REPUBLIC OF SERBIA
CENTRE FOR INVESTIGATION OF ACCIDENTS IN TRANSPORT
SECTOR FOR INVESTIGATION OF ACCIDENTS IN RAILWAY TRANSPORT
AND INTERNATIONAL COOPERATION
Nemanjina 11, 11000 Belgrade

No.: ŽS - 02/17
33 No.: 340-8059/2017-16
Date: 05.01.2018.

FINAL REPORT ON ACCIDENT INVESTIGATION

Type of accident:	Derailment
Train No.:	62946
Place:	Belgrade, open railway line between Junction “B” and Junction “K”
Date:	August 16, 2017
Time:	15:30

This report presents the results of investigation of derailment of the train, No. 62946, occurred on August 16, 2017 at 15:30 h at the main arterial route: Belgrade Marshaling Yard "A" - Junction "B" - Junction "K" - Resnik, between junctions "B" and "K".

Director of the Center for Investigation of Accidents in Transport of the Republic of Serbia established the Working Group for the investigation of this accident by the Decision on the establishment of the working group 33 No. 02-02-8061 / 2017 of 23 August 2017.

In accordance with the Law on Investigation of Air, Rail and Water Traffic Accidents ("Official Gazette of the Republic of Serbia" No. 66/15) and the Directive 2004/49/EC of the European Parliament and of the Council, Sector for Investigations of Rail Transport Accidents and International Cooperation within the Center for Investigation of Accidents in Transport drafted and published the Final Report.

In this report, all sizes and measurements are expressed in accordance with the International System of Units (*SI*).

The meaning of abbreviations used in the text is explained in the Glossary.

CINS has been established in accordance with the Law on Investigation of Air, Rail and Water Traffic Accidents ("Official Gazette of the Republic of Serbia" No. 66/15). The founder is the Republic of Serbia and the holder of founding rights is the Government of the Republic of Serbia.

Sector for investigations of railway transport accidents and international cooperation carries out tasks within the competence of the Centre for investigation of accidents in transport in relation to rail traffic with the aim of possible improvement of safety on the railways by issuing safety recommendations. The investigation procedure in the field of railway traffic is conducted on the basis of the provisions of the Law on Investigation of Air, Rail and Water Traffic Accidents ("Official Gazette of the Republic of Serbia" No. 66/15).

CINS conducts investigations after serious accidents on the railway system with a view to possible improvement of railway safety and the prevention of new accidents caused by the same or similar causes. Serious accident in railway traffic means any train collision or derailment of trains, resulting in the death of at least one person or serious injuries to five or more persons or extensive damage to rolling stock, the infrastructure or the environment, and any other similar accident with an obvious impact on railway safety regulation or the management of safety.

In addition to serious accidents, CINS may also investigate other accidents and incidents that could lead to a serious accident, including the technical failure of structural subsystems or interoperability constituents.

CINS has the discretion to decide whether to open an investigation of other accidents and incidents.

CINS is independent in its work and performs independent accident investigations.

The aim of an investigation is to identify the causes and the possibility of improving safety on the railways and to prevent accidents by issuing safety recommendations.

Professional activities related to safety investigations are independent of judicial inquiry or any other parallel investigations which objective is to determine responsibility or the degree of guilt.

Glossary:

CINS ..... Centre for Investigation of Accidents in Transport
IŽS ..... Serbian Railways Infrastructure
ZJŽ ..... Community of Yugoslav Railways
a.d. ..... Join Stock Company
OJ ..... Organisational Unit
OC ..... Organisational Unit
DTŠ ..... Continuous welded rail
SS ..... Signalling System
APB ..... Automatic block
TK ..... Tele-command
TT ..... Telephone-telegraph
RDV ..... Ground-train radio (link)

Contents

1. SUMMARY

1.1. Short description of the accident

On August 16, 2017 at 15:30 on the main railway arterial route Belgrade Marshalling Yard “A” – Junction “B” – Junction „K“ - Resnik, between junctions “B“ and “K“, the train, No. 62946, derailed. The fifth wagon series *Regs-z* No. 31 72 3924 169-6 derailed, with one bogie (two axles), front bogie, viewed in the direction of the train’s movement. The derailed wagon was loaded with two containers with crushed stone. After derailment, the train passed another 1869 *m* after which it stopped.

1.2. The causes of the accident determined by the investigation

The direct cause of the accident is an unsatisfactory condition of the railway line on the section where the accident occurred, missing and weak rail fastening system and at least 7 rotten and cracked sleepers, combined with partial expansion of track over the exploitation maximum of +35 mm, which caused, under load, rail expansion and falling of the front left wheel of the fifth wagon into the track.

Another factor that facilitated the decline in the track is the fact that on the wagon that derailed, right wheel flange was on the allowed minimum (22 mm).

The bad condition of the railway line, on the section where the accident occurred, is the direct consequence of the maintenance that is below the technically acceptable minimum. The poor condition of the railway line is partly due to the applicable provisions of the Rulebooks regulating track maintenance.

The Guidelines on Unique Criteria for the Control of the Condition of Railway Lines on the network of JŽ (Yugoslavian Railways) (Guidelines 339) from 2001/2004 introduced in the case of an "unsatisfactory" condition of the track (error in the geometry of the track above the exploitation limits "C") as an alternative "speed reduction" which did not exist in the previous editions of the Manual (from 1989). The paragraph from the previous edition of the Manual 339 from 1989, stipulating that before reaching the limits of exploitation the measures for overdraft prevention must be taken, was also deleted. The current Rulebook on technical conditions and maintenance of the railway track superstructure, as well as Manual 339, does not establish explicit and clearly exploitable limits for the condition of sleepers and fastening devices where, due to safety risks, immediate corrective measures must be taken or the traffic track must be closed.

1.3. Main recommendations and information on subjects to which the report is submitted

Aiming to achieve the possible improvement of railway safety and to prevent occurrence of new accidents, CINS issued the following safety recommendations:

To the Directorate for Railways:

SR_01/17 Directorate for Railways shall define, as soon as possible, in the existing Rulebook on technical conditions for the maintenance of the railway superstructure ("Official Gazette of the Republic of Serbia, No. 39/2016 and 74/2016), limit conditions of the track superstructure and substructure elements that require immediate corrective actions or closing of the railway line until the unauthorized condition is eliminated.

SR_02/17 Directorate for Railways shall define in the existing Rulebook on technical conditions for the maintenance of the railway track superstructure ("Official Gazette of the Republic of Serbia, No. 39/2016 and 74/2016), criteria for the periods in which the intermediate overhauling on the railway track superstructure shall be performed.

"IŽS" a.d.:

SR_03/17 "IŽS" a.d shall amend the Guidelines on the Unique Criteria for the Control of the Condition of Railway Lines on the Network of Yugoslav Railways, Guidelines 339 (*Official Gazette of the ZJŽ (Community of Yugoslav Railways) no. 2/2001 and 4/2004*), which is, by the Decision of "IŽS" a.d, No. 4/2015-51-17 from 29 December 2015 still into force in "IŽS" a.d, in accordance with provisions from the Guidelines 339 from 1989, mentioned in point 3.3.5. For future measuring wagons, recommended parameters are in accordance with the Standards: SRPS EN 13848-1, SRPS EN 13848-2, SRPS EN 13848-6.

SR_04/17 "IŽS" a.d. shall prescribe in its internal documents that, if during the measurement using the measuring wagon, there is a disorder in the continuity of the measurement, the control of the superstructure parameters must necessarily be carried out at the site of the resulting disturbance and in the zone for which data are missing. The control aims to eliminate the cause of the measurement disorder and to check the condition of the superstructure, visual control and measurement of the superstructure parameters with alternative measuring devices. After removing the cause of the disorder, it is necessary to repeat the measurement with measuring wagon on that kilometre.

SR_05/17 "IŽS" a.d. shall, having in mind inadequate maintenance and condition of the tracks, sleepers and fastening devices, to assess the risk of train traffic on the main arterial route Belgrade marshalling yard "A" – Junction "B" – Junction "K" – Resnik, between junctions "B" and "K".

“Srbija Kargo” a.d.

SR_06/17 “Srbija Kargo” a.d. shall perform an exceptional training for the locomotive drivers and staff for the case of ejection of the traction protection, to check train condition by visual control from the locomotive (possible derailment), especially if after starting and removal of the protection, there are even the slightest twitches or uneven speeds.

To the Ministry of Construction, Transport and Infrastructure:

SR_07/17 Ministry of construction, transport and infrastructure, Sector for inspection control, Railway inspection group, shall perform an exceptional check of the condition of railway infrastructure on the main arterial route Belgrade marshalling yard “A” – Junction “B” – Junction “K“ – Resnik, and, if necessary, take measures within its jurisdiction.

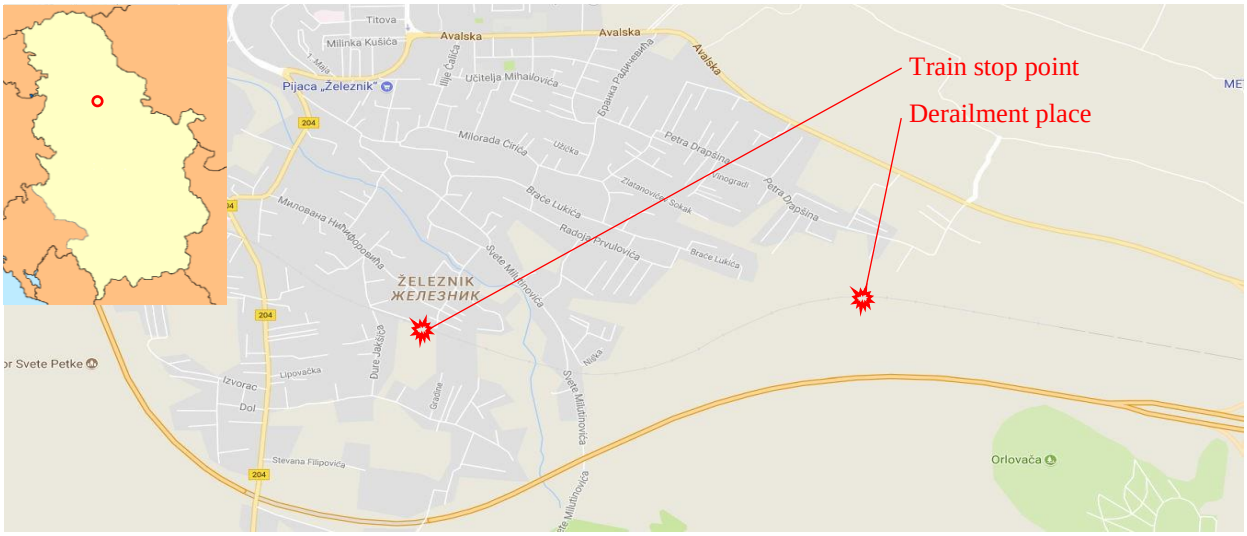
2. DIRECT FACTS ABOUT THE ACCIDENT

2.1. The occurrence

2.1.1. Date, time and place of the accident

The accident occurred on August 16, 2017 at 15:30 in the city of Belgrade, on the main arterial route Belgrade marshalling yard "A" – Junction "B" – Junction "K" – Resnik, between the junctions "B" and "K", at *km* 5+678, between the tunnel and the viaduct in the uninhabited part of the city settlement Železnik.

Perspective of the place of the accident is shown on the picture 2.1.1.1.



Picture 2.1.1.1: Map of the accident site area (*Google maps*)

2.1.2. Description of the accident and the accident site and work of rescue and emergency services

On August 16, 2017 at 15:30 in the city of Belgrade, on the main arterial route Belgrade marshalling yard "A" – Junction "B" – Junction "K" – Resnik, between the junctions "B" and "K", when the train, No. 62946, was moving from Junction "K" to Junction "B", one wagon derailed.

