



CETRA²⁰¹²

2nd International Conference on Road and Rail Infrastructure
7–9 May 2012, Dubrovnik, Croatia

Road and Rail Infrastructure II

Stjepan Lakušić – EDITOR



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CETRA²⁰¹²
2nd International Conference on Road and Rail Infrastructure
7–9 May 2012, Dubrovnik, Croatia

TITLE

Road and Rail Infrastructure II, Proceedings of the Conference CETRA 2012

EDITED BY

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ISBN

978-953-6272-50-1

PUBLISHED BY

Department of Transportation
Faculty of Civil Engineering
University of Zagreb
Kačićeva 26, 10000 Zagreb, Croatia

DESIGN, LAYOUT & COVER PAGE

minimum d.o.o.
Katarina Zlatec · Matej Korlaet

COPIES

600

A CIP catalogue record for this e–book is available from the National and University Library in Zagreb under 805372

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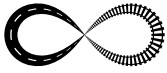
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INTEGRATED PERIODIC TIMETABLE SCHEDULING – TOWARDS AN INTEGRATED TIMETABLE ACROSS CENTRAL EUROPE

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Abstract

The integrated periodic timetable (ITF) is widely seen to be the most economical approach to serve the needs of Central European settlement structures with relatively short distances between rather small urban areas, whereas high-speed lines are better suited for long distances between large metropolitan areas. Many countries are about to start or have already started installing ITF across their railway networks. Others are running either regional networks or single lines in periodic timetables. Infrastructure development in these countries is more and more based upon the needs of ITF compliant railway operation. Furthermore, the latest review of TEN-R no longer talks of (high-speed) lines, but of (integrated) networks.

The growing number of different European networks that follow ITF principles increases the demand for a multilateral, systematic approach towards international timetable coordination as well as infrastructure development to avoid incompatibilities of both timetables and infrastructural measures between the highly interlinked Central European countries.

Based upon several previous studies dealing with both the theoretical and especially mathematical principles as well as the practical application of ITF and ITF compliant infrastructure development, a systematic approach to a supra-regional integrated timetable is presented. It shows that infrastructure investment is substantially more effective if it follows a systematic and therefore ITF based operational concept. Especially the relatively small sizes of countries in the central and South-Eastern European area lead to a high level of mutual interdependency between current timetable development and future national infrastructure projects. We should therefore consider the forthcoming sizeable investments in railway infrastructure in a multilateral context to identify potential problems, aimed at taking full advantage of a future pan-European integrated timetable.

Keywords: railway, passenger transport, ITF, international integrated timetable, periodic timetable

1 Introduction

In recent years, countries across the continent have carried out considerable investments in railway infrastructure as well as in timetable improvements, both in travel times and in the quantity of the offer. Two major railway operation concepts have emerged, Point-to-Point High Speed Traffic and the Integrated Periodic Timetable (ITF). Looking at Central Europe, we explore the main aspects of these concepts and examine their adequacy for Central Europe. Due to the highly interlinked character of the countries, we use an international approach, so to indicate the future direction of European Passenger Transport.

2 Project area

For this study, central and South–Eastern Europe is considered as the project area. This comprises the Czech Republic, Slovakia, Austria, Hungary, Slovenia, Croatia, Bosnia–Herzegovina and Serbia.

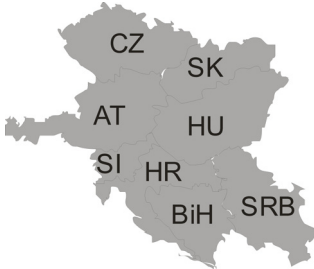


Figure 1 Project Area.

These countries share several similarities: Relatively small towns, one large capital city, short distances in between these towns and population densities between 80 and 130 persons per square kilometre.

3 Current concepts of railway operation

Thus far, two concepts of how to plan and operate a railway network have proved successful and serve as long–term goals: Point–to–Point High Speed Traffic and the Integrated Periodic Timetable.

3.1 Point to point high speed traffic

The main goal of the first High Speed Lines in Japan and then in France was to interlink densely populated agglomerations with each other. These links have the potential to justify both large scale investments in infrastructure and single–purpose Point–to–Point Traffic without integrated connections to other lines. The Tokaido Shinkansen in Japan connects a population of more than 80 million inhabitants, located in cities on average 100 kilometres apart. The LGV Sud–Est in France connects Greater Paris with more than 10 Million inhabitants on one end and cities with together over 10 million inhabitants on the other ends, each between 300 and 500 kilometres from Paris. Since then, this kind of railway operation model has been extended to other countries, always connecting large agglomerations [1].

