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## PROPOSAL FOR SOFTWARE SOLUTION OPTIMISING THE STAFF OF TRAIN ROSTERING

### ABSTRACT

*The paper deals with all the resources and factors that determine or influence to any extent the technological process of staff of train rostering. The Timetable, Train Traction and Traction Vehicle Maintenance Sector and the legal regulations stipulate the basic parameters for rostering and these are explained. The paper also analyses the contents and the method of producing the rostering plan which shows all the practical drawbacks and the limiting factors that influence significantly the possibility of corrections in order to improve the utilisation level of the staff of train. A model has been developed with the presentation of the factors that influence the staff of train rostering. The paper also shows the project of a software solution for the staff of train rostering with the defined and explained Clipper program.*

### KEY WORDS

*staff of train, rostering model, software solution, optimisation, competitiveness*

### 1. INTRODUCTION

The Croatian Railways (HŽ) is undergoing restructuring and gradual modernisation having as objective the transformation into a profitable and competitive company. The success on the transportation market depends to a substantial extent on the organisation and optimisation of all the technological units at HŽ.

With its stable and mobile resources, the Vuča vlakova (Train Traction Sector) significantly shares in the transportation service price. There are 396 traction vehicles and 1700 operational workers in everyday service. This data alone is sufficient to show the extent of the costs for such a great number of units, i. e. possibilities of savings that would come out as the result of optimising their work.

The operating schedule of the traction vehicles and the staff of train is produced on the basis of Direction 256, published in 1984 by ZJŽ.

At the moment, HŽ is investing significant means into the infrastructure, which results in constant closing down of the railway lines and respective train delays.

All the mentioned activities are performed without any software solutions. The introduction of information technology system of the staff of train rostering would mean significant savings as result of the optimisation of their operation, much simpler planning of the needs and improved solving of the railway line closedowns due to repair.

#### 1.1. Structure of HŽ and Vuča vlakova

The HŽ organisation is divided into the activities in the field of the Commercial sector, Train traction and railway vehicles maintenance sector, HŽ infrastructure sector and activities of the administrative area of the corporate administration, Administration Office and Regional offices. The business field of Traction vehicles and railway vehicles maintenance consists of Train Traction and Traction Vehicles Maintenance and the TPV activities and coach maintenance.

The business field of Train Traction sector consists of six Units of Train Traction with twenty Train Traction implemented. The superstructure consists of the Traction Service, Manager and the Director member of the Management.

#### 1.2. Method of operation

The operating schedules for the traction vehicles and the staff of train are produced on the basis of the defined Timetable, and certain parameters are calculated on the basis of the empirical data from the previous years. After publishing the Timetable project, the operating schedule of the traction vehicles and staff of train is made. The operating schedule of the staff of train starts with the distribution of the traction. The representatives of six Train Traction Units take five



days and work on the distribution of the traction with operating schedules (shifts) for their respective area under the supervision of the Traction Service workers who control and unify all the schedules. Subsequently, meetings are held with the representatives of the unions and workers of all the Train Traction sectors, where minor corrections are possible.

### 1.3. The objective

The optimisation of the Train Traction sector is a necessary precondition for successful and profitable operation of HŽ. The current HŽ Management is carrying out the rationalization of the Train Traction Sector mainly by sending the staff of train into retirement paying substantial severance compensations, rather than by optimising the technological business processes. HŽ is facing the implementation of the new Act on HŽ which will enable interoperability, allowing thus competition and market economy operation. The privatization of HŽ sectors and the position of the Train Traction within the organization substantially determine the competitiveness and price of the transportation service. Introduction of information technology with the aim of optimising the train traction may significantly reduce the costs of train traction thus contributing to the lower final price of the transportation service.

## 2. TRAIN TRACTION CAPACITIES

The inventory of the Train Traction sector includes 393 traction vehicles, out of which 318 are in the active rolling stock. The traction vehicles are basically divided into locomotives and trains. The Diesel locomotives are divided into 10 series, and there are 191 of these, out of which 142 are the active ones. There is a total of 107 electric locomotives, out of which 94 are active, and distributed into three series. There are 25 electric railcars, 19 of which are active and they are divided into two series. There are 70 Diesel railcars in the inventory status, out of which 63 are in the active rolling stock, and divided into 4 series. Apart from the traction vehicles, the Train Traction has also significant human potentials. The total number of workers divided into six units amounts to 2138, out of which the engine-drivers are the most numerous with 1407 employees.

