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On passenger saturation flow in public transport doors

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ABSTRACT

In previous studies the authors have shown passengers' boarding and alighting times for the Transantiago system obtained at the Pedestrian Accessibility and Movement Environment Laboratory (PAMELA) of University College London. Following this line of research, the aim of this paper is to demonstrate the existence of pedestrian saturation flows in public transport doors and show some values of this variable under different conditions. The methodology to achieve this aim was real-scale experiments performed in both PAMELA and the Human Dynamics Laboratory at Universidad de los Andes in Santiago de Chile. Different groups of people getting off a mock-up of a public transport vehicle were recorded by means of video cameras. The videos were then visually processed to find values of passenger saturation flow according to door configurations. The variables studied were the vertical gap between the platform and the vehicle chassis and the width of the door. Results indicate that it is possible to define values of passenger saturation flows for different characteristics of public transport doors. These values proved to be statistically sensitive to both the vertical gap and the width of the door. In addition, results indicate that there seems to be both a vertical gap and a door width for which the flow of passenger reaches its optimum rate.

1. Introduction

A main challenge for public transport is to provide a good level of service. This is focused on quantitative and qualitative characteristics of the journey. One of the most important variables that affect the level of service is dwell time. This variable is defined as the time that a public transport vehicle remains stopped while transferring passengers, including acceleration and braking time (TRB, 2000).

Dwell time depends on the number of boarding and alighting passengers and how quick they carry out these tasks. The speed of passengers is determined by the fare collection method, internal layout of vehicles and the density of passengers. However as it is said in the Transit Capacity and Quality of Service Manual the most important variable that affects dwell time is the number of doors, because "the greater the number of door channels, the less time required to serve a given passenger flow" (TRB, 2003: 23).

Passenger flow for public transport doors is defined as the number of passengers that pass through a car doorway width. The data can be partitioned into boarding, alighting or mixed flow. When this flow reaches the highest value it can be called passenger saturation flow, similar to the concept of vehicle saturation at junctions.

According to Akçelik (1995), saturation flow is used at junctions as a basic characteristic to calculate the capacity of a traffic signal approach during a typical signal cycle (C). For a given junction approach, saturation flow is defined as the

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maximum discharge rate of a queue of vehicles during the effective green time (g) of that approach, as shown in Fig. 1. At the start of the green period (G) there is a transient period (L_1), called start loss, before the discharge rate reaches its maximum, which is the saturation flow (S) for that approach. If the queue remains until the start of the amber time (A), there is another transient period (L_2), called end gain, until the start of the red time (R). Thus, the effective green time is defined as $g = G - L_1 + L_2$. The value of the saturation flow and transient periods depend on both the traffic composition and geometry of the junction approach. The histogram shown in Fig. 1 shows the discharge of vehicles during 0.1 min if the queue remains until the end of the amber time. In this example, the green plus amber time is 0.7 min or 42 s. This sort of traffic behaviour is obtained if there is no blockage downstream of the stop line; e.g., the downstream street is not blocked by the backup of vehicles which may reduce the discharge rate. The relationship between saturation (S) and capacity (Q) of a traffic signal approach is $Q = uS$, where $u = g/C$.

We tried to apply a similar concept to the alighting capacity of a public transport door. In the case of a public transport door, the cycle time "C" can be considered as the time between the stop and the start of the vehicle at the station, and the effective green time "g" would be the time during which doors are opened. Therefore, if a vehicle remains a different time period at the station and/or the time during which door are opened changes, the passenger capacity of the door will be different. Which do remain constant is the passenger saturation flow, as in the case of a signalized junction.

The flow–time curve shown in Fig. 1 indicates that not all vehicles in a queue take the same time to cross the stop line at a traffic signal. The question posed by this research is: Could the same behaviour occur in public transport doors? Our hypothesis is that the same sort of discharge curve of passengers may be found at public transport doors. That is, an unobstructed alighting process of a bunch of passengers through a public transport door may be similar to the unobstructed discharge of a queue of vehicles at a traffic signal.

Following this hypothesis, the aim of this paper is to study the passenger saturation flow in public transport doors by mean of real experiments. The results are part of a research project funded by FONDECYT – Chile (No. 1120219) which has the objective of generating design guidelines to public transport facilities in developing countries. This includes the following specific objectives: (a) Demonstrate the concept of passenger saturation flow in public transport doors; (b) to measure passenger saturation flows in laboratory; (c) to study the effects of different physical design variables on the passenger saturation flow such as door width and vertical gap.

This article is made of five sections, including this introduction. In the second chapter the literature review on boarding and alighting times as well as door capacity is summarized. Next, in chapter three the methodology for obtained passenger saturation flows is shown. Results and analysis are presented in chapter four. Finally, the conclusions of this research are provided in chapter five.

2. Literature review

During 2008 and 2009 at UCL PAMELA, a real-scale mock-up of a bus and people getting on and off the mock-up were used to obtain average boarding and alighting times per passenger (Fernandez, 2011). In the 2008 experiments, at PAMELA three variables were controlled: platform height, door width, and fare collection method. In 2009 the effect of the density of passengers inside the vehicle on the average boarding and alighting times was studied. In this case, different passenger densities were considered. More than 300 video records of boarding and alighting processes were obtained in those experiments. Tables 1 and 2 show a summary of the results of the experiments obtained from at least 30 samples for each density, where μ is the mean boarding or alighting time per passenger, σ is the corresponding standard deviation

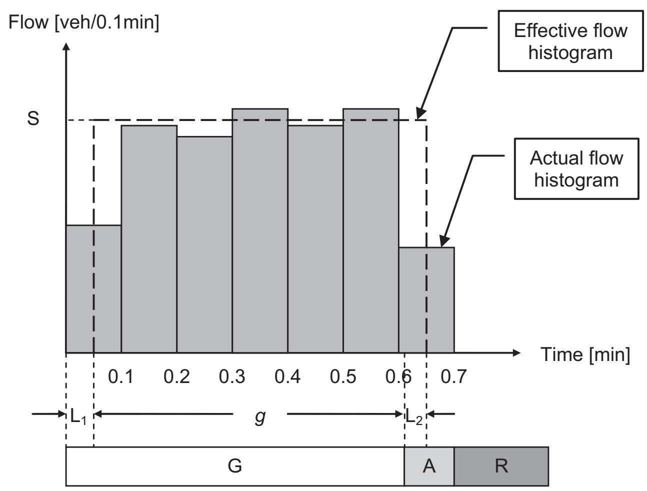

Fig. 1. Typical flow discharge at a traffic signal.