CETRA[2012]

2nd International Conference on Road and Rail Infrastructure
7–9 May 2012, Dubrovnik, Croatia

Road and Rail Infrastructure II

Stjepan Lakušić – EDITOR

Organizer
University of Zagreb
Faculty of Civil Engineering
Department of Transportation

CETRA 2012
2nd International Conference on Road and Rail Infrastructure
7–9 May 2012, Dubrovnik, Croatia

TITLE
Road and Rail Infrastructure II, Proceedings of the Conference CETRA 2012

EDITED BY
Stjepan Lakušić

ISBN
978-953-6272-50-1

PUBLISHED BY
Department of Transportation
Faculty of Civil Engineering
University of Zagreb
Kačićeva 26, 10000 Zagreb, Croatia

DESIGN, LAYOUT & COVER PAGE
minimum d.o.o.
Katarina Zlatec · Matej Korlaet

COPIES
600

A CIP catalogue record for this e–book is available from the National and University Library in Zagreb under 805372

Proceedings of the
2nd International Conference on Road and Rail Infrastructures – CETRA 2012
7–9 May 2012, Dubrovnik, Croatia

Road and Rail Infrastructure II

EDITOR
Stjepan Lakušić
Department of Transportation
Faculty of Civil Engineering
University of Zagreb
Zagreb, Croatia

ORGANISATION

CHAIRMEN

Prof. Željko Korlaet, University of Zagreb, Faculty of Civil Engineering
Prof. Stjepan Lakušić, University of Zagreb, Faculty of Civil Engineering

ORGANIZING COMMITTEE

Prof. Stjepan Lakušić
Prof. Željko Korlaet
Prof. Vesna Dragčević
Prof. Tatjana Rukavina
Maja Ahac
Ivo Haladin
Saša Ahac
Ivica Stančerić
Josipa Domitrović

All members of CETRA 2012 Conference Organizing Committee are professors and assistants of the Department of Transportation, Faculty of Civil Engineering at University of Zagreb.

INTERNATIONAL ACADEMIC SCIENTIFIC COMMITTEE

Prof. Ronald Blab, Vienna University of Technology, Austria
Prof. Vesna Dragčević, University of Zagreb, Croatia
Prof. Nenad Gucunski, Rutgers University, USA
Prof. Željko Korlaet, University of Zagreb, Croatia
Prof. Zoran Krakutovski, University Sts. Cyril and Methodius, Rep. of Macedonia
Prof. Stjepan Lakušić, University of Zagreb, Croatia
Prof. Dirk Lauwers, Ghent University, Belgium
Prof. Giovanni Longo, University of Trieste, Italy
Prof. Janusz Madejski, Silesian University of Technology, Poland
Prof. Jan Mandula, Technical University of Kosice, Slovakia
Prof. Nencho Nenov, University of Transport in Sofia, Bulgaria
Prof. Athanassios Nikolaides, Aristotle University of Thessaloniki, Greece
Prof. Otto Plašek, Brno University of Technology, Czech Republic
Prof. Christos Pyrgidis, Aristotle University of Thessaloniki, Greece
Prof. Carmen Racanel, Technical University of Bucharest, Romania
Prof. Stefano Ricci, University of Rome, Italy
Prof. Tatjana Rukavina, University of Zagreb, Croatia
Prof. Mirjana Tomičić–Torlaković, Univiversity of Belgrade, Serbia
Prof. Brigita Salaiova, Technical University of Kosice, Slovakia
Prof. Peter Veit, Graz University of Technology, Austria
Prof. Marijan Žura, University of Ljubljana, Slovenia

CETRA 2012 7–9 May 2012, Dubrovnik, Croatia
2nd International Conference on Road and Rail Infrastructure

CONTROL SYSTEM FOR TRAINS IN MOVEMENT

Dobrinka Atmadzhova[1], Emil Dimitrov[2], Nencho Nenov[1]
1 Todor Kableshkov University of Transport, Sofia, Bulgaria
2 Technical University of Sofia, Bulgaria

