The Effect of Operations Control on Reliability

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Abstract
RandstadRail is a new light rail system between the cities of The Hague, Rotterdam and Zoetermeer in The Netherlands. During peak hours the frequency on some trajectories is about 24 vehicles an hour. Dealing with these high frequencies and offering travelers a high quality product, according to waiting times as well as the probability of getting a seat, the operator designed a three step controlling philosophy. The first step is to prevent deviations to occur: the infrastructure is exclusive right of way as much as possible and at intersections RandstadRail gets priority over the other traffic. RandstadRail stops at every stop and never leaves before the scheduled time. The second step in the philosophy is dealing with deviations by planning extra time in the schedule at stops, trajectories and terminals. Small deviations can be solved in this way. The final step to get vehicles back on schedule is done by the traffic control centre: they have a total overview of all vehicles and they can respond to disturbances like slowing down vehicles nearby a delayed vehicle. Experiencing major disturbances rerouting and shortening of lines is possible.

RandstadRail is in operation since 2007. The actual data of the performance is used to analyze the actual effects of the control philosophy. It is shown that due to the applied measures the variability of the driving times is reduced. Punctuality has increased as well. This leads to a higher level of service, creating shorter travel times, a better distribution of passengers over the vehicles.

Keywords
Reliability, light rail, controlling operations

1 Introduction

One of the main quality indicators for urban public transport is reliability. Variability in travel times lead to unpunctual and irregular services, resulting in longer travel times for passengers, a decrease in probability of having a seat and an increase in uncertainty about the trip [4,6]. Besides, it leads to the need of extra resources, like crew and vehicles. During the last years reliability has become more important. More often, authorities request a certain level of reliability in their contracts with operators [e.g. 9]. To prevent penalties, operators need to take measures to ensure high schedule adherence.

In 2007 a new public transport service, with high reliability standards, is introduced in the region of The Hague, The Netherlands. A heavy rail line and two tram lines are connected and replaced by a light rail system: “RandstadRail” [5].

RandstadRail is a new regional public transport system with high quality standards: high frequencies, fast, comfortable and reliable. RandstadRail consists of two main networks (illustrated in figure 1):

1. The tram lines 3 and 6 in The Hague are connected to the former heavy rail line in Zoetermeer (called “Zoetermeerlijn”). HTM, the public transport company of The Hague operates theses lines;
2. The secondary, former, heavy rail line between The Hague and Rotterdam (called “Hofpleinlijn”) is connected to the metro network in Rotterdam. The public transport company of Rotterdam (i.e. RET) operates this line.

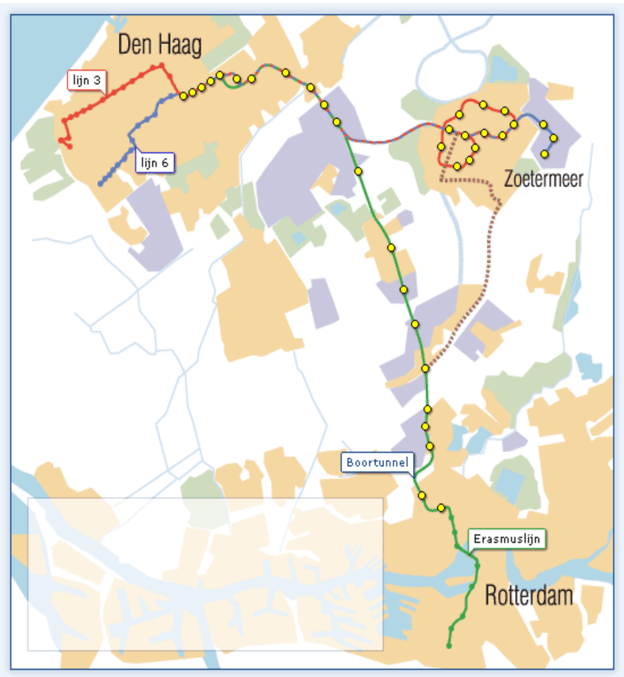

Figure 1 RandstadRail Network

Because of high frequencies, interference with other traffic in the city and signalling, controlling operations is necessary to achieve a high level of reliability. Earlier research [5] describes the control philosophy of RandstadRail, which is developed to accomplish this ambition.

