

# **PASSENGER/OPERATOR OPINION SURVEY FOR TRANSIT STOP EVALUATION USING MULTI-CRITERIA DECISION-MAKING**

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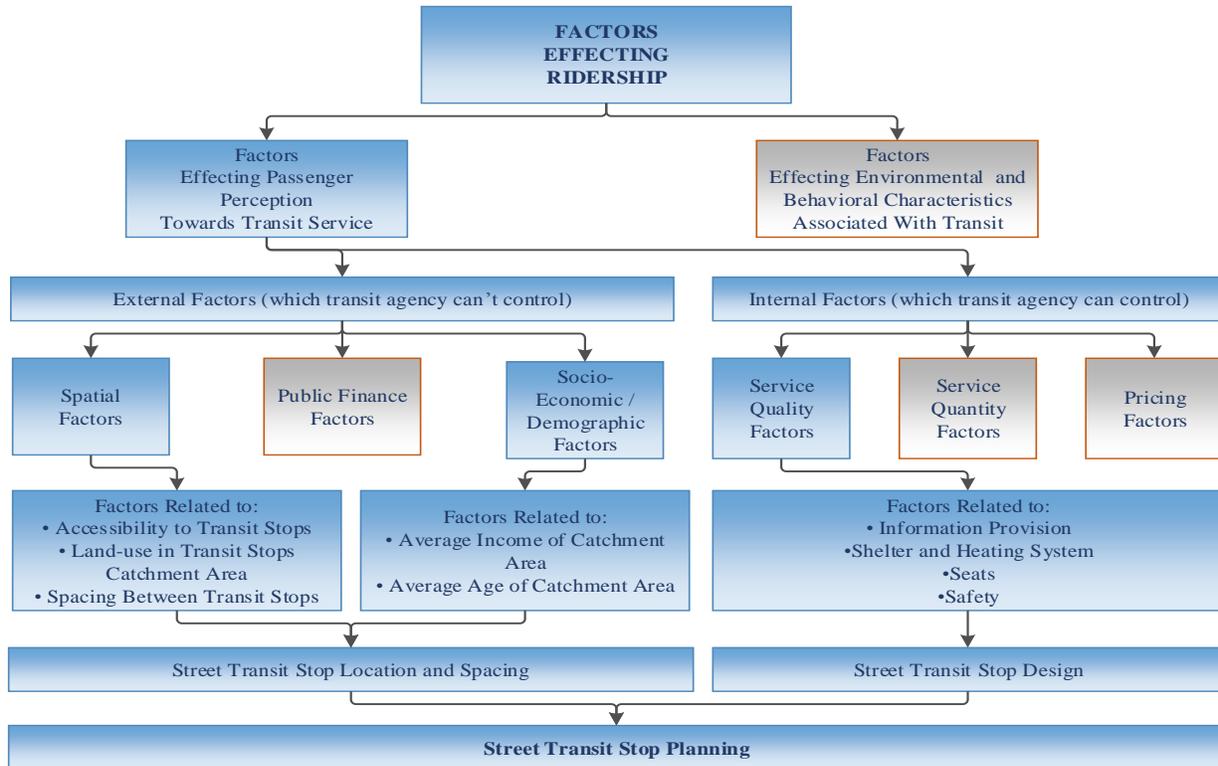
## **1.0 Introduction**

With an increase in automobile sales from 1.6 million in 2011 to 2 million in 2015 (Statistics-Canada, 2016), the concentrations of carbon monoxide, nitrogen oxides, and carcinogen-containing carbon particles have increased to alarming levels (Commoner, 1991). Taking transit not only reduces greenhouse gas emission by 70%, but also 175 tonnes of vehicles pollution in a rush hour can be saved (Statistics-Canada, 2016). However, public transit systems are suffering from many challenges; most importantly, ridership reduction. Ridership in Toronto reduced to the extent that fare collection recovered only 47% of transit expenses in 2012 as compared to 75% in 1986 (CUTA, 2012). This decrease in ridership was also due to government policy that in 1991, Canada reduced the tax on buying new car by 5.5%. The auto industry flourishes at the expense of transit and consequently transit begins to suffer financially. To cover this, the fare of transit increases at the time when auto prices go down. As a result, mode split for City of Kelowna in 2013 is 4.3% for transit compared with 82.2% for personal autos (Okanagan-Travel-Survey, 2013).

