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7–9 May 2012, Dubrovnik, Croatia

## Road and Rail Infrastructure II

Stjepan Lakušić – EDITOR



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University of Zagreb  
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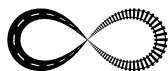
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## PERIODIC TIMETABLE CONCEPT FOR THE BOSNIA AND HERZEGOVINA RAILWAY NETWORK

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*Vienna University of Technology, Austria*

### Abstract

Periodic timetable presents a timetable by which all network trains are set to travel in regular–periodical intervals. To implement the periodic timetable on the already existing network, the following assumptions must be met. In station areas and in periodic crossroad areas the trains entries and exits must be enabled. The infrastructure on these traffic areas must have the same amount of tracks as there are routes. Also, for an adequate periodic timetable to be established for rail traffic users, there should be a significant speed difference between trains that are of different category. Within the framework of this paper different train routes were simulated for certain parts of the railway network, on which periodic timetables for the B&H railway network were made. Because of the absence in speed difference between different categories of trains, this research showed that for all one rail routes the two hour period is the most convenient one. In the end, a network map shows all of the received results of all the examined segments.

*Keywords: timetable, periodic timetable*

### 1 Bosnia and Herzegovina railway network

The Bosnia and Herzegovina railway network consists of two main routes:

- Paneuropean Corridor Vc: (Luka Ploče) Čapljina–Mostar–Sarajevo–Maglaj–Doboj–Modiča–Šamac → Hrvatska–Mađarska
- Parallel of Corridor X: (Zagreb)–Dobrljin–Novi (Novi Grad)–Prijedor–Banja Luka–Doboj–Lukavac–Bosanka Poljana–Živinice–Zvornik → Srbija

Corridor Vc and the Parallel of Corridor x represent the traffic connections towards Central Europe, Mediterranean Europe, South–eastern Europe as well as towards the neighbouring countries of Croatia, Serbia and Monte Negro. Also, another important route is the so called Unska linija (route Una) from Croatia (Zagreb) across Dobrljin–Bosanski, Novi B&Hać and Račić towards Split (Croatia). Apart from that, the B&H rail network consists of branch lines that connect with the Corridor Vc or the Corridor x. The B&H rail network is 1031 km long, out of which 587km are in Federation of B&H, 417 km in Republic of Serbia and 27 km in Brčko District. Only 87 km of the rail network has a double rail track. All of the electric lines have the same system: AC 25kV, 50 Hz. Because of the partially useless signalization system and the absence of security equipment the maximum speed is limited to 70km/h. Figure 1 shows the present state of B&H rail network.

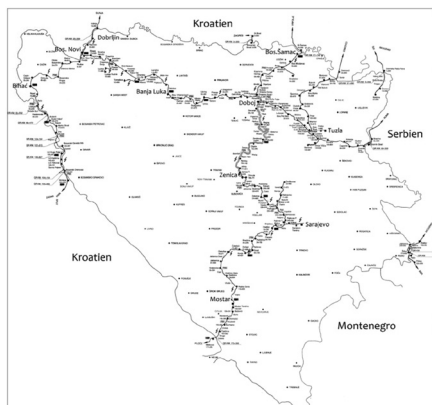


Figure 1 Bosnia and Herzegovina rail network

## 2 Periodic timetable

Periodic timetable presents a timetable by which all of the networks trains travel in regular periodic intervals. Periodic timetable is, as is the regular timetable, described with a graphical diagram. Period time is usually chosen for 30 min, 1 h, 2 h. Integrated timetable that is in accordance to a period represents a conjunction of different route periodic timetables in a periodic timetables network. Railway network periodic lines are connected with integrated periodic conjunctions (IT-conjunctions). It is characteristic for integrated periodic timetable that the period times can be coordinated in such way that when the trains are stopping the IT conjunctions enable changing between the routes. The next image presents the basic principle of an integrated timetable, for one rail routes, with the absence of the train bypass feature [1], [7]:

