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OPERATING THE RAILWAY TRAFFIC CONTROL SYSTEM

Summary. Due to the valid traffic policy and development strategy of the Republic of Slovenia, the Slovenian Railways have to consider the developmental and strategic aims of European railways. The perspective of progress is basically determined by skimming the European system development, by taking over the European system and managing the railway traffic in the connection with the European railway system.

Technology and organization of the railway traffic system present the sum of all technological and organizational elements and processes that takes part in providing aims of the system. The aims are defined as solving transport problems in railway system. The term system is defined, from the formal mathematical viewpoint, as a whole that is usually complicated or even very much complicated. Therefore, the railway system is complex as well, and that is why it has to be managed precisely. In the narrow sense of meaning, technology and work organization both comprises a variety of means and procedures to realize basic activity that can be seen as a perfect unit, and that can be the process of passengers and freight transport in a transport system.

Because of the prompt development of microelectronics and computer engineering, a new generation of electronic signal-safety devices appeared.

All these changes from the past few years that have been introduced into railway technology, enable railway to become attractive and competitive to other means of traffic. Therefore, the Slovenian Railways have to follow novelties in traffic technology development and gradually modernize its railway network.

DZIAŁANIE SYSTEMU STEROWANIA RUCHEM KOLEJOWYM

Streszczenie. Ze względu na wagę polityki transportowej i strategii rozwoju Republiki Słowenii koleje słoweńskie muszą brać pod uwagę rozwojowe i strategiczne cele kolei europejskich. Perspektywa postępu jest zdeterminowana przejęciem europejskiego systemu zarządzania ruchem kolejowym.

Technologia i organizacja systemu ruchu kolejowego przedstawiają sumę wszystkich elementów oraz procesów technologicznych i organizacyjnych. Pojęcie *systemu* jest definiowane z matematycznego punktu widzenia jako całość, która jest zwykle skomplikowana, dlatego też system kolejowy jest również złożony i z tego powodu musi być precyzyjnie zarządzany. W węższym sensie zarówno technologia, jak i organizacja pracy obejmują różne środki i procedury w celu realizacji podstawowej działalności, którą może być proces przewozu pasażerów i towarów w systemie transportowym.

Z powodu szybkiego rozwoju mikroelektroniki i informatyki, pojawiła się nowa generacja elektronicznych bezpiecznych urządzeń sygnalizacyjnych. Wszystkie te zmiany z ostatnich kilku lat, które zostały wprowadzone do techniki kolejowej, pozwalają kolei stać się atrakcyjną i konkurencyjną dla innych środków przewozowych. Dlatego koleje słoweńskie muszą podążać za innowacjami rozwijającymi technologię przewozów i stopniowo modernizować swoją sieć kolejową.

1. INTRODUCTION

The system demands unifiable technique, technology and organization of railway system management. These demands enable operation of the system in a 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. Optimizing 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:

Technical principle is treated by means of typification, standardization and unification of technical means and common regulations in domestic and international sense.

Technological principle is created with the help of elaborating a time table, i. e. with introducing uniform technological processes of passenger and freight transport from the starting point to their destination.

Principle of organization contains all organizational elements (stations, stops, engine depots etc.) that interactingly form wholesome functioning of the railway transport.

Principle of time table 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 in a settled time frame.

Safety principle contains all the elements that provide safe functioning of the whole system, particularly in the passenger and freight transport.

The whole technological process of work is based on the principle of transport velocity and on time reduction for freight manipulation as well as half-way wagon holding back. Modern transport technologies are presented by possible organization with help of remote monitoring of the railway transport in order to gain better overlook of the organization and realization of the railway traffic.

2. BASIC CHARACTERISTICS OF RAILWAY TRAFFIC

The notion system appears in everyday life. It is also applied for various scientific purposes in individual researches. According to the author Mulej (1994) there are 15 groups of contents definitions of the notion system. Among others it is also applied in 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 consequences of interactive relations and influences among the parts. The reason for that lies in the problems that 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.

The concept system means, viewed from the formal mathematical perspective, a certain rounded whole which is usually complex or even very complex. The system of railway traffic is very complex in its structure as well as in individual part of its technological sense of meaning. It is at the same time a part of a greater whole (e.g. transport is a part of the entire economy, society, nature, techical-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 personel, from the point of view of technical condition 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 many possible onesided mental pictures of the treated phenomena. 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 collection of objects that are connected,
- the system is collection of objects united into interaction,
- the system has a structure, realizes the task and outputs or receives information.

According to mentioned theoretical bases the system can be defined as collection of elements that make up 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 picture 1.

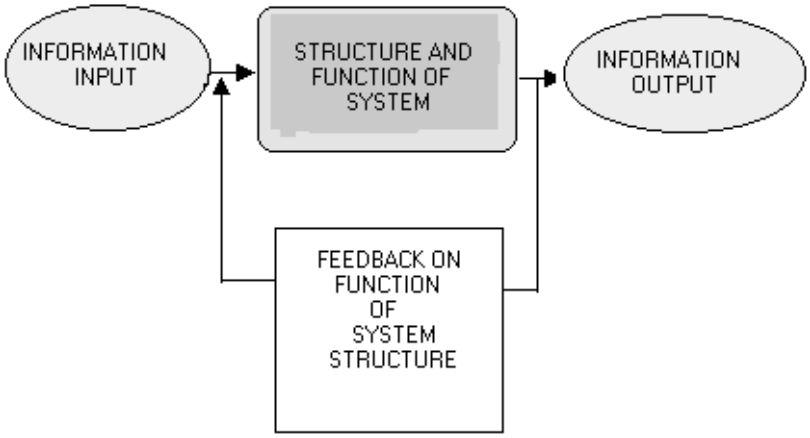

Fig. 1. General components of the system
Rys. 1. Ogólne składniki systemu

Basic structure of each existing system is made of following elements: energy, information, technical-technological element and subject-matter, which are interactively connected. There are, however, other elements that can also be identified: environment that enables the mentioned system to function, limits of the system, objectives, processes, structure and conditions of the system. The environment of the treated system includes external elements. These elements can affect the functioning of the treated system or they only monitor it and do not directly affect it. 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.