The derailment of the train No. 62946 occurred at *km* 5+678. Seen from the locomotive, the fifth wagon of series *Regs-z* derailed, No. 31 72 3924 169-6, with one bogie (two axles), the first bogie, viewed in the direction of the train's movement.

The derailed wagon was loaded with two containers with crushed stone.

After derailment, the train passed another 1869 *m* after which it stopped.

The train stopped so that the forehead of the train (the head of the locomotive 441-512) was found in *km* 3+714, while the wagon was found in *km* 3+809 (front buffers of the wagon).

The train was not decoupled. Derailed wagon was found in the zone of track on its wheels. There was no tilting or overturning of the wagon and no movement or dispersal of the cargo occurred.

For the elimination of the consequences of that accident there was no need to engage the rescue and emergency services.
The elimination of the consequences of the aforementioned accident was carried out by engaging a breakdown train owned by "IŽS″ a.d, which, with mechanization and staff, lifted the derailed wagon and removed it from the accident place. The breakdown train arrived from Belgrade marshalling yard.

2.1.3. Decision to launch the investigation, composition of the investigation team and conducting of the investigation

The main investigator for railway transport received the first notification on the accident on August 16, 2017 at 15:46 by phone from Assistant Director of the Sector for operations of "IŽS″ a.d. Based on the initial information received, the main investigator decided not to go to place of accident. Based on additional notification received the same day at 19.53 h, which was completed with information, that there was significant damage of track equipment and sleepers, the main investigator for railway transport decided to go to the place of accident. On the basis of the facts established by the initial investigation, CINS launched the investigation of the accident in accordance with the Law on Investigation of Air, Rail and Water Traffic Accidents ("Official Gazette of the Republic of Serbia" No. 66/15).
Composition of the working group for the accident investigation was determined by the Decision 33 No. 02-02-8061/2017 of the Director of CINS, from August 23, 2017 and according to articles 6 and 32 of the Law on Investigation of Air, Rail and Water Traffic Accidents ("Official Gazette of the Republic of Serbia" No. 66/15).

2.2. Accident background

2.2.1. Involved railway staff, contractors, other persons and witnesses

Driver of the train No. 62946, employed at railway undertaking “Srbija Kargo” a.d., section Pozarevac, Traction Organisational Unit – Lapovo, participated in the accident.

Staff of the railway infrastructure manager “IŽS” a.d. did not participate in the accident, as well as the contractors, other persons and witnesses.

2.2.2. Train involved in the accident and train composition

The train No. 62946 operated on the route Lapovo – Subotica. The train consisted of: locomotive 441-512, 15 wagons series *R* and 1 wagon series *S,* loaded with containers with crushed stone. The weight of the train is 1148 t gross and 752 t net, and the length of the train is 64 axles, i.e. 325 m.

When the accident occurred, the train No. 62946 was moving from Junction “K” to Junction “B” (from the end to the beginning of the line, in the direction of the descending mileage).

Table 2.2.2.1 gives the list of wagons that were part of the train No. 62946.

Table 2.2.2.1: List of wagons of the train 62946
(from the locomotive)

Ordinal wagon No.	Wagon series	Individual wagon No.
1	*Regs-z*	31 72 3924 529-1
2	*Regs-z*	80 72 3924 925-1
3	*Regs-z*	31 72 3924 921-0
4	*Regs-z*	31 72 3924 761-0
5	***Regs-z***	**31 72 3924 169-6**
6	*Regs-z*	80 72 3924 168-8
7	*Regs-z*	31 72 3924 680-2
8	*Regs-z*	82 72 3924 117-3
9	*Regs-z*	31 72 3924 483-1
10	*Regs-z*	31 72 3924 906-1
11	*Regs-z*	31 72 3924 224-9
12	*Sgnss-z*	31 72 4552 089-3
13	*Regs-z*	31 72 3924 565-5
14	*Regs-z*	80 72 3924 583-8
15	*Regs-z*	80 72 3924 212-4
16	*Regs-z*	31 72 3924 520-0

2.2.3. Infrastructure and control and signalling system

Main railway line Belgrade marshalling yard “A” – Junction “B” – Junction “K” – Resnik, was built in 1970. Permitted axle load is 22,5 *t*. The minimum radius curve is 350 m, and the maximum gradient is 14.6 ‰. The design speed of this line is 70 *km/h*. The actual maximum speed is 20 *km/h* (introduced since 2008).

The type of rails is S 49, produced in 1963, welded in DTŠ. On this part of the open rail line, the distance between two consecutive wooden sleepers is 60 cm, except on the section from *km* 3+100 to *km* 4+400 where concrete sleepers were embedded at the distance of 60 cm. Wooden sleepers on this section were produced in 1965.

Installed fastening track equipment is type “K”.

Railway track panel is laid on ballast made of limestone aggregate.

The line is equipped with automatic block, connected with tele-control installations in TK centre in Belgrade, where the railway traffic is regulated in block sections.

For the purpose of traffic regulation, spatial and protective signals have been installed on the part of the line between junctions "K" and "B" showing two-way signal signs. In order to protect the train, active track balises have been installed next to the signal.

Because of the poor state of the signalling system devices, caused by the frequent stealing of railway property by third parties (missing spatial signals, track balises), traffic on the mentioned part of the railway is taking place at a station distance.

2.2.4. Communication tools

Communication between personnel in charge of traffic regulation on the line is performed by phone via local TT connection. The line of communication includes all the official positions on the line and the TK dispatcher at the workplace TK "indirect route" in TK centre Belgrade. Communication on this line is recorded on the registrar device located in the TT section Makiš (Belgrade marshalling yard), so this type of communication is considered as evidence-based communication.

Due to the large number of disappearances of SS and TT equipment on this line, telephones do not exist in addition to spatial signals, so this type of communication between traction vehicle (locomotive) drivers and traffic control personnel is out of service. This line is equipped with RDV devices, that are working and that allows communication between the personnel in locomotive and the personnel who regulates the traffic (TK dispatcher).

Communication performed by the RDV is recorded on the register device situated in TT section Makiš (Belgrade marshalling yard), so this type of communication is considered as evidence-based communication.

For the communication with the personnel in locomotive, a landline is available in the TK centre in Belgrade, connected to register device that is situated in the TT section Makiš (Belgrade marshalling yard), so this type of communication is considered as evidence-based communication. The communication is performed in the way that personnel in the locomotive make a phone call from mobile phone to the landline phone in the dispatcher centre (TK dispatcher).

2.2.5. Works at or near the accident site

No works were performed near the accident site.

2.2.6. Activation of the emergency plan for railways and the sequence of events

All concerned parties were informed of this accident, according to the regulation. The Railway Infrastructure Manager "IŽS" a.d informed CINS, i.e., the Main investigator for railway traffic. The Railway Infrastructure Manager "IŽS" a.d and railway undertaking "Srbija Kargo" a.d. established a joint investigation commission that conducted an investigation of the accident in accordance with applicable regulations. Upon completion of the investigation, the Investigation Report U-370/17 was drafted.

2.2.7. Activation of the emergency plans of public rescue services, police and medical services and sequence of events

In this accident there was no need to activate emergency response plans for public rescue, police or medical services.

2.3. Deaths, injured and material damage

2.3.1. Passengers, third parties and railway staff, including contractors

There were no deaths or injured in this accident.

2.3.2. Goods, luggage and other assets

The train No. 62946, which participated in the accident transported crushed stone, in containers loaded on the wagons series R and S (1 wagon series *Sgnss-z* and 15 wagons series *Regs-z*). There was no loss or dispersal of the cargo in the accident. There was no material damage on the cargo.

2.3.3. Railway vehicles, infrastructure and environment

In the accident, railway vehicles and infrastructure objects were damaged. No material damage has been caused to the property of third parties.

Apart from the derailed wagon, the damage was also noted on the next wagon on buffing gear and parts of main break-pipe (angle cock).

The structure of the material damage is as follows:

On wagon *Regs-z* No. 31 72 3924 921-0:	42 076,66	RSD
On wagon *Regs-z* No. 31 72 3924 761-0:	56 961,66	RSD
On wagon *Regs-z* No. 31 72 3924 169-6:	1 878 213,00	RSD
On wagon *Regs-z* No. 80 72 3924 168-8:	9 524,66	RSD
Total material damage on wagons:	**1 986 775,98**	**RSD**
On the railway line and facilities:	3 083 000,00	RSD
Total damage on railway line and facilities:	**3 083 000,00**	**RSD**
On catenary - material:	105 075,00	RSD
On catenary – work of staff	38 328,00	RSD
Mechanisation (TMD 916-180):	103 456,00	RSD
Total damage on catenary:	**246 859,00**	**RSD**
Costs of lifting wagon No. 31 72 3924 169-6:	23 617,00	RSD
Costs of operation locomotives with a breakdown train:	99 666,67	RSD
Total costs of lifting the derailed wagon:	**123 283,67**	**RSD**
Total direct material damage:	**5 439 918,65**	**RSD**

The damage is stated in the official currency of the Republic of Serbia (Dinar - *RSD*).

According to the official middle exchange rate of the National Bank of Serbia on August 16, 2017, which is *1 EUR (Evro) = 119,4067 RSD (dinar*), the total material damage caused in the respective accident amounts to 45,557.90 *euro (EUR).*

The material damage in this report is stated based on advance invoices, estimates and/or documents submitted by „IŽS“ a. d. and “Srbija kargo“ a.d. that confirm the stated damage amounts.

2.3.4. External conditions – weather conditions and geographic characteristics

The place where the respective accident occurred is located in the area of the City of Belgrade, in an uninhabited part of the urban settlement Železnik.

The part of the railway line from the point of derailment to the point where the train stopped is located in the horizontal plane. The point of derailment (the point where the first trace of the wheel falling into the track was noticed) is located in the left curve, in the direction of the train movement, with a radius of *R*=900 *m*, on one part of the circular curve. The place where the train stopped is in a straight line.

The geographic coordinates of the place of accident are: 44º 43' 6,58" *N* and 20º 23' 38,7" *E*.

At the time of the accident, the sky was clear, it was sunny and without any wind. Vision was not impaired by anything. The air temperature was 38°*C*.

At the time of the on-site investigation, it was night. The sky was clear, there were no precipitations and no wind. Vision was not impaired by anything, except by usual night operating conditions. The air temperature was 30°*C*.

3. MINUTES OF THE INVESTIGATION AND INTERVIEWS

Information, facts and evidence related to the occurrence of the respective accident were collected and determined based on the following:

- On-site investigation conducted on site by the Main Investigator for Railway Transport from CINS;
- Additional visit to the site of accident and inspection of the derailed wagon performed by the CINS Main Investigator for Railway Transport with members of the working group, in the presence of representatives of „IŽS“ a.d. and „Srbija Kargo“ a. d.
- Materials delivered by the infrastructure manager „IŽS “a.d. and
- Materials delivered by the railway undertaking „Srbija Kargo“ a.d.

For the respective accident, the preliminary investigation on site and the investigation was done by a joint investigation committee of the infrastructure manager „IŽS“ a.d. and the railway undertaking „Srbija Kargo“ a. d.

The police and judicial investigation authorities did not perform an investigation on site.

3.1. Summary of the testimonies

With regards to railway staff that was involved in the respective accident from „Srbija Kargo“ a.d, a written statement from the train driver was obtained.

With regards to the staff that manages the traffic in that part of the main arterial railway line no statements were obtained and they were not interviewed for the reason that the above mentioned staff was not directly involved in the above mentioned accident. Reports on irregularities during operation were obtained from the staff managing the traffic.