## 3. TIMETABLE AND SCHEDULE OF TRACTION VEHICLES AS BASIS FOR STAFF OF TRAIN ROSTERING

The Timetable is the basic plan for the carriage of passengers and goods, and forms the base of the tech-

nological operation process. In making the timetable it is necessary to balance the supply and demand. The timetable has to insure safe traffic of trains and rational usage of means and people. There are a general and a special Timetable. The general timetable usually determines the number of trains for a period of one year, and the special timetable is intended only for special trains and is valid for the operation of these trains only. The transportation plan and material-technical resources form the basis for producing the timetable. Based on the defined timetable, the schedule (shift) of the traction vehicle is made. It is characterised by increasing the need of the staff of train and traction vehicles for the activities that are not directly dependent on the functioning of the Timetable but are necessary for its timely implementation. First of all, this refers to the needs of traction vehicle maintenance.

## 4. STAFF OF TRAIN ROSTERING PARAMETERS

The timetable and traction vehicle schedule form the basis for making the operating schedule roster (shift) of the staff of train. The staff of train rostering is made in compliance with the legal regulations formed by: Labour Act, Work regulations, Regulation on train traction (201), Regulation on working time, shift and break between two successive shifts of the operational staff at HŽ, Instructions for staff operation in train traction sector (201-1) and Collective agreement.

The basic element for the planning of the staff of train rostering is the working time. Full working time is 40 hours a week. The daily work takes 8 hours and not less than 6 hours. The overtime work cannot take more than 10 hours a week. Night work is considered work from 10 p. m. to 6 a. m. the following day. Night shift is the work which is completed after 00 and started before 4. Staff of train is allowed to work for a maximum of two night shifts in a row. During day work, the worker has the right to take a break of 30 minutes. The break should not be during the first two hours and the last two hours of work. The worker has the right to a 30-minute break for the working time of 4 to 8 hours, and another 30 minutes for the work longer than 8 and up to 12 hours. Staff of train must take a break of at least 16 hours between two shifts. During the week the staff of train must take a break of at least 24 hours. Holidays are planned as part of the rostering.

The work time of the operational staff in the train traction sector includes:

- work on preparation and work on clearing of traction vehicle,
- work on the traction vehicle,
- work on vehicle shunting,
- time of work interruption up to 2 hours during work,



- empty run in order to take over the traction vehicle,
- time of reporting to work according to roster, until actual start of work in case of delay of the planned train,
- work at the railway station and on the tracks according to the defined roster,
- time spent as reserve on obligatory standby,
- time from actual reporting to work in case of cancelling work as planned by roster, and
- time of overtaking the traction vehicle which does not perform work.

Apart from regular work, the following activities are also included in the staff of train roosting:

- work on obligatory education, professional training and improvement,
- work on periodical and special knowledge testing,
- work on periodical and special medical examinations,
- work regarding staff of train after 8 hours of rest spent at turnaround station,
- work due to interruption and standstill determined by law,
- work up to the expected train arrival according to the timetable,
- work in case of train cancellation according to operating schedule, within the same period of time that was determined according to the operating schedule,
- work on stand-by,
- work for the employer's bodies,
- work for the union or other activities related to the implementation of rights and liabilities according to the employment, and
- work during the time reserved for the interval during the daily break.

The calculation of the annual needs of the staff of train for the new timetable is obtained on the basis of the data from the old timetable.

The necessary number of staff of train is determined from the following expression:

$$B_r = \frac{(t_{put} + t_{rez} + t_{pr} + t_{rasp}) \cdot 1.03 \cdot \alpha \cdot \beta \cdot 365}{2088} \text{ workers}$$

$B_r$  – number of workers,

$t_{put}$  – train travelling time according to timetable (hours),

$t_{rez}$  – staff empty travelling time per shift (hours),

$t_{pr}$  – preparation time at railway station and depot (hours),

$t_{rasp}$  – clearing time at railway station and depot (hours),

365 – number of days in the year,

2088 – annual working hours,

1.03 – requirement coefficient of the workers for the technological reserve (only for cargo traffic),

$\alpha$  – imbalance coefficient,

$\beta$  – coefficient of working hours loss.

