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Horizons of Railway Transport – Determinants of the development of the railway system in the context of the society-wide assessment of investments in railway infrastructure and public passenger transport

Travel Speed of 100 km·h^{-1} as the Limit of Competitiveness of Railway Transport

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Abstract

In this paper, the authors address the issue of the competitiveness of conventional rail transport, especially in relation to individual car transport where a travel speed of 100 km·h^{-1} can be achieved. The paper gives concrete examples of connections where this speed can be achieved, but also examples where it cannot be achieved, mainly due to insufficient infrastructure. Then, on the basis of the results obtained from the examples of such connections, appropriate conclusions and recommendations are drawn.

Keywords: travel speed, transport connection, railway transport

1. Introduction

Rail transport is considered as a superior mode of transport within the public transport of the country and as a backbone transport system. In order for rail transport to be competitive with other modes of transport (especially individual car transport) it is necessary to have a high quality and functioning infrastructure. Even on a conventional rail network, favourable travel speeds or transport speeds (in relation to travel time) can be achieved. There are many examples of connections in the Czech Republic and other countries where it is the travel speed of (approximately)

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100 km·h^{-1} that makes rail transport win over individual transport in long-distance transport. This paper addresses precisely those connections where rail transport is competitive and also gives examples where this is not the case so far, including possible reasons for this. The authors focus on the conventional rail network, not on high-speed rail. So can a travel speed of 100 km·h^{-1} really be considered the limit of rail transport competitiveness?

2. Travel speed and travel time

It is important to understand what cruising speed is. It is an indicator that is particularly relevant from the passenger's point of view, as it ultimately determines how quickly a passenger is transported between two given locations, obviously in relation to travel time, which includes all stops, stays and possible transfers (Chocholáč et al. 2017; Drdla 2021). It is therefore not just a matter of running a single train between two cities. It is clear, therefore, that good infrastructure in terms of line speed and deployed vehicles capable of using that speed is only one part of achieving the required travel time and speed. Aspects of the timetable itself are also important, for example (Bulíček and Bažant 2020):

- trains in the so-called "express level" are also operated on the line, which stop only in important settlements or do not stop anywhere between two given cities (this eliminates train stays in stations),
- trains on the line are assigned appropriate journey time mark-ups, which are essential in particular for maintaining the stability and reliability of the timetable,
- if a connection requires a change of trains, reasonable transfer times are set to ensure that passengers transfer comfortably at the station but do not unnecessarily increase travel time.

Travelling speed is an indicator used in passenger transport and is defined as the ratio of the distance travelled between the passenger's starting and finishing station and the time taken, which includes the train journey time, stops at stations and stops, extra charges for starting and stopping the train and the time of any changes. It can therefore be determined according to the relationship (formula 1):

$$v_t = 60 \cdot \frac{L}{T_j + (T_1 + T_2) + T_d + T_t} \text{ [km·h}^{-1}\text{]} \quad (1)$$

where:

- v_t … travel speed [km·h^{-1}],
- L … distance travelled [km],
- T_j … journey time of train(s) [min],
- T_1, T_2 … surcharges for starting and stopping trains [min],
- T_d … train(s) dwell time [min],
- T_t … time of transfers [min].

Ľupták et al. (2020) in their paper also deal with travel speed and address the proposal of a unified methodology for the issue of link quality assessment. The purpose is to propose and validate a procedure for evaluating link quality on a transport network and thus contribute to a more effective evaluation of integrated transport systems. The methodology within the network under consideration (here specifically the South Bohemia Region and the accessibility of selected towns from Strakonice) lists, among other things, the average travel speed between two towns as one of the indicators of the quality of the connection.

3. Examples of connections

In the Czech Republic and in neighbouring countries, some examples can be given of city connections where a solved travel speed of 100 km·h^{-1} (in some cases even slightly more) can be achieved. The authors have focused in particular on connections between cities that are located about 100 km apart and the travel time is less than 90 minutes on a given route by at least one of the transport modes under consideration. Train connections were considered primarily by long-distance trains (excluding any high-speed services with line speeds higher than 200 km.h^{-1}) with the shortest travel time on the given route (Bulíček et al. 2021; Gašparík et al. 2017a). Either a shorter journey time than using individual car transport (hereinafter referred to as ICT) or, for the same journey time (i.e. zero difference), the inclusion of the mode with the higher journey speed is a condition for the inclusion of the links on specific routes in the links where rail wins in terms of journey time (Široký et al. 2021). The authors intend to highlight those journeys which, although relatively long in terms of distance, can be used comfortably for daily commuting to work or school because of the attractive commuting time. In the Czech Republic, according to the public database of the Czech Statistical Office, as of 2021, a total of 5,290,071 inhabitants are employed, of which 918,852 work in another district or region. This is roughly 17% of all employed people. It is in these cases that it can be assumed (neglecting those working from home) that these residents commute a greater distance to work. Similarly for pupils and students, of whom there are 1,465,320 as of 2021, with 240,484 commuting to school in another district or region, or 16%. Here, however, the daily commuter ratio will be reduced by those pupils and students who are housed in halls of residence and boarding schools. At the same time, in this case, it can be assumed that a significant proportion of the above values of pupils and students do not own a car or have a driving licence, and therefore the consideration of these commuters is irrelevant for the purposes of this paper. Table 1 shows the cases where the train journey time is shorter than the ICT journey time.