3.1.1. Railway staff

The train driver gave the following statement: “During the ride on the part of the railway line between the junctions „K“ and „B“ I felt a slight jolt, but I did not hear any irregular or strange sound based on which I could have suspected that it came to a derailment. Immediately after that slight jolt I looked out through the side window on my left and did not notice anything, which is why I moved to the right side window and then I saw that the wagon had derailed. I immediately initiated the full application of the brake, but not quick application of the brake, in order to avoid the breaking loose of the train. During the ride from the station Jajinci to the point of derailment I had two stops, both times due to the reaction of the protection and shutting down of the main circuit breaker, which is why I had to go to the engine room to deactivate the protection. Immediately before the derailment of the wagon I was not handling the brake valve, meaning that the train was not braking at that point and was also not in the brake release process“.

3.1.2. Other witnesses

There were no witnesses to this accident.

3.2. Safety Management System

3.2.1. Organisational framework and manner in which orders are given and followed

In compliance with the Safety Management System Manual, „IŽS“ a.d. informed all stakeholders about the accident. The infrastructure manager „IŽS“ a.d. and the railway undertaking „Srbija Kargo“ a.d. formed, in accordance with the Decision on the Determination of House Presence No. 1/2017-4469 from July 26, 2017, a joint investigation committee that conducted an investigation of the respective accident. After the completion of the investigation, the Investigation Report U-370/17 was prepared.

3.2.2. Requirements that must be fulfilled by railway staff and the way they are applied

With the Safety Management System (SMS) Manual, „Srbija Kargo“ a.d. secured competence management, meaning that all employees that are directly involved in rail traffic operation must be trained and competent and that also workloads must be planned. In relation to the respective accident, in which a train driver employed at „Srbija Kargo“ a.d was involved, all activities were implemented in compliance with the applicable regulations.

3.2.3. Procedures for internal reviews and controls and their results

„Srbija Kargo“ a.d. has, as a railway undertaking, an established Safety Management System Manual. The general purpose of the Safety Management System (SMS) is to secure that „Srbija Kargo“ a.d. can achieve its business goals in a safe way.

Apart from safety, the adoption of structural methods enables the identification of danger and continuous risk management in relation to the activities of the organisations themselves with the goal to prevent accidents.

The Safety Management System (SMS) of „Srbija Kargo“ a.d. contains a description of processes and procedures related to safety. The business activity of „Srbija Kargo“ a.d. includes the regular maintenance of rolling stock (freight wagons and locomotives) and of vital components. In relation to the respective accident, the maintenance of freight wagons was performed in accordance with the applicable regulations.

„IŽS“ a.d., as infrastructure manager, has an established Safety Management System Manual. The Safety Management System includes the organisation and all procedures and mechanisms established in „IŽS“ a.d. to ensure safe railway traffic operations.

Risk control related to the maintenance of the railway infrastructure (subsystems infrastructure, energy, control, command and signalling - trackside) and of railway vehicles that are used for maintenance by „IŽS“ a.d. is based on the implementation of defined regular and extraordinary maintenance activities and on their monitoring and control. Regular and extraordinary maintenance includes continuous supervision, controls, inspections, repairs and rectifications.

Requirements, standards and procedures for maintenance in „IŽS“ a.d. were determined based on the legislation, general and special documents of the company, guidelines of manufacturers and standards.

In relation to the respective accident, the regular and extraordinary maintenance of the superstructure of the railway line was not performed in accordance with the applicable regulations.

3.3. Relevant international and national regulations

3.3.1. Railway Law (Official Gazette of the Republic of Serbia no. 45/2013 and 91/2015)

Article 14, paragraph 1:

The infrastructure manager shall ensure permanent, continuous and quality maintenance and protection of the railway infrastructure, undisturbed use of railway infrastructure facilities and other work equipment for rail traffic, as well as the organisation and management of safe and undisturbed rail traffic.

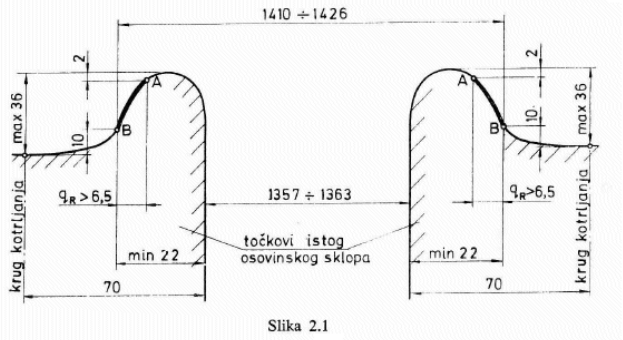
3.3.2. 250 Guidelines for the Operation and Maintenance of Bogies of type *Y 25* and type *Y 27* adopted on the Yugoslav Railways (Official Gazette of the Community of Yugoslav Railways (ZJŽ) no. 2/87)

Note: With the Decision of „IŽS“ a.d. no 4/2015-51-17 dated December 29, 2015 on the Adoption of Regulations Issued by the Community of Yugoslav Railways (ZJŽ) as its Internal Acts pursuant to Article 152 of the Railway Safety and Interoperability Law, and the Decision on the Adoption of Regulations within the Safety Management System of „Srbija Kargo“ a.d No. 4/2015-29-13 dated on December 01, 2015, these Guidelines have been taken over and are still applied in „IŽS“ a.d. and in „Srbija Kargo“ a.d.

II. part of the Guidelines, Item 1.1.1. Wheelset (extract):

- the distance between wheels of the same wheelset and dimensions of flanges must match the dimensions given in the figure;

— razmak točkova istog osovinskog sklopa i dimenzija venaca moraju odgovarati merama prema slici:



Slika 2.1

— širina oboda točkova treba da je između 133 mm (kod kola BR 130 mm do 31. 12. 1982) i 140 mm uključujući i bradavičasta mesta;

— točkovi ne smeju pokazivati tragove pomicanja na osovini;

Tockovi istog osovinskog sklopa = wheels of the same wheelset
Krug kotrljanja = rotation circle

- the width of the wheel rims must be between 133 mm (in wagons BR 130 mm until 31.12.1982) and 140 mm, including the jutting points;
- the wheels must not show traces of movement on the axle;

3.3.3. Guidelines for the Maintenance of Freight Wagons of „Srbija Kargo“ a.d. No. 4/2017-361-139 as from July 14, 2017

Article 6, paragraph 3 (extract):

„The maximum permitted period between two regular repairs (overhauls) of freight wagons intended for international transport is 6 years, with a possible extension of three months. ...“

Annex 1 (extract):

Deadlines for regular repairs and control inspections for freight wagons

Рокови редоних оправака и контролних прегледа теретних кол

Max. дозвољена брзина потпуно натоварених кола	Тип кола	Серија кола	Рокови			
			RIV кола		NE RIV кола	
			редовна оправка (године)	контролн и преглед (месеци)	редовна оправка (године)	контролн и преглед (месеци)
100 km/h	Затворена и плато-кола	G, H, K, R, S	6	36	5	30

Maximum permitted speed of fully loaded wagons	Wagon type	Wagon series	Deadlines			
			RIV wagons		Not RIV wagons	
			Regular repair (years)	Control inspection (months)	Regular repair (years)	Control inspection (months)
100 *km/h*	Closed and flat wagon	G, H, K, R, S	6	36	5	30

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3.3.4. 241 Rulebook on the Maintenance of Rolling Stock (Official Gazette of the Community of Yugoslav Railways (ZJŽ) no. 2/84, 2/88, 7/88 and 13/88), does not apply as from December 08, 2015

Important note: for the derailed wagon that was involved in the respective accident, in the sense of maintenance and deadlines for regular repairs (the regular repair was performed on September 09, 2011), this Rulebook was applicable.

Annex 14 (extract):

CYCLES AND DEADLINES FOR REGULAR REPAIRS AND CONTROL INSPECTIONS FOR FREIGHT WAGONS – Annex 14

CIKLUSI I ROKOVI REDOVNIH OPRAVAKA I KONTROLNIH PREGLEDA TERETNIH KOLA

VRSTA KOLA			Serija kola	Ciklus opravke	ROK	
Tip leža	Dozvoljena brzina	Tip kola			redovne opravke	kontrolnog pregleda
Kotrljajni	100 km/h	Plato-kola	390, 391	VO–VO	60	–

Prilog 14

WAGON TYPE			Wagon series	Repair cycle	DEADLINE	
Type of bearing	Maximum speed	Wagon type			Regular repairs	Control inspection
Roller bearing	100 *km/h*	Flat wagon	390, 391	VO-VO	60	-

. . . . . .

3.3.5. Guidelines on Unique Criteria for the Control of the Condition of Railway Lines on the Network of the Yugoslav Railways, Guidelines 339 (Official Gazette of the Community of Yugoslav Railways No. 2/2001 and 4/2004)

Note: With the Decision of „IŽS“ a.d. No. 4/2015-51-17 from December 29, 2015 on the Adoption of Regulations Issued by the Community of Yugoslav Railways (ZJŽ) as its internal acts pursuant to Article 152 of the Railway Safety and Interoperability Law, these Guidelines have been taken over and are still applied in the „IŽS“ a.d.

Item 2, sub-item 6 (extract):

“ ...Minutes should contain the following basic elements: what is inspected and with what it is inspected, the date when the railway lines were recorded and the mileage of the recorded railway line or section, **disk with the graphic and analytic presentation of the technical condition of the recorded railway line or part of the railway line,** ...“

. . . . . .

Important note: The part of the text in bold replaced, with the amendments from 2004, the following text from the version of the Guidelines 339 from 2001:

„Minutes should contain the following basic elements: what is inspected and with what it is inspected, the date when the railway line was recorded and the mileage of the recorded railway line or section, **registered points that immediately endanger rail traffic safety, ...“**

In item 7 of the applicable version of the Guidelines 339, the text under no. 5. from the version of the Guidelines from 1989 (which is not applicable) is missing in Article 7.

Article 7, no. 5. of the Guidelines 339 from 1989:

„Registered defects that immediately endanger transport safety must be removed on the same day when the track recording wagon has passed. If that is not possible, adequate safety measures must be taken.“

. . . . . .

Item 9, subitem 3) (extract) of the applicable Guidelines 339 from 2001/2004:

- „B – defects due to which works must be planned to remove them“
- „C – defects with values above operating limits **that require urgent removal or speed reduction**“

. . . . . .

Important note: The wording of the part of the text in bold was as follows in the Guidelines 339 from 1989:

„ that must be removed immediately because they affect traffic safety.“

. . . . . .

Item 9. (extract) of the applicable Guidelines 339 from 2001/2004:

„The condition of the track is assessed based on the total length of defects in groups „B“ and „C“ over a length of one kilometre“

The condition of one kilometre of the railway line is:

- „Satisfactory, with up to 250 *m* of defects in group B and up to 25 *m* of defects in group C, or ≤250/25 (B/C)“.
- „Unsatisfactory, with over 250m of defects in group B and more than 25m of defects in group C, or >250/25 (B/C)“.

. . . . . .

Important note: Apart from that, in the Guidelines 339 as amended in 2001, the last paragraph from item 9 was deleted, the wording of which was as follows in Article 9 of the Guidelines 339 from 1989 (extract):

“Immediately after the recording with the track recording wagon, works must be done on all kilometres where the length of defects amounts to more than 200/20, whereby minutes must be taken to determine how this situation occurred. Once the reasons for the occurrence of defects have been determined as well as the location of the defects, a plan shall be immediately prepared to improve the condition of the inspected kilometre....“

. . . . . .

3.3.6. Rulebook on the Technical Conditions and Maintenance of the Superstructure of Railway Lines no 340-201-2/2016 (Official Gazette of the Republic of Serbia No. 39/16 and 74/16)

Article 81, paragraph 1 and 2:

“The technical condition of all types of track fittings and of fittings as a whole must be such to secure a firm connection between rails, between rail and sleeper and to prevent the loosening of fittings and joints.

