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Pedestrian traffic management at BRT stations: a case study in Santiago De Chile

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Abbreviations: BRT, bus rapid transit; EPEV, extra vehicular payment station; LABRT, Latin-American bus rapid transit; HDL, human dynamics laboratory

Introduction

The new type of Bus Rapid Transit (BRT) station called Extra Vehicular Payment Station (EPEV in Spanish) has been implemented at Departmental Street, in the south-east part of Santiago de Chile. The EPEV is similar to other Latin-American BRT stations,[1,2] with different architectural, physical and operational characteristics. The innovation in the actual situation of these stations is to bring a high standard of level of service to passengers. Consider mainly: (1) two adjacent berths, (2) a shelter with special architectural design, (3) controlled access through turnstiles (2 entry turnstiles and 2 exit doors), (4) automatic doors between the platform and the buses, and (5) information and services for users. The stations are 60meters long (54m discounting the turnstile area) and 2.85m wide, which yields a platform area of 154m^2. Considering a maximum density of 1pass/m^2, the stations have a capacity of approximately 150 passengers inside. This project is conceived as a pilot plan that includes two stations: North EPEV East-West direction and South EPEV West-East direction. Both stations are closer to Macul Metro Station (Line 4) as it is shown in Figure 1.

Figure 1 Characteristics and location of EPEV stations in Santiago de Chile.

The problem presented in this case report is the lack of methodologies for estimating the pedestrian traffic management measurements at the EPEV, in which pedestrian traffic management is defined as the rational administration of the movement of people to generate adequate behaviour in the public space and improve the use of pedestrian infrastructure.[3] Despite the important research done on studying bus transit systems,[4–9] there is a lack of studies in which pedestrian traffic management measurements are implemented in BRT stations, which is the main objective of this case report. Recently, some authors,[10–12] have been studying the use of pedestrian traffic management in railway systems such as metro stations, in which door position indicators reduced the conflicts between passengers.

Method

The method used to study the EPEV was classified in two stages: a) Simulate scenarios to analyze the pedestrian traffic management via micro simulator models; b) Propose design recommendations into BRT stations. The software LEGION Studio,[13] was used to study the passenger movement. Unlike other models, LEGION represents each pedestrian as an intelligent entity capable of differentiating their behaviour, preferences, personal characteristics, and including physical and psychological factors such as dissatisfaction.[14] The results of the simulations were compared with indicators such as Service Level or LoS of Fruin,[15] which indicate the degree of congestion and conflict in an area of pedestrian traffic.

At both stations the turnstiles presented an average service time of 3s (maximum of 5s and a minimum of 2s). However, the exit doors presented an average service time of 1s (maximum of 2s and a minimum of 1s). In the actual situation there is no assignment of routes for each berth, so the two berths serve all routes in each EPEV. Table 1 presents the most critical period between 7:00 and 7:30pm, where D is the passenger demand, Q_b is the flow of buses, P is the number of boarding and alighting of passengers by bus, P_s is the number of boarding and alighting of passengers at each berth and Q_s is the flow of buses at each berth.

Table 1 Operational variables for actual situation at most congested EPEV

Variable	Boarding demand				Alighting demand			
Routes	102	107	108	E17	102	107	108	E17
D [pass/h]	44	166	124	14	5	42	19	66
q_b[bus/h]	5	9	7	6	5	9	7	6
P [pass/bus]	8.8	18.4	17.7	2.3	1	4.6	2.7	11
P_s[pass/bus]	47.2				19.3			
q_s [bus/h]	27				27			

Results

Figure 2 shows that the platform at EPEV reaches a LoS C without major problems, with a maximum value of 0.70pass/m^2 (capacity of 108 passengers at the platform). However, the entry turnstiles have a LoS F with a maximum value of 3.5pass/m^2. This involves queues and problems at the entrance to the EPEV. When the density increased at this area it produced a bottleneck at the exit turnstiles, reaching a maximum value of 1.50pass/m^2 (LoS E). Also, in this space passengers are not distributed evenly because 90% used the first door that is always opened by an operator and only 10% used the second door that is manually handled by each passenger. Finally, the urban space of each EPEV have some problems at the entry of the pedestrian crossing (3.30m wide), reaching a LoS E (density of 2.0pass/m^2).

