A Smart Dispatching tool based on AVL data

Pedro Lizana\textsuperscript{1} · Ricardo Giesen\textsuperscript{1,2} · Felipe Delgado\textsuperscript{1,2} · Juan Carlos Muñoz\textsuperscript{2} · Diego García\textsuperscript{1} · Paul Basnak\textsuperscript{2}

Abstract: Headway regularity is one of the main factors for bus quality of service as well as a performance indicator for Transantiago, the bus system of Santiago de Chile. Given that a significant part of headway variability is due to dispatch problems, we developed an algorithm to minimize penalties to operators for frequency and regularity non-compliance, which was then applied in a tool for bus dispatchers starting in mid-2017. The results have been successful:

Keywords: Public transport · Bus dispatch · Headway regularity · Headway optimization

1 Introduction

Frequency and regularity are probably the most important elements in order to provide a good transit level of service. Santiago de Chile is launching a new bidding process for its Transantiago bus system; in this context, the greatest demands made by the citizens in 2016 were frequency and regularity (27%) followed by the service quality (20%) and bus design (13%) (DTPM, 2016). One of the problems faced by operators to achieve high levels of regularity is that bus services have a natural tendency to bunch, due to spatial and temporal variations in passenger demand and travel times (Daganzo, 2009).

Several control strategies have been proposed to solve this problem; among them, holding has been one of the most widely studied (Eberlein et al., 2001; Sun and Hickman, 2008; Bartholdi and Eisenstein, 2012). This approach, which can be very effective but reduces operational speeds, can also be combined with boarding limits, in which the number of boarding passengers in a given stop can be limited in order to increase operational speed (Delgado et al., 2012).

In 2014, we started to implement a real-time control system in several lines of the Transantiago system, based on Delgado et al. (2012) proposal. Even though the results were encouraging, we found that a significant percentage of the irregularity was due to bad dispatching policies which were not addressed by that tool.

Transantiago has currently two compliance standards which apply for specific bus services (Beltrán et al., 2012): ICF, a frequency indicator that measures the percentage of programmed bus-trips effectively provided, and ICR, a standardized regularity indicator based on the coefficient of variation of the headways observed.
in a given period for a particular bus service. In both cases, fines for operators apply under a certain threshold: every company should provide at least a 95% of the programmed services per hour, while the ICR shall be over 0.9 (which implies a coefficient of variation under 0.51). Both standards are calculated with the help of GPS transmitters located in every bus, the same systems that allowed the introduction of the control tool.

Figure 1 shows the headway variability along the service line for each Transantiago operator, expressed in minutes of incidence. This indicator, used in Transantiago as variability standard, represents the difference between programmed \((y)\) and real \((x)\) headways: incidence = \(\max (0, (x-y)^{1.5})\). In this Figure, we can observe that there is great variability in regularity discounts at the beginning of the route among operators; these are in most cases larger for the firms with longer routes. However, service quality progressively degrades down the corridor with a similar trend for all bus route providers, adding around a minute of incidence for every 10 kilometers. Given that the indicator is non-linear, this implies that the headway variability increases with an exponential-type pattern along the routes. In a perfect dispatching regime, regularity fines at the initial point should be zero, which would further reduce the discounts downstream the corridor and would allow a better operation in the following cycle.

![Fig. 1 Minutes of incidence by operator and control point (García, 2016)](image)

2 Problem Description and Model Formulation

2.1 Problem description

In its current manner, the dispatching process suffers a series of other problems that prevent a smooth operation. These problems have several dimensions: physical, technological and information, and human resources. Among the physical problems arise the lack of infrastructure to park buses at the end of each service and the lack of reserve buses in good condition, while in the technological and information side the dispatcher has no real-time information regarding the position of the buses in the corridor, nor a prediction of the arrival times for the next buses coming to the dispatching point. Regarding human resources, there is a lack of trained staff to make dispatching decisions in short periods of time, which are highly complex due to the frequency fine scheme adopted in Transantiago. In addition to these problems, there is lack of additional drivers, and mechanical failures of buses at certain periods tend to reduce the availability of resources.

2.2 Model formulation
In this work, we dealt with these issues from two different fronts: information systems and staff training. For the first one, we implemented a second generation of our digitalized dispatching sheet to include Intelligent Dispatching orders. Our new development, which we started testing in 11 lines operated by Redbus (Unit 6) during mid 2017, dynamically suggests to the dispatcher the departure time of each bus based on an algorithm that considers the position of all the buses in the corridor and the logic of periods and fines introduced by Transantiago (both in terms of frequency and regularity). The objective is to minimize the total fines, given the real-time availability of buses and drivers for each bus service.

The algorithm works as follows: at first it estimates the arrival time of the following 3 buses to the terminal through the current bus locations obtained from GPS data and travel times forecast from their current location to the terminal. Thus, knowing the programmed departure times for these buses, we then determine when each of these three buses should be dispatched in order to reduce the fines in that period. If we forecast that the three buses would be available to depart as scheduled, we assign regular headways; in other case, we assume that one or more of these buses will not be available to comply with the programmed schedule, then we recalculate the dispatch schedule considering the minimal sum of the corresponding fines for non-compliance with frequency (ICF) and regularity (ICR).

We then developed a digitalized dispatching sheet embedded in an Android tablet for dispatcher use. The use of real time information allows the application to provide the dispatcher not only with the departure times of the different buses along the day, but also includes a synoptic to follow buses along the corridor, as well as a dashboard with operational reports. Even though the algorithm suggests the dispatcher the departure time of each bus, at the end, the dispatcher is the one in charge to take the final decision regarding bus departure. Additionally, we trained the dispatchers by developing an online course and providing them a dispatching simulator in which they could practice dispatching decisions under different operating conditions.

3 Experiments and results

3.1 Problem case study

The dispatch tool has been used in Transantiago Unit 6 buses, operated by the firm Redbus, since June 2017. The software application has been gradual and is still in process.

3.2 Results

Figure 2 below shows the evolution of frequency and regularity compliance indicator. The green vertical line denotes the time when the Intelligent Dispatcher was launched. As shown in Figure 2, the Intelligent Dispatcher has helped to have a more reliable operation, increasing the indicators for frequency and regularity compliance. Since the introduction of the tool, both monthly average coefficients have been larger than any previous month: ICF has been always over 98%, and ICR over 0.86.
As a consequence, this resulted in reduced user average waiting times as well as fewer fines to operators, which spared a monthly average of 40,000 US$ since the introduction of the tool and the continuous training of the dispatching staff. Moreover, the tool will allow the operators to keep track of past decisions as well as building performance indicators and operational reports, which can be helpful for future improvements.

**Acknowledgements:** This research was partially supported by CONICYT FONDECYT Project 1150657, the Centro de Desarrollo Urbano Sustentable (CEDEUS), Conicyt/Fondap/15110020, and the Bus Rapid Transit Centre of Excellence funded by the Volvo Research and Educational Foundations (VREF).

**References**


