

Key Attributes of the High Speed Rail System Project

L. Týfa

Czech Technical University in Prague, Faculty of Transportation Sciences, Department of Transporting Systems, Prague, Czech Republic

** Corresponding author: tyfa@fd.cvut.cz*

ABSTRACT: The contribution focuses on the provision of the high speed railway lines (HSRL) in a region, in which the HSRL is being considered. Defined first is the high speed rail system concept, followed by a description of the procedure preceding the implementation of such a railway line, and the basic principles of the HSRL route layout.

KEY WORDS: High speed railway line, rail route layout.

1 HIGH SPEED RAILWAY LINE CHARACTERISTICS

Since this paper deals with the high speed railway lines (HSRL), it would be appropriate to first describe such definitions as accurately as possible, as well as to explain in which aspects the HSRL differs from other railway lines.

Rail systems can be grouped by their different features. In terms of physical features, two differing features can be mentioned that distinguish the two given systems that enable movement of a railway carriage on a long distance railway line – these are the adhesion railway and the railway based on the principle of the magnetic levitation, generally referred to as maglev.

For proper functioning of the adhesion railway, contact between the wheel and the track is necessary. In the case of the maglev, the carriage moves free from contact above its roadway as the result of the magnetic levitation (based on application of the linear electromotor). In commercial services, the maglev operates only in the city and suburban transportation, but projects to also construct long distance railway lines have already been prepared. The advantages of the maglev are the high operating speed, fast acceleration and deceleration (which shortens the travelling time), non-existent mechanical wear of the rails during the carriages' movement, and noise, which is only created by the aerodynamics; its disadvantages are the incompatibility with other transportation systems (creating difficulties in building such rails in stages, as well as cooperation with other types of transport means) and impossibility of the track construction on the earthwork structure.

In terms of the highest trains' speed facilitated by the railway, it appears that the most suitable grouping is the one in terms of the two Council Directives on Interoperability of the Trans-European Railway Systems (Council Directive no. 96/48/EC, 1996; Council Directive no. 2001/16/EC, 2001), which set out differences between the conventional and the HSRL. The HSRL includes specially constructed HSRL for speeds up to 250 km/h and higher, specially modernised railway lines for speeds of the magnitude of 200 km/h, and specially modernised rails of unusual characteristics given by topographic, terrain or urban

limitations, to which the speed must be adjusted in each individual case separately (Council Directive no. 96/48/EC, 1996).

Considered as a new, high speed railway track is therefore such adhesion standard-gauge railway (track gauge 1 435 mm is the basic condition of a railway carriage's smooth crossing between various railway lines) which is chiefly intended for the long distance transport (the railway line length is in the order of hundreds of kilometres), and of which line speed is at least 250 km/h; together with the modernised sections usually rated up to the speed of 200 km/h; these rails then create a high speed railway network.

2 THE HIGH SPEED RAILWAY LINES BASIC PARAMETERS

To determine the basic parameters of the HSRL, it is first necessary to establish the reason for the HSRL's construction and after that to determine which trains will be using the HSRL. Generally, it is possible to find at least a few closely correlating arguments to support the construction of an HSRL (that is why several justifications usually come up almost simultaneously), and of which the following could be applicable examples (Týfa, 2006):

- insufficient capacity of the conventional railway network (especially within large conglomerations with heavy suburban passenger transport)
- slow train speed (long travelling times) by the conventional network (the rail transport is not attractive either to the passenger, or to the transporters, i.e., it is not competitive in comparison with road and air transport)
- heavy transport streams (having potential for further growth) of some connections, which are presently carried out using different transportation means
- unreliability of the conventional trains (failure to adhere to the train schedule due to breakdowns and extraordinary situations), and provision of only low comfort levels to passengers (again, lack of the rail transport's attractiveness and loss of customers)
- independence of non-renewable energy sources – crude oil (this reason will become increasingly more current in the forthcoming decades; the crude oil crises in the 2nd half of 20th century contributed towards the development of HSRL)

One or more of the following train types fall under consideration to be used as the HSRL service (Týfa, 2006):

