Approaches to reduce passenger delays and improve travel time – Challenges of the Railway

Jens Parbo Jensen
PhD-Student
jepar@transport.dtu.dk
Outline

• RobustRailS

• Purpose of today’s presentation

• Presentation and assessment of Service Characteristics

• Conclusions & Future perspectives
Project Description

• Robustness in Railway Operations – RobustRailS

• Large interdisciplinary project (2012-2015) financed by the Danish Council for Strategic Research.

• Main question: *Can we get trains to run on time?*

• Title ”Optimization of rail operations with regard to passenger benefits”.

• Focusing on improving tactical parts of railway operations.

• Main question for my work:
  *Can we provide approaches for a more coherent and reliable service to the passengers?*
Purpose

• Getting familiar with the Service Characteristics used within Railways.

• Examine how Service Characteristics are measured.

• Are there shortcomings or bias in today’s Service Characteristics?

• A process of finding the right objective for a future optimization
Presentation of Service Characteristics

- Punctuality
- Robustness
- Capacity
- Frequency
- Etc.
Punctuality

• From the Freedictionary.com: “Precise”

• Measuring punctuality (DSB, 2012):

\[
\left(\frac{\#\text{ScheduledArrivals} - \#\text{DelayedArrivals}}{\#\text{ScheduledArrivals}}\right) \times 100\%
\]

• Most common definition: “The amount of trains arriving at/departing from the final station (or several large stations) within a given threshold from the scheduled time”

• Thresholds for considering trains as being delayed:
  – Most European countries: 5 minutes
  – Switzerland: 4 minutes
  – The Netherlands 3 minutes
  – DSB S-train 2 minutes
  – DSB IC/Reg. 5 minutes and 59 seconds
## Punctuality

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-Time Arrival at Final Destination</td>
<td>Station → Terminal</td>
</tr>
<tr>
<td>On-Time Arrival En-Route</td>
<td>Station → Station</td>
</tr>
<tr>
<td>Average Delay per Train</td>
<td>+ + + vs. ++ ++ ++</td>
</tr>
<tr>
<td>Passengers Affected</td>
<td>Passengers affected</td>
</tr>
<tr>
<td>Passenger On-Time Performance</td>
<td></td>
</tr>
<tr>
<td>Passenger Hours Delay</td>
<td></td>
</tr>
</tbody>
</table>

(Steen Larsen, 2013)
Robustness

• From the Freedictionary.com: “Powerfully built”

• No common definition!

• Majority of Robustness definitions are verbal

• Some (non-generic) analytical measures have been proposed
Robustness – Verbal definitions

• “A timetable is robust if we can cope with unexpected troubles without significant modifications”. (Norio in Tomii, 2005)

• “Robustness is here defined as the ability of a system to withstand model errors, parameters variations or changes in the operational conditions” (Giorgio Medeossi, 2009)

• “Robustness is the ability to avoid delay propagation as much as possible” (V. Cacchiani et al, 2009)

• “The ability of the railway system to operate normally despite disturbing influences” (Michiel Vromans, 2005)

• “A railway system is robust whenever the average travel time is as small as possible” (Dewilde et al, 2013)

• ......
Robustness – Analytical definitions

• A few attempts to create an analytical measure e.g. The Robustness Index (Salido et al, 2008)

\[
R(x) = \sum_{T=1}^{NT} \sum_{S=1}^{NS} \text{Buff}_{TS} \times \%\text{Flow}_{ST} \times T_{TS} \times NS_{i}cT \times (NS - S)/NS
\]

• Weighted Average Distance of the allocated buffer from the starting point (Fischetti, 2009)

\[
WAD_h = \frac{1}{\sum_{i=1}^{\text{len}(h)-1} s_{i,i+1}} \sum_{i=1}^{\text{len}(h)-1} \frac{s_{i,i+1}(t_{i+1}^h + t_i^h)/2}{t_{\text{len}(h)}^h - t_i^h},
\]

• Trying to allocated the same amount of time supplement between services \(i\) and \(j\) (Dewilde et al, 2013)

\[
\text{Min.} \sum_{ij} \text{buffertime}_{ij}^{-1}
\]

• Simulation studies aiming at reducing delay propagation e.g. (Fischetti et al, 2009).
Robustness – the trade-off

- A balance between the following (figure)
  - Adding recovery time
  - Decreasing capacity utilisation
  - Decreasing heterogeneity
  - Optimizing average speed

- Definition should capture these parameters (both verbal & analytical)

(Salido et al, 2012)
Shortcomings & bias

• No proper measure or definition of Robustness does yet exist.

• The well established Service Characteristics only consider trains – to whom are the train service in reality provided?

• Though, passengers are not totally forgotten. A few studies considered passenger delays (Zhi-bin et al, 2012; Nielsen et al, 2005)

• Both these studies suggest the use of passenger punctuality rather than train punctuality.
Example - Difference between train and passenger delays

- Green train (headway: 20 minutes) is on time.
- Blue train (headway: 10 minutes) is 4 minutes late when it reaches its final destination.
- 50% of the alighting passengers from the blue train transfers to the green train in order to reach their destination.
- These passengers miss their connection, even though the blue train technically is punctual (Danish standard).
- Transferring Passengers will be 20 minutes late – Trains will be on time.
Conclusions & Future perspectives

• Train delays are not equal to passenger delays.

• Tracking passenger delays is not easy.

• The way Service Characteristics are measured may bias the optimization.

• Improving Robustness is a trade-off.

• Robust Timetables should attract more passengers.

• Intelligent allocation of time supplements with a special passenger focus e.g. emphasizing dwell time supplements at transfer heavy stations.

• Defining Robustness as an objective to maximize.
Questions