

## **Network Management Center for East European Railways**

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**Abstract** – Railways in the world are facing increasing competition with other transport facilities like electric cars, electric buses, freight trucks and aircraft. By using digital interfaces to electromagnetic relay-based block automation section or electronic interlocking system like LZB control center from Alcatel-Cegelec, the East European Union Railways must manage the whole long-distance traffic in his whole railway network and the upgrade software program is demanding the hardware part installation.

**Keywords:** Computer Integrated Railroading (CIR), Intelligent Management System (IMS), Total Integral Automation™ (TIA)

### I. INTRODUCTION

Competition means not only lower force for passenger and freight but shortest possible travelling times. Special requirements of the idea *just in time* of industrial companies demand for special conditions of information and the possibility to quickly react upon unexpected events.

Railways in Europe have been reformed to allow for market competition. As a result, railway services and infrastructure management have been vertically separated, allowing many operators to compete. Vertical separation, capacity allotment, and rail access charges have all taken on new forms. This article examines key issues of deregulation in several European nations. The research evaluates how competition has been implemented and controlled, with a particular emphasis on characterizing capacity distribution and tracking access prices. We find that, although being regulated by the same European legislation, the analyzed railroads had varied deregulation results, such as market organization and capacity allocation. Furthermore, few nations have so far achieved effective and transparent capacity allocation. Despite being permitted by law, market-based allocation is either nonexistent or never employed [1, 2]. According to the report, most European railroads still need to develop and experiment with more efficient and transparent capacity distribution systems to create greater competition, which can result in significant societal benefits [1, 2, 4, 6]

Railways private operators are transport providers which usually dispose of traffic route and transport equipment. Therefore, main tasks of the railways are [3, 4]:

- Modular design with a high level of integration and automation;
- Recognition and management of conflicts;
- Extensive statistical functions;
- Ergonomic user interface.

These tasks need a specialized solution, that's why the Romanian Railways West Region has chosen the concept of the Network Management Centre (NMC) [4-8].

### II. CONCEPT

The NMC concept is based on the idea of concentrating all systems for operation and dispatching in one location, together with the systems for maintenance and information, and and to integrate all functions to manage the rail network with all trains in one system. **LZB** system is based on constant exchange of data and dual processing [4 - 7]. Functions which must be integrated are the remote control of the interlockings and the train protection, monitoring and dispatching facilities for the supervision of the trains. The function of the whole rail network depends on the good performance of lot of technical equipment like signals, point machines and Automatic Train Protection (ATP) equipment, together with the equipment for the convenient of passengers, like passenger information systems, elevators and ticketing machines [4, 5]. The heart of high-speed railway operation safety is an ATP system. Now, the system's failure rate change rules are not well understood, and the maintenance approach is not developed [8, 9].

It becomes much more important to integrate the monitoring and maintenance tasks for all technical equipment in the NMC. Furthermore, the systems for customer services and tele-informatics re-linked with the information of the original train and track functions and therefore should be integrated in NMC as well [4, 7].

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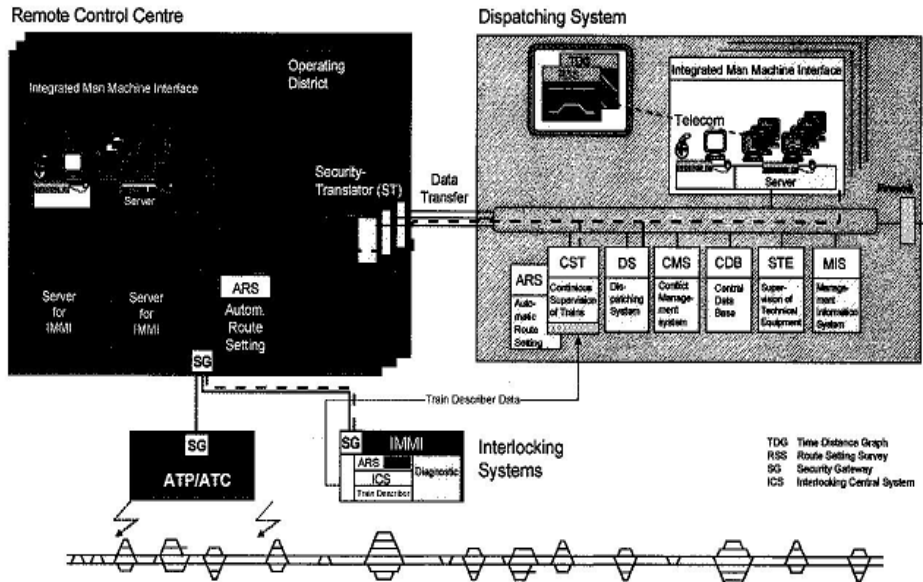


