Banverket experience of capacity calculations according to the UIC capacity leaflet

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Abstract

In a common project with participants from Germany (DB Netz), France (SNCF), Netherlands (Prorail), Austria (ÖBB), Switzerland (SBB), Czech (CD), Italy and Sweden (Banverket) a leaflet, UIC 405-1R, has been written for capacity calculations. The chapters are introduction, definitions, calculation of capacity consumption and application.

Banverket has calculated capacity consumption manually in the annual report for year 2001 and for year 2002 according to the leaflet. In Banverket’s investment plan 2003 – 2015 capacity problems have been estimated for the years 2003 and 2015. Input has been traffic demand, calculation of capacity consumption and traffic simulations.

In the project UIC Capacity Management, capacity consumption is now being calculated for different bottlenecks around Europe. Banverket is studying the line Stockholm – Västerås.

Keywords: capacity calculation, capacity planning, capacity allocation.

1 Introduction

The project UIC Capacity leaflet started in December 2000 and finished in June 2003. Project manager has been Mr Claus Kandels DB Netz the first half and Mr Bertrand Jalard SNCF the second half. The product of the project is leaflet UIC 405-1R [1]. The leaflet is recommendatory and is official from 1 January 2004.

The project “Framtidsplan” started in January 2001 and finished in July 2003. The author was project manager for the capacity calculations.
The working steps for “Framtidsplan” was:
1. Describe the railway system of today
2. a Market analysis Freight traffic
   b Market analysis Passenger traffic
3. Deficiencies and investment proposal list

The investment plan 2003 - 2015 has not yet, January 2004, been decided by the Swedish Government.

The capacity calculation models which were used in “Framtidsplan” were mathematical calculation of capacity consumption, see [1] and [5], running time program, see [2] and [3], traffic simulation program SIMON see [2], [3] and [5] and traffic simulation program Railsys.

2 Capacity consumption

2.1 Banverket annual report 2001

The capacity calculation 2001 has been made manually. 8 persons has been involved 2 persons at headquarter and 6 persons at the regional offices of Banverket. The working hours of the group were about 800.

The first step was to divide the rail network into line sections according to the definition in UIC 405-1R.

A line section is the part of a line, in which
a) the traffic mix and / or the number of trains
b) the infrastructure and signalling conditions
do not change fundamentally.

It consists of one or more coherent sections, which are limited by two neighbouring stations or nodes.

For the Swedish rail network the infrastructure classes have been:

- single-track with remote traffic control
- double track with remote traffic control
- four tracks with remote traffic control
- single-track with no remote traffic control

The total number of line sections was 216.

Table 1: Number of linesections year 2001 for Banverket 5 regions.

<table>
<thead>
<tr>
<th>Region</th>
<th>1 track</th>
<th>2 tracks</th>
<th>4 tracks</th>
</tr>
</thead>
<tbody>
<tr>
<td>BV North</td>
<td>30</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BV Middle</td>
<td>39</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td>BV East</td>
<td>25</td>
<td>30</td>
<td>2</td>
</tr>
<tr>
<td>BV West</td>
<td>27</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>BV South</td>
<td>37</td>
<td>13</td>
<td>-</td>
</tr>
</tbody>
</table>

A typical single-track line section is 50 km and has a crossing station each 10 km. A double track line section is normally in the interval 10 – 50 km.
For single-track the calculations have been made manually by using Excel. The calculations have been made for peak hour traffic, 2 hours maximum consumption, and for the day. The calculation of single track infrastructure occupation time has been made according to eqn (1).

\[
T_{occ} = \sum_{k=1}^{k=n} (T_{\text{time}} + T_{\text{meeting}} + T_{\text{signal}} + T_{\text{remote control}})k
\]  

(1)

\( T_{\text{time}} \): running time between two meeting stations.

\( T_{\text{meeting}} \): extra time for meeting 3 – 5 min dependent on train type

\( T_{\text{signal}} \): extra time when no simultaneous entrance, 2 min

\( T_{\text{remote control}} \): extra time when no remote control, 1 min

In BV North, 5 of the line sections, has short meeting stations and long trains. For these line sections a special formula has been used.

For single-track line we have a strictly defined model. The results were accepted by the project group.

For double-track the calculations for peak hour traffic, 2 hours maximum consumption, were made drawing the free corridors by a green pen. This calculation is similar to the calculation of occupation time in UIC 405-1R, see figure 1.

![Diagram](image1)

Figure 1: Time shares within a timetable, double track and single track.

The calculations for the day have been used according to following formula. For double track infrastructure occupation time (\( T_{occ} \)):

\[
T_{occ} = \sum_{k=1}^{k=n} (T_{\text{train}} + T_{\text{conf}})k + \sum_{j=1}^{j=m} T_{\text{cross}}j
\]  

(2)
$T_{train}$ : time between two trains 3 – 5 min, dependent on traintype and signalling
$T_{conf}$ : conflict time if train $k$ is followed by a train with shorter timetable time
$T_{cross}$ = extra time when a train $j$ is crossing the line, 2 - 4 min

Conflict time ($T_{conf}$) is calculated as following:
$T_{conf} = ( T_k - T_{k+1} )$

$T_k$ is the timetable time for train $k$.

For double track the results is dependent on how you divide your line sections. Because of that we had a process with the regions Banverket East, Banverket West and Banverket South were the results were examined and some corrections were made.

The final results were presented in maps over Sweden with the city areas enlarged.

Figure 2: Capacity consumption year 2002, 24 hours period.
2.2 Banverket annual report 2002

In year 2002 capacity calculations were made only at those linesections where a major change in infrastructure or in traffic were made.