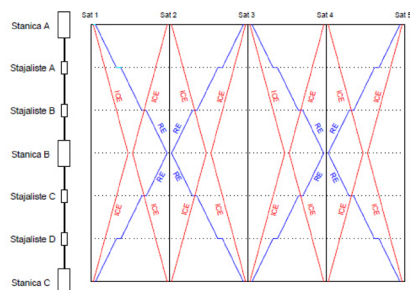


Figure 2 Integrated timetable

The integrated timetable is the consequence of the Swiss railway concept (SBB) of connecting central towns and regions in Switzerland. The regional political project 'Railways 2000' with the motto 'as fast as necessary, and not as fast as possible' is the result of this concept.

## 3 Method

Driving time, for every train, has been calculated with the 'OpenTrack' programme, on which basis the timetables were constructed. The entry parameters for simulation are: infrastructure, transportation vehicles and timetable. Figure 3 presents the 'OpenTrack' simulation timetable that is typical for microscopic simulations of railway traffic.

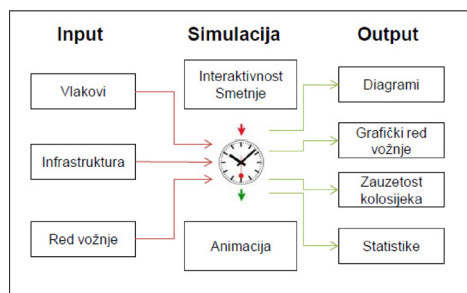


Figure 3 Timeline of the OpenTrack simulation [3]

For the infrastructure depiction in the 'OpenTrack' programme the following data was necessary: the length of the rail track, gradient, maximum route speed, station locations and signal positions. Apart from that, information on train characteristics and the desired departing time were also needed for the simulation. Since the data on accurate positions of signals (inbound and outbound) as well as the distance between signals in the station areas weren't known in detail, this paper approximately assumed the mentioned data. The assumed distances, as well as signal positions, are presented in the Figure 4.

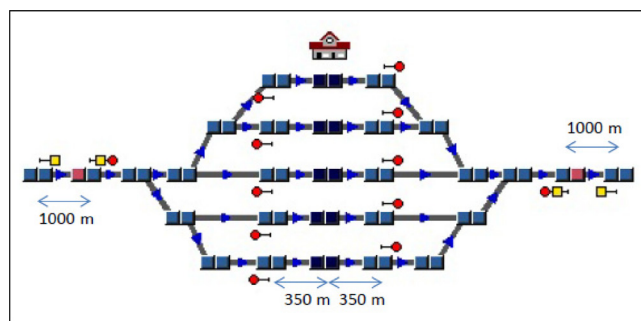


Figure 4 A typical station structure

## 4 Infrastructure segments

On almost all segments of the B&H railroad network, the maximum allowed speed is 70 km/h, and in the station area it is 40 km/h. Fast trains (six coaches) as well as regional trains (three coaches) that are hauled by series 441 locomotives operate on almost every route. On Doboj–Tuzla (heavy traffic) and Bosanski Novi–B&Hać (maximum speed of 50 km/h) route only regional trains operate. Because of the absence in speed difference between fast and regional trains, on most of one rail segments of the railroad network, B&H chose a two hour period. One hour period was successfully applied only on two rail segments and on segments where only regional trains operate.

### 4.1 Sarajevo–Čapljina segment

The 179.3 km long, single track Sarajevo–Čapljina segment presents the southern part of B&H rail network. This segment has 22 stations and 15 stops. In order to establish a periodic timetable, travel duration defined by 'OpenTrack' programme was used for defining the following stations as one hour or two hour conjunctions. One hour conjunctions are stations Sarajevo, Jablanica and Mostar and half an hour conjunctions are Hadžići and Konjic stations. Red li-

nes in the figure 5 represent the fast and the blue lines regional train routes. The train arrival time, technical driving time and stopping time on stations as well as reserve train times are shown in the table 1.

