VEHICLE PRODUCTIVITY IN NEW OPERATED RAIL-SERVICES

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Abstract: *For newly introduced transport services, there´s not only the transport aspect that matters what the new service will bring to passengers, but also the operating costs are very important. In this area the systematic timetable planning plays an important role. Total costs of the transport system are significantly affected by the fixed costs, deriving from the number of regular deployed vehicles and drivers, related to the overall transport performance and total operational productivity. Advanced timetable engineering means a strong link between timetables, vehicles and infrastructure. The article demonstrates this approach on the example of the introduction of new express trains Praha - Plzeň - Cheb / München in the timetable 2017/18.*
KEYWORDS*: RAILWAY TRANSPORT, PUBLIC TRAFFIC, RAILWAY TECHNOLOGY, TIMETABLING, OPERATION PRODUCTIVITY*

1 Introduction

According to the data from Czech Ministry of Transport, passenger rail transport in the Czech Republic has been experiencing a great renaissance in recent years. The increase of passenger transport in passenger kilometers in 2010-2017 is 44%.

The main cause for this sustainable growth is in particular long-distance rail transport and suburban transport around great czech cities (Praha, Brno, Ostrava, Plzeň).

Several factors contribute to the growth of demand. The first is improvement the offer of connections, when the structural changes associated with the implementation of IPT (Integrated Periodic Timetable) between 2005-2009 brought about a fundamental change in the structure and frequency of supply, as well as in the creation of systematic links in IPT nodes. The second is undoubtedly shortening travel times associated with the modernization of transit railway corridors. The third major factor is the improvement of the fleet quality and the improvement of rail carrier services, which is also reflected in the liberalization of the passenger rail market.

Due to the increasing demand for transport and the progressive modernization of the infrastructure, the orderers of public transport react by expanding of timetable links and connections.

Czech Ministry of Transport, the orderer of long-distance passanger trains, has in the timetable 2016/17 introduced new express train segment between Praha - České Budějovice (- Linz) and follows in current timetable 2017/18 new express trains between Praha - Plzeň (- Cheb / München).

Increasingly, expanding transport performance requires productivity and efficient deployment of vehicles, so that these increases in traffic performance were generally financially manageable - both for carriers and for public authorities.

This approach to achieving operational productivity is demonstrated in the article on the example of newly established express trains on the line Praha - Plzeň.

2 Prerequisites for solving the productivity problem

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 III. transit corridor leading from Cheb via Praha to Ostrava and to the border with Poland and Slovakia. Between Praha and Plzeň, the corridor is already completed at 62% of its length, including the longest newly built railway tunnel in the Czech Republic between Rokycany and Plzeň (tunnel Ejpovice), which is 4.15 km long and should be completed and put into operation this year. Czech Ministry of Transport decided to order new express trains between Praha and Plzeň in the Timetable 2017/18, which will be a new additional passenger service to the current fast trains.

The task was to prepare such an operational concept on the railway line, which would achieve the highest operational efficiency while respecting the boundary operating conditions.

These boundary conditions consist of the demand for reaching IPT nodes, the attraction travel time of newly introduced trains, the lack of travel time on existing trains and, last but not least, the current state of infrastructure. The final timetable is thus generated by repeated iterative steps associated with fine minute tuning, taking into account transport and operating parameters while maintaining the IPT principles.

At beginning, there´s necessary to define the transport concept. Until timetable 2016/17, the operation of long-distance trains on the line Praha - Plzeň consisted only from fast trains, in which the Praha - Cheb trains were operated in 2-hour interval, in the 4-hour intervals trains Praha - München and in 4-hour interval trains Praha - Klatovy - all these lines together formed regular 1-hour interval between Praha - Plzeň.

All possible schemes of train paths 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 Germany
3) From the above to derive the latest possible minute arrival to Plzeň (from Praha) 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) control of turn-over times of long-distance trains in end stations, prediction of turn-over times according to the planned works on corridor track, stabilization of the route
7) Minute fine-tuning of express (Ex) and fast trains (R) paths in the Praha - Beroun 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.
Proposal of operational concept was verified by FBS - tool for timetable planning.

The new operating concept preserves only the line Praha - Plzeň - Klatovy as a fast train line with a larger number of train stops, while the lines Praha - Plzeň - Cheb and Praha - Plzeň - München are transformed into a new segment of express trains.