Abstract

Bulgaria's accession to the European transport system and its strategic geographical location has imposed the necessity of a high-level operational reliability in the rail sector. With particular urgency and profoundness, in relation to the commitments stipulated in the regulations of the European Parliament (Directive 2001/14/EC on the allocation of railway infrastructure capacity and the levying of charges for the use of railway infrastructure and safety certification and EN 14363: 2005 E 'Railway applications – Testing for the acceptance of running characteristics of railway vehicles – Testing of running behaviour and stationary tests'), the problem to develop systems for monitoring on the national railway infrastructure has become a priority. The mandatory implementation of control systems for trains in movement should create conditions for continuous objective monitoring on the transport process. It will result in providing traffic safety and preventing accidents as well as in a number of other effects such as increased economic efficiency in operation and maintenance of infrastructure and rolling stock, allocation of railway infrastructure capacity and collection of charges, etc. This paper developed by scientists working in the field of diagnostic equipment to determine the technical condition of the most important vehicle undercarriage elements is intended to interested public. A detailed study and comparative analysis of the systems used by leading railway administrations have been made. The basic principles of the construction are examined and Check PointBG functions related to its regional purpose are determined. Alternative methods have been proposed, which concern the nature of vehicle–track interaction, hence traffic safety. A number of diagrams experimentally established under conditions similar to real operational environment are presented. Some peculiarities in measurement defining the conditions necessary to model the Bulgarian control system of trains in movement are shown.

Keywords: movement of train, control systems for trains in movement

1 Introduction

1.1 Effects of introducing a system for control of trains in movement

The most important benefits of development and implementation of the system of technical, economic and social nature and can be summarized as follows:
- ensuring a high level of rail system operational reliability;
- increasing economic efficiency in infrastructure and rolling stock operation and maintenance;
- preventing failures and accidents;
- allocation of railway infrastructure capacity;
- charging for using the railway infrastructure;
- certification for train traffic safety;
- ride comfort, etc.

1.2 European regulations

- Directive 2001/14/EC on the allocation of railway infrastructure capacity and the levying of charges for the use of railway infrastructure and safety certification
- EN 14363:2005 E, 'Railway applications – Testing for the acceptance of running characteristics of railway vehicles – Testing of running behaviour and stationary tests', Brussels 2005

2 Advanced international experience

In Europe such systems are under development, implementation and operation by the railway administrations of Germany, Holland and Austria.
Example: In 2005 the infrastructure provider ProRail jointly with companies Baas R&D and NedTrain Consulting implemented the system Quo Vadis in the railway network of the Netherlands.
The system is designed for monitoring on the status of infrastructure and rolling stock. Its construction has been initiated by the entry of EU Directive EC 2001/14 into force. The system employs about 40 work points for the construction of which have been invested about 3.5 million EUR. It uses fibre optic technology as the measurement is guaranteed at speeds up to 40 km/h. The trains passing through the adjacent posts carry about 80% of the total passenger transport and about 96% of the freight transport in the country. The system provides information about the mass of the train, axle load, vehicle wheel condition, the speed and number of axles of the trains passed. The operation of all points is controlled remotely from a central post.
The system Quo Vadis registers the condition of wheels (reduces the costs of bandage/ tread grinding) and significantly decreases the number of overheated axle boxes (almost 90%). The information from the system component performing identification of rolling stock provides accurate data of the actual use of infrastructure and its occupation.
The data for 2005 showed that the trains running within the railway system are actually with a mass 16% bigger than estimated according to the train traffic schedule and about 1,6% of the axle passed are of load exceeding the permitted one of 22,5 t. The results obtained from the system can be used as a basis for developing draft amendments of route and track development to streamline operational and technical–economic indicators of the train traffic organization.
According to the data cited in European Railway Review [1], the annual economic effect of the system implementation is about 2 million EUR.

3 Comparison of used Check Point systems by main functions

The following table shows some of the most famouus world systems compared by their most important parameters [3], [4], [5], [6].

Table 1 Comparison by some of the most important parameters.

