Traffic Quality Index to intersections considering fuel efficiency

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Urbanization

+ Traffic Impacts

Impact studies

Intersection analisys

Data obtained **analytically** or by **simulation**.

The available methodologies could consider more comprehensive variables related to **quality** and **fuel efficiency**

USUAL METODOLOGIES:
Highway Capacity Manual (HCM) - criteria: delay per vehicle
Intersection Capacity Utilization (ICU) - criteria: hp volume / saturation volume

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Methodology
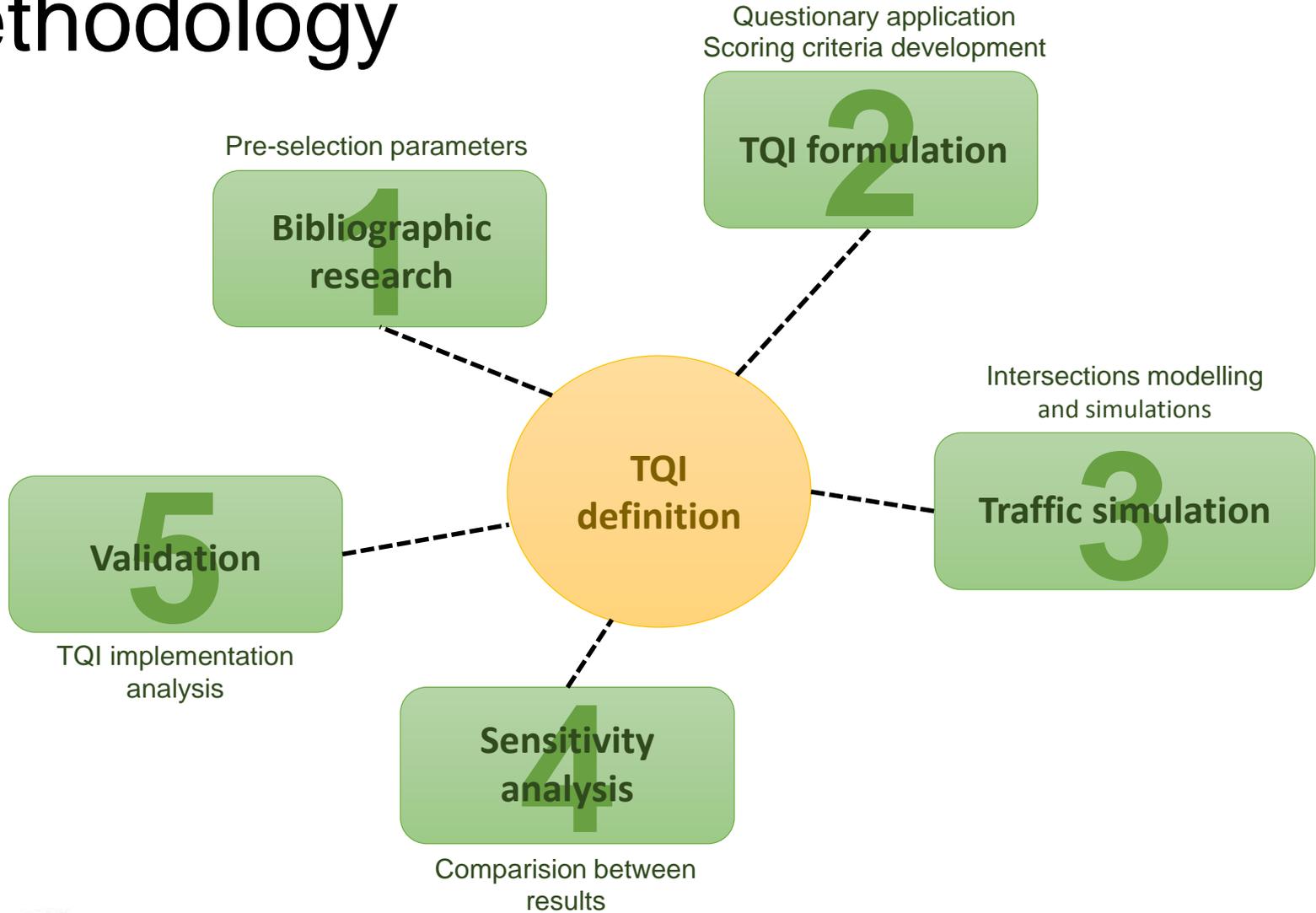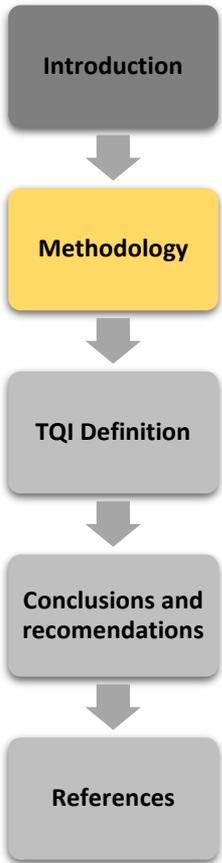
Methodology