Fig. 1 The Network Management Center RBL/RZBL [4]

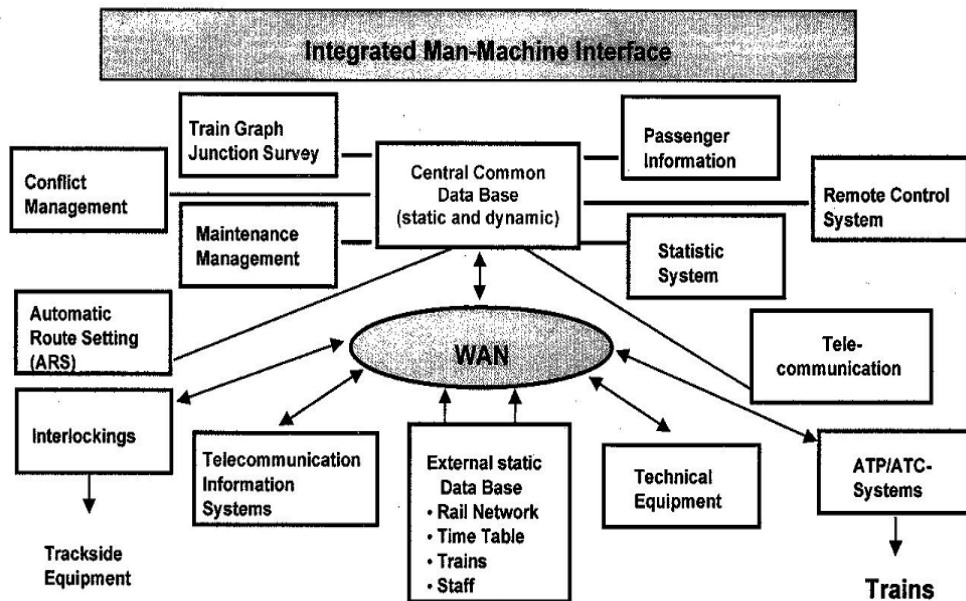


Fig. 2 The architecture of NMC [4]

### III. SYSTEM NETWORK ARCHITECTURE

Fig. 1 gives a system structure overview and the core of the Network Management Centre (NMC). The main feature is, to combine a dual computing network architecture system (SNA) with a lot of operator positions via a Local Operated Network (LON). The design of LON, i.e., use of routers, hubs, etc. depends on the client requirements. Dedicated tasks in the center are distributed to dedicated servers, all using the same database. All field elements are connected using Security Gateways (SG) via Wide Area Networks (WAN) to this LON (similar with the developments of [10, 11]).

The interlocking system such as LZB system, or relay-based systems are complete controlled via the multifunctional operator positions in the center and

ensures safe movement at speeds of up to and more than 300 km/h. To have the full range of the functions of NMC, like remote control and automatic route setting (ARS), it may be necessary to provide for the relay-based systems a computer interface. In east European countries all interlocking status is former presented in the center has to a fail-safe, to allow special interventions like setting a single signal or activating a point machine manually. Although we are using standard PC compatible computers with standard communication interfaces, the presentation of information is fail-safe (similar with the developments of [1, 2, 7, 10, 11]).

A software-based procedures assures the operator, that what he can see on the screen is the exact image of the status of interlocking. If there is any hardware failure of an interruption of the transmission is

detected, the system will give an alarm to the operator. Fig. 2 shows the main idea, how MCR is designed. It is based on the idea to distribute tasks on different hardware for reasons of performance, for reasons of redundancy and for an easy extension in future for extended tasks (as supported by the studies presented in [5, 6, 8]).

