THE MODELLING OF TRAFFIC ON THE RAILWAY IN THE PROGRAM OPENTRACK

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Summary: The paper is focused on modelling of traffic on the railway lines and the necessary software for it. Article also summarizes the findings of the project operate on the rationalization of traffic and transport infrastructure on non-corridor lines, which has been solved by Department of Transport Technology and Control.

Key words: Traffic control, Delay, Simulation, Railway transport

1. INTRODUCION

The Department of Transport Technology and Control has been dealt with the project RACIO during the period 2008 to 2009. The abbreviation "RACIO" is the name of *The Rationalization of Traffic and the Extend of Transport Infrastructure on Non-corridor Lines* which was solved using computer simulation model. The qualitative and quantitative indicators should be evaluated during the extent of transport infrastructure evaluation on the lines. In terms of quality of the service provided for the customers are important qualitative indicators, such as the speed of the initial delay elimination and the number of overdue trains.

2. SOFTWARE REQUIREMENTS

To verify the extent of the rail infrastructure depending on the size of the traffic is necessary to have data not only about a separate infrastructure, but also about vehicles and timetable, which is going to be implemented on the line. The appropriate software tool is necessary to draw relevant conclusions on series of experiments. This software must be able to model the trains´ ride itself by traction characteristics of vehicles and track parameters, but also it must be able to manage with technological processes. One of the software tools, that all these conditions are met, is the Swiss company ETH Zurich program OpenTrack. It also allows determining the stopping point for trains of different lengths, which is primarily used for passenger trains' stopping at stations and stops. Those stopping points can be used as signals "End of platform" and "Stopping point" act from regulation SZDC (CD) D1.

2.1. Data for Model

Each model is based on its original. In order to verify and validate of the simulation model is needed to build the model on the basis of accurate data.

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The data required for simulation can be divided into three basic groups:

- Data relating to infrastructure
- Data relating to vehicles
- Data on the operation

Most of this data is sensitive, for that reason it is necessary to communicate with the Infrastructure Managers and individual carriers, or vehicle manufacturers during the drawing up of the model. All of these subjects should have an interest in the project to easier data retrieval.

2.1.1 Data relating to Infrastructure

This is the most comprehensive body of data. This includes data on structure of the tracks in stations, information about the tunnels, directional and leaning conditions on the track. It means the data about configuration and guidance of tracks in terrain. The data on positions of the crucial elements in the track such as the location of signals, switches and boundary marks create another large group of data, which is necessary. This data for already operating lines are collected from “The Tables of Technical Relationships” and “The Station Plans”. Most of these data is not available in the case of new built lines. The first project studies achieve only basic characteristics of the track guidance. Resolvers must often collected information from the maps. Problems are especially new tracks´ leaning ratios. Individual gradient and descent can be deducted from contours, but in reality the line routes in the cuttings and on embankments. The problem is determined if the information about the location of these components of the railway substructure are not at the disposal.

Studies have usually contained information about the location of tunnels and their length, these are important for calculating the train resistance.

Another major problem is the location of decisive components on the line. Block signals on the track can be placed according to the planned speed. The problem arises whether block signals will be deployed as a friendly signal or not.

The situation is worse in the stations. If the study has at least schematic picture of stations or station type envisaged, the work of programmers is facilitated, because they identify the location of signals, switches and boundary marks, the positions and platforms where passenger trains stop more readily. The experts have to decide what configuration of station tracks in a given location is suitable to the anticipated guided trains in the absence of that information.

2.1.2 Data relating to Vehicles

Data relating to vehicles are most easily recoverable. They are mostly based on the existing rolling stock with well known characteristics of traction and handling. There can be used vehicles which are not in domestic carrier´s rolling stock, but they are offered on the European market, in this case it is possible to try to obtain relevant data from vehicle producers.

2.1.3 Traffic Data (Timetable)

Information about future traffic scope is a problem. The data can go out from the existing timetable or the trains guiding is based on information from the study, or required by the competent public authorities (Region, the Ministry of Transport) and cargo carriers.

In spite of the maximum effort to adapt to the requirements of the individual organizations a real future traffic may be notable modelled. These are cases of potential uncoupling of vehicles on the track/in station or occupation of the track in turnaround stations by parked trains. Sometimes it may appear new demands on the traffic organization depending on the outcome of the simulation etc.

3. TRAFFIC CONTROL IN THE CZECH REPUBLIC

Rail traffic control as well as in other modes of transport is governed by the regulations. There are two ways of control in the Czech conditions:

- Under regulation SZDC CD D2
- Under regulation SZDC CD D3

The first way is the classic way of traffic control with dispatchers, traffic supervisors, but it also includes a remote-controlled lines. The second method is a simplified way of traffic control, where most of the responsibilities associated with control are transferred to the train crew, particularly the engine driver.

The traffic control itself without operational delay is routine matters. Unfortunately there is delay in the normal situation.

The length needed to eliminate the initial delay and the associated number of trains affected is monitored in cases with delay.

4. ELIMINATION OF DELAYS

Total time delay (1) of all trains *P* can be expressed:

$$P = p_1 + (p_1 - z) + (p_1 - 2z) + ... + (p_1 - mz) \qquad (1)$$

Where p_1 is the size of the initial delay,

z is the average advance time (time gap).