The basic principle in Point to Point High Speed Traffic operation is that trips along the line can be considered stand–alone without connections to be considered systematically. Branches, if necessary, are served as direct trips diverging from the main line without further inferring with other routes.

The advantage of this concept is that only the demand along the route needs consideration in the planning process, resulting in very little excess capacity. Furthermore, any infrastructure improvement, no matter how extensive, directly leads to reduced travel times and an improved service.

However, this kind of operational concept is dependent on large agglomerations and sizeable distances (between 300 to 500 kilometres). This means that the population along the line needs to generate enough potential to allow for a dense timetable. This also applies for the aforementioned branch lines, so that connections to agglomerations off the main line also hold enough potential for a reasonable amount of direct connections.

3.2 The integrated periodic timetable

Besides the Netherlands, which put the first network-wide integrated timetable into service in the 1930s, Switzerland is perhaps the most commonly known country for its widespread implementation of an ITF scheme. Switzerland is recognised for strictly basing infrastructure improvements upon the needs of an ITF. It is for this reason, that Switzerland features a mixture of high speed and low speed sections even on main lines, depending upon the travel time necessities of the integrated timetable. Several countries such as Austria, Hungary and the Czech Republic have since followed this example [2].

The main key of this type of concept is the principle of hubs, where connections within the network meet at the same time to allow multi-directional changes for passengers. This hub structure requires ride times that are multiples of half the system interval (multiples of 30 minutes for systems with hourly services) between the hubs as well as multiples of the interval (usually multiples of 60 minutes) along any loop within the network. Therefore, the primary aim of infrastructure improvements is to reach these required ride times.

The major difference to Point-to-Point traffic lies in the consideration of the network rather than isolated lines. Wherever the potential is not concentrated along a line, is too low to allow for point-to-point connections only and/or spread out within small distances (less than 300 kilometres), the focus needs to be on how to organise the network as a whole. Travel time improvements are achieved by an adjustment of the inter-hub ride time, thus optimising the changes at hubs.

Approaching the high degree of complexity in integrated timetable planning must be systematic: Every change on individual lines might potentially affect large areas of the system. The combination of these system dependencies together with market demand and capacity restraints along the line leads to the necessity of simultaneously planning on several levels, from infrastructure up to vehicles.

4 Prerequisites for increasing railway market share

The main aim of any railway service improvement is an increased market share. The railway system is mass transportation, therefore dependent on several prerequisites. Successful railway systems must feature a combination of at least two of the following conditions: distances, masses of people and a network.

4.1 Distances

Compared to road traffic, railways feature a longer access time to the system, thus the market share of railway traffic will be higher for distances where the higher travelling speed will level out against the shorter access time and longer travel time of cars, until eventually air traffic becomes more attractive for very long distances. Generally speaking, we can consider distances between 50 and 500 kilometres relevant for a high market share of railway traffic. [1, 2].

4.2 Masses of people

The most commonly stated advantage of railway traffic is the ability to move masses of people. This is identified in commuter rail systems all over the world. Masses of people typically occur around agglomerations, but this does not automatically imply that railway traffic outside agglomerations will be unsuccessful – if potentials along a line are bundled towards hubs with connections in all directions, there will be considerably more passengers, justifying railway traffic also outside agglomerations. This, however, is only possible with a hub structure, which implies an integrated timetable [3].

4.3 A network

Another prerequisite to increase the market share of railway traffic is the existence of a network. Addressing a network as such is only possible with an integrated timetable, thus allowing attractive connections in the network, including changes. A network therefore not only incorporates different railway products, but also buses, light rail and urban transport. This also automatically implies a hub structure, so that potentials are bundled along the connecting lines [3].