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Pre-selection parameters

1
Bibliographic research

Questionary application
Scoring criteria development

2
TQI formulation

Intersections modelling
and simulations

3
Traffic simulation

TQI definition

5
Validation

TQI implementation
analysis

4
Sensitivity analysis

Comparision between
results

TQI Definition

TQI Definition

$$TQI_S = \sum_{i=1}^{N} W_i Q_i \qquad\qquad TQI_P = \prod_{i=1}^{N} Q_i^{W_i}$$

Where:

TQI_S = Traffic Quality Index – sum formulation;

TQI_P = Traffic Quality Index – product formulation;

W = weight assigned to each variable;

Q = score of the intersection for each selected variable;

i = each variable included in the calculation;

N = total number of variables included in the calculation.

TQI Definition

40 experts
23 quest. 1
18 quest. 2

- TQI formulation
  - Questionary application

№	Variable	Meas.	Answers (%)		
			Include	Not to include	Undecided
1	Delay per vehicle	Seconds	94.4	5.6	0.0
2	Stop delay per vehicle	Seconds	83.3	16.7	0.0
3	Stops per vehicle	Stops/veh	72.2	22.2	5.6
4	Average speed	Km/hour	83.3	16.7	0.0
5	Fuel efficiency	Km/litre	83.3	16.7	0.0
6	Vehicles with denied entry to the road network	Units	66.7	33.3	0.0
7	Maximum queue length	Meter	83.3	16.7	0.0
8	Average queue length	Meter	100.0	0.0	0.0
9	95th percentile queue length	Meter	44.4	33.3	22.2

PS: Highlighted the highest values

TQI Definition

- TQI formulation
  - Questionary application

inclusion rate = inclusions ÷ valid responses

Inclusion rates > 70%
Redundancy 1, 2 and 4
Interdependence 7, 8 and 9
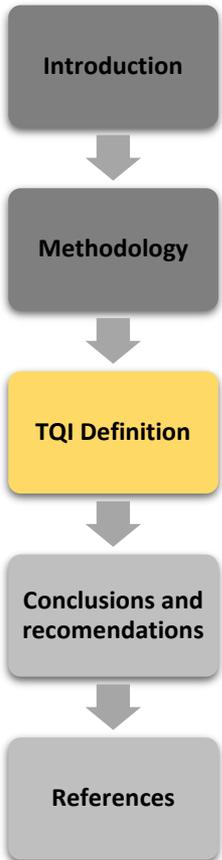
Nº	Variables	Resposes		Incl. rate x Weigh	Final weigth
		Inclusion rate	Weigth		
1	Delay per vehicle	0.9444	7	6.61	0.2778
2	Stop delay per vehicle	0.8333	8		
3	Stops per vehicle	0.7647	7	5.35	0.2250
4	Average speed	0.8333	5		
5	Fuel efficiency	0.8333	7	5.83	0.2450
6	Vehicles with denied entry to the road network	0.6667	5		
7	Maximum queue length	0.8333	8		
8	Average queue length	1.0000	6	6.00	0.2522
9	95th percentile queue length	0.5714	5		
	Sum			**23.79**	**1.0000**

TQI Definition

$$A = f(x) = 0.001x_a^2 - 0.2004x_a + 9.9221$$

$$P = f(x) = 4.0884x_p^2 - 14.542x_p + 10.392$$

$$E = f(x) = -0.0064x_e^2 + 0.8249x_e - 0.5714$$

$$F = f(x) = 0.003x_f^2 - 0.1108x_f + 9.5821$$

- TQI formulation
  - Scoring criteria development

A-Delay per vehicle (s)

P-Stops per vehicle (stops/veh)