This paper presents a detailed analysis of the effectiveness of the proposed control philosophy. The measures suggested in the control philosophy are analyzed in a quantitative way: what is the real effect of them? Actual data is used to show actual effects. The focus is on the urban part of RandstadRail, which used to be operated by regular trams. Line 4, former tram line 6, is taken as an example to analyze the control philosophy. All used data is from working days between 7 and 9 o'clock. RandstadRail numbers date from March and April 2008, tram data is gathered from April until June 2006.

2 Controlling philosophy

Variety in driving times and deviations of the timetable must be prevented. To achieve this, HTM designed a new, three step control philosophy [5]. Figure 2 illustrates these steps.

The first step is preventing deviations to occur: the infrastructure provides exclusive right of way as much as possible and RandstadRail gets priority over the other traffic at intersections. RandstadRail stops at every stop and never leaves ahead of schedule. Broader doors and equal boarding and alightening enable reliable dwellings. The driver has a display in his cabin, showing punctuality, helping him to drive on time. In [2] several preventing measures are presented as well, categorized in terminals, track and rolling stock.

The second step in the philosophy is dealing with deviations by planning extra time in the schedule at stops, trajectories and terminals. This way, small deviations can be solved [1,3,10]. Important when allocating slack time in the schedule is the trade off between operational speed and reliability. Earlier research [6] dealt with this trade off.

The final step to get vehicles on schedule again, is done by the traffic control centre: they have a total overview of all vehicles and their schedule adherence and dispatchers can thereby respond to disturbances such as slowing down vehicles nearby a delayed vehicle [5,7]. If punctuality is disturbed, headway control (balancing time intervals between vehicles [5]) will be applied. A computer system calculates the optimal headways between vehicles. Experiencing major disturbances, rerouting and shortening lines are possibilities [8,11].

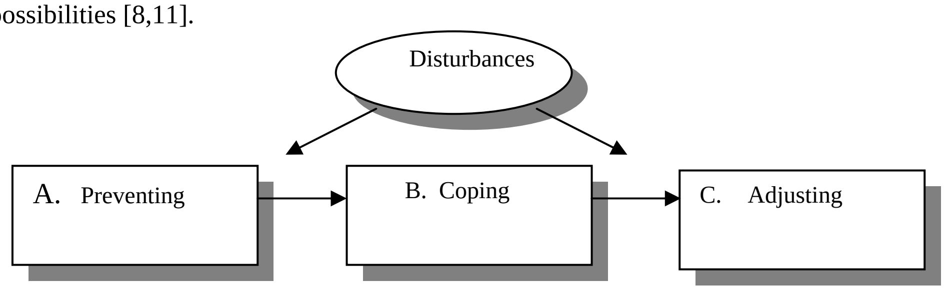

Figure 2: Steps of control philosophy RandstadRail

3 Improvement of operations

In the control philosophy, several measures are presented to improve reliability. Figure 3 shows the overall to be expected effect of all these measures. Black lines are the maximum current deviations. Improvements in infrastructure and of the vehicle, as described in the previous section, will dim the increase in deviations (white line). Improvement of punctuality at the first stop and of preventing vehicles to depart too early will decrease deviations as well (grey line).

Improving operations requires a dual approach: reducing distribution in driving time as well as improving schedule adherence. The next paragraphs show a quantitative analysis of the measures mentioned above and of their effect on reliability.