Table 1. Examples of connections where rail transport is competitive.

Connection	State	Distance [km]		Travel speed [km·h^{-1}]		Minute difference ICT – Train
		Train	ICT	Train	ICT	
Praha-Pardubice	CZ	104	120	**111,4**	**82,8**	**28**
Praha-Tábor	CZ	99	100	**100,7**	**60,6**	**17**
Pardubice-Zábřeh	CZ	100	100	**105,3**	**57,1**	**45**
Břeclav-Přerov	CZ	100	111	**96,8**	**69,4**	**20**
Olomouc-Ostrava	CZ	106	96	**115,6**	**90**	**19**
Praha-Plzeň	CZ	107	92	**85,6**	**80**	**0**
Plzeň-Cheb	CZ	106	107	**77,5**	**77,3**	**1**
Bratislava-Trenčín	SK	123	130	**108,5**	**100**	**9**
Bratislava – N. Zámky	SK	91	113	**94,1**	**80,7**	**21**
Linz-Salzburg	A	123	133	**108,5**	**101**	**11**
Dresden-Leipzig	D	117	117	**103,2**	**97,5**	**5**

The table below shows selected connections which show that rail transport can be competitive with individual car transport in terms of speed. The available data from the timetables in force in August 2023 were used to determine the indicators and the fastest connection within the session and the data from the Mapy.cz route planner were always selected.

However, it is also possible to find connections between large cities where the situation is reversed, and rail transport is disadvantaged mainly due to poor or non-existent infrastructure. Table 2 shows examples from the Czech Republic where the ICT journey time between these connections is shorter than the train journey time.

Table 2. Examples of connections where rail transport is not competitive.

Connection	State	Distance [km]		Travel speed [km·h^{-1}]		Minute difference ICT – Train
		Train	ICT	Train	ICT	
Praha-Liberec	CZ	140	108	**55,6**	**73,6**	**79**
Praha-Chomutov	CZ	177	98	**73,7**	**74,4**	**65**
Praha – H. Králové	CZ	121	114	**72**	**78,6**	**18**
Pardubice-Jihlava	CZ	121	91	**51,8**	**58,7**	**47**
Brno-Jihlava	CZ	104	88	**57,1**	**87,3**	**51**
Č. Budějovice – Příbram	CZ	110	101	**64,7**	**66,8**	**10**
Cheb-Chomutov	CZ	111	100	**68,7**	**74,0**	**16**

For the sake of completeness, the authors decided to show a graphical representation of the travel speeds within the suburban railway to ICT. In such sessions the travel speed is far from reaching 100 km.h^{-1}, due to frequent stops. However, this may not be a barrier for passengers to prefer rail to ICT, but the condition that travel time should be shorter than ICT still needs to be met. However, it should also be added that the graphs attached below only show the travel speed from station to station, they do not include the walking journey or the subsequent public transport journey (Gašparík et al. 2017b; Záhumenská et al. 2018). For ICT, the walking to/from the car or the time spent looking for a parking space is missing.

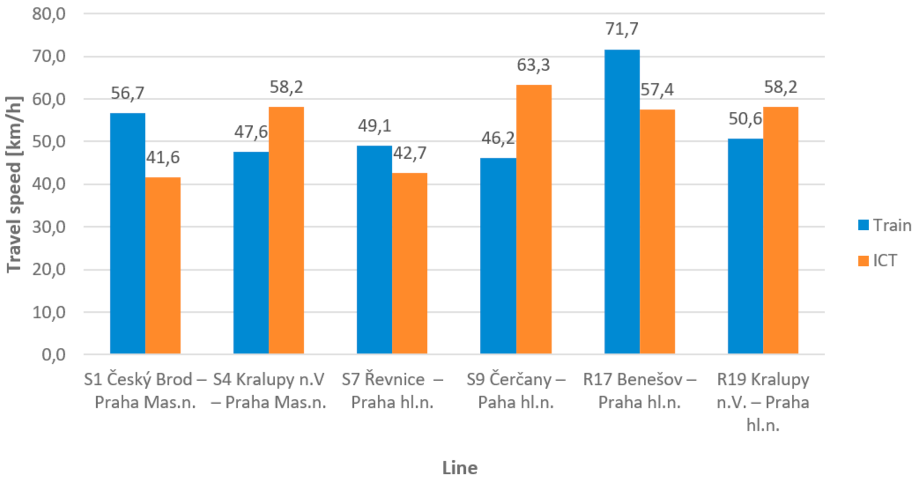

Fig. 1. Graphical representation of travel speed within PID connections.

