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OPERATING THE RAILWAY TRAFFIC CONTROL SYSTEM

ABSTRACT

In agreement with the adopted traffic policy and with the development strategy of the Republic of Slovenia the Slovenian Railways will also integrate into the development strategic objectives of the European railways. The perspective of improvement lies mainly in following the development of the European system.

The technology and organization of the railway traffic system include all the technological and organizational elements and processes that take part in the realization of the system objectives. The notion system from the formal mathematical perspective indicates a roundup whole which is usually complex or even very complex. The technology and organization of work include a multitude of means and procedures in order to carry out the basic activity which presents a roundup whole, the process of passenger and freight transport in the traffic system.

Fast progress of microelectronics and computer science in the last decade has brought a new generation of electronic signal-safety devices.

All the changes of the last years that have been introduced in the railway technology raised the attractiveness of the railway transport. It is competitive with other forms of transport, so that the Slovenian Railways have to follow the development of technology and gradually modernize its line network.

KEY WORDS

operating, management, system, railway traffic, railway transport

1. INTRODUCTION

The basic demands of the system lie in the uniform technics, technology and organization. These demands enable operation of the system in technical and technological sense. System operation has to be homogeneous and wholesome in the system area which enables unified regard of all the operation presuppositions. Optimising the operation of railway transport demands implementation of modern solutions in the field of computer technologies and uniform functioning of technics, technology and organization. Introducing such uniform operation is based on several basic principles.

- The technical principle is treated by means of typization, standardization and unification of technical means and common regulations in domestic and international sense.
- The technological principle is created by elaborating a timetable, i. e. by introducing uniform technological processes of passenger and freight from the starting point to their destination.
- The principle of organization contains all organizational elements (stations, stops, engine depots etc.) that interactingly form integral functioning of the railway transport.
- The principle of timetables with help of which the railway traffic is carried out, has to be determined and published in advance.
- Principle of regularity is the principle of steadiness, punctuality, which means that the railways have to carry out the transport within a settled time frame.
- The safety principle contains all the elements that provide safe functioning of the whole system, particularly in the passenger and freight transport.

The principle of speed of transport rests on the whole technological process of work and tends towards reducing the time of loading and unloading, shorter time of intermediate detention of wagons and towards introduction of modern transport technologies. Modern transport technologies are presented by possible organization with help of remote monitoring of the railway transport in order to gain better overview of the organization and realization of the railway traffic.

2. BASIC CHARACTERISTICS OF THE RAILWAY TRAFFIC SYSTEM

The notion *system* appears in everyday life. It is also applied in various scientific purposes in individual researches. According to the author Mulej, M. (1994) there are 15 groups of contents definitions of the no-

tion *system*. Among others it is also applied in the theory of systems, the science of cognition and operation of complex phenomena which are treated mainly from the perspective of nature of the whole but not its separate parts. Therefore, the main emphasis lies above all on the consequences of interactive relations and influences among the parts. The reason for this lies in the problems that the mankind had to and still has to deal with because specializations are too narrow and an individual cannot have universal knowledge or know enough about things he does not specialize in.

Considered from the formal mathematical perspective, the notion *system* means a certain rounded whole which is usually complex or even very complex. It is at the same time a part of a greater whole (e.g. transport is part of the entire economy, society, nature, technical-technological and other creativity etc.); and it is at the same time made up of smaller wholes (e.g. parts of transport). In this way, the greater whole has properties that its separate parts do not have since they arise out of interactive influences among the parts (e.g. a train has different properties than its separate wagons, etc.). From the perspective of content it is essential that the mentioned mathematical formal definition of the system can be introduced for the same treated phenomena also from many various points of view and despite the variety of contents it stands in every case (e.g. a train from the perspective of passengers, of railway personnel, from the point of view of technical conditions of the rolling stock, tracks, signalling, weather, calculation, ecology etc.).

Apparently, the system is, apart from being mathematic formal a certain rounded whole, contextually only one of the many possible one-sided mental pictures of the treated phenomena (here, for example, transport as part of economy and personal life from the perspective of technology, i.e. realization of traffic flows). Therefore, the railway transport specializes in the perspective of shunting technology which is characteristic for the railway transport. The theory of systems is implemented as a method in order to attain a uniform consideration inside the perspective of the determined system.

