycling frequency



METHOD

- 600 respondents with 9 choice tasks (3 choices per task) → 5400 cases
- Starting with univariate simple logit models→ determine significant variables
- Multivariate models → determine highest performance

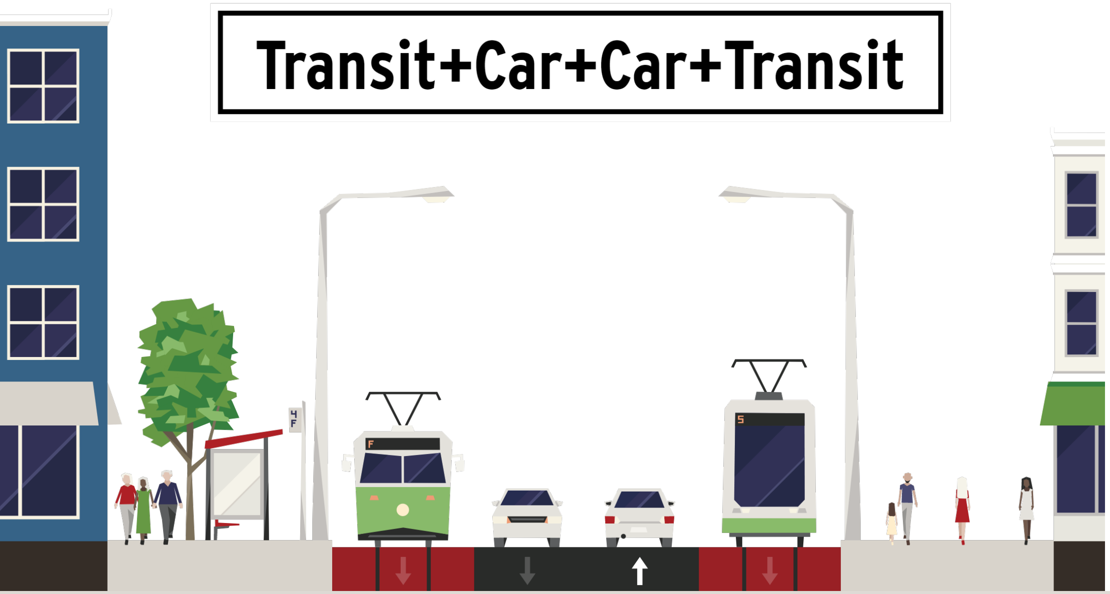
MODEL RESULTS

Table 4: MMNL panel model results from survey data

Explanatory variables	Name	Coefficient (β)	t-test
car + transit + transit + car	CT	0.431	7.55
Standard deviation (car + transit + transit + car)	STDEV	0.808	11.86
transit + transit	TRAN	0.170	2.21
transit + car + car + transit	TC	0.451	9.84
two-way cycle path	TWOCYC	0.243	5.47
one-way cycle path	ONECYC	0.190	3.45
one-way cycle path + on street parking	CP	-0.325	-5.66
trees + 3.2m pedestrian walkway	TREE-WSW	0.305	7.11
curbside outdoor dining and trees + 1.6m pedestrian walkway	SW-CURB	0.185	4.20
3.2m pedestrian walkway	SWONLY	- 0.254	-4.97
Final log likelihood	-5702.58		
AIC	11423.16		