The calculation serves for the estimate of the annual demands of the staff of train but in order to satisfy the legal regulations the roosting needs to be made and monitored annually, weekly, and daily. The entire legal regulations have to be processed and then input into the software solution in the form of a code in order to prevent any violation of the law.

## 5. SOFTWARE SOLUTION PROJECT OF STAFF OF TRAIN ROOSTERING

The software solution of the staff of train roosting consists of: the design model, three tables as databases and constraints in code and program tools Clipper. The presentation of the model shows that the principal database is the Timetable. The operating schedule of the traction vehicles and the operating organisation of the train traction and train traction maintenance significantly influence the staff of train roosting. The constraints that are legally stipulated are designed as a code that controls the annual, monthly, weekly, and daily roosting. The model for the staff of train roosting, Figure 1, is the basis for the development of a software solution.

Tables that make the databases are presented only as samples that need to be supplemented as necessary in the final version in the presented sections.

Table 1 from the Timetable with all the train stoppings assuming that staff exchange may be performed at every stopping place.

Table 1 - Table from the Timetable

Train No.	Traction vehicle series	Traffic place of work	Time of arrival	Time of departure
			(hours)	
500	1142/1061	Zagreb GK		5.45
		Karlovac	6.19	6.20
		Ogulin	7.07	7.14
		Moravice	7.41	7.53
		Delnice	8.20	8.21
501	1061/1141	Rijeka		17.00
		Delnice	17.58	17.59
		Moravice	18.26	18.38
		Ogulin	19.05	19.06
		Karlovac	19.52	19.54
		Zagreb	20.29	



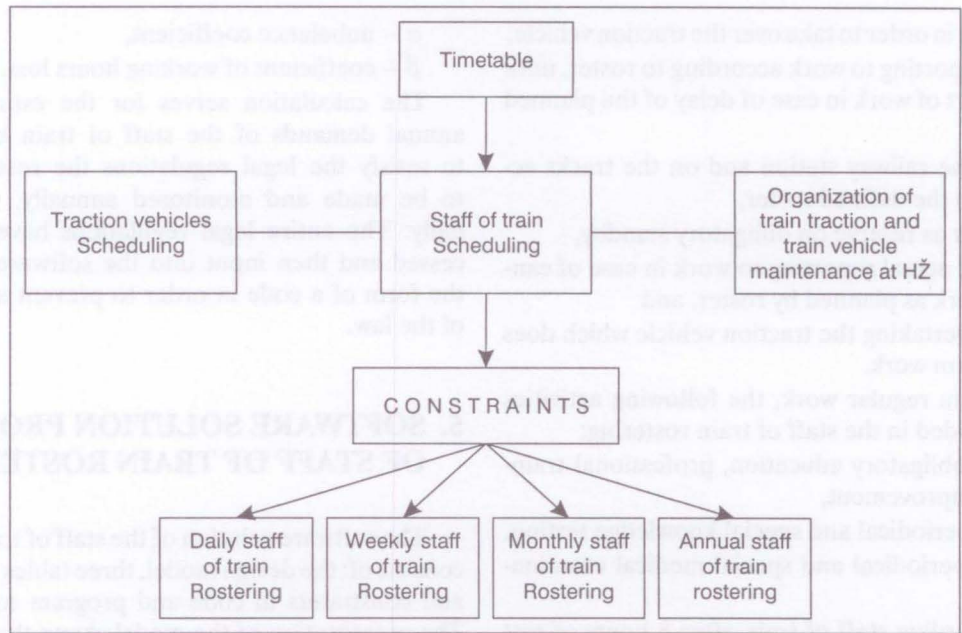


Figure 1 - Model for the staff of train rostering

Table 2 – List of staff of train with traction vehicles series they can control

No.	Place	Engine driver's first & family name	6	1	1	1	6	7	7	7	2	2	2	2	2	2	2	2	2	
1.	Zagreb	X1	yes	yes	yes	no	no	yes	no	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
2.	Zagreb	X2	no	yes	yes	no	no	no	no	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
3.	Zagreb	X3	yes	yes	yes	no	no	no	no	no	yes	no	no	no	yes	yes	no	yes	yes	no
4.	Zagreb	X4	yes	yes	yes	no	no	yes	no	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
5.	Zagreb	X5	no	yes	no	no	no	yes	no	no	no	no	yes	yes	yes	yes	yes	yes	yes	yes
6.	Zagreb	X6	yes	yes	yes	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no

