transnational liner service; rail corridor; corridor capacity; train scheduling

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INFLUENCE OF THE FREIGHT TRANSNATIONAL RAIL LINER SERVICE ON THE TRAIN SCHEDULING IN CASE OF MAJOR CORRIDORS

Summary. In this paper we discuss several consequences of the freight transnational rail liner service on the rail corridor capacity. The Northern part of the IVth TEN-T corridor on Romanian territory has specific feature related to the passenger flows connecting important Romanian demographic and economic clusters, on one side, and on the other side, to its diagonal crossing aspect, from the Western border to the Constanta port, connecting the Central Europe countries to the Black Sea regions, which means that there are a lot of expectation in terms of this corridor rail capacity: this corridor will, be for a long time further, the single and first completed continuous upgraded and modernised rail corridor. Its utilization will necessarily be heterogeneously planned (meaning for passengers rapid trains and freight rapid trains, from domestic/internal market, but especially for external market of Romania). In this paper, we consider a simple mathematical model for the calculus of capacity in two different cases: for a homogeneous utilization, meaning that all trains have the same running speeds and for heterogeneous utilization, when the passenger trains have the higher speed and hence, the higher priority over the freight trains, even if some of them are freight transnational liner service. Special feature of liner rail service has to be considered (fixed schedule, no stops for passenger train advance). We draw several useful possible solutions to be considered in order to preserve the active corridor capacity, and to assure a smooth flow for the transnational liner services, which ultimately will enhance the rail attractiveness.

WPŁYW SERWISU LINII TOWAROWYCH KOLEI TRANSNARODOWYCH NA HARMONOGRAMOWANIE POCIĄGÓW W GŁÓWNYCH KORYTARZACH

Streszczenie. W artykule przedyskutujemy wpływ serwisu międzynarodowego, kolejowego transportu towarów na przepustowość korytarzy. Północna część IV-tego korytarza TEN-T na terytorium Rumunii posiada specyficzne cechy oparte o przepływy pasażerów łącząc ważne demograficznie i ekonomicznie ośrodki Rumunii, z jednej strony, a z drugiej strony o diagonalny aspekt skrzyżowań ze wschodniej granicy do portu Konstanca, łącząc centralne kraje Europy z regionami Morza Czarnego, co oznacza wielkie oczekiwania związane z przepustowością korytarzy kolejowych. Rozważamy prosty matematyczny model obliczania przepływu w dwóch różnych przypadkach - dla jednorodnego wykorzystania, co oznacza, że wszystkie pociągi mają taka samą prędkość przebiegu oraz niejednorodne wykorzystanie, kiedy pociągi pasażerskie maja większą prędkość i stąd wyższy priorytet niż pociągi towarowe, nawet jeśli niektóre z nich są międzynarodowymi liniami towarowymi. Dla tej ostatniej sytuacji zostało narysowanych kilka użytecznych, możliwych rozwiązań rozpatrywanych w szczególności by chronić aktywny przepływ korytarzy, oraz by zabezpieczyć płynny przepływ dla serwisu linii transnarodowych, które w końcu uwydatnią atrakcyjność kolei.

1. INTRODUCTION

The European railways are still in a structural transforming process. The EU territorial cohesion aim requires the larger and longer freight flows (which are in fact the measurement of the economic interaction among economic systems of EU countries), imposing the single European rail network structuring, on one side and, on the other side, requiring the consolidation of the main trade transnational corridors and the modal shift from road to rail.

In Dec. of 2010, European Commission [1] released a detailed analysis of the Trans-European Transport Network, Priority Projects, in order to highlight precisely the progress achieved, the work that remains to be done through an up-dated setting of priorities and the need for the EU to focus even more on the support for cross-border sections. A useful figure, having the deadlines for every of rail sector on Romanian territory, is selected from that document (Fig. 1). It should be noted that the most appropriate solution would be possible to optimize the interface between rail and sea transport [2].