THROUGH LANE PREFERENCES

- With transit > only car
- Cars in the middle lane > transit in the middle lane



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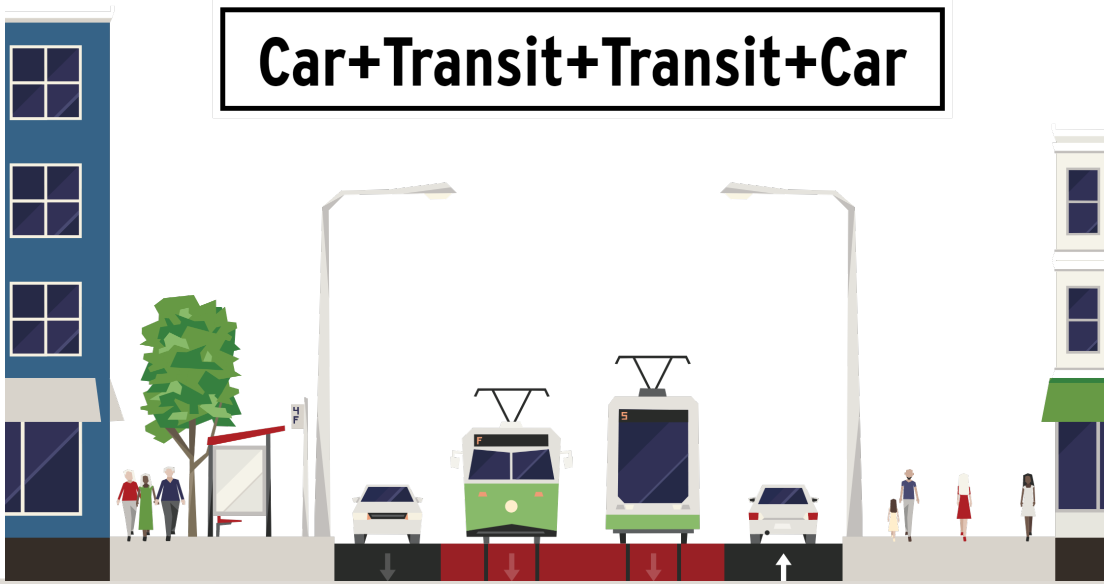
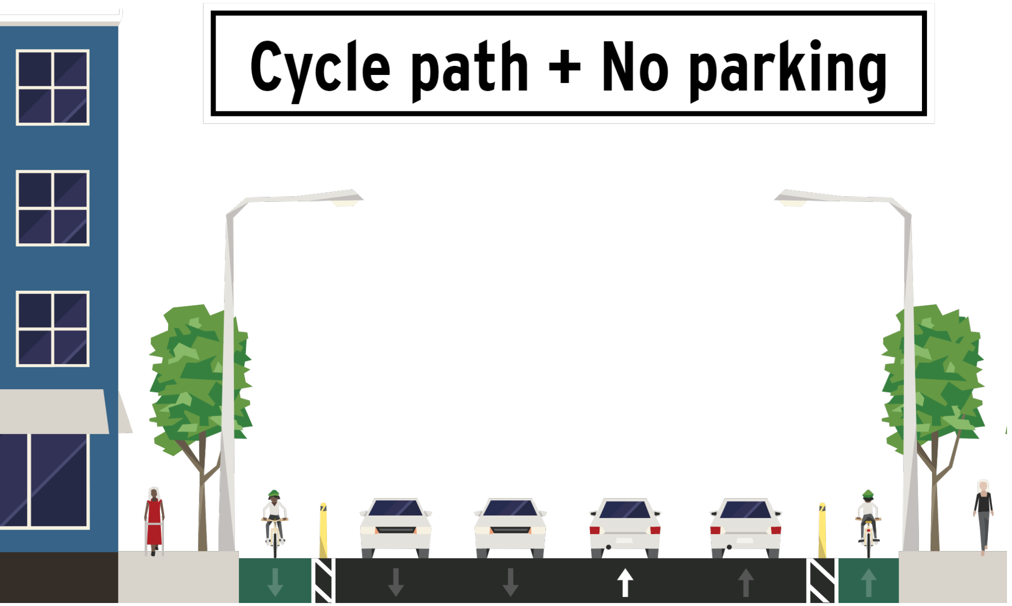


CURB LANE PREFERENCES

- Two-way cycle path > One-way cycle path
- Cycle path only > cycle path with on-street parking