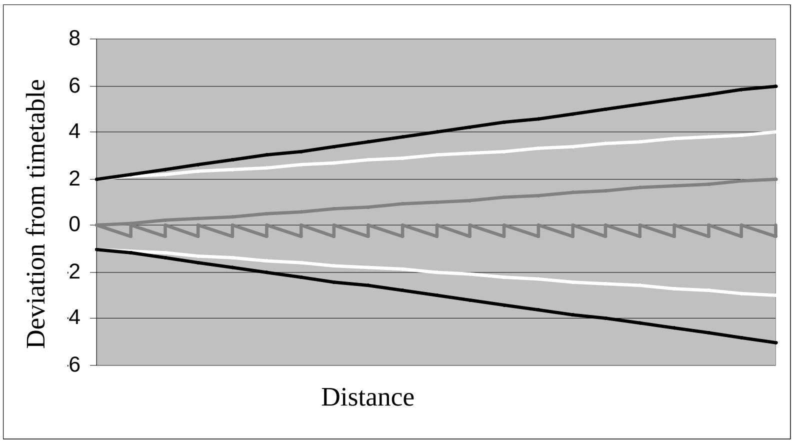

Figure 3: Distribution of driving time during the trip (black=current; white= after improving infrastructure and vehicles; grey=after improvement of departure at first stop and no more early departures)

3.1 Schedule adherence

In the control philosophy [5], it is stated that the departure at the first stop is very important. RandstadRail drivers are not allowed to drive ahead of schedule. They have a display in their cabin that provides real time information about their punctuality to adjust their on-time performance. RandstadRail confirms an improvement of departure punctuality. The percentage of trips departing with a deviation between –1 and +1 minute increased from 70% to 95%.

Figure 4 shows the punctuality (i.e. <-1 min, 3 min>) of line 3 in the city before and after the application of the control philosophy. It is clear that punctuality is greatly improved after the transformation.

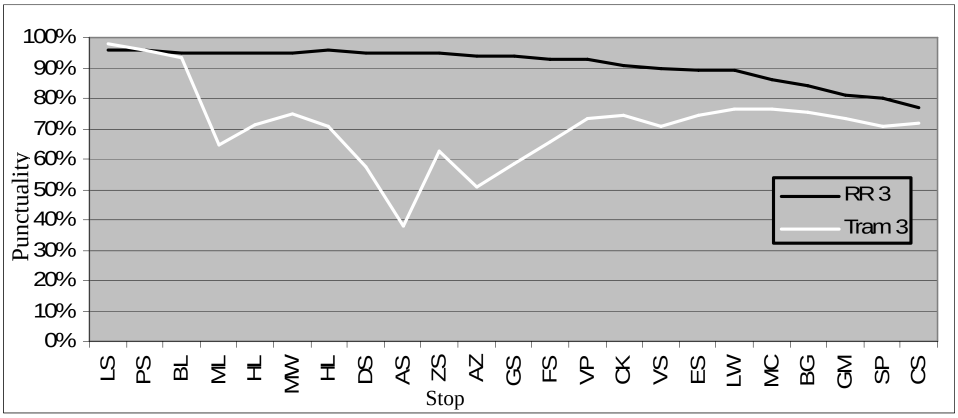

Figure 4: Punctuality of line before and after the introduction of RandstadRail

RandstadRail does not permit driving ahead of schedule. Driving times are planned shorter than they used to be and the cabin display helps drivers to adjust their performance. The central dispatching room also monitors driving ahead of schedule and a computer system automatically generates warnings if thresholds are exceeded. The number of trips departing ahead of schedule decreased from 50% to 5%, after the introduction of this new rule.

3.2 Variability in driving time

Two main sources for variability in driving time are: dwelling at a stop and unplanned stops (e.g. at traffic lights). Research [6] shows that the distribution in these elements leads to a wide distribution in driving times. It is necessary though to reduce all deviations to achieve a narrower distribution of total driving time.

3.2.1 Dwelling

The main advantage of RandstadRail vehicles is the low level floor. Boarding and alighting is easier, especially for elderly and people with trolleys and suitcases. Stops are redesigned as well, creating more space for travellers boarding and alighting.

Figure 5 shows the average dwell time per stop and figure 6 shows the standard deviation of the dwell time of all stops in the city before and after the transformation to RandstadRail. At almost all stops the standard deviation is decreased. The changes in average dwell are less.