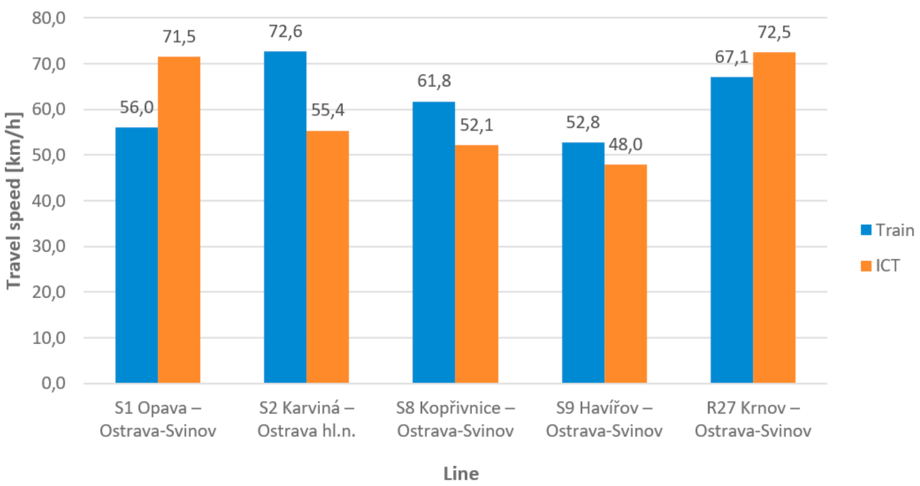

Fig. 2. Graphical representation of travel speed within ODIS connections.

Figures 1 and 2 show that even within the suburban rail system, train travel speeds can be higher than for ICT.

It is necessary to mention that currently the railway transport is competitive on some routes thanks to new or reconstructed lines, on which it is possible to reach speeds of 160 km·h^{-1} (or more), adequate vehicles, due to the lack of a fast alternative in the form of a motorway (e.g. for the Prague-Tábor or Pardubice-Zábřeh connection) and often also due to the expected delays in the form of congestion in large cities. However, this may change in the future, especially in connection with the construction of motorways (for the above-mentioned routes, the D3 and D35 motorways), which may increase the use of individual car transport. In contrast, the well-known plans for the construction of high-speed rail in the Czech Republic should again favour rail transport. Figure 3 shows how the time accessibility of different areas of the Czech Republic from the largest Czech cities will change.

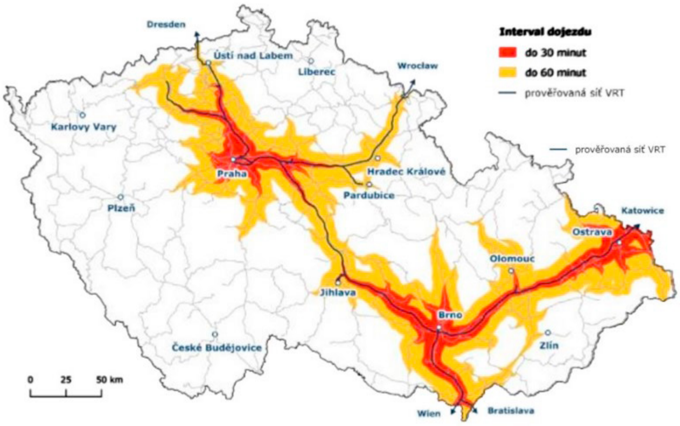

Fig. 3. Time availability after the construction of high-speed lines in the Czech Republic.

4. Partial results of the above research

A survey of journey times and average travel speeds between selected routes was carried out, primarily within the Czech Republic, but also some examples from the Slovak Republic, Austria and Germany. The sessions included were those where the journey time for at least one of the modes is less than 90 minutes and with an average distance of around 100 km, without exceeding at least one of the threshold parameters.