Name	GOTCHA®	LASCA& MATTILD®	MULTIRAIL®	ARGOS®	Zugkontrollei nrichtungen	RailBAM®	MERIDIAN®
Origin	The Netherlands	Germany	Germany	Austria	Switzerland	USA, Australia	Australia
Year	2000г.	2001г.	2001г.	2004г.	2005г.	2001г.	2004г.
Operational speed of movement: rolling stock / (train)	from 15 to 350 km/h	from 1 to 350 km/h	from 10 to 40 km/h	from 5 to 300 km/h	-	from 30 to 180 km/h	from 0 to 80 km/h
Sensors (number, type)	8 -12 optic fibre (OPUS44)	12 laser sensors	8 - 14 sensors	14 sensors	2 Q-areas ; 4 temperature sensors	WCM; TBOGI; WheelSpec;	16 photoelectric sensors
Possibility to be mounted on rails	UIC54; UIC60; BV50;	without limitation	-	-	-	-	-
Length measured: vehicle / (train)	up to 1600m	-	-	min 700 mm	-	without limitation	-
Number of axles measured: vehicle / (train)	up to 500	yes	-	32 for each vehicle	-	up to 1500	up 500
Boundary distance between axles: vehicle / (train)	from 0.7 to 24m	-	-	-	-	yes	-
Wheel diameter	from 330 to 1600 mm	-	-	from 300 to 2000 mm	-	yes	-
Environment temperature	from -40 to +50*C	up to -45*C	от -50 до +70*C	from -30 to +75*C	-	tropical climate	-
Accuracy of the load measured	3%(30-70km/h), (5%70-350km/h)	2 - 3% (min 100N)	0.5% of the total weight	1 - 2% of the total weight	-	-	from 1 to 5%
Accuracy of the speed measured	0.5 km/h	-	-	0.5 km/h	-	-	-
System of vehicle / (train) recognizing	AVI Tags	ZLV-Bus ; AEI-Tagreader; SOFIS;	yes RFID	yes RFID	-	AEI - tags; AVI - tags;	yes RFID
Time to prepare a ready report	1 min	2 min	-	5 sec	-	5 - 15 min	-
Type of a ready report	XML / Network TCP(IP)	FTP; XML; GSV; SAP/ISI;	HTML; text;	XML	-	XML / Network TCP(IP)	HTML; text;
Type of telecommunication connection	GSM-(R)-GPRS, Ethernet, Dual-up	Intranet; Internet; ISDN	LAN / cable	LAN direct; GSM / UMTS	-	Internet	wireless / cable
Power supply voltage	230V AC 50Hz; 24V (110V) DC	230V AC 50Hz	-	9-40V DC; 230V AC	-	DC / AC	-

4 Key functions of the system conditionally called Check Point BG

1 Recognition system for rolling stock / (train)
2 Measuring the load on each wheel:
- reporting for excess axle weight;
- reporting for excess of agreed load of vehicle individual units;
- reporting for uneven load of wheels;
- detection of unbalanced vehicles.

3 Detection of periodic deviations from circularity of the rolling surface (detection of plating, wheelflats)
4 Detection of temperature limits excess:
- axle assembly;
- friction surface of the brake system;
- surface of bandage/ tread profile.

5 Telecommunication link

4.1 Recognition systems

The recognition system of trains by frequency sensors is shown in the figure 1.

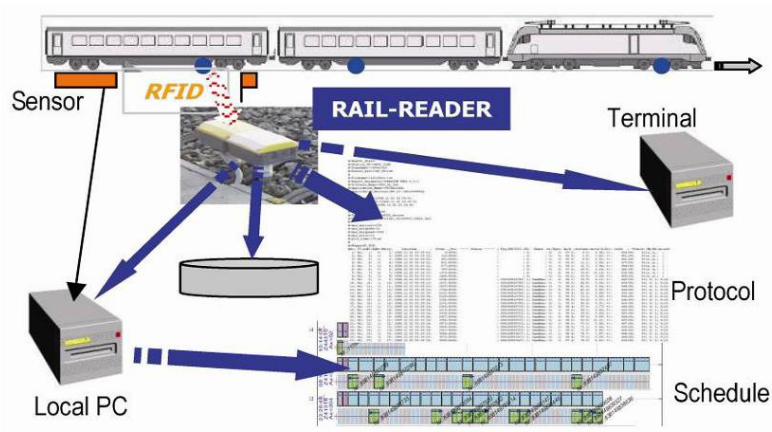

Figure 1 RFID Recognition System

Features of the rail system RFID:

- immediate identification of the vehicle;
- long life cycle, low energy consumption;
- multifunctional applications (infrastructure, logistics and management);
- technology for all types of vehicles and speed of passing;
- not using external power;
- basis for innovative services;
- quick and inexpensive installation.

An example of train recognition system by intelligent optical sensors is shown in the figure 2.

Functions of the optical recognition system:

- reading the wagon (locomotive) number;
- imaging and comparison of the read numbers with database;
- video recording of passing;
- wagon data transfer (number, date and time);
- identifying images of dangerous characters;
- investigation of special vehicles.

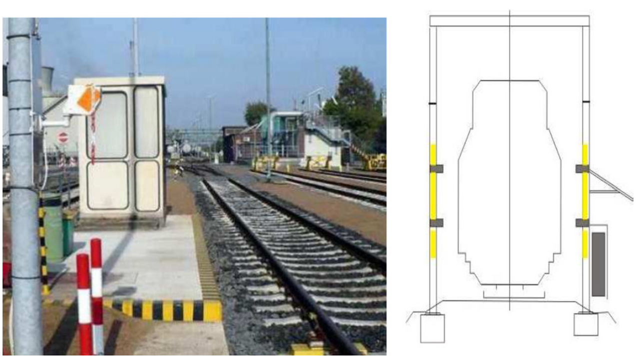

Figure 2 Optical Recognition System

4.2 Measurement of the load of each wheel

The standards and regulations existing and being in force up to now are presented in table 2. The sensor for measurement of wheel load and the device for testing and calibration are presented in figures 3 and 4.