Damaged, worn or missing elements of track fittings must be replaced or added, loosened fittings must be tightened, and individual elements should be greased as needed.“

Article 68, paragraph 1:

„Intermediate overhauls on the superstructure are done periodically with individual replacement and supplement of track material and with the rectification of the track in terms of width, height and direction, so that all elements and the track as a whole are brought into operational condition.“

3.4. Functioning of the rolling stock and of technical installations

3.4.1. Control, command and signalling

On the part of the railway line between the junctions „B“ and „K“, the control, command and signalling devices are not operational. The transport on the mentioned part of the railway line is performed within station distance.

3.4.2. Infrastructure

According to the information about the inspections of the railway line in the period before the occurrence of the respective accident, done by the unit for railway maintenance of „IŽS“ a.d, the Belgrade Railway Maintenance Section, facts were determined that are presented in the text below.

The wear of the rails in the exterior and interior arcs is within limits of operational values.

The rails were welded into a continuous welded rail, which is interrupted due to broken isolated compositions and cracks on rails and installed metal bonds. In order to bring the current condition of the continuous welded rail back into the designed condition, it is necessary to do 38 AT welds.

The fastening track fittings of the type „K“ are worn.

The track screen is in a very muddy ballast of limestone origin.

The geometry of the track is very bad and is manifested in a disrupted level line in the longitudinal and cross-sectional direction. The warping is over the allowed limit, which affects traffic safety.

Due to the bad condition of elements of the superstructure and substructure of the railway line, since 2008 a speed limitation to *V=20 km/h* has been introduced on the part of the railway line from *km* 3+000 to *km* 10+419.

General overhaul has been done in 1995 on the part of the railway line from *km* 6+270 to *km* 7+800.

On the part of the railway line from *km* 2+771 to *km* 3+170, an overhaul of the track was done in 1998 by installing wooden sleepers that were manufactured in 1995.

In the tunnel „Železnik“, sleepers and ballast were replaced in 1998 from *km* 6+200 to *km* 7+850.

On the part of the railway line from *km* 3+170 to *km* 4+170, the superstructure of the railway line was reconstructed in 2013 by completely replacing the track screen including ballast replacement.

Based on the inspection of the railway line done by employees of the Belgrade Railway Maintenance Section in 2016, it was concluded that on the part of the railway line from *km* 4+100 to *km* 8+800 it is necessary to reconstruct the superstructure and substructure of the line due to a large number of rotten sleepers and bad condition of the terrain.

Due to a large percentage of rottenness of wooden track sleepers (the percentage of rottenness is 34%, whereby several groups exist with 15 to 20 pieces of successive rotten sleepers), mechanical regulation of the track is not possible.

In the investigation done on site after the occurrence of the respective accident the condition was determined as presented below.

On the railway line, at *km* 5+678, first traces of train derailment were noticed in the track in the form of metal chips and damaged standing screws on the track fittings next to the right rail of the railway line (left rail, when looking in the direction of the train movement). In that place on the left rail of the railway line and next to the left rail of the railway line no traces were noticed. At *km* 5+678 (at the fourth sleeper after the catenary mast no. 98 in the direction of the train movement), in the left curve in the direction of motion, with a radius of *R*=900 *m*, the first trace of the left wheel falling into the track was noticed. Right after that, twisted metal chips stemming from the wheel were also found.

At *km* 5+608, on the left rail of the railway line (right rail, when looking in the direction of the train movement) traces of the wheel flange climbing onto the rail, of the wheel flange moving on the head of the rail and of the wheel flange coming down from the rail onto the external side of the track were noticed (traces in the form of scratches on the head of the rail and damage to standing screws on the track fittings from the external side of the track).

Between *km* 5+608 and *km* 5+678, in the track, next to the right rail of the railway line, traces of movement of the derailed wheel were noticed in the form of damage to the standing screws on the track fittings, while on the left rail of the railway line and next to the left rail no traces were noticed.

On the part of the railway line from *km* 5+608 to the place where the train stopped, in the direction of the decreasing mileage marks of the railway line, traces of movement of the axles of rail wagons on sleepers and stone ballast were noticed, as well as damage done to sleepers, track fittings and facilities next to the railway line (concrete structure and fence of the railway bridge) and on catenary masts. On SS and TT devices no damage was noticed.

The train stopped in such a way that the head of the train (head of the train's locomotive 441-512) was found at *km* 3+714, whereas the derailed wagon was found at *km* 3+809 (front buffers of the wagon).

During the investigation, the track width and the superelevation of the rails were measured on site in the zone where the first traces of the derailment were noticed.

The measurement was done on every sleeper, with a measuring device for tracks of the *Robel* brand, owned by „IŽS“ a.d. Measured values are shown in table 3.4.2.1.

The sleepers in the table are marked in the following way: the „0“ sleeper is the sleeper that is located at *km* 5+678 (the fourth sleeper after the catenary mast No. 98 in the direction of the train movement), where the first traces of the derailment were noticed (where the left wheel fell into the track). Sleepers marked with the prefix „-“ are sleepers located before the point of derailment, and sleepers marked with the prefix „+“ are located after the point of derailment, when looking in the direction of the train movement. The distance between two adjacent sleepers is 0.60 *m*.

Table 3.4.2.1: Track width and rail superelevation

sleeper	width (mm)	superelevation (mm)	note	sleeper	width (mm)	superelevation (mm)	note
-20	+14	160		-5	+15	133	
-19	+13	161		-4	+16	132	
-18	+13	161		-3	+19	132	
-17	+13	162		-2	+26,5	126	
-16	+12	163		-1	+28	135	
-15	+13	163		**0**	**+35**	**139**	***km* 5+678**
-14	+15	162		1	+42	144	
-13	+17	161		2	> 40	-	Not measurable
-12	+19	159		3	> 40	-	Not measurable
-11	+20	155		4	> 40	-	Not measurable
-10	+21	152		5	> 40	-	Not measurable
-9	+20	149		6	> 40	-	Not measurable
-8	+19	144		7	> 40	-	Not measurable
-7	+16	139		8	> 40	-	Not measurable
-6	+15	136					Not measurable

3.4.3. Means of communication

This railway line is equipped with ground-train radio devices that are operational and with the help of which communication between the staff of the traction vehicle and the staff that manages the traffic (TK dispatcher) is enabled. Talks conducted with ground-train radio devices are registered (recorded) on a registering phonic device that is located in the TT section Makiš (Belgrade marshalling yard), so that this form of communication represents proof of communication.

For the communication with the staff of the traction vehicle, the TK centre Belgrade has also an operational fixed telephone line connected to the registering phonic device that is located in the TT section Makiš (Belgrade marshalling yard), so that this form of communication represents proof of communication. Communication is done by calling from a mobile telephony network (staff of the traction vehicle) to the fixed telephone line (TK dispatcher).

3.4.4. Rolling stock

The derailed wagon was found at *km* 3+809 (front buffers of the wagon). The front bogie of the mentioned wagon derailed to the right side (when looking in the direction of the train movement), whereas the rear bogie was found on the rails. The wheels of the derailed bogie were found at a distance of 60 *cm* from the rails. On the derailed wagon damage was noticed on the derailed bogie and on the body of the wagon. The appearance of the front part of the derailed wagon is shown in figures 3.4.4.1 and 3.4.4.2.

The train did not break loose. The derailed wagon of the series *Regs-z* No. 31 72 3924 169-6 was found as fifth in the train composition, when looking from the train locomotive, in the zone of the track, on its wheels. The wagon did not tip over or capsize and the freight did not move or disperse.

Figure 3.4.4.1: Appearance of a part of the derailed bogie

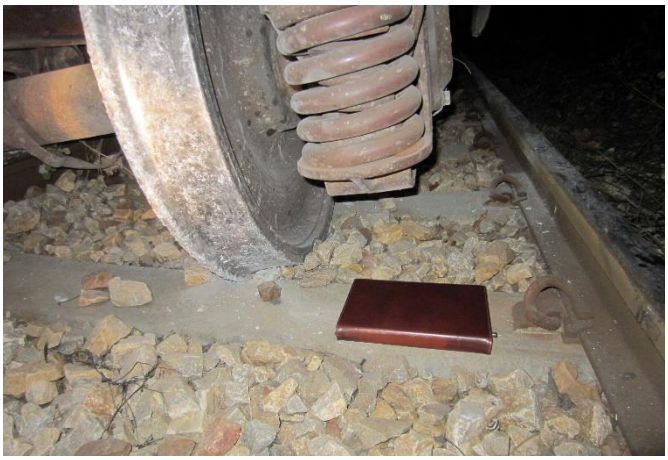

Figure 3.4.4.2: Appearance of a part of the derailed bogie

On the train locomotive 441-512 speed meters of the manufacturer *Hasler* are installed. In the driver's cab „A“ a registering speed meter of the type *RT12i* is installed, with the serial No. *D06.156*, and in the driver's cab „B“ a speed-indicating meter with a pointer of the type *A28i* is installed, with the serial No. *E02.109.*

The registering tape was removed on site from the registering speed meter from the train locomotive 441-512, and the registered data were processed.

By processing the registered data it was determined that the train No. 62946, after departing from the Junction „K“ moved for 3550 *m* without stopping at a speed of up to 19 *km/h*, after which it stopped. After standing still for 1 minute, the train continued to move, went a distance of 1700 *m* at a speed of up to 20 *km/h*, after which it stopped.

Based on the data from the speed-measuring tape it was determined that the maximum permitted speed on this part of the railway line (20 *km/h*) was not exceeded.

From this stopping to the removal of the speed-measuring tape, no train movements were registered. The speed-measuring tape was removed when the head of the locomotive 441-512 (the part of the locomotive at the driver's cab „A“) was located at *km* 3+714.

3.5. Traffic operation and management

3.5.1. Actions taken by the staff that manages traffic regulation, control and signaling

The train No. 62946 moved on the route from Junction „K“ – Junction „B“ within the station's distance. Before the dispatch of the train No. 62946, clearance was obtained regularly for the train in accordance with the applicable regulations and in that sense there were no disturbances.

The train crew received in the accompanying documents their orders and notifications about the operation of the train on that part of the railway line.

3.5.2. Exchange of voice messages in relation to the accident

Immediately before and during the respective accident, there was no communication between the train driver and the staff that manages traffic operation.

Communication between the staff managing the traffic operation and the train driver took place after the respective accident in order to provide information that an accident occurred. The train driver of the train No. 62946 notified the TK dispatcher at TK "indirect route" in the TK Centre in Belgrade.

3.5.3. Measures taken to protect and secure the place of accident

After the accident happened, the main arterial route Belgrade Marshalling Yard „A“ - Junction „B“ – Junction „K“ - Resnik was closed for traffic between the junctions „B“ and „K“.

Due to the fact that after the respective accident the train No. 62946 stopped in the part of the railway line that is lying in the horizontal plane, that one wagon derailed from the train composition but the train did not break loose (the overhead line did not break) and power in carenary didn’t turn off, the train driver did not take any special measures to secure the train from self-movement (placing of manual brake blocks or activation of stop brakes).

As the train was not transporting any goods hazardous for the environment or human lives, no special measures were taken to secure the place of accident.

3.6. Interface between man, machine and organisation

3.6.1. Working hours of the staff involved

For the railway staff, information was submitted based on which it is clear that the train driver of the train No. 62946 had the legally stipulated rest before going to work and that he did not spend more time at work than the maximum working hours defined by law.