E-Fuel efficiency (km/l)
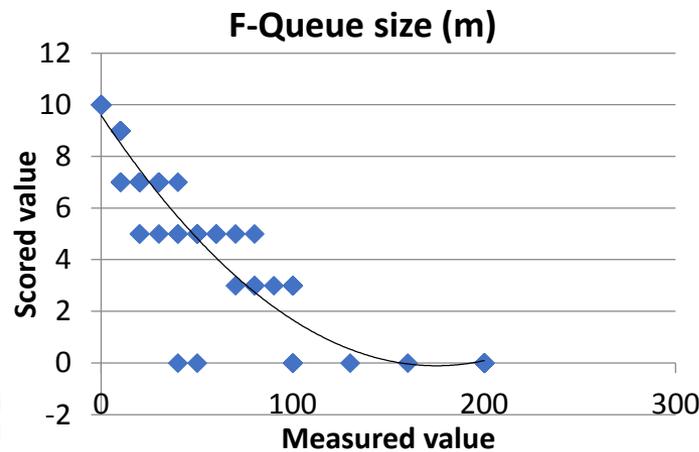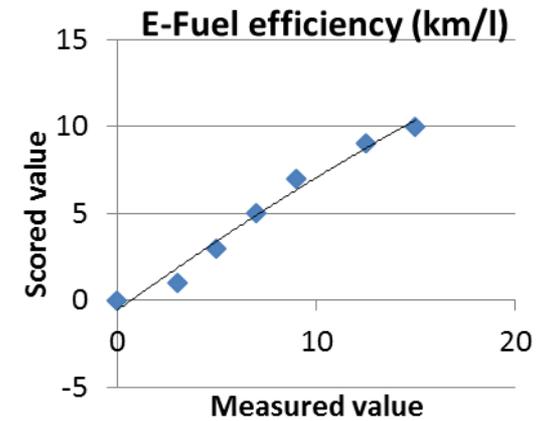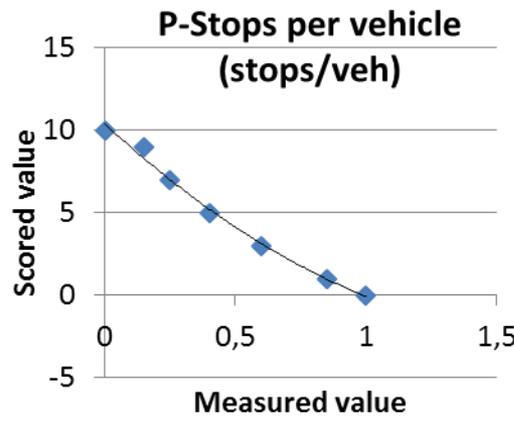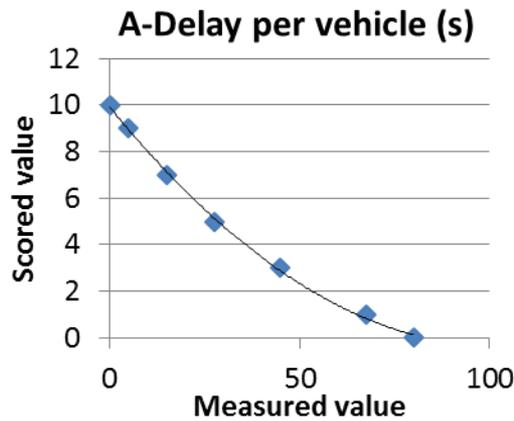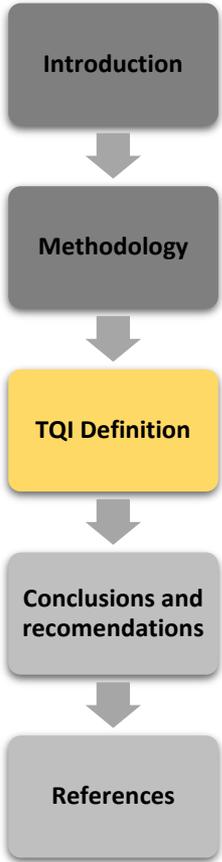
F-Queue size (m)