It should be noted, as is visible from the Figure 5, that train bypass of fast trains as well as regional trains occur without notable disruptions. Because the railway crossroads are pre-ordained by infrastructure, further harmonization of timetables reserves is impossible. On parts where the reserved travel time is less than 3% it would be necessary to increase the present speed limit. This can be achieved by maintenance measures and repairs of the track superstructure.

Sarajevo - Gabela

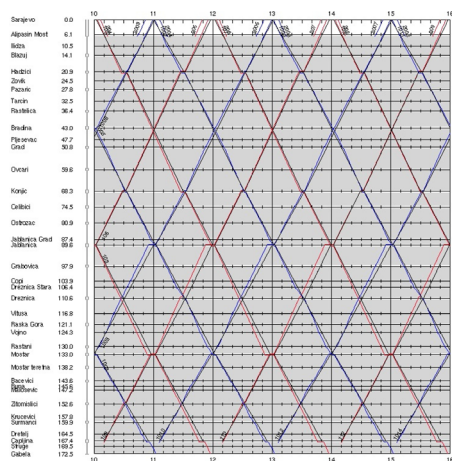


Figure 5 Graphic of the Sarajevo–Čapljina segment timeline

Table 1 Sarajevo–Čapljina segment timeline in tabular form

ICE	K:107	Dvosatni Takt					K:106	Dvosatni Takt				
		Dol.	Vr.Vož.	Odl.	Staj.(s.)	Rezerva. (%)		Dol.	Vr.Vož.	Odl.	Staj.(s.)	Rezerva. (%)
Sarajevo	↓	12:02	12:02				↑	11:58	11:56	12:00	120	8.3
Hadžići		12:29	12:28	12:33	240	3.8		11:28	11:27	11:32	240	1.8
Konjic		13:30	13:28	13:32	120	1.8		10:29	10:28	10:32	180	0.0
Jablanica		14:00	13:59	14:02	120	3.7		9:59	9:52	10:02	180	11.8
Mostar		14:58	14:53	15:02	240	7.7		8:58	8:57	9:02	240	2.1
Čapljina		15:50	15:46	15:52	120	9.1		8:10	8:10			
RE	K:1007	Dvosatni Takt					K:1006	Dvosatni Takt				
		Dol.	Vr.Vož.	Odl.	Staj.(s.)	Rezerva. (%)		Dol.	Vr.Vož.	Odl.	Staj.(s.)	Rezerva. (%)
Sarajevo	↓		11:00	11:00			↑	11:01	11:00	11:02	60	2.8
Hadžići		11:31	11:28	11:31	30	6.7		10:33	10:32	10:33	30	0.8
Konjic		12:32	12:31	12:33	60	0.8		9:32	9:31	9:33	60	4.3
Jablanica		13:02	13:01	13:03	60	1.7		9:00	8:55	9:02	120	8.9
Mostar		14:02	14:00	14:03	60	2.6		7:59	7:57	8:00	60	2.6
Čapljina		14:55	14:52	14:56	60	4.0		7:06	7:06			

## 4.2 Sarajevo–Zenica segment

The 80.3 km long, single track Sarajevo–Zenica segment contains 12 stations and 10 stops and is a part of the Paneuropean corridor Vc. In order to set up a periodic timetable, by using the calculated travel time, the following stations were defined as one hour or half an hour conjunctions. One hour conjunctions are stations Sarajevo, Visoko and Zenica and half an



hour conjunctions are Semizovac and Kakanj. On certain parts of this segment time reserves are sometimes more than 25%. The mentioned travel time reserves are necessary so that rail bypass could be carried out on this segment. It should be noted that because of the absence of reserve travel time between stations Rošćevina and Zenica regional trains do not stop. So that stopping of regional trains on every station of this segment could be achieved, the increment of the present speed limit is necessary.