5 Suitability of railway operation concepts in Central Europe

As explained, the Central European countries considered in this study share most structural attributes. Considering these, none of these countries features relevant distances for high-speed traffic, nor is there relevant agglomerations that justify point-to-point traffic. Taking Mairhofer's gravitational approach [1], the potential for high-speed Point-to-Point traffic within an area is calculated as the sum of the potentials between all agglomerations in an area.

$$V = \sum A \cdot \frac{P_A \cdot P_B}{\epsilon^{1.7}} \tag{1}$$

where P_A and P_B is the population of two agglomerations, ϵ is the distance between them and A is a factor for the affinity for high-speed railway traffic (travel speed of 200 km/h) with the following form:

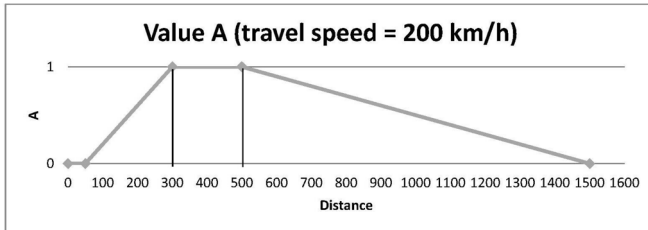


Figure 2 Value A [1]

With this formula, we can estimate the potential of high speed-traffic in Central Europe, comparing it to Switzerland, Germany, Italy and France. It shows that the countries in the project area all feature very low potential for high-speed traffic. If plotted next to the population of the countries (both normed to Austria's values for comparison reasons), one could identify that the potential rises exponentially with the population. However, even if we consider all Central European countries combined, resulting in an approximate population of Italy or France, the project area still bears significantly lower potential for high-speed traffic. This is due to the aforementioned structural characteristics shared by these countries.

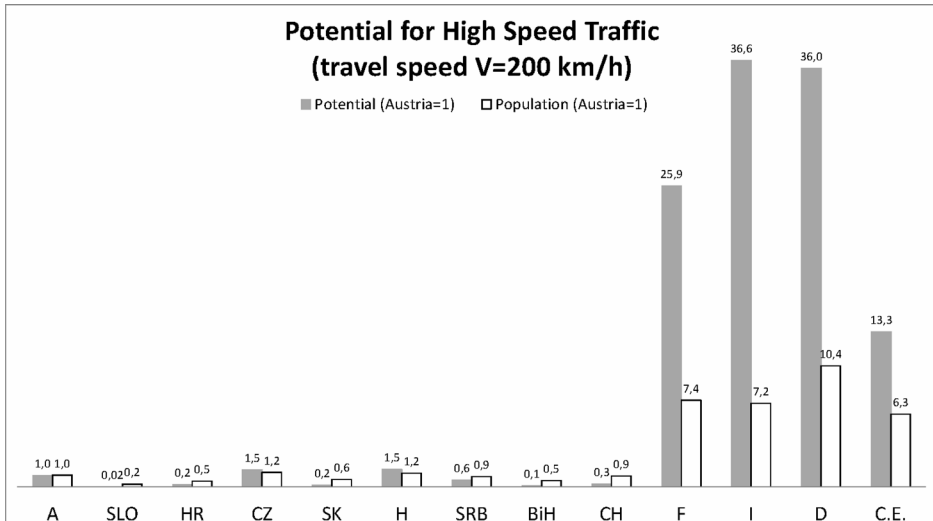


Figure 3 Potential for High Speed Railways in Europe. 'C.E.' denotes all countries of the Central European project area together

Therefore, we can regard high-speed traffic as inadequate for Central Europe. The integrated timetable, as operated in Switzerland with great success, is the ideal form of railway operation, making best use of the potential.

6 Current status of integrated periodic timetables in Europe

To get an overview whether the adequacy of integrated timetables for Central Europe also reflects the individual countries' timetable goals, the current state of Integrated Timetables in Europe was examined:

- The Czech Republic has already introduced an ITF scheme on most relations, including a long-term aspiration for ITF-compatible infrastructure upgrades.
- In Slovakia, the main lines operate in regular intervals, but without an integrated approach.
- Austria introduced its first ITF in 1991. Infrastructure improvements were loosely linked to the timetable requirements, yet led to sensible travel time improvements. In 2011, a long-term systematic concept that linked infrastructure and ITF was published and is followed since.
- Hungary, like the Czech Republic, already features an ITF on a great portion of the network. A long-term objective for integrated infrastructure and timetable development exists.
- Slovenia, Croatia, Serbia and Bosnia-Herzegovina do not feature an Integrated Periodic Timetable at present.

From this status, the conclusion is that Central Europe, generally speaking, is progressing the right way towards a pan-European Integrated Timetable.

7 Integration of national timetables

The widespread occurrence of ITF across Central Europe prompts the question whether the timetables of the individual countries clash along the borders. Three main factors are responsible for compatible international timetables.