In modern theory and practice there are various definitions of the system that can be generally applied.

For example:

- the system contains common elements or separate phenomena,
- the system is a collection of objects that are connected,
- the system is a collection of objects united into interaction,
- the system has a structure, realizes the tasks and outputs or receives information.

According to the mentioned theoretical bases the system can be defined as a collection of elements that make up a whole with all their interactive connections and relations. The relations present certain lines that connect the system elements into a whole.

The elements present the structure of system, they are interconnected and thus enable a synthesis inside the system but it is by no means just a simple mechanical totting up of elements. It is, therefore, obvious that the system is interconnected by separate components which are in functional interdependence. The components can be mechanical or social. Accordingly, it is important to distinguish systems that are made up of the one or the other set of components. It is very likely that the components are combined and from such combination a combined system is gained, which is the most common practice.

The system can be presented in different ways but it has to contain four basic components which are connected with lines as presented in Figure 1.

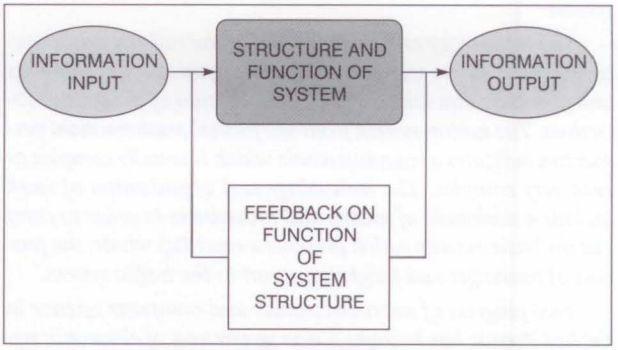

Figure 1 - General components of the system

The basic structure of each existing system is made of the following elements: energy, information, technical and technological element and subject matter, which are interactively connected. There are, however, other elements that can also be identified: the environment that enables the mentioned system to function, limits of the system, objectives, processes, structure and condition of the system. The environment of the treated system includes external elements. These elements can affect the function of the treated system or they only monitor it and do not directly affect it. The connection of external elements with the elements of the system is set up with the help of input (I) in the system and output (O) from the system.

The system has to be presented with a larger number of components (Z-S) in the system structure itself, aiming towards a similar analysis.

The limit of the system divides the system and environment according to the treated system and according to the elements (e1, a1) that are implemented in the system structure. The objective of the system is the function and determination of tasks. When setting the system objectives, several tasks of the system can be

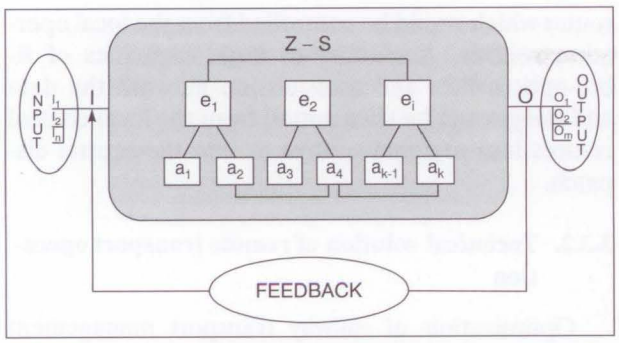

Figure 2 - System structure

dealt with, which had been determined in advance. The process of function is connected with the function of the system according to the work it performs.

The operation of the system is presented by certain activities at the time of running in order to realize the determined system objectives. Therefore, the system needs to be maintained in full organization and stability.

The condition of the system is defined as a number of elements at the determined place and time. This is presented by the elements and their contents. The elements represent separate parts of the system and they have their own properties which affect the whole condition of the system.

The notion *structure* denotes the realistic organization, i.e. the number of all the connections among the system elements. The structure rarely changes; therefore, one may speak of static connotation of structure. However, system operation has a dynamic connotation which can change rapidly in its function.

If there are numerous components with interactive connections in the system, the system is regarded as a homogeneous system, particularly when the connection of separate elements is in the function operating the system as a whole. The wholes can be regarded as subsystems in relation to the basic system, i.e. the main system.

As basis for the analysis of elements of a whole in the system the following criteria apply:

- the system has to have the ability of independent functioning in place and time;
- the system has to have technological integrity of the processes of work, i.e. interactive connection of elements in the system function;
- the level of interactive connection of elements in the system and connection of elements with the environment;
- dynamics of the system which is marked by various processes;
- the structure of management and operation has to include several hierarchic levels.