It is obvious that a lot of effort has to be done in order to connect mainly the Western part of Romanian territory to the Black Sea port - Constanta, and the time horizon for accomplishment is 2020. The estimated costs of the 864 km long line are about 8 bnEUR. This means an average value of almost 10 mioEUR per km of rehabilitation works. The modernization of the railway infrastructure mainly aims to improve the attractiveness of the railway transport by increasing the maximum running speed to 120 km/h for the freight trains, to 160 km/h for passenger trains, and ERTMS level 1, along the entire corridor. The corridor is split in several sections between the Curtici, the West cross-boarding point and Braşov, the important central city, economic and demographic cluster, in Romania.

At the moment, are operational at the designing parameters, the following segments on the IVth TEN-T corridor: *Câmpina – Bucureşti* (92 km), *Bucureşti – Fundulea* (35 km) and *Feteşti – Constanţa* (84 km), in total 211 km, or 24,4% [3].

However, the mixed utilization of the single corridor will bring out the capacity problem, which is close related to the diversity of the train speeds.

The freight/ intermodal block trains and transnational liner rail services have as a main objective to attract more freight from road transport and this is attainable objective only in case of shorter total time, and hence, only in case of higher speeds, in commercial meaning.

This objective is jeopardised by the needed technical operational times for the freight train overtaking by the passenger train (which is supposed to have a higher speed over the freight trains).

According to the actual regulatory frame, in Romania, all passenger trains have absolute priority over any type of freight train.

In this paper we discuss the influence of the mixed utilization of the fourth TEN-T corridor on its capacity, especially in case of the transnational freightliner service, and several solutions in order to preserve a high capacity level on corridor.

We take into consideration the rail infrastructure manager's interests to offer a higher number of freight train slots/paths for binding, in case of a certain number of passenger trains, and the freight trains operators' interest, which is needed for the shorter transport times between the cargo's origin and destinations, without any prejudice for passengers, irrespective of trains category.

The results in FLAVIA project [4] revealed the need for rail transnational intermodal liner services connecting the Central Europe countries to the Black Sea regions and TRACECA countries through the Constanta Port (Fig. 2). Resuming, the rail liner service is defined as a constant and regulated frequency train with large amount of freight/containers, without any operational interruptions along the route. Nowadays, the all European railway administrations use the same principles to calculate the rail capacity; these principles are stipulated in UIC Code 406 [5]. According to this document, the capacity of the railway infrastructure is the total number of possible train paths in a defined time interval considering the actual path mix or known developments respectively and personal assumptions of infrastructure managers in nodes, individual lines or a part of the network taking into account market-oriented quality.

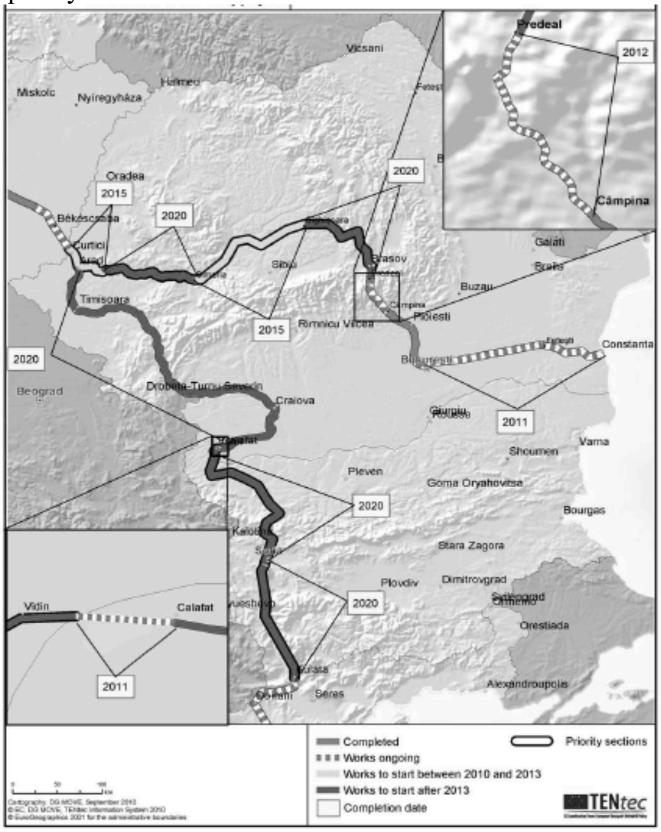

Fig. 1. Deadlines on Romanian TEN-T corridor IV -the segments included into the Priority Project 22