The core element is the common data base, filled with data information of all trains and their time schedulable outside equipment with their planned status. On the other side there is dynamic information coming from the interlockings, the ATP-systems and real-time status of all technical equipment. All this information is available for all subsystems of the NMC.

You can now define events, on which these subsystems will be informed to support the operator, i.e., the conflict management system solves unexpected problems. On the other side the common data base is combined with a powerful statistic system the base for a man-agreement information system (MIS). All operator places have access to all servers, therefore on all places you can have the complete overview of the status of the whole railway network.

#### IV. ADVANTAGE OF CONCENTRATION

The idea of concentrating all functions in one location requires location of man and machines in proximity. This will harmonies the needs of the operational and supervisory roles by allowing planned interruption even in real-time.

It also permits prioritization of repair by reference to the actual status of the rail network and meet the needs of the technical services for a complete overview to deploy staff as effectively as possible.

The arrangement is necessary during planned maintenance work and much more important in case of fault detection and restore of any technical, unexpected error conditions often can handle like planned interruptions.

The concentration of staff in one center avoids the need for expensive communication between operational and supervisory staff and increase the quality of information exchange.

Another important advantage is the ability to assign the staff flexibly to different conditions like rush hour traffic and in off peak and to give the responsibility for more than only one interlocking to one person.

Concentration in one center has the advantage of providing a direct access in real-time to the complete data of the whole technical equipment and permits the development of better diagnostics systems for better quality of information.

It is also possible to provide information to all relevant personnel, including the actual and predicted status of all trains, to optimize services.

#### V. ADVANTAGE OF INTEGRATION

The integration of all services within one center together with modern signaling and control technologies permits the use of high-performance computers. The large - scale computerization and automatization of systems and procedures, with access to all significant data and the ability forecast the status of all trains permitting control over extensive areas.

Flexibility and reaction to changing conditions over a large network needs computer aided tool (CATs).

The most important tool is computerized conflict management, i.e., automatic detection and resolution of conflicts in the railroad network.

Another tool often combined with conflict management, is the direct implementation of routing strategies through the Automatic Route Setting System (ARS). The integration in central systems allow to establish overlapping statistic systems for: capacity and service quality measurements; error analysis and fault synthesis; timetable design; optimized staff disposition.

#### VI. MAIN FUNCTIONS

The modular design of the NMC in hardware and software, combined with communication via standard protocols allows economic adaptation to different situations. The modules will be put together to form an integrated solution, like building a house with prefabricated panels. Any NMC will have to be frequently adapted to changing operational conditions, therefore the system must be designed to work data – based.

The system design permits integration of new features by adding new software or hardware modules. It is possible to start with a small implementation and extend this according to growing needs without losing the initial investments. For increasing performance, the modularity allows to add more micro-computers to share the or to change hardware for another powerful model.

The use of standard protocols makes it possible to install “tailor-made solutions with standard components”, the only economic way to meet the needs of east European railway operators, and maybe central European operators too.

The basic functions, which will be explained later, are the integrated man machine interface, the standard interface to all subsystems of the NMC, the continuous supervision of trains, the system for a permanent overview of the railroad network, the automatic route setting system, the link between the dispatching tasks and the access to the interlockings and the conflict management system, the computer-based tool for handling an extended area.

## VII. INTEGRATED MAN MACHINE INTERFACE

The access to all subsystems of the NMC, the center is designed via standard user-friendly windows techniques. The technical solutions allow operators to select each dialogue on each monitor.

The private operator must log in to the system with his identity code, i.e., name or/and function, and a password.

*Note:* the login procedure provides different authority levels.

It allows selected operators access to selected dialogues or selected regions.