Table 3 - Increase in the work-time of the staff of train for the needs of serving traction vehicles

Number of traction vehicles	Duration of stay prior to train departure (minutes)				Duration of stay after train departure (minutes)			
	Time for preparing traction vehicles and path to the boundary	Path of traction vehicles from boundary to the train	Preparation of train		Stay of traction vehicles upon train arrival	Path of traction vehicles from train to boundary	Traction vehicle equipment	Accommodation and delivery of traction vehicles
			passenger train	cargo train				
1061	30	10	20	40	5	10	15	10
6011	45	10	20	-	10	10	30	15
1141	30	10	20	40	5	10	15	10
1142	30	10	20	40	5	10	15	10

After having selected the computer equipment it is necessary to make the decision on selecting the tools which make it possible to develop the desired software solution. The proposal is to use Clipper as tools in this project, since it is claimed to be the most popular tools for the development of business applications in our re-

gions. Clipper is solid and very reliable tools, completely suitable for the staff of train rostering. With certain work it can use many types of data in different forms and from various platforms. The readymade software solution combines two types of files or tables. The first type are the software files that are used for



the implementation of the application or the software solution, and the second type are data files that contain actual data created and input through the application. The concrete software solution would consist of three major units: updating of the main (matrix) files of staff, traction vehicles, and timetable, data processing i. e. development of the staff work-time schedule and browsing of the received reports should be harmonised according to the constraints and conditions in Table 1. Table from the Timetable, Table 2. List of staff of train with traction vehicles series they can control, Table 3. Increase of the staff of train worktime for servicing the traction vehicles before and after the very train travel planned by timetable according to Figure 1. Model for staff of train rostering. The first unit was explained before. Software code needs to be written for the development of the staff worktime roster. The tools for writing the software code, Clipper, combines the instructions and readymade mathematical functions that are combined respecting the laws of Clipper. These are used to read the data from the files, and they are passed through the constraints that are listed. The software code written in this way has its logical sequence of instructions, functions and all the other necessary elements and forms a well-planned mathematical-visual-logical model of solving the given problem.

## 6. CONCLUSION

The timetable, traction vehicles and their maintenance, conditions that have to be met by the staff of train and the legal provisions are the most important elements which determine the necessary number of the staff of train members. The current rostering of the staff of train is based on the instruction from 1984 which has never been fully implemented and renders the development rigid and complicated. All this leads to the conclusion that HŽ has obsolete technology of developing the staff of train rostering. The introduction of information technology in the process of developing and monitoring the staff of train rostering would optimise the operation of the staff of train, thus reducing the costs of HŽ, and increasing the quality and safety of the staff of train work. The new Act on HŽ will enable interoperability and competitiveness, but only information technology and optimisation of technological processes in the Train Traction Sector can

eventually reduce the price of the transportation service both in cargo and in passenger transport.

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## SAŽETAK

### PRIJEDLOG PROGRAMSKOG RJEŠENJA ZA OPTIMALIZACIJU RASPOREDA STROJNOG OSOBLJA

*Članak obrađuje sve resurse i čimbenike koji određuju ili u bilo kojoj mjeri utječu na tehnološki proces izrade rasporeda strojnog osoblja. Vozni red, Vuča vlakova i održavanje vučnih vozila i zakonska regulativa diktiraju osnovne parametre za izradu rasporeda i oni su objašnjeni.*

*Pojašnjen je sadržaj i način izrade rasporeda rada iz kojeg se mogu sagledati svi praktični nedostaci i ograničavajući faktori koji bitno utječu na mogućnost korekcija u cilj poboljšanja iskoristivosti strojnog osoblja.*

*Izrađen je model s prikazom čimbenika koji utječu na raspored strojnog osoblja.*

*Prikazan je projekt programskog rješenja, za izradu rasporeda strojnog osoblja s definiranim i objašnjenim programom Clipper.*

## KLJUČNE RIJEČI

*strojno osoblje, model rasporeda, programsko rješenje, optimizacija, konkurentnost*

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