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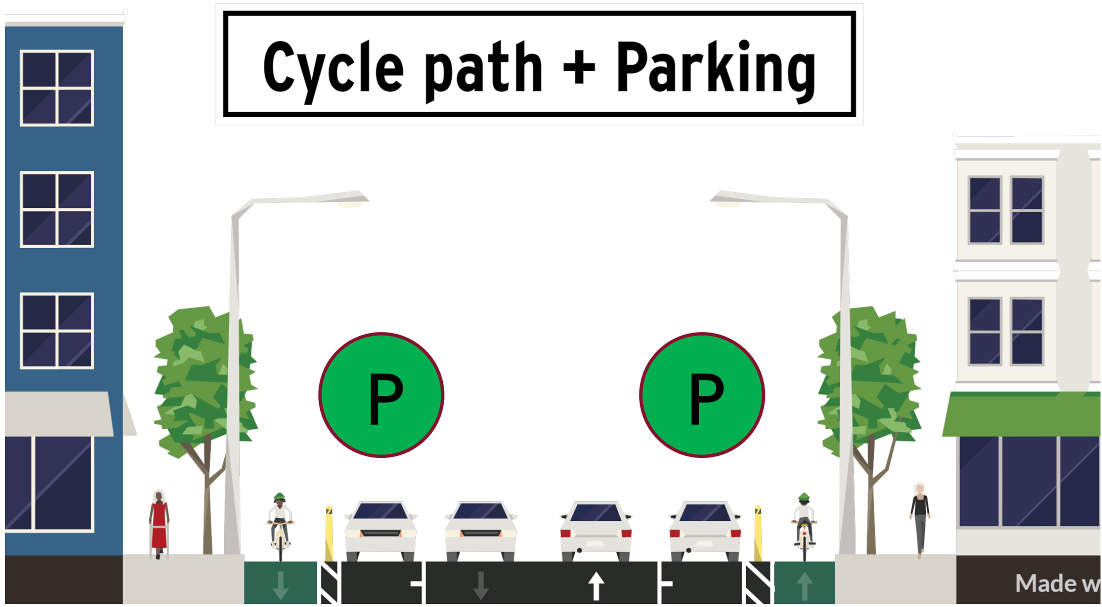
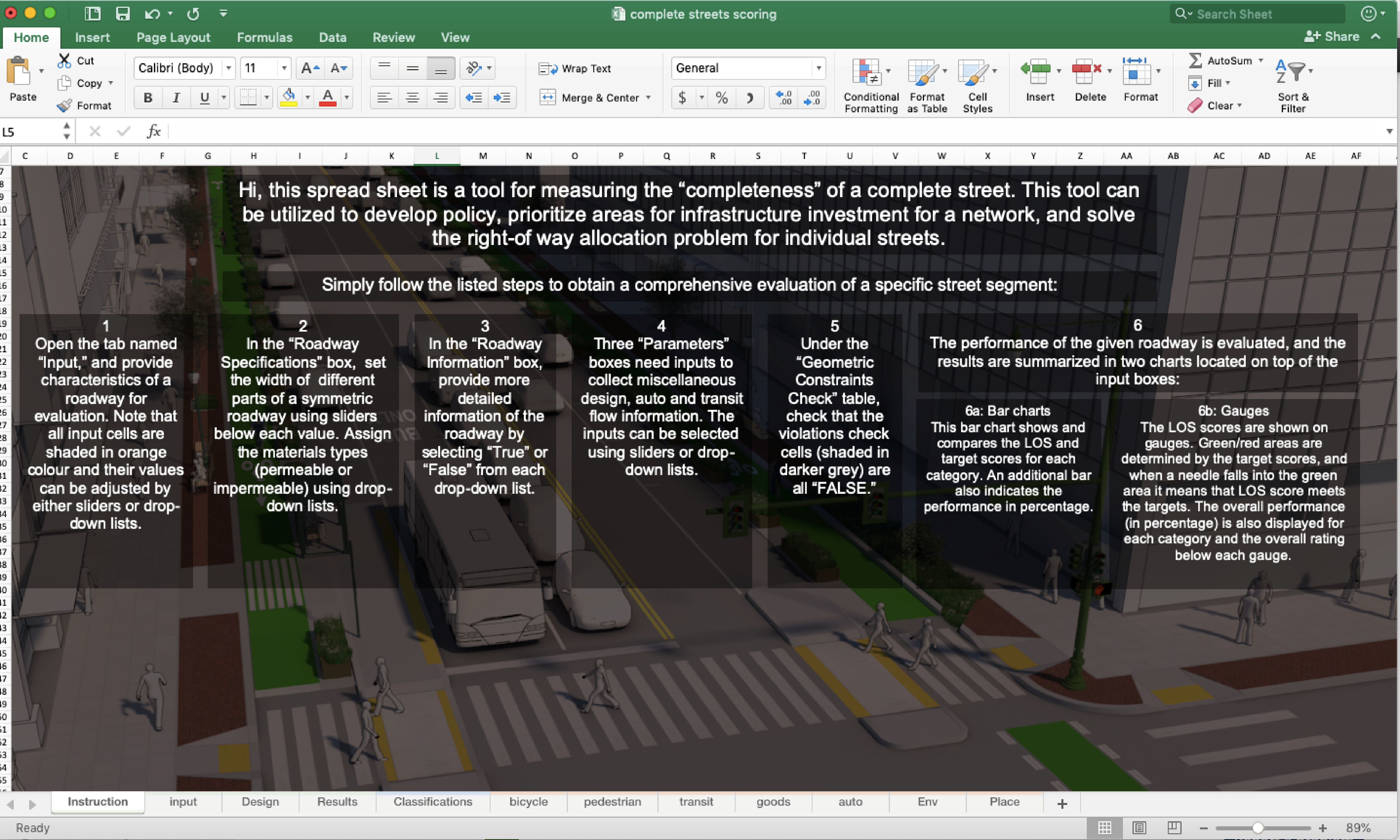