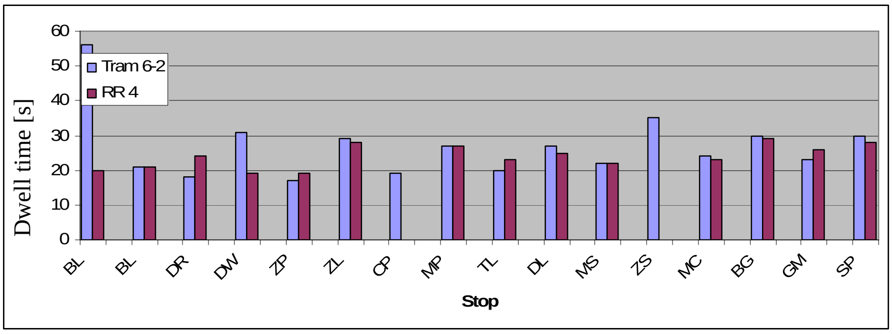

Figure 5: Average dwell times per stop before and after the introduction of RandstadRail

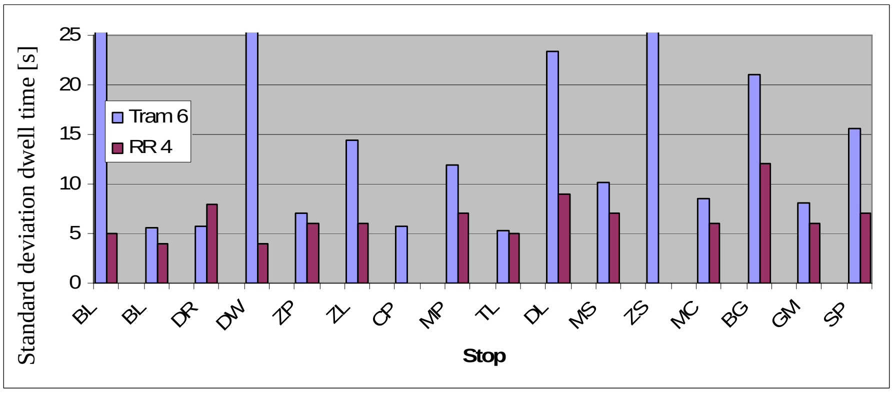

Figure 6: St.dev. of dwell times per stop before and after the introduction of RandstadRail

Table 1: Average dwell time tram and RandstadRail

	Average dwell time	**Average st. deviation**
Tram 6	28 s.	20 s.
RandstadRail 4	24 s.	7 s.

Table 1 shows that the average dwell time is improved from 28 to 24 s. per stop and the standard deviation is reduced from 20 to 7s. This enables more reliable operations with a higher level of service.

3.2.2 Unplanned stopping

To achieve a high quality of service, stopping at locations other than the stops should be avoided. Infrastructure should be designed to enable operations without delays. This is possible when e.g. own right of way and priority at intersections are applied. Table 2 shows the average total delay per trip before and after the introduction of RandstadRail. The average value of delay has decreased and the de standard deviation is also smaller. Figure 7 shows the average length of unplanned stopping along the line before and after the introduction of RandstadRail. This figure clearly illustrates the decrease of this loss of time.

Table 2: Average unplanned stopping time tram and RandstadRail

	Average total delays	**St. deviation**
Tram 6	90 s.	60 s.
RandstadRail 4	20 s.	30 s.