It is also possible to change dynamically the authority levels for easy change of responsibility during a special forced time-period, e.g., in case of accident or maneuver incidents. The main features are:

- Display the status of all trackside equipment, like signals, points etc. and of the trains, with their location, the train number and the magnitude of delay.
- Operating with the train describer system via mouse and standard monitor, to identify trains by adding a train number or to add information to trains which are not completely registered automatically.
- Facilities to change the data base of the automatic route setting system, like timetable or track occupying list.
- Work with the central data base for generating reports, adding information or changing the basic static information.
- Facilities for telecommunications are integrated, the only integrated equipment is one mouse and one standard keyboard to up to eight monitors.

## VIII. CONTINUOUS SUPERVISION OF TRAINS AND AUTOMATIC ROUTE SETTING

The continuous supervision of trains is based on information coming from the train describer system. By identifying a train with a unique train number and deriving its route by analyzing the status of the elements of the interlocking, the system automatically traces all train movements, and the system shows the train on all screens in the right position. The operator can choose the presentation as a map-oriented route display, all stations as lines display or for dispatching the most frequent way as time-distance-graph or junction display.

Most of the trains with a dedicated timetable can move through the rail network by setting the route automatically. The basic information for ARS is the actual status of the interlocking, the actual train position on section, generated by the train describer system, the actual status of the train, the dedicated timetable. Together with a route setting list linked to this train, the system automatically sets the route

when the train reaches a predefined section or when the time for station departure has come.

The system checks the status of the interlocking, and when all conditions are met, the route will be set automatically, and the setting will be displayed.

## IX. CONFLICT MANAGEMENT SYSTEM AND ELECTRONIC INTERLOCKING

The supervision and control of extensive areas requires computer aided conflict management. It is the most powerful tool to reach the key target of the railway. The goal is to achieve increasing quality of traffic. It is only way to react in real-time to unexpected traffic conditions by predicting the outcome and choosing the right solution to avoid problems.

There are basically three kinds of conflicts, the concurrent occupation of a section, i.e. two trains wants to occupy the same section at the same time, the connection conflict, i.e., rolling stock or personnel is dedicated to a train which is late or early, or as a changeover conflict for passengers, when the coming train is too late for connecting with another train, and time table conflicts where a train has a delay against the time schedule (similar with [8, 9]). The base of a powerful conflict management is to obtain nearly complete information, including static information about trains, rail network and timetables as well dynamic information of all trackside equipment. Actual conflicts and predicted conflicts must be indicated and solved quickly.

If the system detects that two trains will occupy the same section, the conflict management system will solve the problem by changing the route of the train, changing train speed or delay or giving the train with higher quality type the priority (as mentioned even in the studies [2, 3, 10]). The solution would be automatically converted into commands via automatic route setting system or direct to the trains by the ATP/ATC-system. Another feature of the conflict management system is its use for optimizing timetable design or staff disposition, using the system for training the staff and using it together with the MIS for statistics diagnostics. The NMC only has direct access to an interlocking center, when this is built up as an independent subcenter, see Fig. 3.

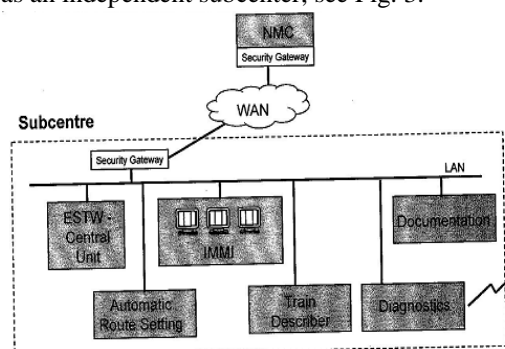


Fig. 3 Interlocking subcenter [4]

To fulfill this task, it is necessary, to extend the standard functions of an interlocking with some special NMC-features. Obviously, it is necessary to give them the feature to communicate with the NMC over a WAN. To run with the automatic functions of the NMC, each interlocking must contain decentralized functions of the ARS and train describer (similar with [10, 11]).

The documentation and the diagnostic systems also must allow remote access from the NMC. Although, the Subcenter is working without any decentralized staff, it has an Integrate Man Machine Interface (IMMI) for testing and for times with broken connection to the NMC. The Subcenter is designed to run about two hours stand alone, in this

time normally an operator will reach the Subcenter to ensure the running of the traffic.