The total delay *P* can be also expressed as the number of delayed trains m_z and mean volume of delay:

$$P = m_z . \frac{p_1 + 0}{2} = \left(\frac{p_1}{z} + 1 \right) . \frac{p_1}{2} = \frac{p_1^2}{2z} + \frac{p_1}{2} \qquad (2)$$

Where p_1 is the size of the initial delay,

z is the average advance time (time gap),

m_z is the number of delayed trains.

The number of delayed trains m_z is determined from the condition:

$$\frac{p_1}{z} \le m_z \le \frac{p_1}{z} + 1 \qquad (3)$$

Where p_1 is the size of the initial delay,
z is the average advance time (time gap).

An important indicator in the field of the delays´ elimination is the coefficient "Speed of initial Delay Elimination" K_{vz}. Coefficient can be expressed as:

$$K_{vz} = \frac{p_1}{T_e} \qquad (4)$$

Where p_1 is the size of the initial delay,
T_e is total time necessary for elimination of p_1 delay.

Causes of initial delay can be categorized into the following groups:

- Technical faults
- Traffic reasons
- Accident
- Disasters

Transposition of trains overtaking and crossing to another station than to the timetable intended one may be needed on the track. It depends on the capabilities of staff, which realise traffic control, how they will evaluate and resolve the situation.

4.1. Delays in the Program OpenTrack

OpenTrack program allows setting the size of delay for each train separately, or creating your own delay scenario. The program can transferred overtaking/crossing to another station in the case of delay. Program's ability to correctly model the situation arising from the delay depends on line parameters.

4.1.1 Train Crossing

The series of tests have identified that the program gives the closest results in the simulation of operating delays to crossing trains on lines with stations equipped with a similar type of interlocking systems, namely for lines where technological times in the various stations are similar.

The distortion takes place in the case of large differences in the duration of the technological times. This applies particularly on lines with the simplified traffic control, where were significant variations compared to reality take place. There are stations, into which can be train crossing transferred using service tracks, on the lines managed in accordance with the regulation SŽDC (ČD) D3. Such crossing entails considerable extension of the time needed for its implementation because of the high value of technological times. The program complies with the technological times, but does not consider them in terms of transferring of the crossing as a dispatcher. A train crossing transfer to such stations can caused that the resulting solution proposed a worsening of the overall situation of the delay´s elimination. It is due to increasing of the initial delay and the transferring of big part of delay to other trains. The concrete situation from line Strakonice – Volary is shown in the Table 1.

Table 1 - Differences between program and human control

Delay [min]	Even direction [min]	Uneven direction [min]
5	1,1	0,4
10	2,1	6,3
15	0,0	4,3
20	7,5	4,5
25	10,2	4,0
30	0,0	2,0
35	2,4	0,0
40	3,1	0,0
45	4,0	0,0
50	0,0	6,6
55	0,0	4,1

Source: Author

The numbers represents average minutes saving when the human traffic control is established. On the basis of a large number of experiments was found that the solution of this problem is complicated. A simple solution consists in disabled crossing in those type of stations does not produce the required results neither in cases where there are stations with shorter technological times in the nearest surrounding. This is due to the fact that there is a certain time zone of delay, in which shall be paid crossing in those stations.

4.1.2 Overtaking

The program can handle passing trains according to the timetable and scheduled delay. Problem takes place in the case of double-track lines with both directions taxiing tracks and operational delays. The program allows using track in the wrong direction, if it is entered by user. When the situation of transfer of overtaking of equal importance trains takes place, then problems occurs in front station as in the case of the crossing. The program does not consider the way forward and it may happen that the resulting time required to eliminate the delay will be significantly higher than in real.

5. ADVANTAGES AND DISADVANTAGES OF TRAFFIC MODELING IN OPENTRACK

OpenTrack has its advantages and disadvantages as any other programs. On the other hand it can give a basis for decision about the transport infrastructure and its extent according to the planned traffic.

Advantages

- Detection of bottlenecks of transport infrastructure
- Detection of extended infrastructure
- Stability Timetable

Disadvantages

- Need for a large number of repetitions
- Dependence on solver´s knowledge
- Great time-consuming for a comprehensive assessment

6. CONCLUSION

The dynamical modelling of trains running on the specified infrastructure based on timetable is a new tool for evaluating the extent of infrastructure and the size of traffic. The simulation model can reveal bottlenecks of the newly proposed timetable, or lack of a range of transport infrastructure in some nodes or on some lines. The project RACIO has confirmed that the simulation tool OpenTrack can faithfully model traffic on the Czech railway without problems although it does not know some Czech unique qualities such as a simplified way of traffic control. Within each partial experiment, it was found that the program manages to resolve the traffic situation with variance from the timetable. However, its weaknesses include the lack of perspective that could address the problem of crossing/overtaking transfer in relation to the whole line. Therefore the elimination of initial delay analysis should be human intervention. On the other hand, the program behaves as in the case when for traffic control would be called a man without knowledge in the line. Series of tests can therefore prove that it is desirable that the remote-controlled lines´ dispatchers must be thoroughly acquainted with the parameters of the track.

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