- special high-speed passenger train units, providing long distance transport at designed speeds of (300 - 350) km/h
- long distance (alt. regional) passenger trains, consisting of a locomotive and passenger carriages (plus optional controlling carriage), which are capable of reaching speeds of (160 - 200) km/h
- Transeuropean passenger express trains, transporting at the same time the travellers' passenger cars (so called trailer-trains) consisting of a locomotive, sleeping and couchette carriages and special freight wagons to transport passenger cars, and which are capable of reaching speeds of (120 - 160) km/h
- special freight train units to transport post (and alternatively other similar consignments) of designed speeds of (300 - 350) km/h
- freight trains intended especially for the provision of unaccompanied combined freight transport, which are capable reaching speeds of (120 - 160) km/h

The selection of the train types and their parameters plays a key role in terms of the evaluation of the investment to be expended, including regular operating costs required for the maintenance and operation of the railway line, when usage of HSRL is to be considered – its attractiveness to the transporters.

To be able to determine the basic design parameters of the HSRL, it is necessary to know at least the characteristics of the afore-mentioned individual train types (and not only of their driving units):

- max. speed, which the train is able to achieve
- max. acceleration to reach the train's max. speed and the braking distance from the top speed
- max. longitudinal gradient of the railway line, on which the train is able to maintain its highest speed, alternatively max. speed, which the given train is able to maintain on such longitudinal gradient, and which is the highest applicable to the highest performance train assumed
- grouping of the train to the loading class (max. mass on the axis and the unit of the carriage length)
- max. length of the train

To determine the design parameters of the railway line it is not crucial as to how the specific category of the train will be marked or what the exact route of the railway line will be, but which characteristics will correspond to the given group of trains. On the basis of the knowledge of the described train types' characteristics and in conformity with the technical norms and legal regulations, it is possible to determine the critical parameters of the HSRL layout as follows:

- min. radius of the horizontal curve
- max. longitudinal gradient of the railway line
- min. effective length of the running track in the HSRL operating control points
- min. length of the platform edge of the HSRL stations' platforms

A necessary condition to be considered applicable to carriages of all train types is their assignation to rails with normal gauge, and the adherence to the limited dimensions of the carriage's contour in accordance with international standards. Equipment of the railway line comprising solid parts of the interlocking system and the electric traction can be in principle adapted to any HSRL route. All HSRL parameters must be in conformance with the Technical Specification of Interoperability (TSI) applicable to the Transeuropean high speed rail system.

Upon expert selection of the trains and determination of their parameters it is possible to approach the design of the HSRL routes' options. Once their layout is completed, it is necessary to perform the travel simulation of all train types, in terms of the dynamics of their travel (affected especially by the longitudinal gradient of the individual track sections), and it is through this that the calculation of the travelling time of the train and the traction energy consumption will be carried out, as well as verification that the line speed has been reached.

The bigger the trains' variety and the wider their parameters' range, the stricter the HSRL design criteria becomes; consequently, the search for the optimal route becomes more demanding and its construction more expensive. Big differences between the maximum speeds of the fastest and the slowest trains will manifest itself by the necessity of a large radius of the horizontal curves and increased wear of the railway's superstructure. The traction characteristics of the train, considerably influenced by its mass and the power output of the drive-axle assemblies, will manifest itself directly in the maximum longitudinal gradient of the railway line.

For HSRL combined operation (passenger and freight trains) it is possible to determine the radius of the horizontal curves as approximately 7 000 m, and for the HSRL operation of only special high speed units, a radius of the horizontal curve of approximately 4 000 m will suffice. The smallest admissible values of the horizontal curves' radius are further lowered when a solid track-bed is used in the track construction. The biggest HSRL longitudinal

gradient with combined operation can be determined as 18 ‰. An example of the HSRL intended only for the special high speed units are the rails in France, where the TGV units overcome ascend of values of up to 35 ‰, or in Germany, between Cologne and Frankfurt, where the ICE 3 units manage the longitudinal gradient of up to 40 ‰. (Lichtberger, 2005)

Especially within the territory of the Czech Republic, characterised by the complex configuration of the terrain, scattered settlements and a unique natural and cultural heritage, even small changes in the limiting values of the HSRL routing parameters play a key role in the capital intensity of its construction.