The results were the following.

Table 2a: Capacity consumption max 2 hours, number of linesection.

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2001</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number linesections Shortage (81–100%)</td>
<td>83</td>
<td>79</td>
<td></td>
</tr>
<tr>
<td>Number linesections Problem(61–80%)</td>
<td>61</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Number linesections Balance (&lt; 60 %)</td>
<td>73</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>217</strong></td>
<td><strong>216</strong></td>
<td><strong>216</strong></td>
</tr>
</tbody>
</table>

Table 2b: Capacity consumption 24 hours, number of linesections.

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2001</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number linesections Shortage (81–100%)</td>
<td>16</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Number linesections Problem (61 – 80 %)</td>
<td>40</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>Number linesections Balance (&lt; 60 %)</td>
<td>161</td>
<td>165</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>217</strong></td>
<td><strong>216</strong></td>
<td><strong>216</strong></td>
</tr>
</tbody>
</table>

Between 2001 and 2002 the capacity consumption has increased. The reason is a big increase in passenger traffic. The number of train km for passenger traffic has increased with 6.5 % between 2001 and 2002. During 2002 only smaller infrastructure investments has been finished and the change in freight traffic has not been so big.

2.3 Application UIC Capacity leaflet Stockholm – Västerås

The railway line Stockholm - Västerås is 111 km. It is double track apart from the last two km Karlberg – Stockholm which is four tracks or more.

Stockholm – Västerås consists of 3 linesections. The linesections are Stockholm – Karlberg (2 km), Karlberg – Kungsängen (24 km) and Kungsängen – Västerås (95 km). The linesections Stockholm – Karlberg and Karlberg – Kungsängen has highest capacity consumption. In this study the calculation of capacity consumption is only made for the linesection Karlberg – Kungsängen.

The capacity problem (4 hours time window) is worst in the morning between 6 am and 10 am. During this period there is maximum of passenger trains and no freight trains.

For the capacity calculations two alternatives with more trains have been constructed. In alternative 2 new passenger trains Stockholm - Västerås have been added. Alternative 3 also have two freight trains.

The occupation time for each block section has been calculated in the traffic simulation tool Railsys. Between each train the relevant block section has been identified (see figure 3) and the relevant block section time has been calculated. When possible a 30 s buffer time has been added to the occupation time for each train.
Table 3: Capacity consumption and not used capacity alternative 1, 2 and 3.

<table>
<thead>
<tr>
<th>Traffic</th>
<th>Line Stockholm - Västerås</th>
<th>Line Stockholm - Västerås</th>
<th>Line Stockholm – Västerås</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freight traffic</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Passenger traffic</td>
<td>9</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Commuter traffic</td>
<td>22</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>31</strong></td>
<td><strong>35</strong></td>
<td><strong>37</strong></td>
</tr>
<tr>
<td>Infrastructure occupation [min]</td>
<td>133,5</td>
<td>159</td>
<td>167,5</td>
</tr>
<tr>
<td>Buffer time [min]</td>
<td>14,5</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Supplement maintenance [min]</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Capacity consumption [min]</td>
<td>148</td>
<td>173</td>
<td>181,5</td>
</tr>
<tr>
<td>Capacity consumption [%]</td>
<td>62%</td>
<td>72%</td>
<td>76%</td>
</tr>
<tr>
<td>Necessary quality factor [min]</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Necessary quality factor [%]</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Not used capacity [min]</strong></td>
<td><strong>92</strong></td>
<td><strong>67</strong></td>
<td><strong>59</strong></td>
</tr>
<tr>
<td><strong>Not used capacity [%]</strong></td>
<td><strong>38</strong></td>
<td><strong>28</strong></td>
<td><strong>24</strong></td>
</tr>
</tbody>
</table>
Figure 4: Capacity problems 2003.

Figure 5: Number of trains 2003.
The capacity consumption is 62% in alternative 1, 72% in alternative 2 and 76% in alternative 3. The buffer time is 14.5 minutes in alternative 1 and 14 minutes in alternative 2 and 3. No supplement for maintenance or any additional quality factor has been taken into account in the calculation.

3 Capacity problems

In Banverket there is a discussion about how to best present the capacity situation. The capacity consumption maps have a very strong position within Banverket especially in single track network. Although the maps have some disadvantages. The first disadvantage is that the map does not show the importance of the traffic. The action to solve this problem was to produce a map which shows number of trains for each line section. The next disadvantage is that the traffic demand is not explicit in the model. In some parts of the network they want to run more trains in other parts there is no demand to increase the traffic. Because of that a new method was developed.

The new method was:
1. define infrastructure
2. define traffic
3. a calculate capacity consumption
   b estimate traffic demand
4. estimate capacity problem

This new method was used in the last phase of “Framtidsplan”. The results were presented in a report about traffic situation 2003 and 2015 (see figure 4 and figure 5).

4 Conclusions and further work

The leaflet UIC 405-1R gives possibility to calculate capacity consumption for traffic and infrastructure of today and for tomorrow. This can be done for the whole network or for a specified line.

In Banverket infrastructure investment plan for 2003 and 2015 capacity problems has been estimated. The main reason is to take bigger impact where in the network there is a demand for more trains.

In the project UIC Capacity management a study is done about capacity consumption, time supplements and punctuality for lines with capacity problems all around Europe. The method is UIC 405-1R and traffic simulations according to a common protocol. This project will be finished the 1st of April 2004.

Acknowledgements

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References


