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Alleviating a subway bottleneck through a platform gate

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ABSTRACT

This paper shows the results of an experiment in which a gate allowing only unidirectional flows was installed on the middle of a Metro platform. The results were very positive: operation of the Metro Line was improved, travel times were reduced, and both regularity and frequency of trains increased. Finally, the perception of the service by its riders also saw an improvement. The main cause of this impact is that the gate encourages riders to arrange themselves more efficiently on board the train allowing the platform to clear much more quickly. A video about the intervention can be found here: https://www.youtube.com/watch?v=p2PcgDt4cFs.

1. Introduction

The world's population is becoming urban and wealthier. Both of these trends directly increase the number of daily trips made in cities, particularly in peak periods. This increasing mobility affect public transportation systems, leading to growing crowding problems in stations and vehicles. Metro stations are quite sensitive to crowdedness, affecting not just users' experience and safety but also the system's capacity.

The relationship between pedestrian crowdedness in a Metro station and its capacity has been observed and studied (Jiang et al., 2009; Lam et al., 1999), while several authors have provided models to represent this relation (Daamen, 2004; Hänseler et al., 2017; Suazo-Vecino et al, 2017; Zhang et al., 2008). To address a capacity drop due to crowdedness, two different approaches emerge. The most common is to increase the capacity through investments in vehicles or infrastructure. The second, less common alternative, consists on increasing the capacity through operational changes. This article is an example of the latter, in a case where the passengers' choice regarding which car of the train to use and which stair to evacuate the station where reducing the capacity of the full line.

Inducing a different behaviour in the passengers require understanding their choices. Passengers consider multiple factors beyond waiting and travel time to choose their preferred public transport route. Raveau et al (2014) show for the case of Santiago and London that many usually ignored attributes, as the transferring experience or the directness of the followed path, play an important role in how users value different routes. Similarly, the location of the stairs within the platform, explain why passengers choose specific cars to locate themselves inside the train (Kim et al., 2014; Szplett and Wirasinghe, 1984).

In Santiago, the metro system transports more than 2.3 million passengers each weekday, constituting the backbone of Santiago's public transport system. By 2014, the Santiago Metro's five lines constituted a total of 108 km and 106 stations, as shown in Fig. 1. During morning peak hours, Line 1 services those areas where employment is most concentrated; while the other lines (2, 4 and 5)

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Fig. 1. Santiago Metro network in 2014. Tobalaba Station, which connects Lines 1 and 4, is circled in blue.

connect passengers to Line 1. Line 4 is located in the eastern side of the city and connects the *comuna* of Puente Alto, which had 492,915 inhabitants according to the 2002 census, to Line 1. Line 1 represents the central axis of the metro system, and stretches along the Alameda, to Providencia, Apoquindo, and finally to Tobalaba Station (see Fig. 1). Line 4 is 23 km long, and has 23 stations (3 of which connect with other lines). In its busiest stretch, Line 4 transports more than 36,000 passengers per hour to Santiago's downtown during morning peak hours (7:15 to 8:15am).

Tobalaba's platforms (Line 4) were not built to accommodate its current level of demand; they are too narrow (3.2 m wide) and lack adequate exit capacity. This combination of shortcomings makes it necessary to delay Line 4 trains at the Tobalaba Terminal, in order to safely clear the platforms. This results in a growing queue of upstream trains that have to delay their arrival at the terminal during peak hours, which in turn delays all riders on that particular section of the Metro system. Arriving trains often offload users onto an already busy platform, worsening users' travel experience.

The lack of stairs is not the only reason for excessive delays upon clearing the platform. Fig. 2 shows the placement of the seven stairways on the platform, related to the position of train cars: rider distribution aboard arriving trains worsens the congestion