SIDEWALK PREFERENCES

- Trees + wide (3.2 m) walkway 
- Narrow sidewalk + trees & outdoor dining > Wide sidewalk

CONTINUING RESEARCH

- Relation of preferences to socio-demographics and travel habits
- ‘Dashboard’ platform to visualize and assess various street designs→Policy-support - commercializable product


complete streets scoring
Hi, this spread sheet is a tool for measuring the "completeness" of a complete street. This tool can be utilized to develop policy, prioritize areas for infrastructure investment for a network, and solve the right-of way allocation problem for individual streets.
Simply follow the listed steps to obtain a comprehensive evaluation of a specific street segment:
1
Open the tab named "Input," and provide characteristics of a roadway for evaluation. Note that all input cells are shaded in orange colour and their values can be adjusted by either sliders or drop-down lists.
2
In the "Roadway Specifications" box, set the width of different parts of a symmetric roadway using sliders below each value. Assign the materials types (permeable or impermeable) using drop-down lists.
3
In the "Roadway Information" box, provide more detailed information of the roadway by selecting "True" or "False" from each drop-down list.
4
Three "Parameters" boxes need inputs to collect miscellaneous design, auto and transit flow information. The inputs can be selected using sliders or drop-down lists.
5
Under the "Geometric Constraints Check" table, check that the violations check cells (shaded in darker grey) are all "FALSE."
6
The performance of the given roadway is evaluated, and the results are summarized in two charts located on top of the input boxes:
6a: Bar charts
This bar chart shows and compares the LOS and target scores for each category. An additional bar also indicates the performance in percentage.
6b: Gauges
The LOS scores are shown on gauges. Green/red areas are determined by the target scores, and when a needle falls into the green area it means that LOS score meets the targets. The overall performance (in percentage) is also displayed for each category and the overall rating below each gauge.
Instruction
input
Design
Results
Classifications
bicycle
pedestrian
transit
goods
auto
Env
Place

INPUTS (OUR ENGINEERING APPROACH)

Roadway Specifications	Grass	Sidewalk	Buffer	Striped parking	Bike Lane/ paved shoulder	Buffer/ striped parking	Curbside through lane	Through lane 2	Through lane 3	Median/2-way left turn lane	Through lane 4	Through lane 5	Curbside through lane	Buffer/ striped parking	Bike Lane/ paved shoulder	Striped parking	Buffer	Sidewalk	Grass
Width (m)	3	1.5	2.4	0	1.5	0.2	3.6	0	0	3	0	0	3.6	0.2	1.5	0	2.4	1.5	3
Designed with permeable materials?	TRUE		TRUE							FALSE							TRUE		TRUE

Roadway Information

Is there a raised buffer between sidewalk and other users (e.g. planters, trees)?	FALSE	Is there unstriped parking in the curb lane?	FALSE	Is the median actually a 2-way left turn lane?	TRUE

Note: designed for analysis of symmetrical roadways only. In reality each direction of travel should be analyzed seperately

Miscellaneous Design Parameters

Available width (m)	34
Street Classification	Local Arterial
Pavement condition (1:Worst; 5:Best)	3
Is street in CBD of a city with population > 5M?	TRUE
Are there also exclusive left-turn lanes? (2-way left turn lane does not count)	FALSE
Segment Length (m)	200
Signal Progression Type	Adverse signal progression