#### **4.3 Zenica–Doboj segment**

The 96.6 km long, double track Zenica–Doboj segment, has 7 stations and 18 stops. In order to set up a periodic timetable, by using the calculated journey time done with 'OpenTrack' programme, stations Zenica, Zavidovići and Doboj were defined as one hour, and stations Nemila, Zavidovići and Ševalije as half an hour conjunctions. One hour period was successfully implemented on this segment of the rail network. The application of one hour period was enabled because of the double track. For this segment we should note that regional trains that travel towards Doboj, because of the single track part of the network between the Jelina and Zenica stations, have a ten minutes train following time. The result is longer stopping time of regional trains in Nemila station. Apart from that, it's been shown that regional trains that travel towards Zenica stop longer in Ševalije station. The cause of these delays in Ševalije station lays in the following times of fast trains that amount to 8 minutes. The mentioned problems could be efficiently optimized through infrastructure improvement measures on which basis a better harmonization (adjustment) of reserve travel time could be achieved.

#### **4.4 Doboj–Tuzla segment**

Not all the relevant data necessary for travel time calculations of the single track Doboj–Tuzla segment is available. The full length of this segment is 87.5 km. The rails gradients that are unknown are in this paper assumed to be 0‰. On the 27.5 km long railway part between Doboj and Jošava, additional stations and stops probably exist that are not known in this paper and because of this they were not taken into account in this simulation. The known part of this segment has 11 stations and 2 stops. Using the calculated travel time (for establishing periodic timetable) stations Doboj, Sočkovac and Tuzla were defined as one hour, and stations Jošava and Lukavac as half an hour conjunctions. On this part of the railway regional trains travel in one hour periods and train crossroads are used as stops as well. It should be noted, for this segment, that regional trains travelling in both directions between Lukavac and Sočkovac stations have low travel time reserves (0.5 %–1.8 %). Stopping time between these stations is about 30 seconds and is already on the lowest level. Travel time reserves can only be increased if some stops are eliminated or if the present speed limit is increased.

#### **4.5 Doboj–Bosanski Šamac segment**

The 60.6 km long, single track Doboj–Bosanski Šamac segment connects the B&H and Republic of Serbia railroad networks. Between stations Doboj and Srpska Kostajnica is a short segment of double railway track. Using the 'OpenTrack' programme simulation, stations Doboj and Modriča were defined as one hour and Bosanski Šamac and Gornja Koprivna as half an hour conjunctions. The simulation showed that fast trains have long travel time reserves that are necessary for periodic timetable travelling. Unlike fast trains, regional trains on some parts of this rail segment have, according to the UIC recommendation, too short time travel reserves. Because of this, trains travelling towards Doboj do not stop between Koprivna Gornja and Srpska Kostajnica.

#### 4.6 Doboј–Banja Luka segment

The 96.5 km long, single track Doboј–Banja Luka segment has 12 railway stations and 14 stops. Using the calculated travel time, railway stations Banja Luka, Pristoje and Doboј are defined as one hour, and railway stations Jašavka and Snjegotina as half an hour conjunctions. Time travel reserves are really short on this segment. Because of the time issue, stopping of regional trains on stations and stops is impossible. Because of the constant follow-up of fast trains, on this part of the railway there cannot be a tact conjunction set up in Pristoje station. Regional trains from Doboј arrive to Banja Luka at 13:11 which is not favourable for establishing a periodic timetable towards Dobrljin. Research showed that establishing a periodic timetable, for this part of the railroad, is really difficult. On one part the problem lies in the speed limit and on the other hand in the absence of crossroad possibilities. For periodic timetable improvements maximum speed increment is necessary. On certain parts infrastructure improvements, meaning construction of a second track on certain parts of the segment, would also be necessary. Speed increment would be necessary at least for the part between Jašavka and Banja Luka, since it would be the basis on which the regional trains would be able to arrive to Banja Luka before the full hour, and because of this the further connection towards Dobrljin would stay undisturbed.