The LZB from Alcatel-Cegelec perfectly fulfill the needs for a decentralized operation.

Due to the modular design, see Fig. 4, the interlocking can build up step by step in line with the growing of a new rail line or with the gradual replacing relay-based interlocking by electronic equipment, when a line is modernized. LZB is designed with three main modules, each fail safe and redundant. The interface to all trackside equipment, the element control module (EAM) is connected via serial lines to the interlocking module (SM). Therefore, it can be placed on each place along the line with no need for the overhead system nearby (as described by the studies [3 – 6]).

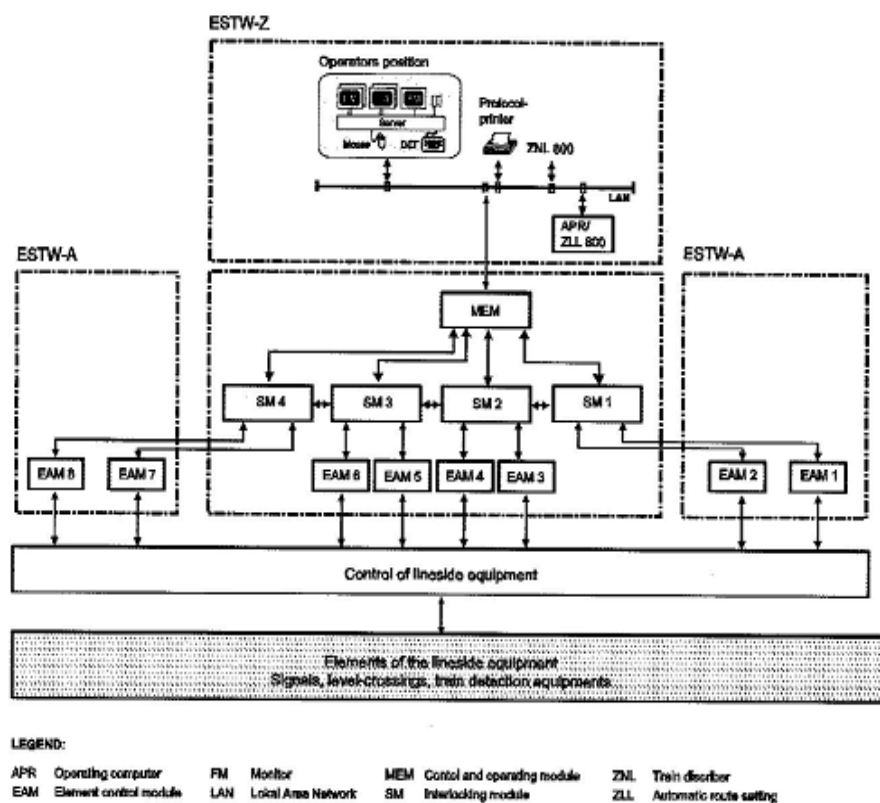


Fig. 4 The RBL/RZBL NMC [1]

The serial transmission method is independent of the transmission technology. The interface to the operator places is built by the control and operating module (MEM). All modules are designed as two out of three systems logic. The modular design, together with the serial link structure, allows a testing and proving strategy with a maximum of work already done in the test center, with independent testing of the overhead to hierarchically superior systems (MEM and SM) and the field level (EAM). The testing and proving time at trackside will decrease to a minimum.

## X. CONCLUSIONS

The use of computer-aided management systems in transport automations improve the infrastructure

through advanced technical solutions. While headways decrease, route capacity and speed must be increased. Interconnections must be assured throughout the network. Overall performance has multiple requirements: careful planning, the processing of data for traffic management, the application of microcomputers for train routing, on-board controllers for automatic train control, and dynamic passenger information system.

Future developments and studies are related to the Transport White Paper that outlines two categories of the transportation market where rail would benefit from a bigger share. These are long-distance overland freight and medium-distance passenger travel, particularly with the expansion of high-speed rail. Milestones for the next years are depicted in the table below, where the baseline is 1990 and the metrics are

calculated per passenger-km (passenger service) and ton-km (freight service).

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