TQI Definition

- Traffic Simulation

Delay
ICU

Delay per veh.
Stops per veh.
Fuel efficiency
Queue size

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Int. 1A

Int. 1B

Int. 2A

Int. 2B

Int. 3A

Int. 3B

Int. 4A

Int. 4B

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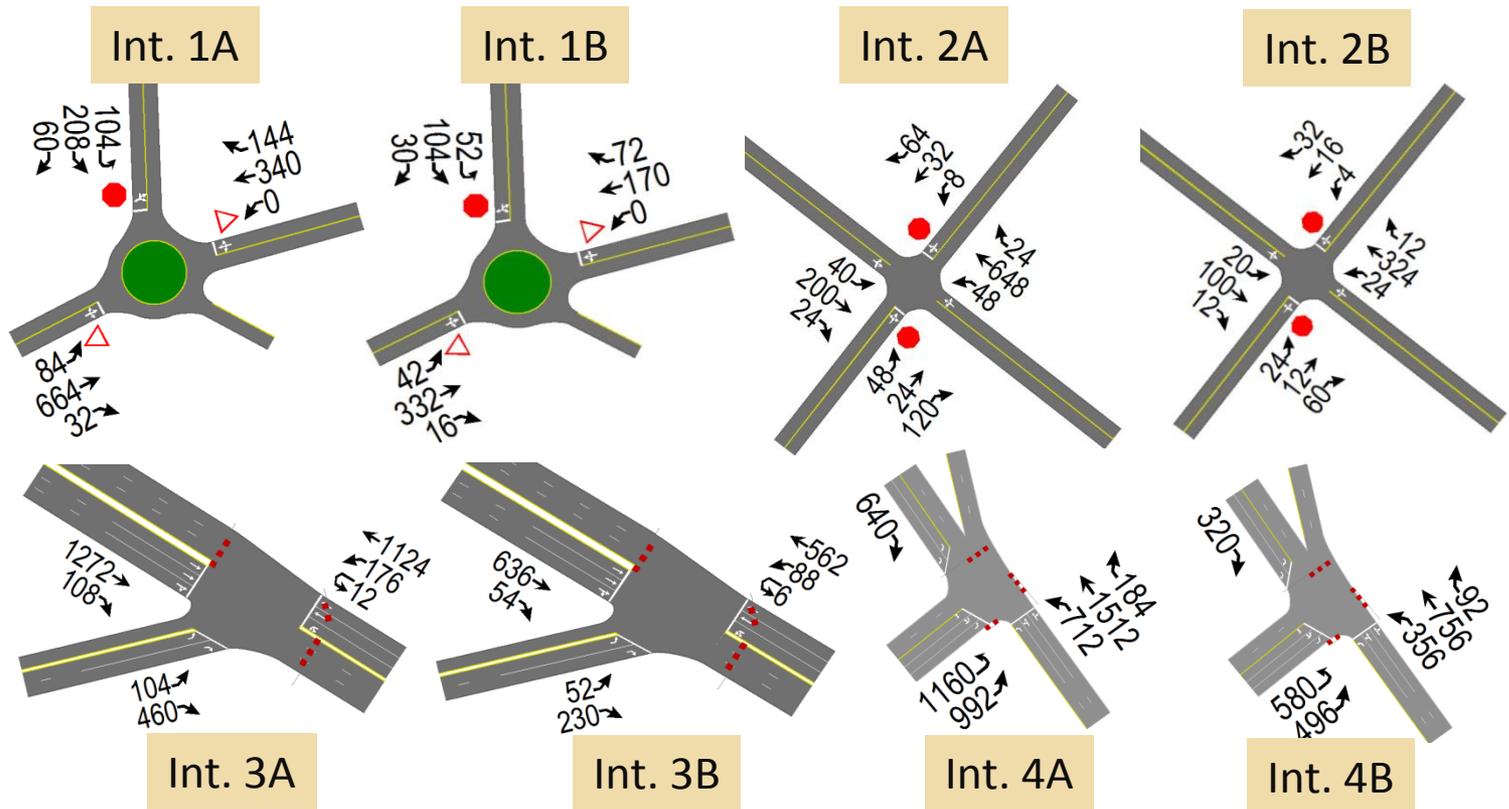
- Sensitivity analysis and validation

$$TQI_S = 0.2778A + 0.2250P + 0.2450E + 0.2522F$$
$$TQI_P = A^{0.2778} \times P^{0.2250} \times E^{0.2450} \times F^{0.2522}$$

Int.	TQI_S			TQI_P		
	A	B	B-A	A	B	B-A
1	6.40	7.71	1.31	6.00	7.58	1.58
2	8.20	8.88	0.68	8.13	8.84	0.71
3	4.89	5.82	0.93	4.62	5.56	0.94
4	4.86	5.62	0.76	3.95	5.41	1.46

>0   **>0**

Greater amplitude

Int.	IQT_S	IQT_P	ICU	HCM
1A	6.40	6.00	F	E
1B	7.71	7.58	A	A
2A	8.20	8.13	C	B
2B	8.88	8.84	A	A
3A	4.89	4.62	D	E
3B	5.82	5.56	A	B
4A	4.86	3.95	F	F
4B	5.62	5.41	A	B

TQI large variations not necessarily imply ICU and HCM large variations

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Conclusions and recomendations

Conclusions and recomendations

- The proposed index consists of indicators **commonly observed** in transport planning routine through computer simulation;

- This research indicates that the quality of the traffic of an urban intersection can be better analyzed if include in the formulation **stops per vehicle, fuel efficiency and queue length**, than just the delay per vehicle variable;

- The TQI formulation showed greater susceptibility of the **product equation** to the traffic volume change effects;

- **Index should not be static**.

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Thank you