For journey times and the competitiveness of rail transport on individual routes, the main criterion is whether a motorway network is available between the destinations. This has a major impact on whether it is preferable to use the car or the train. In these cases, therefore, a high-quality infrastructure allowing higher line speeds with adequate parameters is essential for the preference for train transport (Potkány and Krajčírová, 2017). If such infrastructure is not available, then the competitiveness of rail transport cannot be achieved. At present, in order to achieve the competitiveness of rail transport, but also to minimise land occupation in the countryside, the trend is to build new rail infrastructure in parallel with the motorway network; in a number of Western European countries, several such sections of high-speed lines have already been implemented (e.g., Stuttgart - Ulm, Frankfurt am Main - Fulda). Projects for high-speed lines in the Czech Republic also envisage such parallel routing, for example between Hranice na Moravě and Ostrava parallel to the D1 motorway, or between Prague and Ústí nad Labem parallel to the D8 motorway.

The relief and natural conditions on the monitored route also have a major influence on the monitored parameters of the transport modes in question. For example, between Bratislava and Nové Zámky, or between Berlin and Leipzig, the flat nature of the landscape allows for both types of infrastructure without significant bridge and tunnel structures and without the need to implement curves, which naturally reduce the line or travel speed (Tischer et al. 2020). It is the mountainous landscape and rugged terrain that affects, for example, journey times between routes such as Prague and Liberec or between Linz and Salzburg.

Another influence on the journey time between the monitored sessions is clearly the number of tracks in the case of rail transport. Where there are the largest differences between train and ICT journey times there is usually only a single-track rail line available. On this track it is necessary to make crossings at stations, which slows down the train travel speed considerably. This phenomenon mainly occurs on the lines Prague-Liberec, Pardubice-Jihlava or Brno-Jihlava, where the difference between the ICT and train journey times is more than 50 minutes in favour of ICT vehicles. The increase in travel speed in these cases can be achieved mainly by increasing the number of tracks or at least by implementing places for fleeting crossing or fleeting overtaking.

The above aspects can be demonstrated by two examples from the Czech Republic, namely the hourly time availability from the cities of Pardubice and Liberec (shown in Figure 4). While the city of Pardubice is located on a double-track transit rail corridor with line speeds of up to 160 km·h-1 in the lowlands, the city of Liberec (and indeed the entire Liberec Region) does not have any line of similar parameters on its territory (Nachtigall and Ouředníček 2018; Kučera and Chocholáč 2020). This corresponds to the time availability. From Pardubice, passengers can get across the entire region to Prague or Zábřeh in an hour, but in Liberec, it is possible to talk about travelling only within the region at the same time.

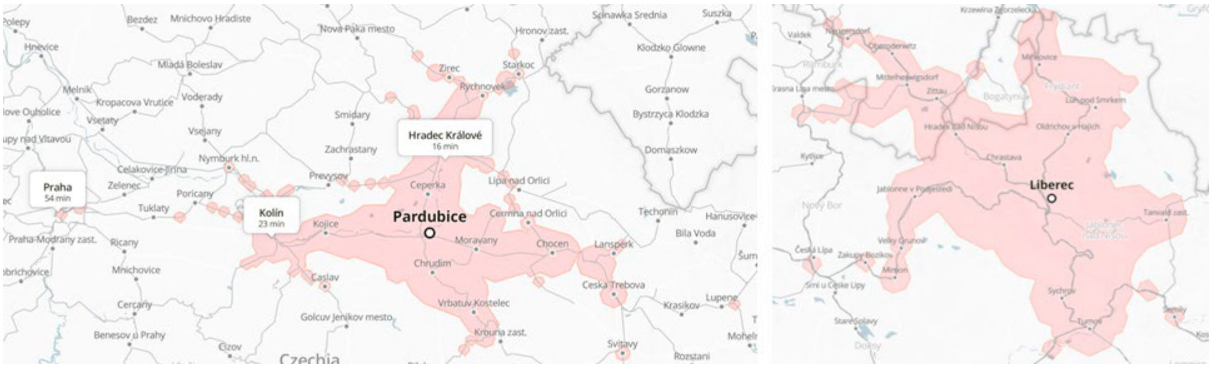

Fig. 4. Current hourly accessibility from selected cities.

5. Conclusion

Consequently, it is necessary to answer the question raised at the beginning of this paper, namely **whether the travel speed of approximately 100 km·h^{-1} is the limit of competitiveness of rail transport** on selected routes. The examples of connections given clearly show that this is not the case. The quality of the road infrastructure between the destinations in question, and in particular the existence of a motorway network, is what matters. It can be said very unprofessionally that if the road network is of poorer quality, then even rail transport with poorer quality infrastructure that does not allow higher line speeds (> 100 km·h^{-1}) can be competitive on such a route. However, this is only until the parameters of that road infrastructure are improved. Thus, it is necessary to invest regularly and improve the quality of the greener rail transport to keep it competitive.

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