Measuring Robustness, Reliability and Punctuality within passenger railway transportation – a literature review

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1 Background & Aim

The RobustRailS research project started one year ago with the aim of interdisciplinary research with regard to robustness of railways and rail transport. RobustRailS is a cooperation between several DTU departments and industrial stakeholders, and is funded by the Danish Council for strategic Research. The aim of the project is to answer the question: Can we get trains to run on time?

Different organizations use various "ad hoc" measures and definitions of robustness. This study discusses the relevancy of the existing measures for the three service characteristics: *Robustness*, *Reliability* and *Punctuality*. Then an overview of these existing methodologies of defining and measuring the three service characteristics within the railway sector is provided. Finally recommendations with regard to performance indicators and guidelines for more comprehensive definitions of the different measures are outlined. The main idea is that these measures, when defined, should be used for further work within the RobustRailS project and as decision support in the Danish Railway Sector in general.

The existing methodologies of measuring service characteristics are evaluated in terms of their ability to reflect the actual (provided) level-of-service also from a passenger's perspective. Today most countries measure reliability and punctuality of their railway systems on a daily basis. Common to both of these service characteristics is that they are measured after the operation has taken place. Robustness is a rather new measure in regard to railway operations and has therefore not received the same attention in the literature as reliability and punctuality, which means that no generic measure of robustness exists. This study looks at some of the factors that impacts the schedule adherence and proposes different indicators reflecting the robustness of a railway schedule, which could be included already in the planning phase in order to get timetables of higher quality.

2 Existing approaches/Literature Review

The service characteristics are today mainly used by railway operators as performance measures. Typically a railway company has a contract stating what level-of-service (i.e. minimum values for the service characteristics) at least should be provided to the customers. Mostly the service characteristics of consideration measure train performance rather than passenger performance. This may seem counterintuitive since the focus of a well-functioning transportation system mainly should be on moving passengers from A to B as smooth as possible according to a predefined schedule.

The current study provides an overview of how the three service characteristics (*Robustness*, *Reliability* and *Punctuality*) have been measured and defined. The way of measuring service characteristics is of great interest because the chosen approach may bias the results obtained when the performance of railway networks is assessed. It is considered how these measures could be defined in order better to reflect the level-of-service provided seen from a passenger's perspective.

Reliability is typically measured as the percentage of train arrivals actually performed on the day of operation compared to the number of train arrivals planned according to the published schedule. An obvious drawback of the measure is that reliability is measured regardless of the actual arrival time as long as it occurred within the planning horizon. This means that, while significant delays may occur, the measured reliability will remain high as long as all the scheduled arrivals take place.
Adapting this measure to the passengers is not straightforward since all passengers entering the system are assumed to leave the system not before reaching their final desired destination. A modification to the measure is therefore made to ensure the ability to reflect the number of passengers affected by a train cancellation and also how this affects their overall travel time.

Punctuality is mostly measured as the percentage of trains departing from/arriving at stations within a pre-defined time threshold for delay. The most used approach to accommodate punctuality issues is to introduce timetable supplements either at the track segments between two stations, at the stations or when turning the trains at the terminal stations.
This measure can somehow easy be adapted to the passengers. Knowing passengers origin, destination and desired arrival time, on time performance can easily be tracked. In fact this has already been done be Nielsen et al (2009). From this study it can be seen that high train punctuality not necessarily equals high passenger punctuality.

Naturally, reliability and punctuality are complementary measures but they are both measures which can only be used to assess the performance of a timetable after the operations have taken place. It is the idea that a robustness measure should be able to reflect the anticipated schedule adherence of a timetable based on historical data and known delay distributions.

Robustness is in this context the ability of a railway system to resist consecutive delays. Since initial delays are often exogenous, these may be to some extent unavoidable, whereas consecutive delays may occur because of a too tight schedule. This fact leads to a big issue when considering the robustness of a timetable. The trade-off between having a very tight schedule, which in a non-disturbed environment is able to accommodate the most trains and then having a robust timetable which is able to absorb some of the disturbances is one of the planners' main challenges.

At the moment proper robustness measures are to the authors' knowledge not used by any practitioners, most railway companies simply allocate a predefined amount of buffer time in the schedules in order better to cope with disruptions. In academia different approaches for adding robustness (here defined as the ability to avoid delay propagation) to a railway timetable have been presented. Cacchiani et al (2009) consider the

railway timetable problem, where they try to impose robustness by adding timetable supplements on stations as well as change the departure of different trains. A bit more elaborate in their way of measuring robustness is (Salido et al, 2008), who propose a robustness index, which takes into account five different parameters: buffer time, # trains, # commercial stops, flow of passengers and network density. Salido et al (2008) conclude that the measure does not say anything absolutely, but it could be used for comparison between two or more timetable proposals.

The current study defines different robustness indicators, which takes into account the passenger perspective. The link between robustness and reliability and punctuality shows when disruptions occur, in this case a robust timetable will be able to absorb these disruptions and maintain a given level of punctuality and not being forced to cancel any trains, while having a too tight schedule may result in reduced punctuality and maybe also cancelled trains (Steenhuisen & van Eeten, 2010). The proposed robustness indicators facilitate a more comprehensive comparison of timetables. Besides the factors associated to trains, this study focuses on the user perspective, which means that also passengers' route choice and transfer patterns are considered. This is done in order to ensure that timetable supplements are added the places where the benefit is largest. Including the passenger perspective as robustness indicator is crucial because of the tendency among authorities to put greater emphasis on the things that are actually measured (Landex, 2007)

3 Applicability & Future Perspectives

In this paper the three service characteristics *Robustness, Reliability* and *Reliability* have been discussed. In the future, focus will be on implementing the robustness indicators and the service characteristics with a passenger focus as recommended by the current study. All this together should form a tool for decision support for politicians as well as the Danish Railway Sector in general.

At the moment passenger punctuality and reliability can only be derived theoretically by passenger delay models, but in the future, when more comprehensive travel data from Rejsekortet A/S becomes available, it will be possible to track passengers' travel pattern through the system and then guesstimate the delay they experienced and their travel time deviation. Introducing robustness indicators and service characteristics with a greater passenger focus, should form a step in the direction of making the railway a more reliable service, hence forming a more attractive transport alternative for the passengers.

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