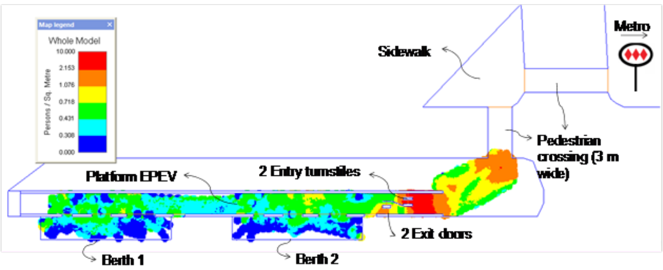

Figure 2 Pedestrian density maps at EPEV in actual scenario with assigned routes for each berth.

The actual scenario can be modified to improve the flow of passengers. For which it intends to apply a set of improvements, which it is called the optimized scenario. The first improvement is the layout of turnstiles. Three entry turnstiles and only one exit door were considered. Also, a handrail of 7m long was included to canalize passenger flow between the entry and exit at the entrance of each EPEV. Urban furniture was incorporated at the inside of each EPEV and the width of the pedestrian crossing was increased to 5.0m. These improvements reached a LoS D at the exit door with a maximum value of 1.0pass/m^2 (33% less than the actual situation). Also, at the platform the situation remains stable at a LoS C without major problems, reaching a maximum value of 0.70pass/m^2. The pedestrian crossing reached a LoS E, with a maximum value of 1.60pass/m^2 (20% less than the actual situation).

In a situation with double demand of passengers and flow of buses, the optimized scenario can be improved using an EPEV in "sawtooth" bay. Figure 3 shows that the platform in "sawtooth" allows independent movements of buses to and from each berth (to achieve over passing when two tracks are at one EPEV). This would involve adjusting the EPEV modularly in such form, reaching a length of 56m (62m length including the area of turnstiles) and a width of 2.85m. Each EPEV will be connected by a platform corridor of 7m^2. This means that the whole system will have a platform of 166m^2 and a maximum space of 65 m long. With respect to LEGION simulation it is noted that the platform remain stable with a LoS C and a maximum value of 0.7pass/m^2, without major problems of congestion. In this case, the shape of the EPEV generates an underutilized area at the connecting of the platforms, forming corners, where you can install urban furniture (maps, seats, trash bins, etc.) which does not affect the natural flow of passengers. In addition, at the turnstiles, LoS F is reached with a maximum value of 3.50pass/m^2 and the exit door reaches a LoS E with a maximum value of 2.0pass/m^2.

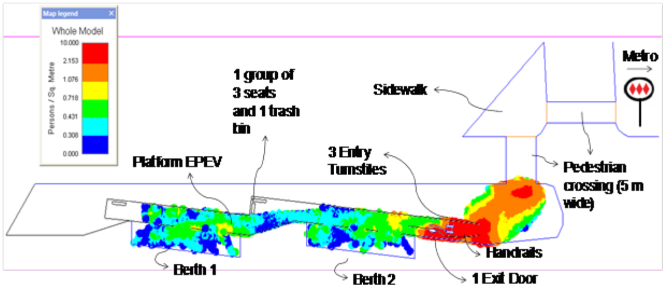

Figure 3 Pedestrian density maps at EPEV in "sawtooth" bay in optimized scenario with double passenger demand and flow of buses.

Conclusions

In conclusion, it is necessary to optimize the layout of the EPEV. It was found that EPEV stations should include three turnstiles for entry and only one exit door. This zone can be improved with handrails or any form of channelization of passengers. If the EPEV includes urban furniture (seats and trash bins) it must be provided in spaces that do not affect the natural pedestrian flow. In the urban space the EPEV should consider wider pedestrian crossing (more than 5m). In relation to the best scenario if passengers demand and flow of buses is increased twice it is suggested alternatives such as an EPEV in "sawtooth" bay. This produces independent movements of buses to and from each berth. A "sawtooth" bay requires a maximum spacing of 65m and the EPEV go modularly adjusted in such form.

As a general conclusion, our method can be used by traffic engineers to apply pedestrian traffic management to any bus stop or BRT station. This in turn can help in designing passenger facilities at transport infrastructures and would generate significant savings in operating costs of BRT systems, with very low investment cost compared to the value of the infrastructure involved. Future work will include the realization of the more experiments in a full-scale model in the Human Dynamics Laboratory (HDL) in Universidad de los Andes. Santiago de Chile. In these experiments, the results of the simulations with LEGION will be compared with those obtained in the HDL, as a way to validate the simulation tool for evaluating pedestrian traffic management measures on public transport systems.

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Conflicts of interest

The author declares that there are no conflicts of interest.

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