Rys. 1. Ostateczny termin dla rumuńskiego korytarza TEN-T IV-tego segmentu zawartego w Priorytetowym Projekcie 22

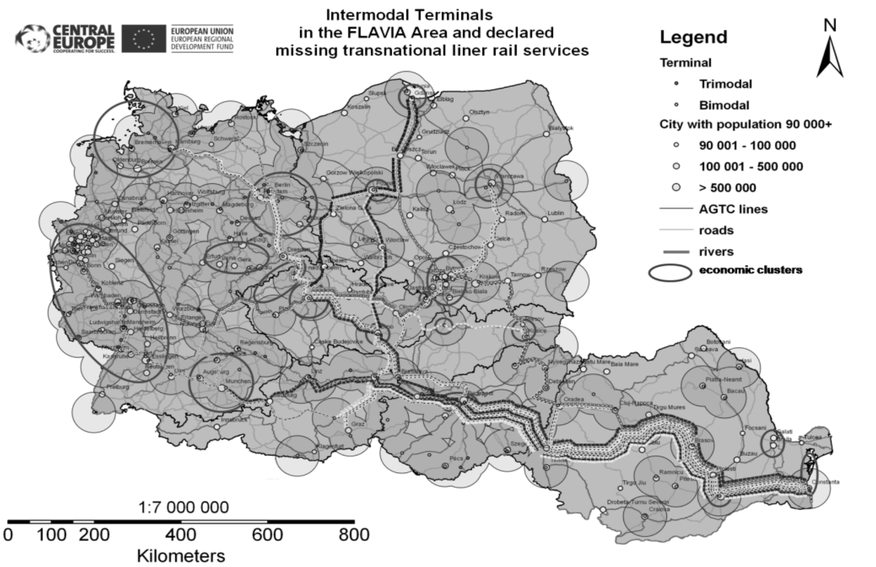

Fig. 2. The needed liner rail transnational services along the IVth TEN-T Corridor, connecting Central Europe to Constanta port

Rys. 2. Potrzebne serwisy linii towarowych kolei transnarodowych wzdłuż IV-tego korytarza TEN-T, łączącego centralną Europę z portem Konstanca

The paper is structured into the following sections: hereafter, in second section we present the Northern part of the fourth TEN-T corridor, on the Romanian territory, and highlight the most important economic centres and demographic clusters, which are generating, and respective, attract main passenger flows and freight trains to/from central and western Romanian regions from/to the Bucharest area and Constanta port. In order to draw the specific principles for the rail scheduling, in the third section we present a mathematical model for the calculus of capacity in different cases: (i) -in case of homogeneous utilization, meaning that all trains have the same running speeds and the same stops; (ii) in case of heterogeneous/mixed utilization, and the passenger trains have the higher speed and hence, the higher priority over the freight trains, even if some of them are freight transnational liner service, for different corridor length cases. For the second case, in the conclusive section, we draw several useful possible solutions for future analysis in order to efficiently manage the active corridor capacity, and to assure a smooth and reliable running for the transnational liner services, too, which ultimately will increase the rail transport attractiveness.

2. SOCIO-ECONOMIC FEATURES ALONG THE NORTH PART OF THE IVth TEN-T CORRIDOR ON THE ROMANIAN TERRITORY

The accomplishment of the Northern part of the IVth TEN-T rail corridor on Romanian territory is a very expected event, because of its diagonal crossing position and its role for connecting important economic and social clusters (Figure 3). Regions with the highest share of industry in the GDP are marked in blue colour. Central Region (24,9%), South Region (14,5%), Bucharest-Ilfov Region (14,3%) and South-East Region (13,9%) are the most industrialized districts in Romania [7].

Main logistic operators in Romania are, as follows: incumbent rail operator CFR Marfa SA, Grup Feroviar Roman, DB Schenker Romtrans, Navrom, Ceta, Wim Bosman, Servtrans Invest. It is worth to underline that rail and road transport are the most used by logistic operators – each of them are used with a share of 43%. The last is water transport – 14%. All of the logistic operators work on foreign markets – especially the countries of European Union. This is another reason of the expectation that the corridor to be intensively used.