Railway transport represents a homogeneous whole with all the elements included in the structure of the railway system. Taking into consideration the theories of systems it can be established that the railways is a homogeneous system made up of various objects and processes, and their interactive connections.

As a peculiarity of the railway transport system the following elements are to be put forward:

- it is a multilayered system of wide horizontal and vertical structure;
- it is a homogeneous system made up on the basis of integral system in connection with the transport process within the range of its basic activities, out of which its hierarchic structure is formed into several levels;
- as a system it functions in all areas of transport network in the sense of organisation which demands place and time homogeneity of work;
- it is a dynamic system in which the change of condition and operation is in the function of place and time;
- it is a system with numerous functions.

The implementation of the system theory or the method of decomposition when describing the railway traffic system lead to four basic elements or subsystems: technical, technological, economic and information elements.

Fundamental subsystem in the railway transport is the technical system which includes the following elements: tracks, stations, push-pull rolling stock and other technical means and devices. With the help of the technical element the railways are a homogeneous technical system.

The input elements are energy, passengers, freight, information during the time of transport, expenses, etc. The output elements are transport services, price, quality of transport, etc.

Railway transport can be evaluated as a non-linear cybernetic system of a higher rank, made up of numerous subsystems. The realisation of objectives of each separate subsystem enables the railway system to realise the common goal of the system, as for example quality transport service, remote monitoring, management and operation of transport, etc.

3. REMOTE MONITORING AND OPERATING THE RAILWAY TRANSPORT

The analysis of the structure system could reasonably be implemented by the central traffic directions for establishing a central transport monitoring point. The central dispatch would provide the main dispatcher with video information of train movements (identified by numbers) from the regional control centres. The central dispatcher would then be able to dispose of transport in the whole area.

Such organization exists in the European railway directions and is called "video dispatching" or "video monitoring". The mentioned mode provides optimal disposition of transport in a large area, e.g. in the area of the whole direction at the German Railways.

The advantage of such form of transport operation lies in case there is video transmission malfunction. In case of malfunction there are still telephone links to the regional centres available. Transport disturbances can be avoided since the traffic can be monitored from the regional control centres. For these instances redundant transmission paths have to be developed in order to ensure proper and reliable transfer of telecommunication and video devices.

3.1. Centralized transport operation

Introducing centralized transport operation would result in large concentration of manpower in one place. This again questions the effect of work and transport management as well as the organization itself.

In case of centralized traffic management there should be only one centre for "telecommand of haulage" which would have to be placed at the same point as the "telecommand of traffic" as it is common practice in other railway directions. This variant is almost unattainable since in this case in the system structure too many elements would appear which would mutually exclude, rather than combine one another. Connecting all the elements is, nevertheless, essential, for it shows the homogeneity of the system and its structure. Moreover, a homogeneous system affects the synthesis of elements of the railway transport.

From all the above mentioned it can be concluded that such concentration of all elements in one place is not practical and it is too vulnerable. Apart from that, due to noise, conversations and telephone calls the working conditions become intolerable.

3.2. Decentralized transport operation

Decentralized transport operation is transport operation on individual routes, mainly from the existing regional control centres. From the regional control centres the whole railway network of the Slovenian Railways can be monitored. The data from these centres would be transmitted into the central dispatch where the central dispatch and monitoring would be performed.

The present state analysis of the form of operating transport leads to the conclusion that the centralized transport operation is appropriate for the main transport cross of Slovenia, whereas the decentralized transport operation is appropriate for the individual routes which would be controlled from the local operation centres. According to large capacities of fibre-optic cables and transmission network the data and images can be transmitted from the local control centres into regional centres or into the central dispatch.

3.3.2. Technical solution of remote transport operation

Optimization of railway transport management demands implementation of modern solutions in the field of computer technology and software. The increased functionalism and safety of the transport operation dictated creation of the modern computer system APIS-90 DKP/ANI, designed for railway transport operation at various levels.