3 HIGH SPEED RAILWAY LINES ROUTING

In accordance with the reasons that lead to the proposal of the new HSRL and the train types, of which operation is assumed on the HSRL, the HSRL route connects important residential and industrial conglomerations as the sources and target journeys of the travellers (alternatively goods), replaces sections of the low line speed conventional rails, or increases the almost used up capacity of the existing rails. Routing of the new HSRL is constrained by the limiting design parameters and effort to minimise the investment costs of the construction and the future operating costs, as well as efforts to make the route as short as possible. At the same time the HSRL routing is limited by the availability of the free space between the residential formations, industrial zones and transport constructions as well as the necessity to protect the cultural and, especially, the natural assets of the territory.

To the limiting conditions indicated in the preceding clause have to be added the problems with the location of the passengers' boarding / exit / transfer platforms and the crossing of the trains from the high speed rail network to the conventional one, and vice versa. One of the biggest advantages of passenger rail transport in comparison with air transport is the fact that the train can bring the traveller directly into the city centre, where there is a natural concentration of all services, availability of transfer to interconnecting public transport systems, and about equal accessibility to any place in the city.

One of the options of the HSRL route and a city's connection is therefore termination of the HSRL at the periphery of the residential agglomeration into the conventional network (see Figure 1b), which will facilitate use of the existing railway to enable trains to consequently travel to the central station. However, this solution has two main drawbacks, which must be examined for each specific case. Firstly, it involves extending the trains' travelling time during the travel within the urban area on the existing rails (although reconstructed within available means), especially for the travellers, who are passing through the given city, and secondly, the complications with the saturated capacity of the existing rails, which occurs especially due to the concentration of urban passenger transportation. As advantageous (but, at the same time, costly) a solution appears in the construction of a new railway line, segregated from the other transport systems, through the city centre (i.e., at a different height level – above ground, or more often underground), building a station or a stopping place as close as possible to the city centre, or an important changing transport terminal. This option became practicable, for instance, in Antwerp, Belgium or in Berlin, the capital city of Germany.

Another possibility as to how to provide a link between the HSRL and the residential area is to build a HSRL bypass around the agglomeration (plus connecting, as and when possible at suitable places, the HSRL with the conventional rail network), and build on it a completely new railway station (see Figure 1a, 1c, 1d), which would be a part of the transport terminal, connected to a good quality network of other types of the public transport services, and provided with ample parking space of the P&R type. The advantage of this option, in spite of the longer HSRL route when compared to the preceding option (bypassing the city instead of going through it) is usually a shorter travelling time, as the result of better design parameters

of the railway line (higher line speed), lower investment costs (lesser share of tunnels and bridging structures can be expected on the border of the town residential zone and the rural area, and their lower capital intensity), and the possibility of cooperation with the Individual Automobile Transport. For instance this route was taken by France in implementing the Paris east bypass (LGV-Interconnection), bypassing Lyon with the Lyon-St Exupery (TGV) station, or the new station Avignon TGV.

The attractiveness of high speed rail system can also be increased by interconnecting stations built on HSRL with airport terminals (e.g. Paris – Charles de Gaulle, Frankfurt a. M., Schiphol near Amsterdam). The advantage of such interconnection lies in the fact that on intercontinental flights and Transeuropean routes the passengers are carried by airplanes and then, after changing the airplanes for HSRL, they can be easily carried to the centres of the European metropolis with great comfort and in high speed. Regardless of the chosen means of transport, the journey is realized on the basis of a single ticket issued by the transporters involved in the cooperating system; the application of the airplane ticket on the train is considered as “flight at zero level”. Another advantage rests in the lowering of air space loading. For instance, the building of HSRL on the Paris – Lyon route originally posed a threat to air traffic in terms of competitiveness, but later on resulted in mutually satisfactory co-operation.

During the HSRL routing it is necessary to approach its interconnection with other conventional rails with special consideration. These connections, ensuring trains' smooth crossing between both rail networks, are, on one hand, advantageous for both rail networks, but, on the other hand, can be a source of complications. The contribution brought about by the connection of both rail networks rests in the fact that the travelling speeds of the conventional trains, which use the HSRL for part of their travel, increases, while at the same time the usage of the HSRL capacity increases as well. However, if the rail network interconnections are made in unsuitable places, they can become a potential source of unreliable operation; namely, serious problems can occur in cases when the train, which is supposed to depart to the HSRL at certain exact time, can not do so due to the occurrence of delays in the conventional network. Travel of various types of trains onto the HSRL, which in addition are also leaving and coming onto the HSRL at different places, poses high demands on the processing of the Train Traffic Timetable (TTT), and that is why there is usually not a big enough margin to shift the train route during the dispatch control of the operation. The TTT design simplifies when certain types of trains are routed only during a certain part of the day (e.g., passenger trains mostly during the daytime, freight trains at night time). (Týfa & Vachtl, 2005)