7.1 Selection of the same cities as hubs

For historical reasons, several of the studied countries feature important railway stations close to the border, resulting from former border checks and system boundaries. Due to their operational importance, many of them have been selected as ITF hubs. On the other side of the border, however, we very often find the same situation, with a low ride time between these hubs. For serving both hubs, this travel time has to be stretched artificially to multiples of 30 minutes.

The only solution here is a multilateral agreement on which of the two stations should serve as hub and which one serves simply as an ordinary intermediate stop. Given the fact that a lot of border stations do not feature a potential to justify a stop of long-distance trains, a very convenient solution is to abandon both stations as hubs, thus spreading necessary infrastructure improvements among the involved countries and in doing so minimising construction costs.

7.2 Considering loops instead of lines

As mentioned in [4], ITF networks should be considered as multiple interlinked loops. Thus, international connections do not only form a line, but part of two elementary loops. If the two neighbouring ITF would request an unattainable ride time between hubs, a separation line extending across the whole network can ease infrastructure demand on several lines simultaneously, adding the same amount of ride time to all affected lines. If the line is cautiously drawn along problematic lines, construction costs can be significantly reduced.

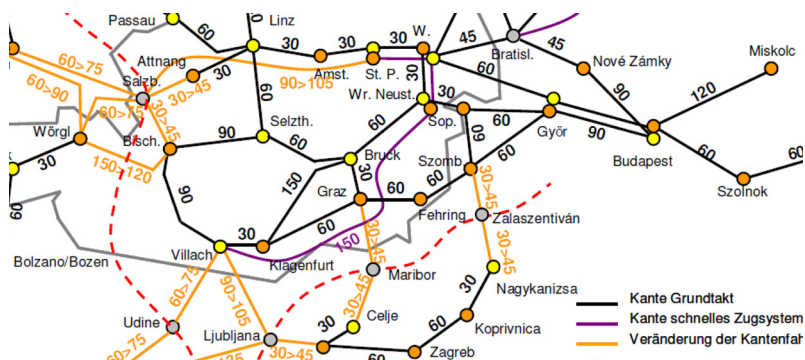


Figure 4 Separation lines within the network [2]

7.3 Softening of strict ITF rules

The basic principle of the ITF implies very strict rules and can result in unattainable infrastructure requirements [2]. However, these rules are based upon the idea of an identical interval across the whole network. As many lines in the project area already operate at a 30-minute headway, loops touching these lines have double the possibilities of ride time reduction. Also, very often there is more than one long-distance product, resulting in two different travel times along one line, which allows more possibilities and reduced construction costs.

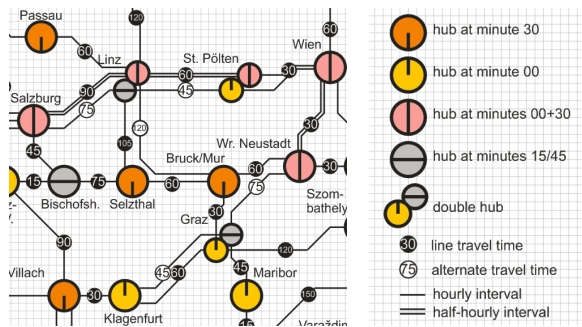


Figure 5 30-minute headways and products with different ride times.

7.4 Timeline for network integration

It is obvious that current infrastructure often does not allow sophisticated travel time reductions. It is also obvious that any international coordination, even if based upon the current network, will significantly improve the offer in railway traffic, mostly though optimised changes at hubs.

Therefore, the international coordination in terms of network integration needs to start immediately, to rapidly approach the first steps of an improved offer.

Furthermore, the future networks of the individual countries need to be coordinated. Any investment resulting from a concentration on just the national networks could potentially result in sunk costs. Therefore, coordination for future networks also needs to start right now.

8 Conclusion

It has been deftly demonstrated that the Integrated Periodic Timetable is the most appropriate solution for Central European railways. As many countries are developing ITF schemes and as greater numbers of infrastructure projects are based upon the requirements imposed by the ITF, the development within Central Europe is progressing successfully. However, efforts for international cooperation for integrating national ITF concepts need to be made in order to optimise the international integration of the respective railway networks.

The best point in time for starting these coordinations is now, as

- Infrastructure demands highly depend upon the ITF and
- Upgrade of Infrastructure is planned for the coming years.

Only in taking ITF principles into account in planning the upgrade of the infrastructure, sunk costs can be avoided and the benefits, nationally and internationally, of the investments can be maximised.

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