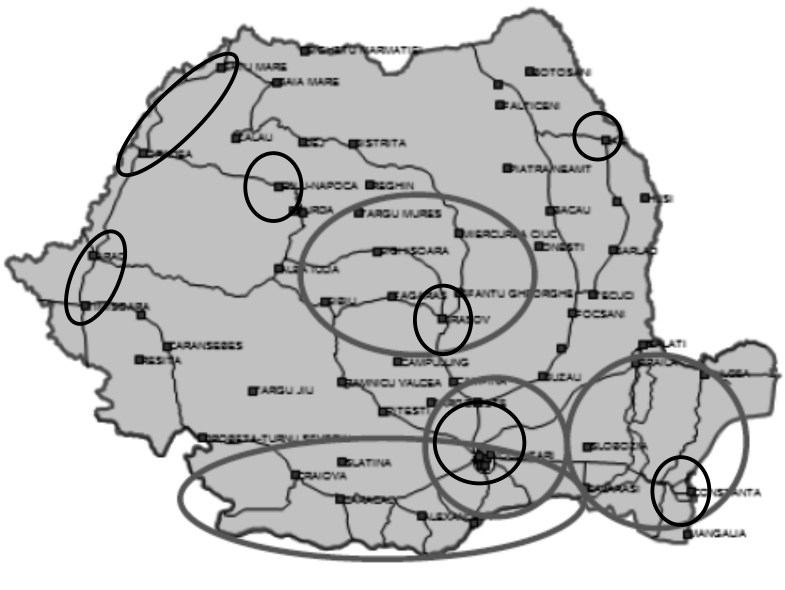

Fig. 3. The most important economic and demographic clusters and their location, near/on corridor [7]
Rys. 3. Najważniejsze ekonomicznie i demograficznie rozgałęzienia oraz ich lokalizacja obok/na korytarzach [7]

Station 2 H H H H time [min] Station 1

From demographic point of view the most important area is the big agglomeration around capital city Bucharest. Bucharest is by far country's largest city. Iasi is second in size (app. 320 000 inhb.) followed by Cluj-Napoca (app. 317 000 inhb.) in the North-West part of the country, and Timisoara (app. 317 000 inhb.) in the Western part of the country. There are other app. 20 cities with more than 100 000 inhb. The larger generators for passenger traffic are Timisoara (plus Arad) and Cluj-Napoca (and Oradea/ Satu Mare), and larger attractors are Bucharest and Constanta. These are additional reasons for an expectation that the corridor will be used also by passenger trains, when the works will be accomplished.

3. MODEL OF RAIL CAPACITY CONSUMPTION

Let us to consider a rail corridor with double tracks and different train authority system for movement (Automated Train Protection or European Train Control System Level 1). For the purpose of this paper we use the following notations:

- station 1, 2, ... are the important rail terminals, usually related to the important demographic clusters/cities; the short rail stops along the sections for passengers' boarding/down boarding purposes are not considered;
- H is denoted for headway between two successive trains, irrespective of the train authority system for movement;
- T_{ment} - the needed total time for maintenance works on a rail section;
- $N_{\max}$ - the maximum capacity of a rail section;
- t_{sa} and t_{sd} - safety time in a station between trains for arriving, and respective, departure in the same direction;
- Δt_{r12} - the difference between running times of two trains (having different speeds) on the same section, bounded by the station (stop) 1 and station 2.

3.1. Case of a double tracks line and homogeny utilization

In the very well-known case of a homogeneous utilization, there is a maximum capacity available on the rail section (figure 4).

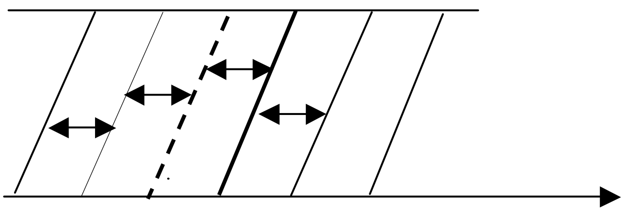

Fig. 4. Maximum capacity for homogeny utilization
Rys. 4. Maksymalny przepływ dla wykorzystania niejednorodnego

In this ideal case, maximum number of train paths is:

$$N_{\max} = \frac{1440 - T_{ment}}{H} \tag{1}$$

where:

T_{ment} is the total time in a day for the infrastructure or power system maintenance.

