Service reliability improvement by enhanced network and timetable planning

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The last few decades have shown a substantial increase in personal mobility. Urban traffic and transport volumes have been increasing for years. However, the share of public transport in this mobility growth did not change much and still remains rather limited. To ensure the accessibility and liveability of our cities for future generations, however, a substantial quality leap in public transport is necessary. This will facilitate a desired modal shift from car traffic towards public transport, which is safer, cleaner and produces less congestion. In this paper, we demonstrate that several promising opportunities exist to improve service reliability (i.e. the certainty of service aspects compared to the schedule as perceived by the user), being one of the most important quality aspects of public transport. Literature shows that in urban public transport substantial attention is given to ways to improve service reliability at the operational level (Vuchic 2005, Ceder 2007). It is not clear how and to what extent strategic and tactical design decisions in public transport systems might affect service reliability. Only traffic light priority and exclusive lanes are extensively considered during the planning of urban public transport in order to improve the level of service reliability (see for instance Chang et al 2003, TRB 2003 and Currie and Shalaby 2008). We expect that more instruments at these planning levels enable high-quality services at the operational level, especially with regard to service reliability.

In this paper, we present several planning instruments that facilitate enhanced service reliability. In addition, we show forecasting tools we developed and we introduce a new indicator that expresses the impacts of service reliability more effectively than traditional indicators, namely the additional travel time per passenger. This way, the assessment of public transport benefits will be substantially improved, thereby enabling cost-effective quality improvements. We show the impacts of unreliable services on passengers, being average travel time extension, increased travel time variability and a lower probability of finding a seat in the vehicle. We demonstrate how actual vehicle trip time variability (i.e. service variability) affects service reliability and passenger travel time.

To improve service reliability through enhanced network and timetable design, we selected five planning instruments by analysing the causes of service variability (Van Oort 2011). Since the arrival pattern of passengers is very important when calculating service reliability effects, we performed a passenger survey in The Hague. It showed that passengers tend to arrive at random at their departure stop if scheduled headways are 10 minutes or less. In the case of longer headways, passengers on average plan their arrival about 2 minutes prior to the scheduled vehicle departure time.

At the strategic level, the instruments that improve service reliability are:

- Terminal design; The configuration and number of tracks and switches at the terminal determines the expected vehicle delay and thus service reliability.

- Line length; The length of a line is often related to the level of service variability and thus service reliability. A trade off consists between direct connections and service reliability.

- Line coordination. Multiple lines on a shared track may offer a higher level of service reliability than one line (assuming equal frequencies).
The following instruments may be applied at the tactical level:

- Trip time determination;
  In long-headway services, scheduled vehicle departure times at the stop, derived from scheduled trip times, determine the arrival pattern of passengers at their departure stop. Adjusting the scheduled trip time may affect the level of service reliability and passenger waiting time.

- Vehicle holding.
  Holding early vehicles reduces driving ahead of schedule and increases the level of service reliability. The design of the schedule affects the effectiveness of this instrument.

The terminal design instrument relates to (new) rail lines with tail tracks as terminal or short-turning facilities. For high-frequency, distributed lines, we recommend compact tail tracks with double crossovers directly after the stop. Concerning (new) lines with a clear break point in passenger pattern, we recommend to split the line or to apply holding points. For long-headway services we propose to use the 35-percentile value for scheduled trip time. And if parts of lines are very crowded, we suggest investigating the effects of coordination. We calculated that by applying these instruments a passenger growth of 5-15% is achievable, due to enhanced service reliability.

A tentative cost-effectiveness assessment showed that the tactical instruments (trip determination and vehicle holding) are cost-effective in almost every case. Their benefits are substantial and the costs are nil. These instruments should be considered in the design of every public transport system. However, the vehicle holding instrument is only beneficial if the passenger pattern has a clear break point and trip time determination only is relevant in long-headway services. It is presented that strategic instruments have considerable benefits as well. Optimized terminal design enables enhanced service reliability. Coordination and shorter lines may result in reduced passenger travel times as well. However, these instruments may look costly due to necessary additional infrastructure and or (occasionally) additional vehicles.

We demonstrated that the costs are limited in relation to the potential welfare benefits. We roughly estimated the costs of unreliability at € 12 million per year in The Hague in the Netherlands and we estimated the potential savings at € 8 million per year by applying the five planning instruments we analysed in our research. The estimated costs of these instruments are assessed to be only a part of the benefits with a maximum of € 3 million per year, showing the added value of the instruments.

In this paper we presented planning instruments that facilitate enhanced service reliability. To achieve a higher level of service reliability in practice, we recommend considering service reliability explicitly in the design of infrastructure networks, service networks and timetables using our developed control framework and tools.

References


