DEVELOPING TRENDS OF RAILWAY TRAFFIC CONTROL

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Summary The future of a railway operator is depending on the success of the simultaneous improvement of service quality and cost effectiveness. In this paper we are going to investigate, how traffic control systems – by their developing trends – can contribute to the improvement of service quality and cost effectiveness. In course of this, the following topics will be highlighted: effects of the application of automation and telematics; issues of interoperability and the application of satellite based location.

1. INTRODUCTION

Railway companies were operating in the first hundred years of their history without competition. However, in the following decades the competition has been sharpened between the railway and other modes of transportation, and at the present the competition has begun between different railway operators by the liberation of the use of infrastructure. In such a competitive situation the future of a railway operator is depending on the success of the simultaneous improvement of service quality and cost effectiveness.

Service quality is mainly influenced by the subsystems of the railway traffic (track, vehicle and control system) and by the co-operation of them. In this paper we are going to investigate, how traffic control systems – by their developing trends – can contribute to the improvement of service quality and cost effectiveness. In course of this, the following topics will be highlighted:

- effects of the application of automation and telematics;
- issues of interoperability;
- application of satellite based location.

2. AUTOMATION AND TELEMATICS

Automation and telematics improves the competitiveness of railway by enabling a reduction in the number of the necessary personnel working on the stations [6]. The necessary manpower on a station is dependent on the points switching method (see Tab. 1).

Table 2 shows the three eras of railway traffic: the first hundred years are featured by the centralization of points switching. The following periods are characterized by the application of automation and telematics, what also means a further advance in centralization.

Tab. 1.

Method	Distance	Nr. of points	Service places
Local	some 10 m	some	More at each station head
Points wire	some 100 m	some 10	1 or 2 at each station head
Electrical	some km	100 to 200	1 for each station
Remotely operated	some 100 km	more thousands	1 for hundreds of stations

Tab. 2.

Era	Function	Technique	
First 100 years	Mechanization and centralization of points switching Basic interlocking	Mechanic/ electromechanical	Railway specific
Next 50 years	Occupancy detection Fully safe operation Automation, remote control	Relay based	
Recently	Advanced automation Integrated services	Electronic, informatics	General

It must be noticed that the techniques of the three eras are present at railway operators simultaneously and will surely operate together for a long time. Railway operators can improve their competitiveness by replacing technologies of former eras by newer technologies, thus improving the proportion of new technology.

The most important factor in the reduction of the stress of station personnel is the automation of route setting. The most advanced mode of this is, when trains automatically set their routes when approaching the station, based on the stored timetable and according to the predefined routes to each train identifier (Fig. 1) [3].

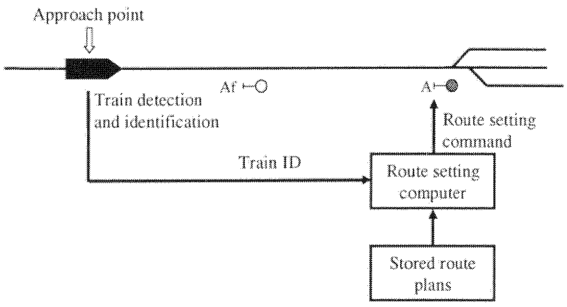

Fig 1. Automatic Route Setting.

With help of the automation of routine tasks, a signalman is able to control not only one station, but a longer line. Controlling of the traffic of more stations from a single centre is enabled by the remote control of station interlocking systems (Fig. 2) [6].

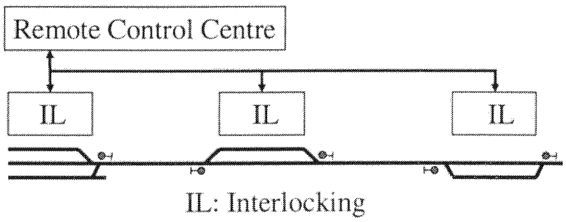

Fig. 2. Remote control of stations.

By using electronic interlocking systems a cost effective system structure can be developed: the interlocking logic of the whole railway line is located in one centre, while the outdoor equipment is controlled by distributed periphery controller computers, located on the stations. Computers of the centre and that of the stations are coupled by a safety bus system (Fig. 3).