H - the headway time between trains depends of the type of train separation [6]. On the Romanian railway infrastructure, having block section equipment, usually three block sections are fixed distance

Station 3

H

t_{sa}

Station 2

t_{sd}

time [min]

Station 1

TD

between trains, for a smooth running of trains, and about six minutes are the headway, which is called "green line" running.

As an example, for simplified case of no maintenance time, and H=6 minutes, the total capacity on a double tracks railway is about 240 trains per day. In case of ETCS Level 1 implementation on corridor, we expect to have more available capacity, as the minimum headway will be lower. However, the homogeneous utilization with different train classes is possible only in very specific safety conditions and future research is needed for this aim.

3.2. Capacity in case of mixed utilization

Let us consider the simple case of a corridor composed from two rail successive sections, as in above Figure 5, and the freight trains with lower speed, as preponderant, and the single higher speed train with a small (or without any stop) at intermediate station 2.

In this case, there is a total time called disturbance - T_D, which is not used for circulation, but for train running protection. The disturbance time is not used at all for trains running, it is well-known.

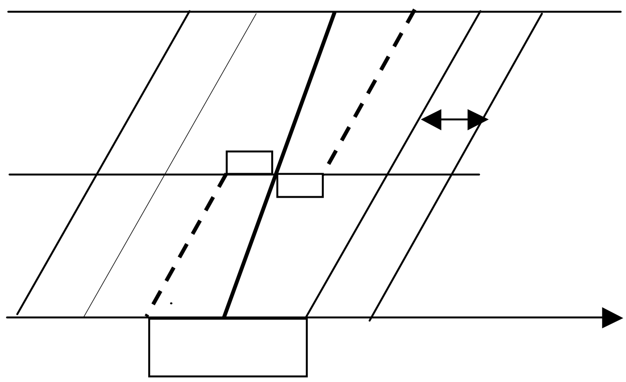

Fig. 5. The influence of a higher speed passenger train on the freight liner service, in case of a corridor composed from two successive rail sections, disturbance time TD

Rys. 5. Wpływ większej prędkości pociągów pasażerskich na serwis liniowców transportowych w przypadku korytarzy utworzonych z dwóch kolejnych sekcji kolejowych, zakłócenie czasu TD.

The disturbance time is composed from two parts: one part before and other after starting time of higher speed train, and we have in this case:

$$T_D = (\Delta t_{r12} + t_{sa}) + (t_{sd} + H - \Delta t_{r12}) \quad (2)$$

It is obvious that the total disturbance time on a corridor, composed from several sections, is as long as many sections are on it, and as many over-takings are planned for higher speed trains.

When the corridor is composed from three successive rail sections, as in Figure 6 is depicted, than the T_D increases for the sake of the higher speed train protection, when t_{sa} and t_{sd} has to be assured in case that the freight train (we depicted a rail liner service with dashed line) is overtaken by the higher speed passenger train (depicted with bold line).

In this case the disturbance time, which is not used for circulation but for train protection, has again two parts, as follows:

$$T_D = (\Delta t_{r12} + t_{sa}) + (t_{sd} + 2H - \Delta t_{r12} - \Delta t_{r23}) \quad (3)$$

In particular case of "identical" rail sections, which means one of two cases: the equal length of sections or the equal running times of train on every section on corridor, the Eq. (3) is:

$$T_D = \Delta t_{r12} + t_{sa} + t_{sd} + 2(H - \overline{\Delta t_r}), \quad (4)$$

where $\overline{\Delta t_r}$ denotes the average time difference between running time of higher speed train and running time of lower speed train, on a same single section of a corridor.

In case of a long rail corridor (as the TEN-T rail fourth corridor is) with *n* main stations/stops (including ending stations) it is possible to generalize the Eq. (4), as follows:

$$T_D = \Delta t_{r12} + t_{sa} + t_{sd} + (n-2)(H - \overline{\Delta t_r}), \tag{5}$$

which is available in case of $H \geq \overline{\Delta t_r}$.

We may proof that in the otherwise case, when $H \leq \overline{\Delta t_r}$, there is the same amount of disturbance time, but from other diagrammatic scheme, which depicts the trains' tracks relative positions, according to that fulfilled condition.