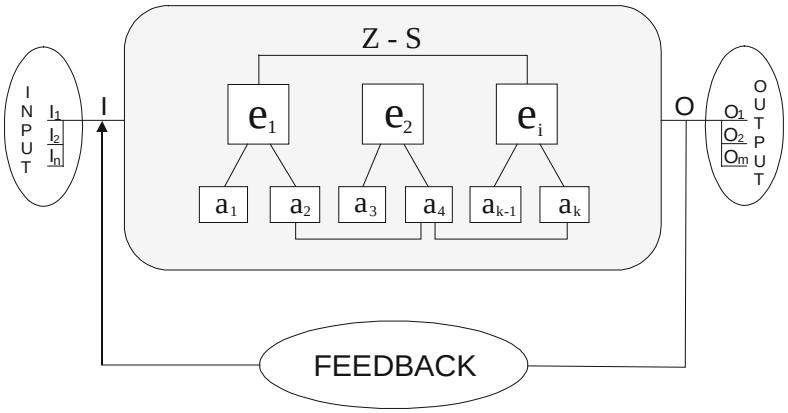

Fig. 2. System structure
Rys. 2. Struktura systemu

The limit of 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 function and determination of tasks. When setting the system objectives, several tasks of the system can be dealt with, which were determined in advance.

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

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

Structure rarely changes therefore it can be spoken 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 to as a homogeneous system, particularly when the connection of separate elements is in function operating the system as a whole.

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

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

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

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 bases of integral system in connection with the transport process in 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 sense of organization, which demands place and time homogeneity of work;

- it is a dynamic system, in which the change of condition and operation is in function of place and time;
- it is a system with numerous functions.

Implementation of 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 help of the technical element the railways are a homogeneous technical system.

Railway transport can be evaluated as nonlinear cybernetic system of a higher rank, made up of numerous subsystems. Realization of objectives of each separate subsystem enables the railway system to realize 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 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 with transport in the whole area.

Such organization exists in European railway directions and is called "video dispatchering" 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 of 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 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 there would appear too many elements which would mutually exclude one another instead of connecting. Connecting all the elements is, nevertheless, essential, for it shows homogeneity of system and its structure. And, 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 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 pictures can be transmitted from the local control centres into regional centres or into central dispatch.

3.3. Technical solution of remote transport operation

Optimization of railway transport management demands implementation of modern solutions in the field of computer technology and software. 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 system APIS-90 DKP/ANI considered all the trends of development of computer technology as well as railway transport operation, namely:

- 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 upgrade of the system;
- choice of tools, which base on the concept of windows and increase friendliness of intermediator between man and system;
- choice of quality and capable computers and widespread, practically standard software packages;
- introduction of concept of transport operation on the basis of tracking the train number, automatic setting of transport route, transport control on basis of time table 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 (function DKP) and automatic railway announcement (audio/video public information system – function ANI). The system DKP/ANI is designed mainly as rational and effective solution of railway transport management on side and main routes.

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

- complete remote monitoring and operation of stations without local personnel on the basis of classical or electronical signal-safety devices;
- change of classical command tables with the possibility of satellite remote operation of 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 disposing of transport and thus solves the problems of the intermediator with the signal-safety device and local audio/video public information system.

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

3.3.1. System structure of DKP/ANI

The system of DKP/ANI consists of several subsystems that makes up a homogeneous whole of the system. In the subsystem the following elements are included:

- 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 connection of the network of the remote control station and the central dispatch;
- additional audio equipment for adjustment and connection of the existing or installation of new supply with loudspeakers at the stations for the automatic railway announcement;

- additional equipment for video public information system.

Software is 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 link to the superior operation centre.

The whole system DKP/ANI or an adequate application software can be adjusted to the 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 suit optimally specific demands, regulations and technology of management.

3.3.2. Basic operation principle of system

The complete system is carried out as software system with several functions. 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 rests on signal-technical-safe review of the route picture in the coloured monitor and on entering commands with the mouse.

Safe review of the track picture in the monitor bases of two-channel principle, cyclic two-channel principle, cyclic two-channel restoration of the picture and the support with the test pictures. This principle of safe review of the route picture follows certain UIC and ORE recommendations. As accompanying support functions for operating the transport functions of additional reviews are also available, alarm functions and functions of chronological protocol of events.

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

Condition of objects (signals, switches) is shown in scheme and colour mode in a dynamic and surveyable way and correspond their actual condition. In the route picture the train number is also indicated. As static elements are shown the borders among sectors, buildings, platforms, subways and element indicators.

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

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 picture review with only periodically required information to a minimum, the indications of conditions can be given in a separated review with state of counters for registration of special commands.

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

4. CONCLUSION

Considering enormous investments, the set 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 set up of 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:

- 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 required information to the regional or the main control centre.

Introduction of electronic switch boxes, their incorporation in the system structure of remote transport monitoring presents an important technical innovation for the signal-safety technics 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 formation of places of work;
- preparation of the computer system upgrade;
- simple integration of additional functions for the automatization of transport management.

An alternative realizable solution is 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 system with new computer components is simple and does not require intervening into users' 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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