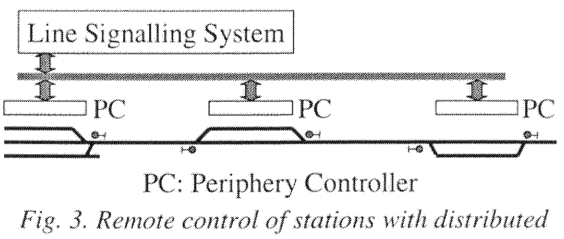

Fig. 3. Remote control of stations with distributed signalling system.

Application of remote control enables to centralize not only the stations of a single line, but to control a large area remotely. The structure of these complex service operation control systems may be different at different railway operators.

For example, the network of the German Railways (DB) has been divided into seven districts: from one district centre about 5000 km of railway line with about 450 stations are controlled remotely [2]. Automatic functions, which are deployed on the stations, makes possible to continue the traffic control for a while, even if the communication link between the centre and the stations is erroneous (Fig. 4). Since the stations can be located 200-300 km away from the centre, special organization solutions must be applied, to allocate personnel on the stations, if the disturbance exists for a longer time.

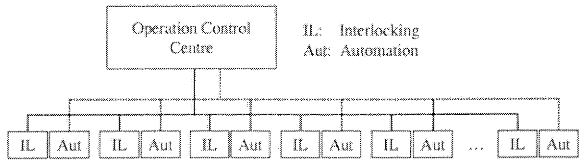

Fig. 4. Traffic Control Concept of DB.

The Austrian Railways (ÖBB) plans to realize a three-level solution, which would be based on the already installed line remote operation [1]. This system consists of 44 line remote control centres, each controlling about 70 km of track. Automation functions are installed in these line remote control centres, rather than at the stations. Additionally, 5 supervisory operation control centres are planned to realize in such a way, that neighbouring centres can assist to each other in case of faults (Fig 5).

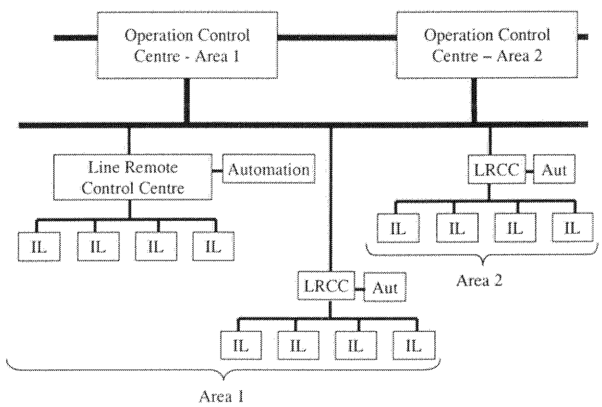

Fig. 5. Traffic control concept of ÖBB.

3. INTEROPERABILITY

Traffic rules and signalling systems are historically different at different European railways. Track-to-vehicle information transmission modes are also multitudinous. European railways apply almost 30 different types of train control systems. Wireless communication systems are different as well, even within one railway operator (different frequencies, technical solutions).

Railways in Europe have recognized that all of this hinders the interoperability, i.e. border crossing without any obstruction. Therefore, European railways decided to elaborate the so called European Rail Traffic Management System (ERTMS), which is based on standardized operational and technical interfaces. ERTMS consists of the following basic components:

- Harmonisation of Railway Rules for Operation of ERTMS – HEROE
- Global Systems for Mobile communication for Railways – GSM-R
- European Train Control System – ETCS.

The **standardized communication platform** of railways will be provided by **GSM-R**, a GSM based technology [5]. In course of the selection the following aspects were taken into account:

- GSM is a mature technology
- with extensive services, and
- it is able to satisfy special requirements of railway domain.

Railway requirements are more rigorous, than that of the general applications of GSM. Main areas of improvements are

- quick connection setup,
- handling of priorities,
- rate of successful calls,
- availability of the network,
- data transmission delay and
- data transmission failure rate.

Important factors that influence the fulfilment of the demands are

- frequency of handovers,
- success rate of handovers (min. 99,5%),
- duration of handovers (max. 300 ms outage),
- radio frequency coverage along the track.