#### 4.7 Banja Luka–Dobrljin segment

The 100.1 km long, single track segment Banja Luka–Dobrljin connects the B&H and Republic of Croatia railway networks. This segment of the railway has 13 stations and 15 stops. For establishing periodic timetable, using the calculated travel time with the 'OpenTrack' programme, stations Banja Luka and Kozarac are defined as a whole hour and stations Potkozarje and Svodna as half an hour conjunctions. On parts where reserve travel times are less than 3% it is necessary to increase the present speed limit. For this segment it should be noted that regional trains travelling in both directions stop on certain parts. This is necessary because the crossing of trains on certain places would be impossible, and the consequence of this would be a disturbance of the whole periodic timetable. It is necessary to increase the present speed limit so that stopping of regional trains on every segment station could be possible. With the maximum speed limit increment a whole hour conjunction on station Bosanski Novi could be established, and this would be of great importance for the rail connection towards Bihać.

#### 4.8 Bosanski Novi–Bihać segment

The 65.9 km long, single track Bosanski Novi – B&Hać segment has 7 stations and 4 stops. On this part of the railway regional trains travel in accordance with one hour period, and train crossroads are used as stops likewise. Using the 'OpenTrack' programme simulation, stations Bosanski Novi, Bosanska Krupa and Bihać are defined as one hour and stations Blatina and Cazin–Srbijani as half an hour conjunctions. Stopping time at stations amounts from 30 to 60 seconds. Short reserve travel time can be increased with the elimination of stops or with the increment in speed.

### 5 Connecting partial results

Figure 6 presents partial results with associated one hour and half an hour conjunctions. The figure represents a scheme of an integrated timetable for the B&H railroad network.

## 6 Overview

This paper tried to establish a periodic timetable concept for the B&H railway network. First, travelling time for fast trains was calculated using several simulations. Assumed travelling time reserves (5–10% of technical drive time) were added to travelling time and after that whole hour and half an hour conjunctions were defined. Then, regional train journeys were simulated and finally periodic timetables were optimised. This research showed that a two hour period is the most suitable for all single track segments of the B&H network. Figure 6 schematically shows all periodic timetables. Also, figure 6 shows how an integrated timetable could look on the present B&H railway network. In the end, it can be said that the periodic timetable implementation, on the present railway network in B&H, is possible. Simulation received travelling time results can be better harmonised through infrastructure improvement measures, on which basis time travelling reserves, where necessary, can be increased. Apart from that, the increment of the present speed limit in certain segments would enable stopping of regional trains on every station and stop. Through the increment of present speed limit, whole hour and half an hour conjunctions could be realised to be accurate in a minute.

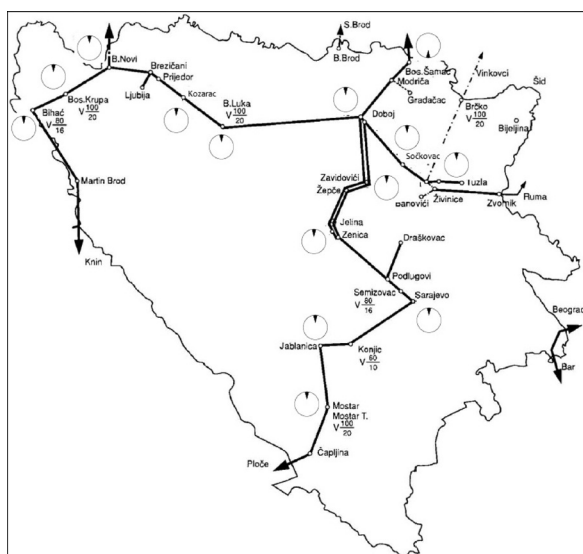


Figure 6 A schematic image of all the results, integrated timetable for the B&H railway network

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