To study factors which increase ridership, two groups of factors could be identified, as shown in Figure 1 (Taylor & Fink, 2003). Out of these two groups, factors affecting passenger perception are believed to draw more ridership and are divided into internal and external factors. Internal factors are those over which the transit authorities have full control contrary to external factors over which transit agencies have no control. Among six external and internal factors, three factors are directly linked towards transit stops.

Numerous planning guidelines and service standards have been developed to examine the effect of transit stop on various service performance factors which suggested that transit routes with suitably spaced and located transit stops have faster travel times and are more economical to operate. However, a major drawback of these transit manuals is that the guidelines differs from one to the other and this difference adds uncertainty in the transit stop planning process. For example, according to best practices in transit service planning (Center-for-Urban-Tranportation-Research & University-of-South-Florida, 2009), the transit stop is desirable for at least 200 household units. However, according to OCTA(OCTA, 2004), a

transit stop is desirable for at least 500 household units. These differences in guidelines make it difficult for a transit stop planner to take decisions.



**Figure 1: Criteria Development**

Unavailability of relative importance between factors is another limitation of transit manuals like TCRP 19, TCRP 100 (Hunter-Zaworski, 2003), TCRP 26, BC Transit, Palm Tran Service Guidelines, Best Practices in Transit Service Planning, and SEPTA, to name a few. For example, it is not provided in any guideline that either vertical gap is more important or horizontal gap is more important. Similarly, according to TCRP 19 (Jacques & Levinson, 1996), factors like transit stop width, waiting time, weather condition, sidewalk width, distance of fire hydrant tank must be considered in providing seats at a transit stop. But like all other, they did not provide any ranking or prioritization of these factors. Further, best practices of all factors involved in transit stop planning are also not provided. For example, taking the above stated example of seats, TCRP 19 (Jacques & Levinson, 1996) does say that these factors are important in order to decide the seat provision but it didn't say anything on how much waiting time should be to provide the seats or how adverse weather conditions should be to provide the seats.

Given limited funding for transit stop design, decision of amenities provision is crucial for transit planners. To attract more riders, the priority of transit users must be considered in providing amenities.

Therefore, two separate surveys were conducted under this study (i.e. transit planning expert opinion survey and transit user opinion survey) to draw conclusions about the difference of agency and user perspectives. The specific objectives of this study were;

1. Develop best practices for factors effecting passenger perception for small, medium, large and metropolitan cities in Canada.
2. Develop priority ranking of perception factors from expert and user point of views.
3. Analyze the difference of expert and user opinion.

## **2.0 Survey Design**

### **2.1 Sample Design**

The target population of the survey is the transit planners and users across Canada. Besides transit agencies, transit planners are expected to be members of the transportation professional bodies. For the target population, the Canadian Urban Transit Association (CUTA) is contacted and a sample frame of about 773 professional members, working in Canadian transit industry, was obtained. For the transit user population, this survey focused on two cities, namely the City of Kelowna and the City of Vancouver. In Kelowna, out of the 4.8% trips made through transit, student share is more than 40%. Student mode split of UBC Okanagan campus, located in Kelowna, shows that 32% of students use public transit, which is expected to increase to 56%. In City of Vancouver, out of the 18% trips made by transit, student share is 58% in 2014. Therefore, in this survey, students of UBC Okanagan and UBC Vancouver campus were considered as target population.

The method for calculating the sample size is adopted from the study of Idris et al (Idris, Nurul Habib, & Shalaby, 2012) and calculations for sample size is given in Table 1 below.

### **2.2 Instrument Design**

An online questionnaire was designed and used to collect user/expert opinions. Respondents were invited through an email that included a link to the questionnaire. The expert survey was divided into the following 4 sections; however, the user survey only consisted of Section A.