The scheme of the APIS-90 DKP/ANI system considered all the trends of development of computer technology as well as railway transport operation, namely:

- the distribution of computer architecture (standard networks and communication protocol);
- openness and compatibility of device and system software; openness enables heterogeneous structure of system and simple adjustment and upgrading of the system;
- the choice of tools, based on the concept of windows and increased friendliness of the man – system interface;
- the choice of quality and powerful computers and widespread, practically standard software packages;
- Introduction of the concept of transport operation on the basis of tracking the train number, automatic setting of transport route, transport control based on timetable and registering transport in real time.

The product DKP/ANI is an independent computer system with integrated functions of remote control of the railway transport (DKP function) and automatic railway announcement (audio/video public information system – ANI function). The DKP/ANI system is designed mainly as rational and effective solution of railway transport management on the secondary and on the main routes.

The complete system structure is optimised for the following basic cases of application:

- complete remote monitoring and operation of stations without local personnel on the basis of classical or electronic signal-safety devices;
- change of classical command tables with the possibility of satellite remote operation of the neighbouring stations.

In both instances the system enables creation of complete infrastructure for simple upgrade with the transport operation centres at the level of dispatch operation and controlling transport and thus solving the

problems of the intermediator with the signal-safety device and local audio/video public information system.

The system advanced on the grounds of long-lasting experience in the field of operating the railway transport and it is today in the phase of introduction into the structure of the railway system.

3.3.1. System structure of DKP/ANI

The DKP/ANI system consists of several subsystems that make up a homogeneous whole of the system. The subsystem includes the following elements:

- central station of the DKP system which has to be placed in the traffic office of a chosen railway station and will serve as the central dispatch for remote monitoring and operating the system and transport;
- remote control stations which are to be placed at all stations in the area of remote monitoring and the central dispatch;
- additional modem and link equipment for connecting the network of the remote control station and the central dispatch;
- additional audio equipment for the adjustment and connection of the existing or installation of the new supply with loudspeakers at the stations for automatic railway announcements;
- additional equipment for the video public information system.

Software plays an important part of the structure of the remote monitoring system of transport operation. Software consists of modular and parameter structure, which is:

- remote monitoring of transport DKP (survey of condition, alarm, commands, protocol of events);
- TDS functions of tracking and accounting the numbers of trains;
- ANI automatic railway announcement (in the range of audio announcement);
- RTU remote control station;
- CTC intermediator for links to the superior operation centre.

The whole DKP/ANI system or adequate application software can be adjusted to adequate functional technical specification which is written before the realization of the project. This enables the investor to take part in the final version and functionalism of the offered software in order to satisfy the optimally specific demands, regulations and technology of management.

3.3.2. Basic operation principle of the system structure

The complete system structure is carried out as a software system with several functions. The basic tool for organization of transport is the command console which is placed on the existing desk of the operator. The command console consists of one or more monitors in colour, a standard keyboard and a mouse.

The basic principle of remote transport monitoring on the central console lies in the signal-technical-safe review of the route image on the coloured monitor and in entering the commands by means of a mouse.

The safe review of the track image on the monitor is based on the two-channel principle, cyclic two-channel principle, cyclic two-channel restoration of the image and the support with the test images. This principle of safe review of the route image follows certain UIC and ORE recommendations. As accompanying support functions for operating the transport functions of additional reviews, alarm functions and functions of chronological protocol of events are also available.

The function of tracking trains and the indicated train number are the bases for automatic railway announcements. The ANI function works automatically on the basis of the timetable, calculated or intermediate data about delays, criteria for announcement and tracking trains numbers in the area of the DKP/ANI system.

The condition of objects (signals, switches) is shown in the scheme and colour mode in a dynamic and clear way and corresponds to their actual condition. In the route image the train number is also indicated. The borders among sectors, buildings, platforms, subways and element indicators are shown as static elements.

The dispatcher gives commands for setting up of transport paths as well as other commands by means of assigning indicators to the appropriate elements of the image using the classical "start/end" principle or the "object/function" principle. There, before entering separate commands or series of commands the basic category of the command has to be chosen.

The selected commands are automatically arranged in the register window where instructions can be visually checked, and if required, they can be corrected or cancelled before being sent on and carried out. Following the principle of reducing the information load of the route image review with only periodically required information to a minimum, the indications of conditions can be given in a separate review with the state of counters for registration of special commands.

This enables quick and effective instructions input with minimum probability of error. At the same time, the review of route image is freed from superfluous reviews of indications, command buttons and less important information.