3.6.2. Health-related and personal circumstances that have effect on the accident, including the presence of physical or mental stress

For the railway staff, information was submitted from which it can be seen that the train driver of the train No. 62946 was professionally qualified and fit to perform his tasks and that he possesses the licence to operate the traction vehicle.

With the inspection on site and after an interview it was determined that the train driver was not injured and did not show any signs of mental stress.

3.6.3. Design of the equipment that has influence on the interface between user and machine

The part of the main arterial route Belgrade Marshalling Yard „A“ – Junction „B“ – Junction „K“ - Resnik between Junction „B“ and Junction „K“ was designed for speeds up to 70 *km/h* and an axle load of 22.5 *t*.

According to the designed condition, there are automatic block devices that are connected to TK devices at the TK Centre Belgrade, so that the traffic in that part of the railway line is managed centrally from the TK dispatcher in the work place TK "Indirect route" in the TK Centre Belgrade.

Due to the bad condition of the railway line, the designed speed of 70 *km/h* was reduced even back in 2008 to 20 *km/h*.

Due to frequent theft of parts of the railway traffic management equipment by third parties, the automatic block devices in that part of the railway line are not operational, so that, in accordance with traffic regulations, traffic is managed within the station's distance.

The locomotive is operated by the train driver with commands from the driver's cab, which were designed when the locomotive was manufactured. In locomotive 441-512 all deficiencies were removed that were noticed on operation systems and devices, so that no remarks or deficiencies were registered.

In the designed technical and operational characteristics of the wagon of the series *Regs-z* and during wagon maintenance no remarks or deficiencies were registered.

3.7. Previous accidents of similar nature

Based on the data obtained from „IŽS" a.d, for the period from January 01, 2013 to August 16, 2017, on the main arterial route Belgrade Marshalling Yard „A" – Junction „B" – Junction „K" - Resnik, between Junction „B" and Junction „K" a total of 5 accidents, train derailments, occurred. An overview of these accidents is presented in Table no. 3.7.1.

In all accidents that occurred there were no injured persons and no fatalities.

Table 3.7.1: Overview of accidents occurred in the period from 01/01/2013 to 16/08/2017

Ordinal No.	date	time	Short description	Cause
1	09.08.2013	16:15	At *km* 4+870 derailment of the train No. 46875 (derailed locomotive:461-002 with 1 axle)	**Bad track condition**
2	16.08.2013	18:48	At *km* 4+870 derailment of the train No. 40767 (derailed wagon No. 33 88 4961 495-7 with one bogie)	**Bad track condition**
3	22.08.2013	02:20	At *km* 5+400 derailment of the train No. 52941 (derailed locomotive:461-138 with 1 bogie)	**Bad track condition**
4	27.08.2013	05:30	At *km* 4+830 derailment of the train No. 40773 (derailed wagon No. 37 80 4954 057-8 with one bogie)	**Bad track condition**
5	18.08.2015	02:05	At *km* 4+750 derailment of the train No. 72004 with 7 wagons owned by RŽD (derailed wagons are wagon No. 0000 234, No. 0000 440, No. 0000 432, No. 0000 428, No. 0000 435 and No. 0000 224 with all axles and wagon No. 0000 437 with 1 axle)	**Bad track condition**

4. ANALYSIS AND CONCLUSIONS

4.1. Final review of the course of events and adoption of conclusions about the event based on facts determined during the investigation and interviews

On August 16, 2017 at 15:30 h on the main arterial route Belgrade Marshalling Yard „A“ – Junction „B“ – Junction „K“ - Resnik, between Junction „B“ and Junction „K“ the train No. 62946 derailed. The train was composed of the locomotive 441-512 and 16 wagons (64 axles) loaded with containers with crushed stone, with a total gross mass of 1148 *t*, thereof 752 *t* net (railway consignment note No. 62946 from August 16, 2017). When looking from the locomotive, the fifth wagon of the series *Regs-z* No. 31 72 3924 169-6 derailed with both wheelsets of the front bogie in the direction of the train movement (corresponding to axles 4 and 3 on the wagon). The derailed wagon was loaded with two containers with crushed stone with a gross mass of 63.55 *t* (weight specification, no. 32202/2117 from August 17, 2017).

Figure 4.1.1: Point where the wheel fell into the track

The inspection on site and the submitted information no. 1/2017-4822 from August 18, 2017 from „IŽS“ a.d showed that the train was moving from Junction „K“ to Junction „B“. At *km* 5+678 (at the 4th sleeper after the catenary mast No. 98 in the direction of the train movement), in the left curve in the direction of the train movement, *R*=900 *m*, the first trace of the left wheel falling into the track was noticed, fig. 4.1.1. Immediately after that also twisted metal chips stemming from the wheel were found. The sleeper where the first trace on the rail and on fasteners was noticed was marked as sleeper 0 for the needs of this report (fig. 4.1.2 and 4.1.3). The next two sleepers in the direction of the train movement were marked as sleeper 1 (fig. 4.1.4) and sleeper 2 (fig. 4.1.5), and sleepers before sleeper 0 as sleepers -1, -2 etc, looking in the direction of the train movement. The sides of the sleepers were marked as L – left and D – right.

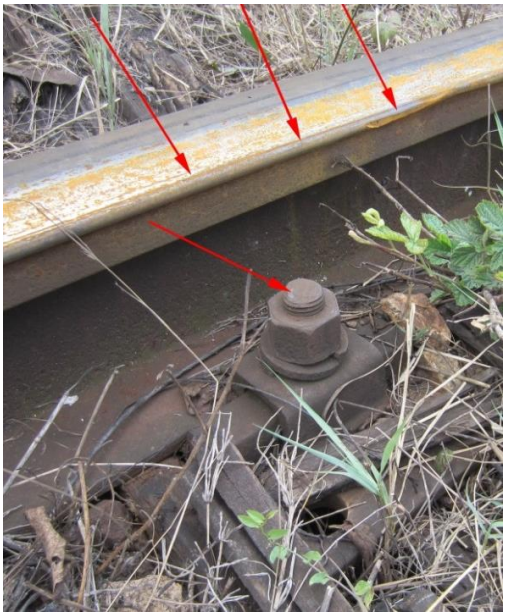

Figure 4.1.2: Traces at sleeper 0L

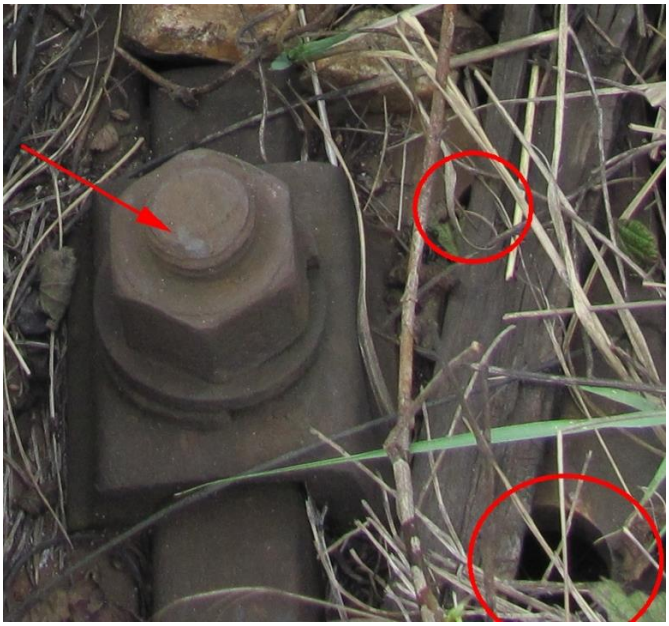

Figure 4.1.3: Condition of the sleeper and of the fasteners at sleeper 0L

Figure 4.1.4: traces at sleeper 1L

Figure 4.1.5: Traces at sleeper 2L

The left wheel continued to move within the track next to the left rail, and the right wheel continued to move on the rail. Such movement continued for the next 25 *m* causing the widening of the track from 50 to 60 *mm*, when the fallen left wheel hit the welded rail composition (traces in figure 4.1.6, recorded 12 days after the accident), which caused the right wheel to climb onto the rail and to move on the rail with the tip of the wheel flange (traces in fig. 4.1.7).

From that point the measured width of the track is within the permissible tolerance, therefore less than 35 *mm* because, consequently, the side force diminished. The right wheel was twisting, which is shown by the traces of movement of the wheel flange on the head of the rail and after 8 *m* (at sleeper 58 from the catenary mast No. 98) it returned onto the track, that is, it continued moving on the running surface. During that time the left wheel moved within the track next to the left rail. From the place where the right wheel went back into normal position and further on, it has been determined that the track widened by 60 *mm* as a consequence of the increase in the side force due to the fallen wheel.

Figure 4.1.6: Traces on the left rail in the direction of motion, at 25 *m* after the point where the left wheel fell in

Figure 4.1.7: Traces of the first derailment of the right wheel at 25 *m* after the point where the left wheel fell into the track

The second climbing of the right wheel onto the rail and the movement of the wheel flange on the rail head was noticed on the 119th sleeper after the catenary mast No. 98, that is, 70 *m* after the point where the left wheel fell into the track (*km* 5+608). The point is located 1.2 *m* after a similar welded composition on the left rail on which there is also a trace of impact of the left wheel (figure 4.1.8), so that the side force induced and increased in this way probably caused the wheel to climb onto the rail and after less than 2 *m*, that is, between the 121st and the 122nd sleeper, the right wheel to descend outside of the track. At that moment, the second axle in the direction of motion continued moving on the rail. Several tens of meters after that, due to the ejection of the protection, the train stopped (explained in more detail in item 4.2.1) and after that it started moving again.

Figure 4.1.8: Trace of the second impact of the left fallen wheel on the welded joint

Further on, the derailed first axle caused, while moving, damage to sleepers and the track.

Due to the damage to the track and the lack of clear traces, it is difficult to determine when the second axle of the front bogie derailed, but as in one moment the side deviation to the side of the first wheelset from the track axis increased to more than 0.5 *m*, the bumping angle of the second wheelset onto the rail was large and in these conditions it also derailed to the right side in the direction of the train movement.

The derailed wagon hit later on, on the right side when looking in the direction of the train movement, into the beginning of the concrete structure of the bridge, after which it continued moving and damaged the fence of the bridge (figures 4.1.9 and 4.1.10). The train driver felt in that period a jolt and looked first through the left and then through the right window and saw the derailment, after which he initiated full application of the brake (Minutes from the interview with the train driver from August 23, 2017 for the case No. 38/2017-833).

After the first trace of the wheel falling into the track, the train moved for another 1869 *m*, after which it stopped, so that the head of the train (head of the train locomotive) stopped at *km* 3+714.

Figure 4.1.9: Point where the wagon hit the beginning of the concrete structure of the bridge

Figure 4.1.10: Damage to the fence of the bridge

4.2. Analysis of facts determined during the investigation

4.2.1. Analysis based on records of the speed meter tape and statement of the train driver

According to the statement of the train driver (Minutes from the interview for the case No. 38/2017-883 from august 23, 2017), after departing from the station Jajinci to the point of derailment (note: obviously here the final stopping is meant after the wagon hit the fence of the bridge), the train had two stops due to the reaction of the protection and the ejection of the main switch.

