Big data supports light rail in Utrecht

Transport planners are starting to consider how “big data” retrieved from passenger smart cards, computers and mobile phones could improve the design of urban rail networks and timetables, and improve operations by predicting ridership. Niels van Oort, assistant professor at Delft University of Technology, and consultant at Goudappel Coffeng, explains how big data was utilised to support the business case for a proposed light rail line in Utrecht.

We are currently living through the big data age. All around us technology is collating reams and reams of data about our everyday activities, including travel habits and preferences. But how can this data, and information about passengers’ habits in particular, be utilised effectively to aid public transport planning?

In the last decade or so, more and more attention has been placed on improving the level of service reliability at all levels of public transport planning and operations. However, I found that in cost-benefit analyses (CBA) of specific projects this quality aspect is rarely taken into account. Instead a qualitative assessment or expert judgement is used rather than proper calculations.

One of the main reasons for ignoring service reliability impacts in CBAs is the difficulty to quantify the service reliability effects of projects on passengers. In general, the focus of service reliability indicators is on vehicle effects, while the passenger effects are of importance when calculating costs and benefits. My work therefore aimed to bridge this gap by focusing on passengers and utilising new data sources to calculate, illustrate and determine their potential impact on a CBA for a transport network, which could inform decision making.

Service reliability is currently taken into account more in road schemes than public transport. While similarities do exist, public transport applications are more complex since a schedule is involved and a passenger trip chain consists of waiting, transferring, accessing and egress time in addition to the time it takes to complete the actual journey. As well as setting up the theoretical framework for improving service reliability, we applied new big data sources such as onboard computer and smart card data to perform a case study in Utrecht, the Netherlands’ fourth largest city with over 300,000 inhabitants, with the aim of improving the CBA process through a practical application. The study was particularly pertinent because the results were used to assist the Dutch government as it considered whether to support the construction of a light rail line in Utrecht between the central station and the Uithof in the east of the city, the location of the hospital and campuses of Utrecht University and the University of Professional Education Utrecht as well as other businesses.

The quality of existing public transport services between Utrecht central station and the Uithof is quite poor. Although services are operated by 23 double-articulated buses per hour per direction, which carry 23,000 passengers per day, capacity is lacking, with passengers often having to wait for two or three buses to board during peak times, while dedicated right of way is provided only on short sections of the route, which leads to conflicts with cars and cyclists. This is particularly apparent at the border of the old town, where road space is limited and delays are commonplace. Bunching of two or even three buses sometimes occur, while the average deviation of the timetable is four minutes exceeding the scheduled headway of about 2.5 minutes.

The city of Utrecht hopes to expand the area around the Uithof by 25% by 2020 with up to 53,000 students and 30,000 employees expected to use this area everyday. The city aims to achieve this growth without building additional car parks and as result plans to accommodate the expansion by stimulating increased use of bicycles and public transport. Subsequent demand forecasts conducted by Goudappel Coffeng in 2011 indicate growth of up to 45,000 public transport passengers per day in 2020. This will require more than 50 buses an hour per direction to provide adequate capacity, which the existing infrastructure is clearly not able to support.

To deal with this large expected increase in public transport use, and to provide a high level of service, a new connection was designed and proposed as a light rail rather than a bus route in order to achieve the desired level of service. The plan to construct a new light rail line is expected to operate 16-20 services per hour, per direction during the morning peak.

Primary benefit

In addition to fewer emissions, the primary benefit of converting the bus route into a light rail line is that it is possible to operate fewer vehicles, which are less prone to interference from road traffic and decrease the probability of bunching. However, the construction and operation costs of light railways are higher than bus operations, especially because this is Utrecht’s inaugural project. It was therefore appropriate to conduct a CBA to highlight the pros and cons of building this line in order to argue the case for investment from the Dutch Ministry of Infrastructure and Environment.

In the CBA, we calculated the service reliability benefits of transferring the existing bus operation into a light rail system. We compared five future situations for the route in 2020 including bus rapid transit alternatives, but for this article we will only focus on the reference case and the preferred alternative.

The reference case states that no additional infrastructure will be constructed and the capacity of the bus service is limited to its current levels. Since ridership and the number of...
buses will increase, it is expected that unreliability will increase.

In contrast, in the light rail case the service is operated by LRVs on a dedicated right-of-way. Due to sufficient capacity on the track and at the stops, and with limited interaction with other traffic, the expected level of service reliability will be high. In addition, compared with over 50 buses required to operate a comparable service, the number of vehicles is limited, thereby reducing the probability of bunching and delay propagation.

**Our results showed that in the reference case the level of service will be very low due to high passenger demand and insufficient bus infrastructure.**

When considering the impact of service reliability on passengers for the CBA, we analysed the actual performance in 2008, which we used as the base for the 2020 predictions. The level of service was determined by investigating onboard computer data, which offered insights on the distribution of dwell times per stop, overall journey times and delays. Smart card data was also analysed to illustrate passenger flows, with results from both data sources combined using our framework to calculate the passenger impacts of the level of service reliability. Specifically, onboard computer data was used to calculate the effects of changes in waiting times, and the change in distribution of total travel times on passengers, while we also calculated future demand by using the Omnitrans demand model. This information was used to develop a simulation of new vehicle and passenger data, and the expected resulting trip times, dwell times, delays, and the level of bunching, which helped us to calculate the passenger effects.

Our results showed that in the reference case the level of service will be very low due to high passenger demand and insufficient bus infrastructure. In case of the light rail line, sufficient infrastructure is provided and light rail services require fewer vehicles thereby reducing the probability of bunching.

After the calculation of these passenger impacts, the monetary values of these effects were found using values of time and values of reliability. The total costs and benefits of the project showed the substantial contribution of improved reliability to the positive score of the CBA, which is 1.2 i.e the benefits are 20% higher than the costs. The impact of reduced waiting times due to the light rail line's enhanced service reliability is €123m over the complete life of the line, and the reduction of distribution in travel time results in an €78m reduction in societal costs. So, service reliability and related benefits account for two-thirds of the project's total benefits of €336m.

Without this method and big data, it would not have been possible to calculate the benefits of enhanced service reliability, which proved to be a major part of the total benefits which contributed to the CBA result of 1.2. This result was critical in convincing the Dutch Ministry of Infrastructure and Environment to provide €110m for the light rail project and for the line getting off the drawing board. Construction is now underway on the 7.5km route which is being managed by Uithoflijn, a joint undertaking between the Utrecht region and city municipality, and is expected to open in 2018. Utrecht's existing 21km "snelltram," which runs to Nieuwegein and IJsselstein, will be converted to low-floor operation to offer a through service to the new line.

This project shows the potential value of utilising big data in railway planning. In this case study the impacts of quantifying service reliability were substantial and made the difference between a positive or negative business case, and ultimately the construction of a light rail line which will improve the quality of transport for millions of passengers in Utrecht in the years to come. IRJ