Impact of faster freight trains on railway capacity and operational quality

Comprail 2020

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Agenda

1. Introduction
2. Methodical approach
3. Case study
4. Discussion
1. Introduction (1)

- Growing rail passenger traffic
- Growing importance of rail freight

- Higher occupation of railway infrastructure
- Overloaded corridors with insufficient capacity

- Measures to increase capacity
1. Introduction (2)

Measures to increase capacity

- Technical innovations
- Operational measures
- Harmonisation of speeds
- Expansion of infrastructure
  ...
  Faster freight trains
1. Introduction (3)

Faster freight trains - distinction between two cases:

A) Freight trains can **occasionally** make use of their allowed higher speed level **only when needed**:
   - higher recovery margins
   - higher flexibility to recover from delays or blend in with passenger traffic
   - operation with conventional timetables and speed profiles

B) Freight trains are scheduled to so-called **“express train paths”**:  
   - more homogeneous timetable profiles  
   - strict obligation to run faster than with conventional timetables
1. Introduction (4)

- **Theoretical capacity**: the number of trains that could run over a route during a specific time interval; defines the upper limit for line capacity [1]
- **Practical capacity**: number of train paths that can be scheduled with market-oriented quality (“level of service”) [2,3]

- Different approaches to measure and evaluate railway capacity:
  - constructive methods
  - concatenation according to UIC code 406
  - simulations
  - analytical approaches

- methods have both advantages and disadvantages with respect to output parameters, processing efforts, independence from timetables or how close the models are to real-life train operations

- Microscopic simulation using RailSys ® was chosen
2. Methodical Approach (1)

- Detailed microscopic simulation model (heavily occupied mixed-traffic line):
  - simulation period: 24 hours, evaluation period: 16 hours
  - distribution of entry delays (e.g. freight trains delay by an average 10 minutes with a probability of 0.6) [4]
  - Considerable effect of the dispatching configuration on results

- **difference in delays** as an indicator of operational quality (difference of exit and entry delay) has three states [5]:

<table>
<thead>
<tr>
<th>state</th>
<th>delay</th>
<th>operational quality</th>
<th>comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>positive</td>
<td>increasing</td>
<td>defective</td>
<td>overloaded system</td>
</tr>
<tr>
<td>0</td>
<td>neither increasing nor decreasing</td>
<td>“satisfactory“</td>
<td></td>
</tr>
<tr>
<td>negative</td>
<td>decreasing</td>
<td>good</td>
<td>additional trains could be added</td>
</tr>
</tbody>
</table>
2. Methodical Approach (2)

- enrichment of a reference timetable with additional freight train paths:
  - higher number of freight trains
  - operational quality deteriorates
- additional trains are step by step added as long as there is still space for additional paths
- measure of the difference in delays for each step

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Name</th>
<th>Allowed maximum speed of freight trains (km/h)</th>
<th>Case*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>Reference timetable (RTT)</td>
<td>conventional (100)</td>
<td>Reference case</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>RTT ( v_{\text{max}} ) 120</td>
<td>120</td>
<td>Case A)</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>RTT ( v_{\text{max}} ) 140</td>
<td>140</td>
<td>Case A)</td>
</tr>
<tr>
<td>Scenario 4</td>
<td>RTT ( v_{\text{max}} ) 160</td>
<td>160</td>
<td>Case A)</td>
</tr>
<tr>
<td>Scenario 5</td>
<td>Express timetable ( v_{\text{max}} ) 160</td>
<td>160</td>
<td>Case B)</td>
</tr>
</tbody>
</table>

*case A): recovery case, case B) express paths
3. Case study (1)

- Line segment between Offenburg and Freiburg
- Part of TEN* corridor
- Publicly accessible data:
  - Infrastructure
  - Timetables
- Four freight train model classes:
  - container trains, trains with bulk goods, block trains and trains with mixed goods
  - German passenger train categories
- 100 simulation runs
- Measurement of difference of delays

*TEN = Trans European Network
3. Case study (2): results

difference in delays, scenario 1: reference timetable:
3. Case study (3): results

difference in delays, comparison of scenarios:

![Graph showing difference in delays for various scenarios]

- **scenario1, reference**
- **scenario2, vmax 120**
- **scenario3, vmax 140**
- **scenario4, vmax 160**
- **scenario5, vmax 160 express**

The graph illustrates the difference in delays across various scenarios with an increase in the number of additional freight trains.
3. Case study (4): results

- comparison of reference scenario 1 (left) and express paths scenario 5 (right):

  - **Long distance trains**: massive decrease in difference in delays in scenario 5 compared to scenario 1 (by approx. 30 to 40 seconds)
  - **Freight trains**: difference in delays rises by approx. 25 seconds (see blue line, comparing from left to right)
  - negative influence outweighs the positive due to the distribution of train categories
4. Discussion (1)

- overall operational quality seems to rise by allowing freight trains a higher maximum speed in case of delay:
  - case A) seems promising: approx. two additional freight trains per hour and direction (could be lower given network-intrinsic constraints)
  - speed homogeneity and speed of freight trains have a significant influence on the capacity of mixed-traffic rail corridors
- faster freight train operations do not seem to bring advantages per se:
  - case B) (scenario 5) does not seem to be promising against the background of raising capacity
  - strictly raised obligatory maximum speed slightly deteriorates operational quality
  - assumption: better during night time or in a less occupied infrastructure
- free capacity can also be used to reduce overall delays
4. Discussion (2): further research

- change of results if freight trains were given a higher priority
  - => isolated analysis of headway times is not sufficient for an overall understanding of capacity
- comparably small difference between scenarios 2, 3 and 4
  - possibly, the highest allowed speed level is not necessarily the optimal choice
- full migration was assumed:
  - all freight trains had the characteristics of the particular scenario
  - mixed scenarios were not analysed
  - demand for conventional freight trains will remain
  - identify demand for express freight (e.g. package delivery sector or with non-durable or chilled goods)
- additional freight trains do not necessarily mean higher overall transport capacity
References


Impact of faster freight trains on railway capacity and operational quality (Geischberger, Mönsters)© 2020 WIT Press, www.witpress.com
ISSN: 2058-8305 (paper format), ISSN: 2058-8313 (online), http://www.witpress.com/journals
DOI: 10.2495/tdi-V4-N3-274-285
https://www.witpress.com/elibrary/tdi-volumes/4/3/2688
Thank you for your attention

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