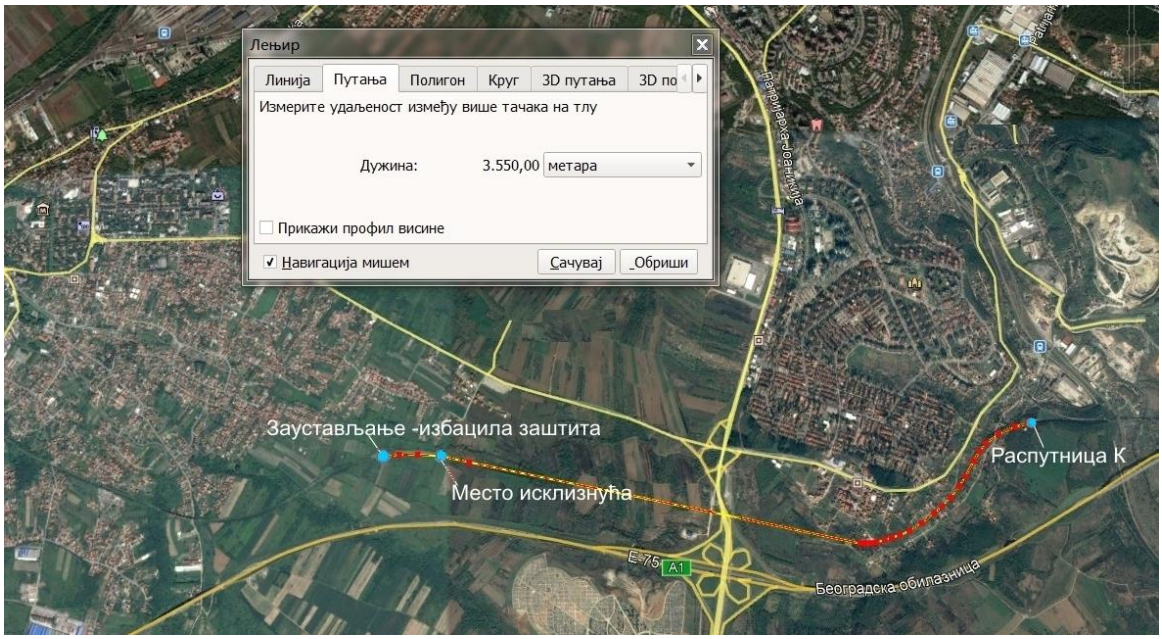

Figure 4.2.1.1: Path crossed from Rasputnica „K“ until the train stopped due to the ejection of the protection (Google Earth)

Путања = path; дужина = length; заустављање – избацила заштита = stopping – protection ejected, место исклизнућа = point of derailment, Распутница К = Junction Rasputnica K

Based on the submitted copy of the speed meter tape of the locomotive 442-512 and the letter from the Section for Train Traction Belgrade No. 3-463: „Information from the speed meter tape“ from August 16, 2017, the locomotive, after departing from Junction „K“, went 3550 *m* at a speed of up to 19 *km/h* and stopped. When comparing this to the statement of the train driver, this was the second reaction of the protection. In figure 4.2.1.1 this path is drawn and the point where the front left wheel of the fifth wagon of the train fell into the track is marked. In figure 4.2.1.2 there is a detail from which it can be almost concluded that after this stopping the locomotive was located ca. 240 *m* behind the point where the wheel fell in. It is very probable that this ejection of the protection happened due to increased movement resistance after the first wheel fell into the track and after the train moved some 70 *m* with the fallen wheel until the second derailment of the right wheel. The train driver, however, did not notice at that stopping any jolts and once the protection was deactivated he restarted the train.

In figure 4.2.1.3 the further movement of the train is shown. After the derailed wagon hit into the beginning of the concrete structure of the bridge, the train driver felt a slight jolt, after which he looked first through the left window, where he did not notice anything. After that he looked through the right window and when he saw the derailed wagon, he initiated full application of the brake.

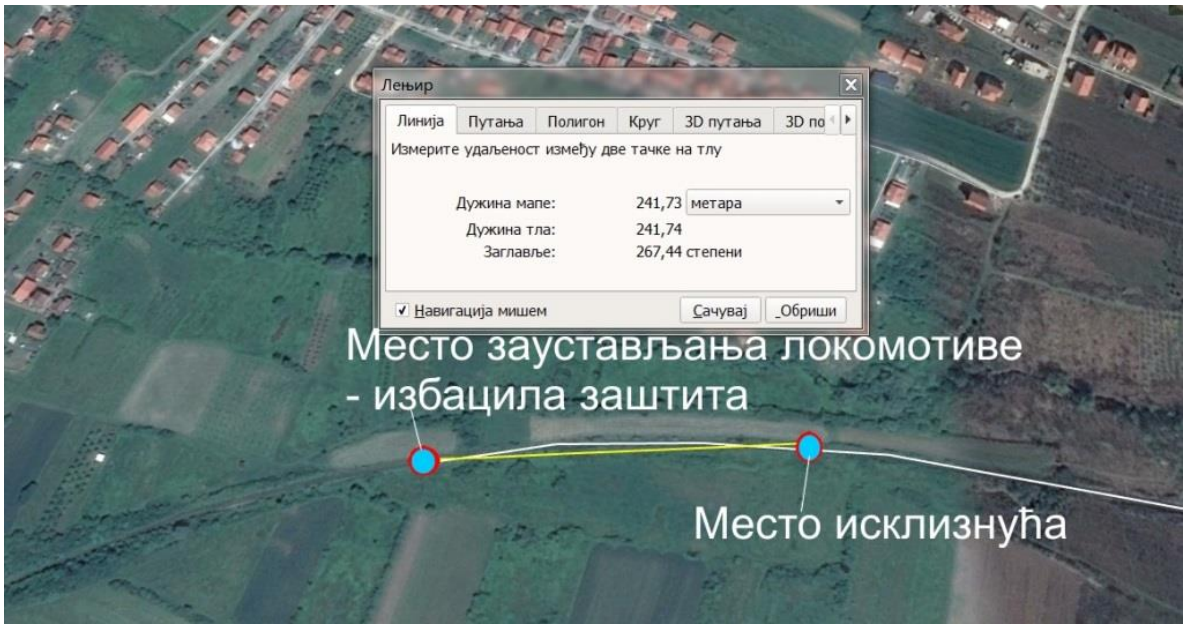

Figure 4.2.1.2: Distance between the point of stopping and the point where the first axle fell into the track (Google Earth)
Место заустављања локомотиве – избацила заштита = point where the locomotive stopped – ejected protection
Место исклизнућа – point of derailment

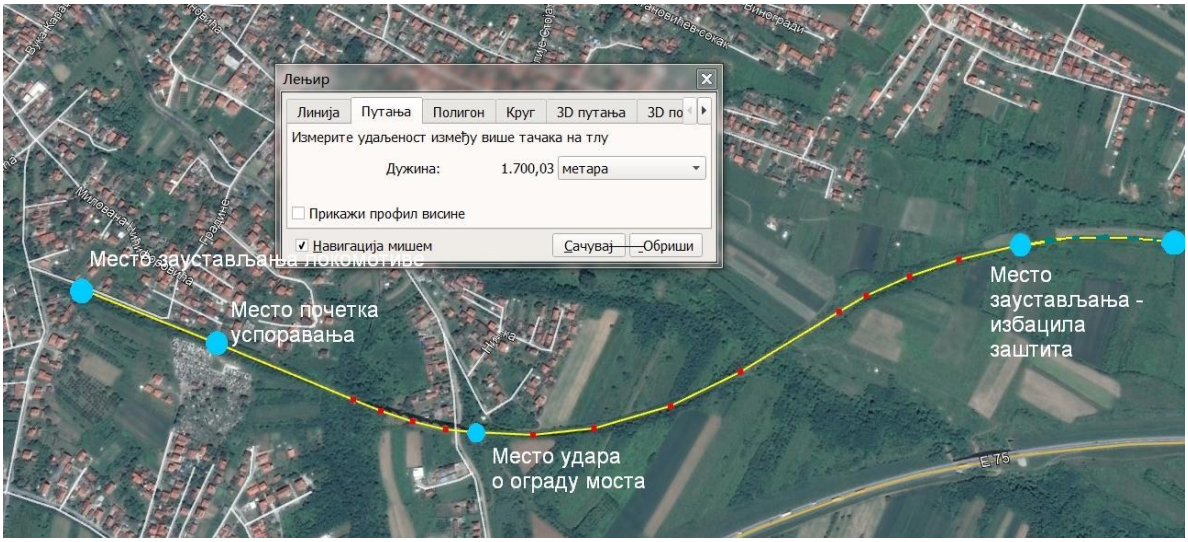

Figure 4.2.1.3: Movement from the ejection of the protection to the final stopping of the train (Google Earth)
Место заустављања локомотиве =point where the locomotive stopped
Место почетка успоравања=point where the train started slowing down
Место удара о ограду моста=point of impact with the bridge fence
Место заустављања – избацила заштита=point of stopping – ejected protection

4.2.2. Inspection of the derailed wagon in the workshop

The derailed wagon of the series *Regs-z* No. 31 72 3924 169-6 was inspected after the derailment in the workshop and characteristic measures of the wheelsets relevant to this investigation were measured again (see item 3.3.2). Members of the working group also did independently measurements of characteristic measures of the wheel profile. Based on all these data the following can be determined:

- The thickness of the flange on all wheels is within permitted limits, whereby in wheels 3L and 4L it is on the lower permitted limit of 22mm,
- Flanges of the wheels 3L and 4L (figures 4.2.2.1 and 4.2.2.2) were strongly damaged in the derailment so that the height of the flange and measure q_R for those wheels cannot be determined. The values for the other wheels are within permitted limits. (Note: for the respective case these measures are not relevant),
- The interior distance between wheels of axles 1, 2 and 3 are within permitted limits,
- On the fourth axle the wheels and the axle have been deformed due to the movement outside of the track and impact with the concrete structure of the bridge after the derailment, so the interior distance between wheels was measured in three sections as being unequal and not within permitted limits, in two sections „-“, and in the third in „+“.
- The exterior distance of flanges on axle 1 is within the permitted limits, on axles 2 and 3 it is below the lower permitted limit by 1 *mm* and 2 *mm*, respectively. On axle 4 due to deformations this distance cannot be determined. The exceeded permitted limits at axles 2 and 3 are not relevant for this case of derailment, but could be critical in other situations (going over crossings and turnout points).

Figure 4.2.2.1: Damaged flanges of wheels 3L

Figure 4.2.2.2: Damaged flanges of wheels 4L

4.2.3. Inspection of the documentation about the maintenance of the derailed wagon

By inspecting the documention for the freight wagon of the series *Regs-z* No. 31 72 3924 169-6, owned by „Srbija Kargo“ a.d. the following was concluded:

- The person in charge of maintenance of the vehicle is „Srbija Kargo“ a.d,

- The regular repair of the wagon was done on September 09, 2011 in the Wagon Factory Kraljevo (according to the inscription on the wagon),
- The guidelines of the wagon's owner (see item 3.3.3.) foresee regular repairs of this wagon to be performed after six years, which means that the deadline expired on September 09, 2017, that is, after the date of the accident,
- The guidelines of the wagon's owner (item 3.3.3.) foresee control inspections of the wagon 36 months after the date of the last regular repair. There is no information about the control inspection, but according to the previously applicable Rulebook (see item 3.3.4.) this inspection did not exist, and due to the close deadline for the regular repair the alignment with the new rulebook was not justified.
- On the wagon it was written that on May 30, 2014 an inspection of the brake of the rank *RK1* was done in workshop 173 (Niš marshalling yard).

Based on the above mentioned, the wagon was maintained in accordance with the applicable regulations.

4.2.4. Reports on the condition of the track

In the letter sent by the deputy head of the Belgrade Junction Infrastructure Section (OC for railway line maintenance Belgrade) No. 31/16-II-192 from February 09, 2016 to the Sector for Construction Affairs, the following is stated for the main arterial route Belgrade Marshalling Yard „A“ – Junction „B“ – Junction „K“ - Resnik:

„Due to the very bad condition of the railway line, in particular elements of the superstructure and substructure of the railway line, since 2008 a speed limitation to *V*=20 *km/h* has been introduced from *km* 3+000 to *km* 10+419.