Classical long-distance fast trains (train category R) are operated in a basic interval of 120 minutes between Praha - Plzeň - Klatovy, and for most of the working day it is completed for 60 minutes interval between Praha - Plzeň. The long distance trains R are reaching wider IPT node 00 in Praha, the complete IPT node in Rokycany in the minute 30 and are bounded to IPT node 00 in Plzeň (from Plzeň to Klatovy is depart before the whole node). The suburban regional transport service at Praha is operated in a basic interval 30 minutes between Praha and Beroun. At the nearest agglomeration section between Praha and Řevnice 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 Praha and Beroun, 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 Praha and Beroun is shifted exactly 30 minutes to the current fast trains. There should be found such path for the express train, which enables as possible to reach IPT node 00 in Plzeň. 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 Germany (for reaching transfer connections in stations Schwandorf, Regensburg and München). By express trains to Cheb, there were necessary to keep the existing IPT node 30 in Cheb. In total, there were introduced a 2-hour interval of direct express trains Praha - München and 2-hour interval of direct express trains Praha - Cheb, where both these 2-hour interval make together 1-hour interval of express trains between Praha - Plzeň.

Overall, this represents an increase of 55% transport performance, which is about 600 000 trainkm / year.

3 Operational productivity and efficiency

Productivity is generally defined as the ratio between the output of the enterprise and the necessary inputs. Since each output arises from a larger number of input variables, there is used in measuring the productivity of a larger number of partial indicators "partial productivity." Changes in output can not always be assigned to only one factor, and pursued partial productivity can not be seen as isolated endpoints and there should be monitored more parameters.

High productivity can be achieved through high efficiency and effectiveness. The effectiveness can be defined as a measure of how strongly the system output is produced in accordance with the desired output.

The efficiency can be described as the ratio between the produced output and input needed for its implementation (produced output / input). Some sources describe this difference clearly as "doing things right" (effective venue) and "doing the right thing" (effective action). Effective action means: do the right thing at the right moment in time, while effective venue allows you to do these things with minimal resources.

Typical input quantities in the measurement of productivity in rail passenger transport are for example engines, engine-drivers or passenger cars. The offer in the timetable, expressed by train- or seat-kilometres means the produced output.

To assess (includes future) success of the TOC (rail carrier - Transport Operating Company), there is important to monitor important indicators for the assessment of productivity - there is seat km/car, train km/engine, train km/staff, train km/engine driver, seat km/train staff. They display, how well available resources are used to create an offer in the schedule.

Rail transport is specific to a generally high proportion of fixed costs. Variable costs are in terms of the Czech Republic about 60% of the level, when approaching a vehicle operating utilization of 80% (due to low travel speeds and thus small run over of vehicles). Such utilization in the Czech Republic is achieved usually on such lines, where it is consistently applied the IPT.

Certain costs of rolling stock, such as maintenance depend on the vehicle run over. These costs may be changed due to the implementation of measures to increase the productivity, although in comparison with the investment costs would be their impact rather small. These problems tend to magnify during major investment in the rolling stock. The acquisition cost of new rolling stock is comparable in the Czech Republic and abroad.

So the current approach described in chapter 2 applied by creating new transport concept is focused to offensive offer, where the existing resources in the field of rolling stock and staff are used to create higher level of service, while the growth of variable cost components must be covered by additional revenues.

4 Results

To ensure the original timetable concept, there were needed 9 engines with an average daily run of 683 km / day.

In the new timetable concept with considerable increase of the the transport volume, there had to be planned 4 additional engines, with enhanced productivity of the circulation, increasing the average daily run of the locomotive to 745 km / day. However, this state is only temporary, because after the opening of the Ejpovice tunnel, the travel time of fast trains between Praha - Plzeň will be shortened by 7 minutes in each direction. The structure of the operational concept is so prepared, that at the same time will allow a quick turnaround of the engines in Praha. Average daily run of locomotives will thus rise to 806 km / day.

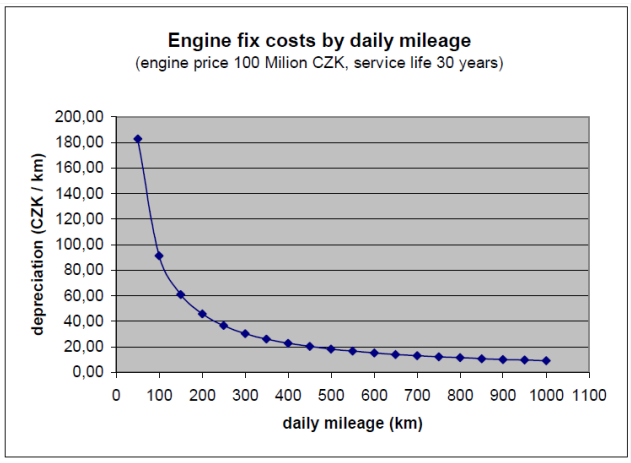

Fig. 1 *Influence of the depreciation cost of the vehicle on transport performance depending on the traffic enforcement*

Modern rail vehicle with a small mileage represents for each carrier an economic trap, since its operation by the usual amount of compensation (in the CR average 130 CZK / train km) isn´t long financeable. The growth in vehicle productivity thus contributes to lowering the unit price of transport performance.