The total waiting time of the rail liner service (dashed line) in Station 2 (see Fig. 6), for overtaking reasons, is:

$$t_W = t_{sa} + t_{sd} + H - \Delta t_{r23}. \tag{6}$$

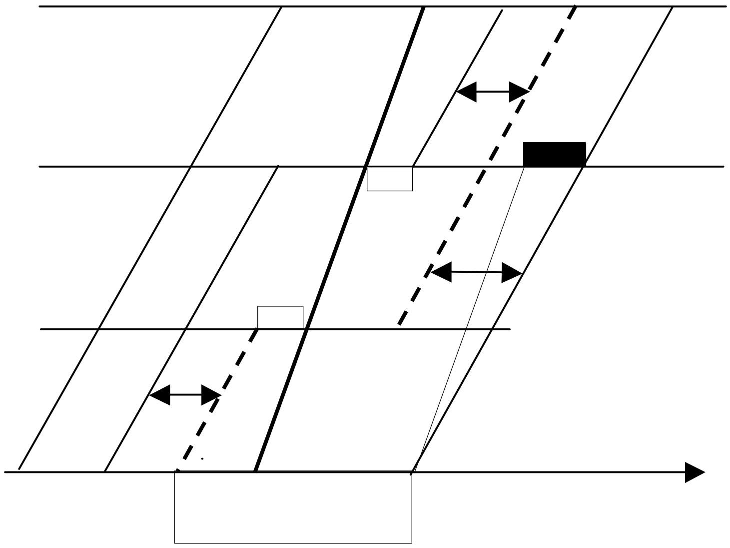

Fig. 6. The influence of a higher speed passenger train on the capacity, in case of a corridor composed from three successive rail sections- disturbance time TD

Rys. 6. Wpływ większej prędkości pociągów pasażerskich na przepływ w przypadków korytarzy utworzonych z trzech kolejnych sekcji kolejowych - zakłócenie czasu TD

In case that, additional sections are included in corridor, there it might be possible that the departure time B_0 of the rail liner service to be changed into the B_{00}, somewhere, after the starting moment of the higher speed train. The minimum condition for this change is:

$$\Delta t_{r12} + \Delta t_{r23} \leq H. \tag{7}$$

We resume here the several used hypotheses: H is equal all over the corridor; the running times include the acceleration and deceleration times; there is homogeneous equipment for train separation along corridor, at least for a single national territory.

4. CONCLUSIVE DISCUSSIONS

When the corridor is relatively long, there is an extended disturbance time, needed for safety reasons, meaning for the train protection, in case of larger number of overtaking operations. The total sum of the disturbance time for all higher seed trains diminishes the available active capacity;

As many sections are included along corridor and long distance trains in a mixed utilization, as much time is consumed for safety reason, reducing the active time for running capacity;

Because of the quasi large number of the expected passenger trains on the same corridor, the active time for circulation of the freight train will be diminished, even in case of "in time separation" technologies of trains (ETCS);

Special attention need to be spent in order to cut the stops of the freight liner transnational service and to assure its special features: uninterrupted running, fixed schedule, finally, reduced time on corridor between its origin and destination;

There is a practical measure for capacity improvement: the provision/adoption of quasi equal running speeds for all type of trains ($\overline{\Delta t_r} \cong 0$), at least during the window time, when the mixed utilization is not avoidable. This is quasi-similar with the binding all freight trains during the night time, which is already experienced, as “train running separation during the day time”. This requires additional researches for running conditions (maximal gross weight of the certain freight train, infrastructure and/or traction conditions and the window time “moving” on a long TEN-T corridor, etc.);

In case of transnational rail liner service, it is necessary to study especially the cross-boarding time (procedure) in every transit country, in order to decide if the starting time on corridor on a specific country is possible to be changed to avoid overtaking (in Figure 6. there is B_0, which might be possible to be changed somewhere in B_{00}, after the higher speed train departure). In this case, additional researches are needed in order to find the adequate regulation frame for a reliable transnational service provision;

There is also another practical measure related to the temporarily changing of the train priority: depending the local optimisation condition, a transnational freightliner service obtains a higher priority over the local (internal/intra-regional) passenger train. Again, additional conditions and regulation frame have to be studied.

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