Table 2 Regulations for a wheel loading of rolling stock.

Tolerances related to the forces in rail-wheel contact				
Standard	Force in rail-wheel contact for a single axle	Force in rail-wheel axle contact		
		Two-axle wagon	Wagon with 2 two axle boogies	General assessment
prENV 14033-1	$\lvert F_{Rl} - F_{Rr}\rvert$ ≤ 8 % от F_{RS}	$\lvert F_{RS1} - F_{RS2}\rvert$ ≤ 20 % от $m_g g$	$\lvert F_{DG}1 - F_{DG2}\rvert$ ≤ 50 % от $m_g g$	–
МСЖД 610	$\lvert F_R - (F_{RS}/2)\rvert$ ≤ 4 % от $F_{RS}/2$*[)]	For leading wheel axles, regardless of their number and location: $\lvert F_{RSi} - (\Sigma F_{RSE})z\rvert \leq 2$ % reduced sum, divided by z*[)]		$\lvert F_{Rr[l]i} - (m_g g)/n\rvert$ ≤ 4 % от $m_g g/n$*[)]
EN 50215	$\lvert F_R - (F_{RS}/2)\rvert$*[)]	For leading wheel axles, regardless of their number and location: $\lvert F_{RSi} - (\Sigma F_{RSE})z\rvert$		$\lvert F_{Rr[l]i} - (m_g g)/n\rvert$ ≤ 4 % от $m_g g/n$*
VDV 151	N/A			$\lvert F_{R,i} - (m_g g)/n\rvert$ ≤ 8 % of $m_g g/n$ for loaded and unloaded wagons

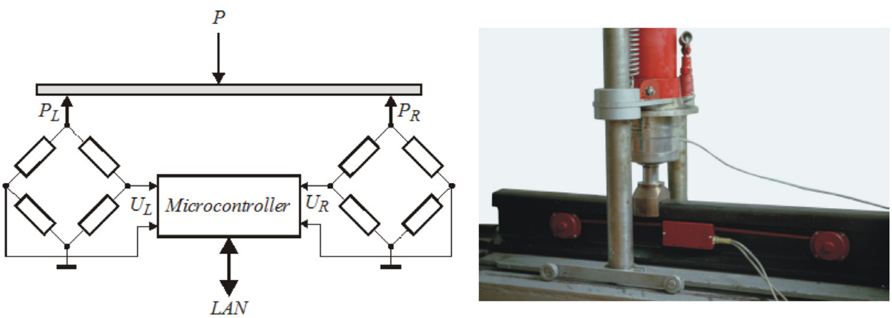

Figure 3 Sensor for measurement of wheel load and the device for testing and calibration

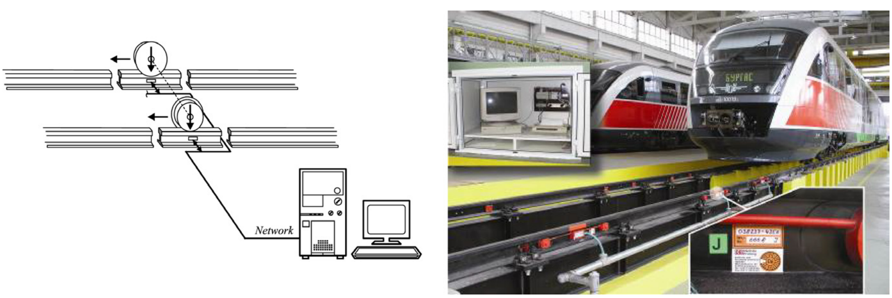

Figure 4 Principle of measurement and Device for measuring load of DMU and EMU Siemens

4.3 Detection of periodic deviations from circularity of the rolling surface

Figure 5 shows typical wheelflats / entrenchment (stratification) on the rolling surface of the wheel and a block diagram of the electronic measuring system.

