TECHNOLOGICAL ASPECTS OF EXTENSION OF TRANSPORT OPERATION ON RAIL-LINES IN RECONSTRUCTION

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Abstract: *High quality of operational concepts in railway transport represents one of the basic premises of functional public transport system and public transport services. In this area the systematic timetable engineering plays an important role. Advanced timetable engineering brings a strong contribution for an effective use of infrastructure capacity. This systematic approach is very important, especially when the new railway service is being introduced on such railway line, which is in the state of reconstruction with numerous restrictions. The article demonstrates this approach on the example of the introduction of new express trains Prague - Linz in the timetable 2016/17.*

***KEYWORDS**: RAILWAY TRANSPORT, PUBLIC TRAFFIC, RAILWAY TECHNOLOGY, TIMETABLING, FBS*

1 Introduction

In the Czech Republic, over a period of more than 20 years, intensive renewal of railway infrastructure, primarily transit railway corridors, has taken place. One of these cases is IV. transit corridor leading from Děčín via Prague to the border with Austria in the direction of Linz. Between Prague and České Budějovice, the corridor is already completed at 75% of its length. The Ministry of Transport, as the orderer of long-distance trains, decided to order new express trains between Prague and České Budějovice in the Timetable 2016/17, which will be a new additional passenger service to the current fast trains. Between Prague and České Budějovice, there is motorway D3 in construction, so it is also not yet completed and the new express trains have a travel time comparable to that of individual transport.

The task was to prepare such an operational concept on the railway line, to make the most of the modernized infrastructure for the new trains, the trains of existing trains did not deteriorate and the technological impacts on the sections in the reconstruction (eg cruising in single track sections or sections under the construction) were minimal.

2 Prerequisites for solving the rail capacity and timetable problem

The timetable is a basic instrument for organizing railway transport. Though, it represents supply of connections in network for passengers. Generally, timetables can be divided into fixed-interval (periodic) and commercial (non-periodic).

The way from the basic idea of transport concept to final daily operation is long and complicated – from the transport planning with regards to present infrastructure parameters through timetable planning to the simulation of the transport concept. Within the stage of transport planning the transport relations (OD-Matrix) and estimated Modal-Split of railway passenger transport have to be determined followed by the line network scheme defining the lines, period of services and capacity of operating vehicles. These two phases generate the background for a rough draft of operational concept. Finally, this proposal of operational concept has to be verified by tool for timetable planning.

The problems of the new operational concept on the corridor line Prague - České Budějovice can be defined by three topics.

The first was the capacity of the line itself - line sections before the reconstruction are in many places only single-track with limited possibilities of train crossing. There are also some double-track sections under reconstruction, which have to be operated as only single-track. The capacity of the line is further limited by the fact, that in the Czech Republic the speed of the trains by working places on the tracks is reduced to 50 km/h and for stations to 40 km/h (with regard to the provisional state of the signalling equipment).

The second problematic topict was defined by the constraints of the transport concept. Classical long-distance fast trains (train category R) are operated in a basic interval of 120 minutes, and for most of the working day it is completed for 60 minutes interval. The long distance trains R are reaching the complete IPT (interval periodic timetable) node in Tábor in the minute 00, the wider IPT node in Veselí nad Lužnicí at minute 30 and the wider IPT node in České Budějovice in the minute 00. The suburban regional transport service at Prague is operated in a basic interval 30 minutes between Prague and Benešov. At the nearest agglomeration section between Prague and Strančice the interval is concentrated in peak hours of working days to 15 minutes. The paths for long-distance fast trains are in the timetable so designed, to avoid overtaking regional trains in the section between Prague and Benešov, i.e. to avoid the loss of time for passengers in suburban transport. From this constraint it follows logically, that for the new express trains (train category Ex), the only path which could be used between Prague and Benešov is shifted exactly 30 minutes to the current fast trains. Thus, the entire timetable interval scheme of the Ex and R trains with regional trains had only such a time-manipulation space, to avoid disturbing current IPT nodes while avoiding overtaking regional trains. The conditions for the timetable construction of the path for new express trains were such, that a path with the smallest technological conflicts had to be found, which at the same time fulfilled the time conditions for passing trains on the border with Austria (for reaching transfer connections in station Linz). Although only 8 pairs of new express trains per day were introduced, a virtually periodical timetable scheme with Ex path in every hour must be found. This is due to the fact, that the Ex trains were introduced on the principle of a 4-hour period Prague - České Budějovice - Linz, supplemented by one express connection Prague - České Budějovice - Český Krumlov (UNESCO city with a tourist attendance of more than 1.3 mil persons per year) and 3 pairs of express trains Prague - České Budějovice in peak hours of working days.