. . .

On another part of the railway line, from *km* 4+100 to *km* 8+880, it is necessary to rehabilitate the superstructure and the substructure of the railway line due to a large number of rotten sleepers and bad condition of the terrain.

. . .

The geometry of the track is very bad and is manifested in the disrupted level line both in the longitudinal and cross-sectional direction, and the warping is exceeding the permitted limits, which endangers traffic safety. Mechanical track regulation is not possible due to a large percentage of rotten sleepers (34%), there are „nests“ consisting of 15 to 20 pieces of rotten sleepers.“

After the above mentioned document, further three documents were delivered (letters „IŽS“ a.d. No. 31/16-II/327 as of March 17, 2016, No. 31/16-II/412 as of April 04, 2016 and No. 31/16-II/1303 as of October 19, 2016), which refer to the condition of the respective railway line and in which the mentioned condition is confirmed.

Contrary to the previous reports, the Report on the condition of railway lines and railway facilities in the territory of the organisational unit for railway line maintenance Belgrade no. 31/16-II-1085 from August 24, 2016, sent to the National Inspector for Railway Infratstructure, does not contain any data about the bad condition of the railway line for the main arterial route

Belgrade Marshalling Yard „A“ – Junction „B“ – Junction „K“ - Resnik, nor is it mentioned that traffic safety is endangered, and there is no explanation of why the actual maximum speed is 20 *km/h* instead of the designed 70 *km/h*.

4.2.5. Records from the track recording wagon

Based on the submitted records from the recording of the condition of the railway line with the track recording wagon on the stretch Rasputnica „B“ – Resnik as from 27/04/2017, it can be seen that in the zone of the derailment of train no. 62946 (*km* 5+678), in the summary part from *km* 5+000 to *km* 6+000 (figure 4.2.5.2), defects of the type „B“ appear over a length of 230 *m* as well as defects of the type „C“ over a length of 34 *m*. Data are missing for the part of the line between *km* 5+367 and *km* 5+720 (353 *m*), that is, in the zone where the wheel fell into the track.

Based on the submitted records from the recording of the condition of the railway line with the track recording wagon on the stretch Belgrade Marshalling Yard „A“ – Junction „K“, as from October 20, 2016, in the summary part from *km* 5+000 to *km* 6+000 (figure 4.2.5.1), defects of the type „B” appear over a length of 290 *m* and defects of the type „C“ over a length of 68 *m*. Data are missing for the stretch between *km* 5+669 and *km* 5+750 (81 *m*), that is, in the zone where the wheel fell into the track.

Due to a longer disturbance in the operation of the track recording wagon and a large amount of missing data (353 *m* as opposed to 81 *m),* apparently the length of defects is in 2017 less than in 2016.

Pursuant to the applicable Guidelines on Unique Criteria for the Control of the Condition of Railway Lines on the Network of Yugoslav Railways, Guidelines 339 (Official Gazette of the Community of Yugoslav Railways no. 2/2001and 4/2004), see item 3.3.5, the railway line in the zone where the wheel fell into the track (from *km* 5+000 to *km* 6+000) was neither in October 2016 nor in April 2017 in a satisfactory condition.

It is unacceptable that a track condition defined as "unsatisfactory" in compliance with the Guidelines 339, as well as defects above the operational limits that affect transport safety, are tolerated, that is, removed by reducing the maximum speed.

In figure 4.2.5.1 an excerpt from the records of the track recording wagon in the critical zone of the railway line from October 2016 is shown, and in figure 4.2.5.2. from April 2017. It has been noticed that the disturbance in the operation of the track recording wagon occurs at points where limit values are significantly exceeded, in particular for parameters „warping“ and „track width“. There is a very strong indication that the condition of the track in the zone where the wheel fell in is very bad, because the operation of the track recording wagon was disturbed in that same zone during two successive recordings and the critical zone was skipped during both recordings, due to the disturbance in the operation of the track recording wagon.

„IŽS“ a.d. submitted an analysis of the records of the track recording wagon, but not a report on measures taken after discovering irregularities during the recording with the track recording wagon. By comparing the two subsequent records it can be concluded that in the zone of the accident there has been no improvement of the track condition. In compliance with the effective Guidelines 339 (see item 3.3.5) the measure taken was the permanent reduction of speed to 20 *km/h*, and with this measure it is obviously not possible to prevent an accident.

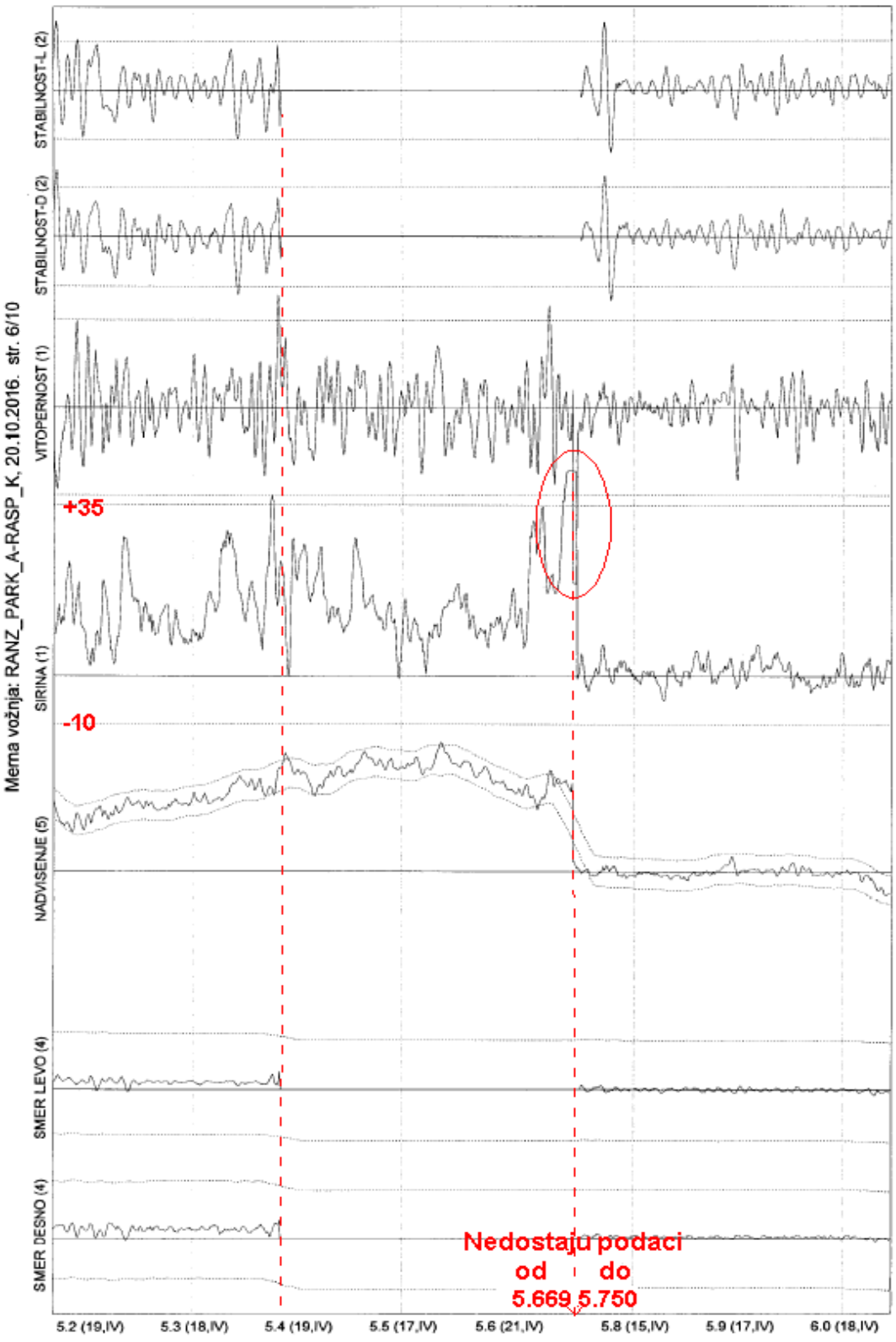

Figure 4.2.5.1: Records from the track recording wagon from *km* 5+000 to *km* 6+000 from October 2016.

SMER DESNO – direction to the right, SMER LEVO – direction to the left; NADVIŠENJE – superelevation, ŠIRINA – width, VITOPERNOST – warping; STABILNOST – stability, NEDOSTAJU PODACI – missing data

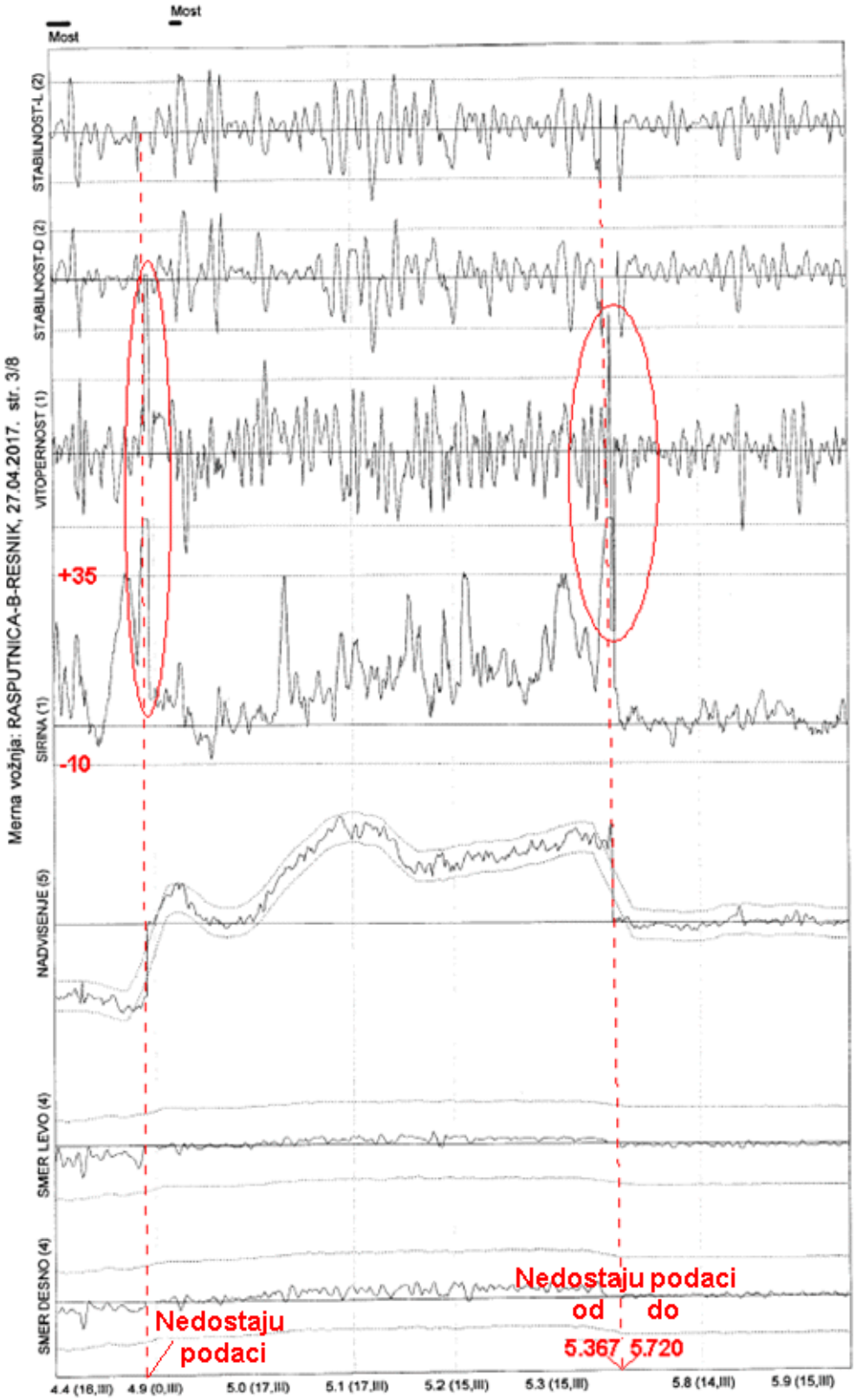

Figure 4.2.5.2: Records from the track recording wagon from April 2017

SMER DESNO – direction to the right, SMER LEVO – direction to the left; NADVIŠENJE – superelevation, ŠIRINA – width, VITOPERNOST – warping; STABILNOST – stability, NEDOSTAJU PODACI – missing data

Condition of sleepers, fasteners and fittings

The falling in of the wheel into the track can occur due to the movement of wheels on the axle (weakening of the pressed set) and reduction of the inside distance between the wheels, or due to the moving apart of the rails. When inspecting the wagon, no movement of wheels on the axle was found and also no deviation of relevant dimensions over the permitted limits.