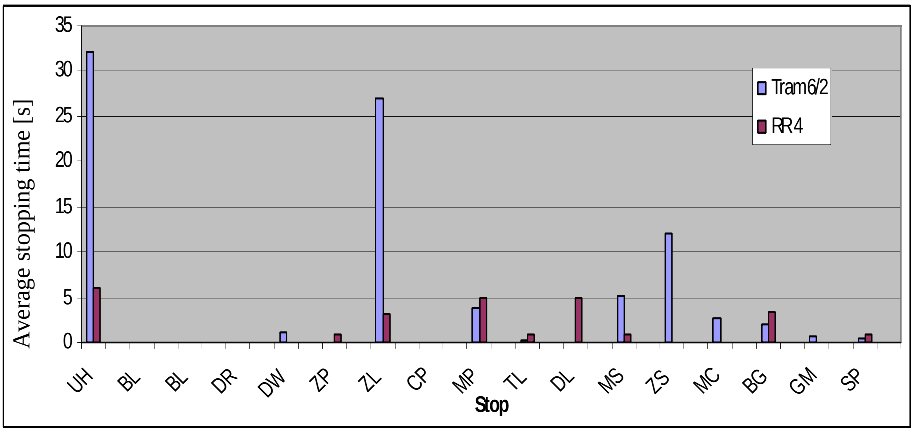

Figure 7: Standard Deviations of Dwell Times per Stop before and after the introduction of RandstadRail

3.2.3 Total effect

A control philosophy is designed to achieve a high level of reliability on RandstadRail. The goal of this philosophy is to improve the level of reliability by decreasing the distribution in driving times and improving the punctuality. Several measures, like vehicle and infrastructure improvements, showing punctuality to the driver and no early departures, decrease the average dwell time and delays and their standard deviation. Figure 8 shows the 15th and 85th value of driving time of tram line 6 before and after the application. Due to higher schedule adherence mean travel times of passengers are reduced. An increase of punctuality and regularity decreased overcrowding and uncertainty.

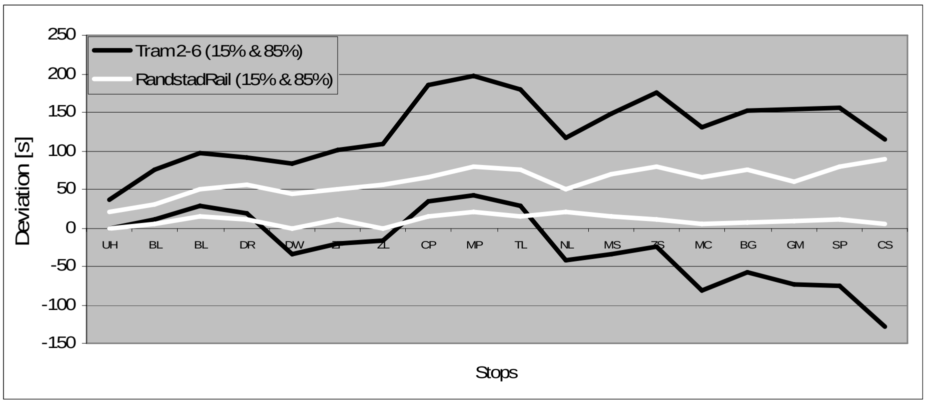

Figure 8: Schedule deviation tram and RandstadRail (15- and 85- percentile values)

4 Conclusions

RandstadRail is a new public transport line, which replaces and connects two tram lines and a former heavy rail line. RandstadRail is a high frequent system sharing its track with trams and metros. To offer high quality service, regarding punctuality and regularity, and to make efficient use of the infrastructure it is decided to apply a new control strategy. Preventing, coping and adjusting are the main elements of the control philosophy. The punctuality of the vehicle is shown to the driver, so he can adjust his driving style. On top of that, all vehicles with positions and punctuality are shown in the central dispatching room. The dispatchers use a system, supporting them in adjusting operations, if necessary. RandstadRail has a high percentage of exclusive right of way and priority at traffic lights. The vehicles got low floors and broad doors, which reduces deviations in dwell time.

The effect of all these measures is analyzed after the start of RandstadRail. It is shown that due to the control philosophy, the variability of driving times is decreased and the schedule adherence is improved. Due to higher schedule adherence mean travel times of passengers are reduced. An increase of punctuality and regularity decreased overcrowding and uncertainty.

It is to be expected that this increase of level of service will continue due to technical improvements and growing experiences.

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