The third problematic topic concerns to the vehicles, which are necessary for newly established express trains. The new operational concept was based on using of new passanger seating cars with modern locomotives type 380 ČD (Czech Railways)

and velocity of 160 km/h. There were 6 locomotives and 6 car-sets needed to ensure the project. However, a new restrictive condition was embedded by preparing the project, namely that with regard to the number of vehicles, that ČD could release for the project only 4 locomotives of the type 380 and only 4 car-sets for the speed of 160 km/h allowing international traffic. For the remaining trains, two older locomotives type 362 were released, with maximum speed of 140 km/h and two modernized car-sets for domestic operation. The preparation of the vehicle circulation plans had to be planed separately and designed so, that both types of sets could be correctly maintained.

3 Suggested solution for new express train paths

Proposal of operational concept should be verified by tool for timetable planning.

Inputs for this verification should be represented by infrastructure parameters, e.g. track station lay-out and location, velocity and propensity profile, curve radii and tunnel profiles. Speed-traction-effort curve, distribution of traction effort, tonnage of train and the stopping time at the stations are required for the running time calculation.

Faculty of Transportation Sciences at the Czech Technical University (CTU in Prague) use the software FBS (iRFP Dresden – Germany) since 1999. CTU in Prague has adapted tool FBS to Czech operational conditions.

FBS is a programme family for railway conception, which has been developed since 1993. Naturally, it combines the opportunities of today‘s computer technology with scientific calculations and the knowledge of daily railway operation. FBS represents an efficient tool concerning creation of timetables and utilization of obtained data.

The timetable programme currently consists of the following programmes:

- FBS-Dispatcher (survey of files)

- Integrated planning program iPLAN

- Station Database Editor BSV

- Train type and h’code Editor ZNV

- Engine Database Editor TFZ

FBS is available in a wide range of functions as well as in versions for industrial purposes and for research and teaching purposes.

Basic object management is performed in iPlan programm, which integrates other program modules.

More complex technological tasks are dealt for example by work with a scheduled timetable across multiple lines.

FBS defines an optimised interaction between infrastructure, rolling stock and operation.

All possible schemes of train crossings have been verified as part of the search for acceptable variants. Under the terms of the periodic timetable, a solution that is symmetrical by minute 00 has always been sought.

The timetable constructional principle of the express train path was:

1) Examine the shortest travel time on infrastructure conditions with all constraints due to the reconstruction

2) Time binding to a time position agreed for passing trains on the border with Austria

3) From the above to derive the latest possible arrival from Prague to České Budějovice (from Prague) and for this time to find the closest path, realizable periodically and symmetrically

4) Overlapping of the time scheme of express paths (Ex trains) with the scheme of fast trains paths (R trains) and identification of technological collisions

5) Solving the collisions primarily by adjusting the fast train (R) paths so, that the constraints of the existing connections in the IPT nodes are respected - the aim of the step was to make as few changes as possible for existing trains and linkages

6) Minute fine-tuning of express (Ex) and fast trains (R) paths in the Prague - Benešov section, within the exact time spacing of 30 minutes for collision-free timetable construction of suburban regional transport

In the search for variants, it was always proceed first theoretically, by examining the mathematical conditions of the edge time lengths (in this case, the edge between the IPT nodes was replaced by an imaginary edge between the crossing stations) in the presence of both periodical segments in 1-hour period, by applying the edge equation over the sums of 30 min within one segment and over the sums of 15 min within a combination of both segments.

Under the constraints, in co-ordination with the Austrian partners, it was possible to find such solution, that led to the acceleration of trains on the Austrian side (due to the introduction of the two-segment operation between Pregarten-Linz), which in addition to shortening the travel time itself leads to a comfortable transfer link at Linz to Salzburg, Zurich and Vienna) and to extending of time for changing trains from approximately 8 to approximately 20-25 minutes (which has a positive effect on the reliability of long-distance journeys).

4 Results

From the point of view of the resulting combinations, it was finally possible to find and create such a timetable variant in the section Prague - České Budějovice, that in the single track section before reconstruction only the express trains (in Střezimíř) are crossing and all other train crossings (express / express, express / fast train, fast train / fast train) are realized on already completed double-track sections.