The GSM-R system became available in the recent years at most of the European railways: the GSM-R network is already operating in several countries. GSM-R nowadays is just about to put into operation in other countries, while other networks are under construction or in a tender phase. According to this tendency, this decade is characterized by the general application of GSM-R.

Deployment of GSM-R along Trans European Network (TEN) lines is obligatory; it is recommended on other main lines (because of unification). GSM-R could also help in realization of Low Cost Signalling systems on branch lines.

Beside the European countries, Japan, China, South-Korea and the USA are also investigating the applicability of GSM-R.

For the **ETCS** three levels have been defined, according to the application of traditional trackside objects and GSM-R (Table 3) [6]. For the location of trains fix balises are used as electronic milestones at all the three levels. Balises are deployed between the rails and operate on the transponder principle. They are used to transmit fixed information to the moving train. The train measures the distance between two balises with help of an odometer.

At level 1 controllable balises are also used, for transmitting the signal aspects of the trackside signals to the train. At level 2 and 3 movement authorities are not announced by trackside signals anymore, but they are transmitted by the signalling systems via the Radio Block Centre (RBC) with help of GSM-R telegrams.

Track occupancy detection at level 1 and 2 is solved by traditional trackside objects: track circuits or axle counters. At level 3 the locomotive's on-board equipment transmits the location of the train to the signalling system with help of GSM-R telegrams. The onboard equipment controls the running of the train, according to the movement authority received from balises or by GSM-R telegram, and if a hazard is identified the system interacts (emergency brake).

Tab. 3.

	Trackside objects	**Fix balise**	**Controllable balise**	**Short loop**	**On-board equipment**	**GSM-R**
Occupancy	1/2					
Train integrity	1/2				3	3
Location		1-3			1-3	3
Movement authority	1/2		1			2/3
Infill information				1		(1)

4. SATELLITE BASED NAVIGATION

The Navigation Satellite Timing and Ranging Global Positioning System (NAVSTAR GPS) was developed in the USA for military navigation purposes. Nowadays its civil application is gaining ground. Beside naval and aerial transportation it is widely applied in road transport and several projects aim at the railway application of GPS [4].

Accuracy and availability requirements of the satellite based positioning depend on the application. The most rigorous requirements are claimed by traffic control and safety applications. The main issue in this area is that at some sections of the track the GPS equipment cannot receive signals from enough satellites and that the received signals are often erroneous.

The effect of some errors can be reduced significantly by the so called Differential GPS (DGPS) system, with help of which the accuracy can be improved by 1 or 2 orders of magnitude. In case of a DGPS equipment the vehicle receives not only the satellites' signals but also correction signals from a nearby base station, the exact position of which is known. Communication between the DGPS basis and the vehicle can be based on radio (e.g. GSM) or on satellites (SBAS, Satellite Based Augmentation System).

The effect of another group of errors (e.g. limited visibility of satellites) can be reduced by the application of additional inertial unit which contains odometer and accelerometer sensors. Safety-critical applications require further augmentations.

The European system of satellite navigation (**Global Navigation Satellite System**, GNSS) a total of 48 satellites are available: 24 from the American NAVSTAR and 24 from the Russian GLONASS systems. The European Galileo system with its 30 satellites is expected to operate from 2008. This will mean not only an increase in the number of visible satellites, but probably an increased confidence in satellite based navigation, since the Galileo is planned to be a civil operated system.

The European Union supports about 75 projects at present, that aim the application of GPS, among which several deal with railway applications. For example: the goal of the LOCOPROL project is to elaborate a safe and cost effective way for positioning with special regard to low density traffic lines (LDTL). Another current project called GADEROS (GAlileo DEmonstrator for Railway Operation System) aims at the integration of satellite based positioning into the ERTMS/ETCS system.

5. CONCLUSIONS

In the following 5-10 years the railway traffic control will be characterized by the expansion and the spreading of the current technologies. These are

- operation on main lines without local personnel, using line remote control centres or area remote control centres with integrated services;
- establishment of the operational and technical interoperability (ERTMS HEROE/ GSM-R/ ETCS) at least on TEN lines;
- safe and cost effective application of satellite based positioning systems, mainly on LTDL, partly on main lines.

As a final remark, it must be noted, that the effectiveness of the new systems is dependent on the success of the change and the migration technically as well as in the human areas.

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