1. Expert Information
2. Section A: Prioritization of factors and indicators
3. Section B: Best practices of indicators
4. Survey Feedback and Submission

**Table 1: Sample Size Calculation**

Sr. No.	Parameter		Values Used	
	Description	Abbreviation	Expert Opinion Survey	Transit User Survey
1	Target population size	N	773	61,113
2	Maximum population variability	P	0.5	0.5
3	Margin of error	e	5%	5%
4	Confidence Interval	CI	95%	95%
5	Design effect	DE	1.0	1.0
6	Z – value	z	1.96	1.96
7	Final sample size	n	257	382

**Expert information** was gathered to perform analyses on the data. To develop the transit stop guidelines based on the city size, city of employment was added in this section. Years of experience have a profound impact on the expertise level. Similarly, occupation and organization were added to judge the level of expertise which would be helpful in analyzing the results. All these questions were text type open-ended questions.

**Section A** gathers the prioritization (i.e. relative importance) of transit stop planning factors using pairwise comparisons. Factors of spatial and demographics were first arranged followed by design factors. At the start of section, an explanatory example was provided to help the respondents understand how to fill the questionnaire. 3-point bipolar Likert scales were used to input the weights of each factor. Figure 2 shows a snapshot of the user opinion survey (i.e. Section A of the expert opinion survey).

In this Likert scale, the transit user and transit planner were given the option to decide on the relative importance of two factors (i.e. which one is more important or both are equally important). The intensity level chosen was “*strongly more important*”, “*more important*” or “*equally important*”. Of the two factors provided, position of “hand”  shows the more important factor and its intensity.

**Section B** collects best practices in transit stop planning. Similar to Section A, Section B starts with an illustrative example which is also available on start of every page but kept hidden by default. Figure 3 shows a snapshot of section B for expert opinion survey.

Three cases were designed in Section B, “*Enter as Three Categories*”, “*Enter as Binary Category*” and “*I don’t Know*”. By default, “*Enter as Three Categories*” is selected where the expert is expected to classify best practices into three classes of “*Excellent*”, “*Acceptable*” and “*Unacceptable*”.

For mentioned purpose, indicate the relative importance of pair of factors using the provided slide bar.

For deciding location of street transit stop



**Figure 2: User Opinion Survey / Section A of Expert Opinion Survey**

Research on human capacity to deal with information has shown that there are some limitations on the amount of information that humans can retrieve, process, and remember. The number of categories can be defined by experts and can range from a minimum of three to a maximum of eleven qualitative levels (Khan & Sadiq, 2005). Accordingly, the survey was designed such that the upper limit of the “*Excellent*” category is auto-filled in the lower limit of the “*Acceptable*” category. Similarly, the upper limit of the “*Acceptable*” category is auto-filled in lower limit of the “*Unacceptable*” category. The default values were chosen according to a comprehensive literature review. For example, in Figure 3, all cited design manuals agree that stop spacing of 90m to 300m is acceptable. Therefore, it is assigned to “*Excellent*” category. However, one of the cited manuals indicates that up to 400m is also acceptable. Therefore, 300m to 400m is assigned to the “*Acceptable*” category. None of the referred manuals says that above 400m is acceptable. Therefore, stop spacing of more than 400m is assigned as “*Unacceptable*”. However, if the experts do not know about the three classes but know the acceptable range, “*Enter as Binary Category*” is selected where there is only one class of “*Acceptable*”. The default values were selected to satisfy all refereed manuals.

Case “*three*”, “*I Don’t Know*”, gives the opportunity to the expert to skip the question and move to next question. At the end of each question, a text box is provided to facilitate the experts to give their feedback about the question. In the above example, the stop spacing is considered as a function of the catchment area density (central business district, urban area, sub-urban area or rural area). However, if the expert thinks that stop spacing also depends on some other indicator, one can write in this text box.

Question 31: Stop Spacing - Central Business District (CBD)

Best practices in transit service planning suggest different values/ranges for the street transit (e.g. bus and streetcar) stop spacing in CBD, as shown below:

- Stop spacing can range from 200m to 300m, but typically can be 200m (Reference: <http://www.co.miami-dade.fl.us/transit/library/pdfs/misco/2013-title-vi-program-report/attachment-k.pdf>)
- Stop spacing can range from 90m to 300m, but typically can be 180m (Reference: <http://teachamerica.com/tih/PDF/transit-design-manual.pdf>)
- Stop spacing can typically be 400m (Reference: <https://at.govt.nz/media/imported/4394/AT-ARTA-Guidelines-Bus%20Stop%20Infrastructure%20Guidelines%202009.pdf>)



Please enter the typical values/ranges you would recommend for the above mentioned factor into the designated cells below. For your convenience, the cells below are pre-populated by typical values based on literature review. Please feel free to change or accept these values.