This one crossing is also evident from the model tachograph of the express train. From the tachograph of the ride are also visible all speed restrictions on the sections in the reconstruction. The tachograph is for direction Prague - České Budějovice, the 380 ČD locomotive and the 250-ton car set:

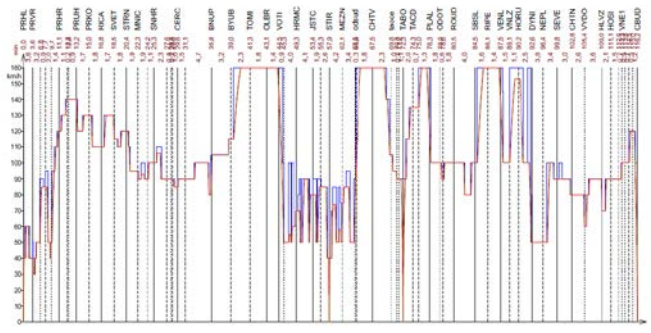

Fig. 1 *tachograph of Ex train Prague - České Budějovice*

From the point of view of reached travel times, the straightening looks as follows:

- travel time of fast trains (R) in periodic path Prague - České Budějovice in timetable 2015/16: 2 hour 23 min

- travel time of fast trains (R) in periodic path Prague - České Budějovice in timetable 2016/17 (by solved timetable conflicts with Ex trains): 2 hour 20-25 min

- travel time of new introduced express trains (Ex) in periodic path Prague - České Budějovice in timetable 2016/17: 1 hour 58 min

Even more interesting is the result achieved in the relation Prague - Linz.

In the timetable 2015/16, the Prague - Linz connection was made with fast trains (R) which continued to Linz from train Prague - České Budějovice, in the amount of 2.5 pairs a day (in one direction were 3 connections, the other 2 and the one ending In České Budějovice). Travel time Prague - Linz was 4 hours 50 min.

In the timetable 2016/17 the connection between Prague and Linz is provided by express trains, where between České Budějovice - Linz the already existing fast train paths were used. At the Austrian side, the Pregarten - Linz service was modified to two-segment operational concept and the express train use the higher segement path. The total balance of time savings is 25 minutes on the Czech territory between Prague - České Budějovice (Ex path), 8 minutes on the Czech territory (removal of the locomotive overpass in České Budějovice) and 12 minutes on the Austrian territory (influence of two-segment service Pregarten - Linz). The total time savings achieved 45 minutes and the resulting travel time of the Prague - Linz train is currently 4 hours 5 minutes.

5 Conclusion

This paper has presented, what timetable solutions could be achieved by appropriate technological combinations on the railway infrastructure, that is undergoing reconstruction, but it already enables higher transport attractiveness. All technological processes and variants have been reviewed in FBS. The state of construction of the 4th railway corridor between Prague - České Budějovice allowed, in conjunction with other follow - up measures of operational and technological nature, the introduction of a new express train segment, which led to shorter travel times not only in the relation itself, but also in the international relation Prague - Linz.

From the point of view of travel times, there was found such solution, which by introducing new express trains (Ex) did not damage existing fast train segment (R), including its transfer links. The average travel speed of fast trains (R) Prague - České Budějovice is 73.7 km/h. The average travel speed of the newly established express trains (Ex) Prague - České Budějovice is 87.5 km/h. Between Prague and České Budějovice, there is not yet a motorway D3 completed. The current travel time by individual transport is so comparable with the travel time of the newly introduced Express trains. This is the reason, why newly introduced trains have become a very attractive and sought after connection.

With further construction works, the constraints for train paths will also change and the technological solution founded for timetable 2016/17 is only temporary. However, we believe, that applying the same procedures a methods will result in a further shortening of travel times of long distance trains (both categories Ex and R) as soon as infrastructure capabilities allow it, naturally without impacting on existing interconnections and IPT nodes of lower service segments.

Advanced timetable engineering brings a strong contribution for an effective use of infrastructure capacity – it´s possible to say, where the current limits and bottlenecks of the infrastructure are – using these support tools is possible to enumerate, what the most important precautions in operation and investment in relation to capacity, reliability and safety are. This effectiveness is particularly fundamental by investment-consuming railway infrastructure. Practical application of these tools makes necessary link between theory and praxis.

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