4. CONCLUSION

Considering enormous investments, the setting up of the remote transport monitoring system requires several separate phases of setting up the management system in order to attain positive results as they develop. All the installed objects and devices would have to serve the final goal, the setting up of the centralized transport management. Managing the traffic control system from one control station would provide the system structure with homogeneous operation and reduce the deviations from the system. The system structure could be organized in two ways:

- the centralized form of transport operation for the main transport cross of Slovenia, with the central point in Ljubljana;
- decentralized form of transport operation for the individual routes from the local station management centres.

Large capacities of fibre-optic cables and transmission paths enable local management centres, presented in the structure as subsystems, to send the required information to the regional or the main control centre.

With the introduction of the electronic switch boxes their incorporation in the system structure of remote transport monitoring presents an important technical innovation for the signal-safety technology as well as for the safety in traffic. The main advantage lies in the introduction of modern computer technology which enables:

- reduction of size of technical points (rooms, areas);
- reduction of maintenance costs;
- ergonomic design of places of work;
- preparation of the computer system upgrade;
- simple integration of additional functions for the automation of transport management.

An alternative feasible solution is a limited organization of remote transport monitoring and management which is founded on the standard, open system of architecture device and system software. Its modernization and extension of the system with new computer components is simple and does not require intervening into the user's software. On the other hand, its deficiencies are also known and they would have to be removed before its final incorporation into the remote monitoring system.

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POVZETEK

UPRAVLJANJE SISTEMA ŽELEZNIŠKEGA PROMETA

V skladu s sprejeto prometno politiko in razvojno strategijo R Slovenije se bodo tudi Slovenke železnice vključevale v razvojno – strateške cilje Evropskih železnic. Perspektiva napredka je predvsem v posnemanju razvoja evropskega sistema.

Tehnologija in organizacija sistema železniškega prometa predstavljata množico vseh tehnoloških in organizacijskih elementov in procesov, ki sodelujejo pri ustvarjanju ciljev sistema. Pojem sistem pomeni gledano s formalno matematičnega vidika, neko zaokroženo celoto, ki je običajno zapletena ali celo zelo zapletena. Tehnologija in organizacija dela v ožjem pomenu vsebujeta množico sredstev in postopkov pri realizaciji osnovne dejavnosti kar predstavlja neko zaokroženo celoto, in to je proces prevoza potnikov in tovora v transportnem sistemu.

V zadnjih desetih letih se je, s hitrim razvojem mikroelektronike in računalniške tehnike, pojavila tudi nova generacija elektronskih signalno varnostnih naprav.

Vse te spremembe, ki so zadnja leta nastale in se uveljavile v železniško tehnologijo omogočajo, da je zopet železnica postala atraktivna in konkurenčna drugim vrstam prometa, zato morajo tudi Slovenke železnice tekoče spremljati novi razvoj prometne tehnologije in postopoma modernizirati svoje progovno omrežje.

KLJUČNE BESEDE

menedžment, sistem, železnica, promet, železniški transport, upravljanje

LITERATURE

[1] **Žitnik, A.**: (1996) *Sodobne signalno varnostne naprave*, Ljubljana.

[2] **Kolenc, J.**: (1992) *Automatizirani informacijski prometni sustav*, IPZ Zagreb.

[3] **Mulej, M.**: (1994) *Teorija sistemov*, EPF Maribor.

[4] **Babič, D.**: (1999) *Možnost organizacije daljinskega vodenja in krmiljenja prometa na območju Slovenskih železnic*, Maribor.

[5] *External Effects on Transport*, International Union of Raiways, Paris, 1995.

[6] **Pepevnik, A., Pepevnik, U.**:(2000) *Harmonizacija železniških storitev v RS z Logističnim sistemom EU*, Zbornik, 2. kongres Transport – promet – logistika, Portorož.

[7] *ELEKTRONISCHE STELLWERK ESTW L90 info mape*, Standard Elektrik Lorenz AG, Stuttgart 1992

[8] *Railway traffic control system APIS-90, uporabniška dokumentacija*, I. A. P. Ljubljana 1990.

[9] *Sistem daljinskega krmiljenja in avtomatskega informiranja potnikov*, skripta 3, L.A.P., Ljubljana 1996.

[10] *Organizacijski predpis OP 999 Sekcija za promet Maribor*, Ljubljana in Postojna, Ljubljana 1998.