	Lower Limit	Upper Limit
Excellent	90	300
Acceptable	300 [auto filled]	400
Unacceptable	400 [auto filled]	999

Enter as Three Categories  
 Enter as Binary Factor  
 I Don't Know

For any other comments, please fill the textbox below:

Type here

**Figure 3: Section B of Expert Opinion Survey**

**Respondent feedback** is finally collected about the selection of factors and indicators using a 5-point Likert scale. The scale varies from strongly agree to strongly disagree, going through agree, tend to agree, and disagree. A text box is provided at the end to add any further factor/indicator which also affects the ridership. A screenshot of the feedback section is shown in Figure 4.

**2.3 Data Collection Process**

Phase – 1 of the survey was the pilot survey to test the survey instrument design. the pilot survey was carried out from March 1<sup>st</sup>, 2017 to March 15<sup>th</sup>, 2017. The sample size of the pilot survey was 27 individuals that included transit planners, faculty members, and UBC Okanagan students. The reason for selecting this population for pilot was that they judge both types of surveys (i.e. expert opinion survey and transit user survey).

#### Feedback on Survey:

Does the survey cover all factors that affect transit ridership?

Strongly Agree



Strongly Disagree

Please mention any other factor(s) that can be considered (optional):

Type here

#### **Figure 4: Feedback on Survey**

Transit planners were chosen as they were the main respondents of survey Phase –II (main survey) and their feedback to improve the survey was of utmost importance. Faculty members and students use public transit as their primary source of commute and they are also a part of target population for transit user survey. Being involved in the transportation engineering planning and design, they are believed to have some basic knowledge about transit stop planning and the technical terminologies used in survey. Part A of the survey was straightforward and it was not expected to be problematic. However, there were some minor suggestions for Part B which were then added into the main survey. After incorporating the feedback in survey, phase – II (main survey) will be carried out from March 20<sup>th</sup>, 2017 to April 15<sup>th</sup>, 2017. In phase – II, email addresses of transit planners, obtained from CUTA and ITE, will be used to send the invitations. The pilot results of Part A will be merged with the result of main survey because of their sample population relevance and accuracy. However, the results of Part B will not be merged, but they gave a foundation for preparation of the result generation sheets and further statistical testing.

#### **2.4 Data Analysis Procedure**

The data obtained from surveys will be preliminary analyzed according to the city size and occupational level of expert. The inputs of experts and users will be analyzed using the following methods:

For Part A of surveys, the inputs will be analyzed by taking weighted geometric mean of all the experts/users prioritization to define a single number for small, medium, large and metropolitan cities each. Geometric mean is considered instead of arithmetic mean because priority decided by the expert/user is a ratio between two factors/indicators. Weighted geometric mean is used because number of years of experience has a profound impact of expertise and hence, the opinion of a person having more experience is more important than the opinion of a person have less experience.

For Part B of the expert opinion survey, the inputs will be analyzed by:

- Performing t-test to find the variation in upper and lower limits
- Finding the coefficient of variation (CV) of each level to determine how much is the variation in expert/user opinion

### 3.0 Summary and Conclusion:

Transit stop plays a very important role in improving transit system performance, maintaining traffic flow, passenger safety and security. In public transportation system, transit stops are the points which effect passenger perception towards transit system and can affect ridership. Till date, operational factors are given more importance; therefore, this paper discusses important passenger perception factors to be considered while planning a transit stop. Guidelines for street transit stop planning are available in several transit agency manuals and mathematical models. However, these guidelines do not report on every street transit factor, vary a lot from each other, and do not give rank-based factor list. Further, transit user opinion is also important to rank the amenities provided at transit stop. To answer these limitations, this paper report on expert and user opinion surveys, their population and sample size, instrument design, preliminary pilot survey findings and procedure for result analysis.

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