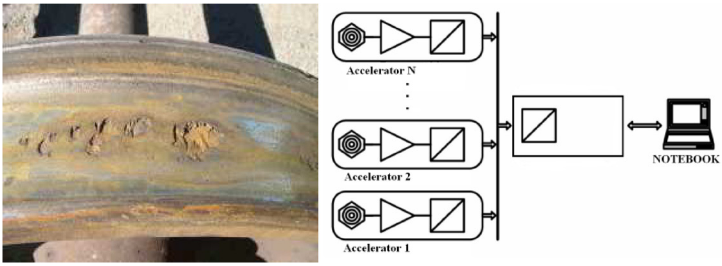

Figure 5 Wheelflats and Block scheme of the electronic system

The sensor unit is attached to the bottom ('foot') of the rail and measures the accelerations caused by the passing wheels with periodic deviations from circularity. The registered signals are processed by Wavelet–decomposition of the signal, replacing the classical decomposition in Fourier series.

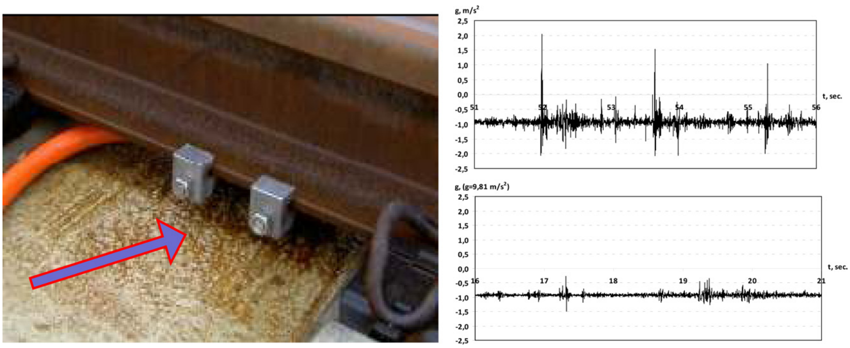

Figure 6 Sensor unit and signals with a faulty/properly operating wheel

4.4 Detection of temperature limit excess

Detection is achieved by thermal imaging cameras and processing and analyzing software. This subsystem monitors the excess of the limit values for temperatures of axle bearing assemblies, of the adhesion braking system friction surfaces, of the surfaces of tread profiles, etc.

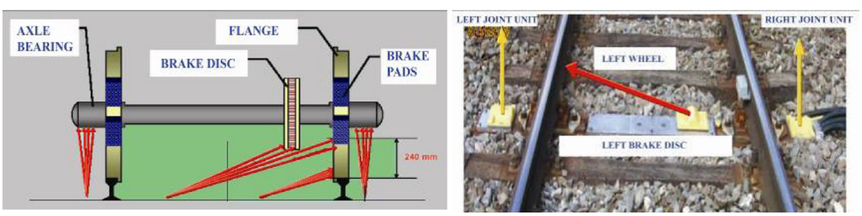

Figure 7 Principles of measurement and detection of overheating

4.5 Telecommunication connection

The information from each local point of the systems enters the central server from where control activities are generated and entire diagnostics information is accumulated analyzed and summarized [6].
The second system component allows monitoring on the cargo location and condition of, transport service pricing (without influence of the human factor) and on this basis, payment between the shipper and transport operator and between the operator and infrastructure provider.

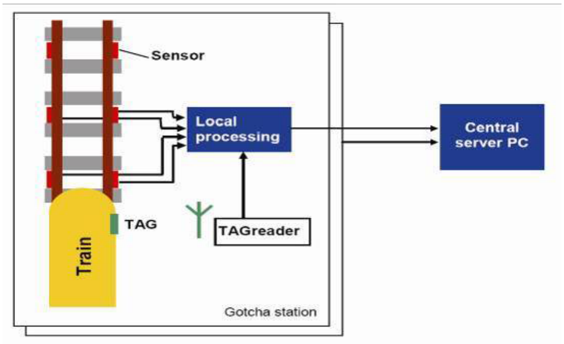

Figure 8 System for telecommunication connection with the central server

5 Conclusion

This paper has examined the main principles for building Check Point systems defining their main functions. It suggests alternative methods to control a set of parameters whose characteristics of changing are directly connected with the nature of 'vehicle–track' interaction, hence with traffic safety. A number of diagrams proved through experiments are presented and some peculiarities in the measurement philosophy defining the prerequisites for modelling the Bulgarian system of train control in movement are shown.

References

[1] European Railway Review, №3, p.80-86, 2005.

[2] Mallab S., A wavelet tour of signal processing, Academic Press, 1999.

[3] Lasca: Automatic monitoring of the running quality of railway vehicles, Railway Technical Review, 2/2007.

[4] MATTILD – Laserwaage fuer die Messung von Radlasten und Flachstellen am fahrenden Zug, Signal + Draht ,1+2/2003.

[5] www. argos-systems.eu.

[6] www.gotchamonitoringsystems.com.

[7] www.railbam.com.au.

[8] www.schenckprocess.com.