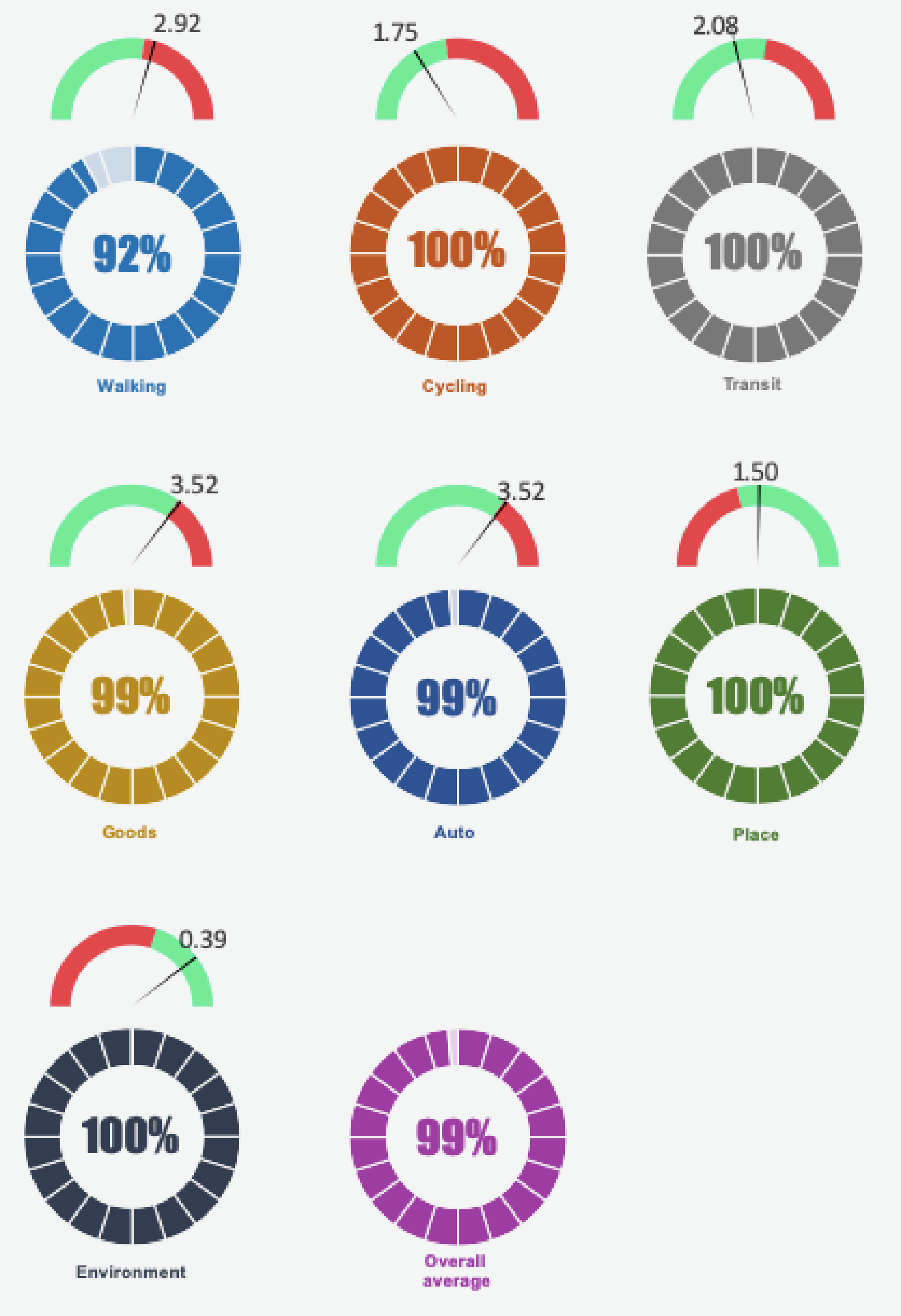
Auto Traffic Flow Parameters

Posted Speed Limit (km/h)	56
Average operating speed (km/h	29.17
Average annual daily traffic volume *	10000
Peak Hour Factor *	0.92
Peak Factor *	0.08
Directional Factor *	0.55
Percentage heavy vehicles	5%
On-street parking occupancy	0%

Transit flow parameters

Has buses?	TRUE
Has streetcar?	FALSE
Average transit operating speed	20
Transit Headway (minutes)	10.82
Average excess wait time per trip *	10.51
% bus stops in study section direction with shelters	100%
% bus stops in study section direction with benches	0%

OUTPUTS


2.92
92%
Walking
1.75
100%
Cycling
2.08
100%
Transit
3.52
99%
Goods
3.52
99%
Auto
1.50
100%
Place
0.39
100%
Environment
99%
Overall average

NEXT STEP

- Working with Ontario College of Art and Design and ESRI to bring the evidence base into a graphical design environment

THANK YOU!
QUESTIONS?