The link between the TTT and the HSRL route (TTT travelling time and track capacity requirements) causes an actual problem in creating efforts for the HSRL parameters to conform rigorously to so-called system travelling times of the Integral Tact Traffic Timetable in the long distance rail transport. This requirement, in some connections, leads to the belief that in these sections it is not the aim to achieve the technically lowest travelling times of the high speed trains, and so it may at first glance appear that all that is required to be connected into the HSRL network is to modernise the existing railway line. However, such cases can be affected by the following pitfalls:

- HSRL are rails primarily intended for high speed trains, which create their own European link system, and therefore they are the changing links between the trains of this type that must be primarily monitored. Creation of the individual high speed lines' tact is naturally desirable, as it leads, in terms of the passengers, to an increasing attractiveness.
- The high speed trains are supposed to compete with road vehicles travelling on highways, and also with airtraffic – both groups of transport means are trying to shorten their driving and travelling times as much as possible.

- Construction of any new transport infrastructure is a matter of several years, built at high financial costs, creating a perceivable intervention in the landscape, and its assumed lifespan is at least 100 years. This is why it is necessary to always create certain reserves in the newly built rails' parameters, with the foresight of looking to the future, as the carriage stock is developing faster than the construction of the rails and the organisation of the rail transport operation might change even more dynamically.

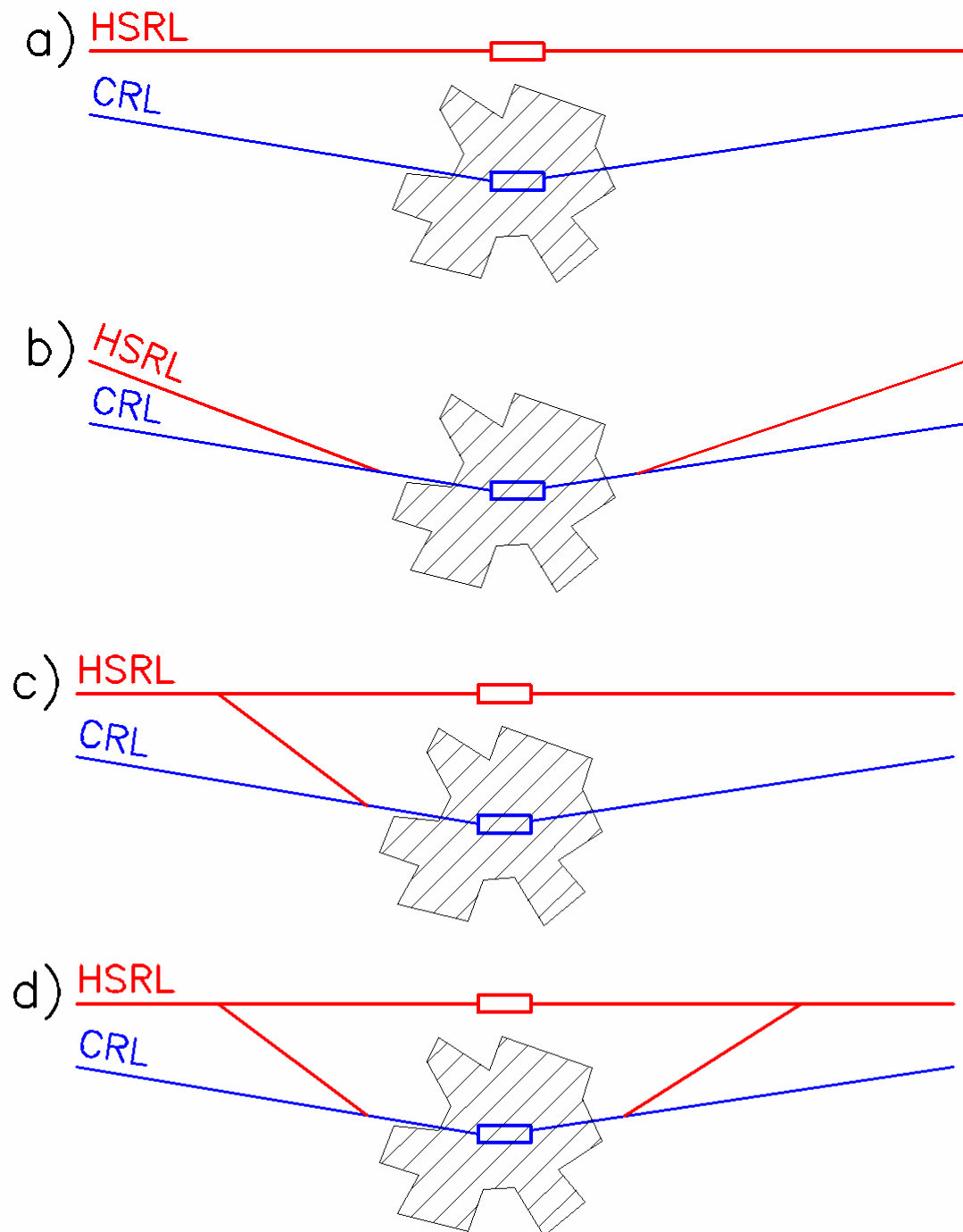
At the end of this chapter a general procedure of the HSRL design is given: After the technical design of the railway line, determination of the travelling times of all train types and the design of a few versions of the TTT is necessary, including the prognosis of the transport streams. Through such a prognosis an adequate utilisation of the railway line's capacity can be ascertained, followed by the financial evaluation of the whole construction. The financial evaluation of the construction should also include the all-society benefits and negative aspects, i.e., especially the improvement of the regional transport improvements, increased transport safety, increased transport independence from crude oil, removal of some of the transport streams from other transport systems which create an environmental burden; noise and vibration emissions, landscape deterioration (aesthetic, area fragmentation).