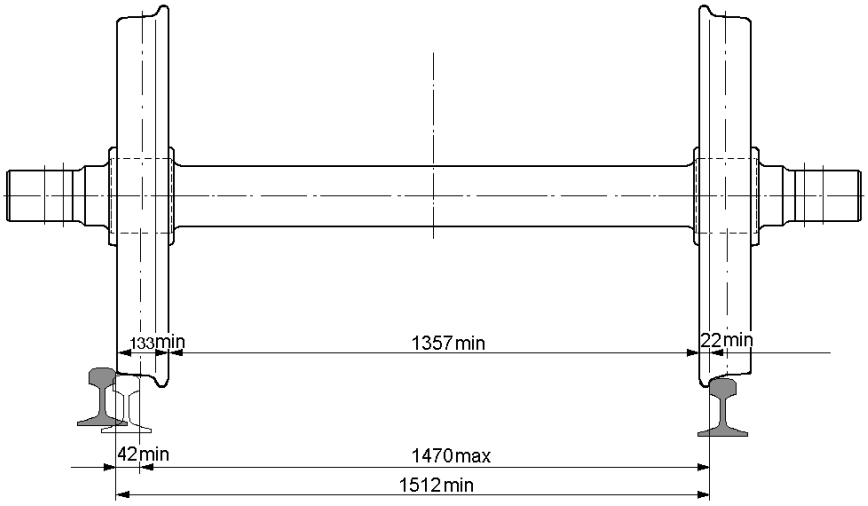

Figure 4.2.6.1: Conditions for the wheel to fall into the track

In figure 4.2.6.1 the special relation between the dimensions of the track and of the wheelset is illustrated that is necessary for the wheel to fall into the track, when the reference dimensions reach the permitted limits. It has been observed that it would be necessary that the rails move apart, due to loose or missing fasteners and fittings or rottenness of the sleepers, for at least 42 *mm* over the permitted limit of 1435+35 *mm*. The records of the track recording wagon show that on several points the widening of the track is above the operational limit of +35 *mm*, and at such points it is possible for the wheel to fall into the track even with a small additional moving apart of the rails.

By inspecting the condition of the sleepers and of the fastening material it has been established that in the broader zone around the place where the wheel fell into the track, the track is in a defective condition due to loosened or missing fittings, moved rail clips or rotten and cracky sleepers. The production year of sleepers is marked on the sleepers, it is 1965, which means that they are more than 50 years old.

In table 4.2.6.1 an illustration of the condition is shown based on the inspection made on site. In figures from 4.2.6.2 to 4.2.6.9 the determined condition is illustrated.

Table 4.2.6.1: Condition of sleepers and fasteners and fittings in the zone where the wheel fell into the track

Sleeper	left, in the direction of motion	right, in the direction of motion	Figure
-3	The inside screws jut out by some 20 *mm*. One outside screw is missing, the other is almost torn out. The rail clip is moved.	The inside screws jut out some 5 *mm*, the outside screws are loose.	4.2.6.8, 4.2.6.9
-2	On the outside one screw is missing, The other is unscrewed by some 10 *mm*. One interior screw is unscrewed by some 15 *mm*, and the other is loose. On the outside the sleeper is decomposing.	The inside screws jut out by some 15 *mm*, the outside screws are loose.	4.2.6.6, 4.2.6.7
-1	One screw on the outside and one screw on the inside are missing, others are loose. The sleeper is on the outside partly decomposed.	All screws are loose. The sleeper has deep cracks.	4.2.6.4, 4.2.6.5
0	All 4 screws are missing. The sleeper is decomposing.	On screw on the outside and one screw on the inside are missing, the other two are loose. The sleeper is rotten.	4.1.2, 4.1.3, 4.2.6.2, 4.2.6.3
1	Both inside screws unscrewed by ca. 20 *mm*. The rail fastening screw is unscrewed by some 15 *mm*. On the outside both sleeper screws are loose. The sleeper has deep cracks.	The screws are loose.	4.1.4
2	On the outside one sleeper screw is missing, the other is unscrewed by some 10 *mm*. The sleeper on the outside is decomposing. Both inside screws are unscrewed by 10 *mm*.	The inside screws are unscrewed by some 5 *mm*. The outside screws are loose.	4.1.5
3	The outside screws are missing. In the inside screws are unscrewed by 5 -10 *mm*.	The screws are loose.	-

The mentioned condition is not in accordance with the requirements from the applicable Rulebook on Technical Conditions and Maintenance of the Superstructure of Railway Lines No.: 340-201-2/2016 (Official Gazette of Republic of Serbia no.39/16 and 74/16), see item 3.3.6.

Figure 4.2.6.2: Sleeper 0D

Figure 4.2.6.3: Sleeper 0L

Figure 4.2.6.4: Sleeper -1D

Figure 4.2.6.5: sleeper -1L

Figure 4.2.6.6: sleeper -2L

Figure 4.2.6.7: Sleeper -2D

Figure 4.2.6.8: Sleeper -3L

Figure 4.2.6.9: Sleeper -3D

4.3. Conclusions

4.3.1. Immediate cause of the accident

Based on the analysis performed it can be concluded that the immediate cause of the accident is the unsatisfactory condition of the railway line on the section on which the accident occurred. The direct cause are the missing and loose fasteners and fittings and the rotten and cracked sleepers in series of at least 7 sleepers, combined with occasional track widening over the operational maximum of +35 *mm*, which caused, under the load, the rails to move apart and the front left wheel on the fifth wagon to fall from the train composition into the track. The additional factor that facilitated the falling of the wheel into the track is the fact that the thickness of the flange of the right, leading wheel was at the permitted minimum (22 *mm*).

4.3.2. Basic causes resulting from skills, procedures and maintenance

The maintenance of the railway line on the section observed is below the technical acceptable minimum.

4.3.3. Main causes resulting from the requirements defined in the legal framework and from the application of the safety management system

The Guidelines on the Unique Criteria for the Control of the Condition of Railway Lines on the Network of the Yugoslav Railways (Guidelines 339) from 2001/2004 introduced for the case of an „unsatisfactory“ condition of tracks (defects in the geometry of the track above the operational limits *„C“*) "speed reduction" as an alternative measure, which did not exist in earlier versions of the Guidelines (from 1989). Also a paragraph was deleted from the earlier version of the Guidelines 339 from 1989 that stipulated that before the operational limits are reached measures are to be taken to prevent the exceeding of limits. Neither the applicable Rulebook on Technical Conditions and Maintenance of the Superstructure of Railway Lines nor the Guidelines 339 define explicitly and clearly operational limits for sleepers and fasteners and fittings that lead to safety risks and require the taking of immediate corrective measures or the closing of the track for traffic.

4.3.4. Additional remarks on deficiencies and shortcomings found during the investigation, which are not relevant for the conclusions about causes

None.

5. MEASURES TAKEN

After the occurrence of the respective accident, The Section for Railway Line Maintenance Belgrade started determining the damage arisen and preparing a plan for the organization of works to rehabilitate the damage on the railway line. As the volume of required works is large, the company “ZGOP Novi Sad“ was hired. In accordance with the approval obtained from the management of „IŽS“ a.d, the company “ZGOP Novi Sad” was hired starting from September 09, 2017 to completely replace elements of the superstructure on the part of the railway line from *km* 4+120 to *km* 6+145. Employees of the Section for Railway Line Maintenance Belgrade were instructed to replace concrete sleepers on the part of the railway line from *km* 3+714 to *km* 4+120. In the course of these works 370 pieces of concrete sleepers were replaced. After the construction works were completed, the railway line was reopened for train traffic on October 11, 2017 at 14:30 h.

6. SAFETY RECOMMENDATIONS

Aiming to achieve the possible improvement of railway safety and to prevent occurrence of new accidents, CINS issued the following safety recommendations:

To the Directorate for Railways:

SR_01/17 Directorate for Railways shall define, as soon as possible, in the existing Rulebook on technical conditions for the maintenance of the railway superstructure ("Official Gazette of the Republic of Serbia, No. 39/2016 and 74/2016), limit conditions of the track superstructure and substructure elements that require immediate corrective actions or closing of the railway line until the unauthorized condition is eliminated.

SR_02/17 Directorate for Railways shall define in the existing Rulebook on technical conditions for the maintenance of the railway track superstructure ("Official Gazette of the Republic of Serbia, No. 39/2016 and 74/2016), criteria for the periods in which the intermediate overhauling on the railway track superstructure shall be performed.

"IŽS" a.d.:

SR_03/17 "IŽS" a.d shall amend the Guidelines on the Unique Criteria for the Control of the Condition of Railway Lines on the Network of Yugoslav Railways, Guidelines 339 (*Official Gazette of the ZJŽ (Community of Yugoslav Railways) no. 2/2001 and 4/2004*), which is, by the Decision of "IŽS" a.d, No. 4/2015-51-17 from 29 December 2015 still into force in "IŽS" a.d, in accordance with provisions from the Guidelines 339 from 1989, mentioned in point 3.3.5. For future measuring wagons, recommended parameters are in accordance with the Standards: SRPS EN 13848-1, SRPS EN 13848-2, SRPS EN 13848-6.

SR_04/17 "IŽS" a.d. shall prescribe in its internal documents that, if during the measurement using the measuring wagon, there is a disorder in the continuity of the measurement, the control of the superstructure parameters must necessarily be carried out at the site of the resulting disturbance and in the zone for which data are missing. The control aims to eliminate the cause of the measurement disorder and to check the condition of the superstructure, visual control and measurement of the superstructure parameters with alternative measuring devices. After removing the cause of the disorder, it is necessary to repeat the measurement with measuring wagon on that kilometre.

SR_05/17 "IŽS" a.d. shall, having in mind inadequate maintenance and condition of the tracks, sleepers and fastening devices, to assess the risk of train traffic on the main arterial route Belgrade marshalling yard "A" – Junction "B" – Junction "K" – Resnik, between junctions "B" and "K".

“Srbija Kargo” a.d.

SR_06/17 “Srbija Kargo” a.d. shall perform an exceptional training for the locomotive drivers and staff for the case of ejection of the traction protection, to check train condition by visual control from the locomotive (possible derailment), especially if after starting and removal of the protection, there are even the slightest twitches or uneven speeds.

To the Ministry of Construction, Transport and Infrastructure:

SR_07/17 Ministry of construction, transport and infrastructure, Sector for inspection control, Railway inspection group, shall perform an exceptional check of the condition of railway infrastructure on the main arterial route Belgrade marshalling yard “A” – Junction “B” – Junction “K“ – Resnik, and, if necessary, take measures within its jurisdiction.