On fast trains and express trains, two-system locomotives of the type ČD 362 of the 1980s are currently deployed, but they will have to be gradually replaced in the following years by new engines. Even with regard to this future investment, it is still necessary to monitor the productivity of vehicles and to make any adjustments to the operational concept to interact between the timetable - vehicle - infrastructure.

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

- travel time of fast trains (R) in periodic path in timetable 2016/17: Praha - Plzeň: 1 hour 37 min; Praha - Klatovy 2 hours 40 min; Praha - Cheb 3 hours 11min

- travel time of fast trains (R) in periodic path in timetable 2017/18: Praha - Plzeň: 1 hour 42 min; Praha - Klatovy 2 hours 38 min

- travel time of new introduced express trains (Ex) in periodic path in timetable 2017/18 Praha - Plzeň: 1 hour 25 min; Praha - Cheb 2 hours 54 min

It is obvious, that the only time-penalized passenger frequency is in the fast trains Praha - Plzeň, but in this relation the passengers are reaping the newly introduced express trains running every hour.

In the case of the fast trains Praha - Klatovy, the current travel time was hold. Connection to Cheb has become as part of new express service, and therefore there is significant time saving in this relation.

In the case of the international connection Praha - München, which is newly part of the introduced express segment between Praha - Plzeň, there was an increase in direct trains from 4 pairs to 7 pairs per day. Travel time in timetable 2016/17 ranged between 5 hours and 50 minutes to 6 hours, while in the 2017/18 timetable it was unified for 5 hours and 45 minutes.

5 Conclusion

This paper has presented, how timetable technological combinations could influence engine productivity in passenger rail services. All technological timetable processes and variants have been reviewed in the software FBS.

Since the beginning of creating the timetable concept, it is necessary to plan within the limits of interactions of the triangle timetable - vehicle - infrastructure and outside of it the transportation linkages take into account technological linkages and possible engine circulation between trains too. So an increase of the average daily run and of the productivity of the vehicles could be achieved.

This approach applied by introduction of a new express train segment between Praha - Plzeň led on one side to shorter travel times, on other side to increasing operational productivity.

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.

With further construction works, the constraints for train paths will also change and the technological solution founded for timetable 2017/18 is only temporary. While in the timetable 2017/18 the average daily run of the locomotives increased by 9%, the operational concept is prepared so, that by applying the same approach and methods will result in next increase of the average daily run in timetable 2018/19 by another 9% and in saving of one locomotive.

Advanced timetable engineering brings a strong contribution for an effective use of resources of TOC. Practical application of these tools makes necessary link between theory and praxis.

REFERENCES

1. JANOŠ, V. and KŘÍŽ, M.: *Technological aspects of extension of transport operation on rail lines in reconstruction*. In: international scientific journal tran&MOTAUTO WORLD. 2017, II(5/2017), 196-198. ISSN 2367-8399
2. DRÁBEK, M., MICHL, Z.: *Smart rail infrastructure planning for smart cities: A Prague rail hub case study* In: 2017 Smart Cities Symposium Prague (SCSP) - IEEE PROCEEDINGS. New York: IEEE Press, 2017. ISBN 978-1-5386-3825-5
3. POSPÍŠIL, J., KŘÍŽ, M., a DRÁBEK, M.: *Targeted upgrading of railway infrastructure as a result of systematic public transport planning*. In: Systemy Transportowe. Systemy Transportowe. Katowice, 22.09.2014 - 23.09.2014. Katowice: Wydział Transportu Politechniki Śląskiej. 2014, ISBN 978-83-935232-4-5
4. JANOŠ, V. and BAUDYŠ, K.: *Competitiveness of the national rail carrier in the process of market opening for public passenger rail transport* In: 21st International Symposium EURO - ŽEL 2013 - Recent Challenges for European Railways - Symposium Proceedings. ŽILINA: ŽILINSKÁ UNIVERZITA, 2013. pp. 90-95. ISBN 978-80-263-0380-0.
5. SCHEMERHORN J.: *Management for Productivity*, John Wiley & Sons, Canada, 1986