4 CONCLUSION

With the development of technology, commerce and tourism in the 2nd half of the 20th century, most countries of the world have experienced a fast growing demand for transport and the increasing demands of travellers and transporters for transport reliability. The automobile and air transport operators have adapted to these requirements in a versatile manner. Rail transport has also had to start offering their customers higher travelling speed, reliability, sufficient range of connections, comfort and complex range of services. During this revival of rail transport it was consequently recognised, among other things, that certain track sections' capacities were not adequate, and also discovered that their routing and technical parameters were inadequate as well. This gradually led to the radical modernisation of important rail routes in many countries around the world and development of a new HSRL.

Construction of the high speed rail system has also seriously been considered a few times in the Czech Republic (and in former Czechoslovakia). So far, preference has been given to modernisation and optimization of the existing rails, which is certainly needed and through which the previously neglected maintenance has been caught up with; the moral lagging of the railway line infrastructure behind the technical progress of its times and the customers' requirements also have to be attended to. But the modernisation as presently perceived can not, in the long term and on a bigger scale, satisfy the needs of the inhabitants and visitors of the Czech Republic in a Europe without national borders. Neither it is able to compete with other types of transport, which are much more harmful to the environment. It also must be mentioned that the modernisation of the conventional rails is not in contradiction with the construction of the new HSRL, but rather to the contrary – they suitably complement each other. The future rests in two railway networks, each with different functions, but closely and mutually cooperating.

The Czech Republic occupies a strategic position in the centre of Europe, which also predestined it to be at the centre of big events and a crossroad of important routes. But if it does not react quickly to the changes taking place in the rail transport in the neighbouring countries (especially in Germany and Austria), which are, among other things, substantially increasing the qualitative and capacitive level of their railway line infrastructure, the natural potential of the advantageous position will remain unused, and this will reflect in the declining level of the whole economy.



Legend: HSRL – High Speed Railway Line, CRL – Conventional Railway Line

Figure 1: Relation between city and HSRL:

- a) HSRL bypass around the agglomeration with a new railway station on it;
- b) Termination of the HSRL at the periphery of the residential agglomeration into the conventional rail network;
- c) HSRL bypass around the agglomeration with a new railway station on it, plus connecting the HSRL with the conventional rail network on one side of the city;
- d) HSRL bypass around the agglomeration with a new railway station on it, plus connecting the HSRL with the conventional rail network on both sides of the city.

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