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

No.: ŽS - 01/17
33 No.: 340-07684/2017-006
Date: 01.03.2018.

FINAL REPORT ON INCIDENT INVESTIGATION

Type of incident:	Train decoupling
Train number:	8011
Place:	Belgrade, area of junction and the stop Pančevački Most
Date:	August 03, 2017
Time:	07:55

This report presents the results of the accident investigation, the decoupling of the train number 8011, occurred on August 3, 2017. at 07:55 at the main arterial route E 66: Belgrade Center - Pančevo Main Station - Vršac - State border - (Stamora Moravita) on area of junction and the stop Pančevački Most. Director of the Center for Investigation of Accidents in Transport of the Republic of Serbia established the Working Group for the investigation of this incident by the Decision on the establishment of the working group 33 No. 02-02-7832/2017 of August 15, 2017.

In accordance with the Law on Investigation of Air, Rail and Water Traffic Accidents (*"Official Gazette of the RS" No. 66/15)* and the Directive 2004/49/EC of the European Parliament and of the Council, Sector for Investigation of Accidents in Railway Traffic 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 RS" No. 66/15*). The founder is the Republic of Serbia and the holder of founding rights is the Government of the Republic of Serbia.

Department for investigations of railway traffic accidents and international cooperation carries out tasks within the competence of the Centre for investigation of accidents in traffic 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 Law on Investigation of Air, Rail and Water Traffic Accidents (*"Official Gazette of the RS" 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
JŽ	Yugoslav Railways
RS	Republic of Serbia
a.d.	Join Stock Company
OJ	Organisational Unit
SS	Signalling System
APB	Automatic block
TT	Telephone-telegraph
RDV	Ground-train radio (link)
EMV	Electric multiple unit
TSI	Technical Specifications for Interoperability
KPO	Control and receiving body
ŽTP	Railway Transport Undertaking
ŽTO	Railway Transport Organisation

Decoupling is used in this document to describe an unintentional decoupling of a train, thus affecting its integrity adversely.

Content:

1. Summary

1.1. Short description of the incident

On August 03, 2017 at 07:55 at the *km* 3+817 of the main arterial route *E 66*: Belgrade Centre - Pančevo Main Station - Vršac - State border - (*Stamora Moravita*), in the area of junction and the stop Pančevački Most, on the right track of the double-track railway, when driving in the direction from the station Vukov Spomenik to the junction and the stop Pančevački Most, after passing beside the protective signal *Su 92*, the train No. 8011 decoupled (train from BG VOZ system, EMV 412/416-061/085). The accident occured in the city of Belgrade, between the junction and the stop Pančevački Most, on the section located in a tunnel below the city center.

1.2. The causes of the incident determined by the investigation

The immediate cause of the incident is wear of a threaded joint between set thread of draw bar and the short coupling box, due to which the threaded joint disconnected during driving.

In the last regular repair in 2012, the threaded joint was not properly checked and controlled. In addition, the check list for the threaded joint has no prescribed margin (limit value), which means that it is not clearly defined when the threaded joint has to be repaired or replaced. The deadlines between regular services (carried out before the entry into force of the Law on the Railway Safety and Interoperability) were not in accordance with the applicable by-laws at that time (Rulebook 241).

The maintenance cycle, and in particular deadlines for regular repairs, were altered by internal decisions without a proper technical basis. Decisions on extending the deadlines of the regular repairs were made on the basis of reviews, not on the basis of measuring the critical dimensions of parts which are wearing and without control and the determination of the condition of parts vulnerable to damage or aging during repair.

The last extension of the deadlines between regular services has not been carried out in accordance with the procedure prescribed in the valid Rulebook on the Maintenance of Railway Vehicles. This led to a situation where the period between two regular repairs was long enough for the threaded coupling assembly to be worn throughout, without measures and procedures in place guaranteeing the safe operation until the next regular repair.

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

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

“Srbija Voz“a.d:

SR_01/18 “Srbija Voz“a.d. should make changes in the measurement sheet IB:594 244 so that the wording “Measurement limit“ is replaced with “Measurement limit *d-D1*“ and based on a corresponding analysis (calculation and similar) it should define and enter in the measurement sheet the limit value for safe operation between two regular repairs (explained in item 4.2.3).

SR_02/18 "Srbija Voz"a.d. should consider the possibility to make structural changes on the couplings between vehicles during regular repairs of EMV 412/416 in order to provide for a back-up alternative force transmission in case that the threaded connection is separated, or to apply other measures to reduce the risk of separation of the threaded joint (explained in item 4.2.3).

SR_03/18 "Srbija Voz"a.d. should, in the submitted Instructions for the Repair of Couplings between Vehicles, which was produced within the Project for the preparation of the technical and overhaul documentation for the electric multiple unit of the series 412/416 by the Institute "Kirilo Savic" from Belgrade in 2004, align item 7 with the Working Instructions for the Control and Receiving Bodies of JŽ (*"Official Gazette of the ZJŽ", no 1/03*), (explained in item 4.2.5).

SR_04/18 "Srbija Voz"a.d. should inform the control and receiving bodies about this case and take measures to dedicate special attention during regular repairs to the control of works performed on components that have a significant impact on safety.

SR_05/18 "Srbija Voz"a.d. should harmonize its Instructions for the Maintenance of Traction Vehicles no.4/2016-16-4, dated February 23, 2016, with Article 34, paragraph 2 and Article 36 of the Rulebook on Rolling Stock Maintenance no. 340-382-7/2015 dated December 04, 2015 (*"Official Gazette of RS", no. 101/15*), or to thoroughly reexamine the deadlines for regular repairs by taking the original technical documentation as a basis and to change them only after performing a risk evaluation and risk assessment based on information about the determined condition (especially measurement limits) during previous regular repairs, as well as perform analyses of extraordinary repairs and unplanned works.

SR_06/18 "Srbija Voz"a.d. should perform a risk assessment for passenger transport in EMV of the series 412/416 where the extension of the deadlines for regular repairs was done before a previously performed risk evaluation and risk assessment based on the extension of these deadlines, as specified in paragraph 1, under 2) in Article 36 of the Rulebook on Rolling Stock Maintenance no 340-382-7/2015 dated December 04, 2015 (*"Official Gazette of RS", no.101/15*) and in paragraph 2, item 4.13. of the Rules of Procedure of the Safety Management System of "Srbija Voz"a.d. (due to the incident that occurred).

To the Railway Directorate:

SR_07/18 The Railway Directorate should reexamine the content of the Maintenance File for EMV 412/416 and take measures from its area of competence, as the changes of the maintenance conditions specified by the manufacturer were not performed in accordance with Article 36 of the Rulebook on Rolling Stock Maintenance no 340-382-7/2015 dated December 04, 2015 (*"Official Gazette of RS", no 101/15*).

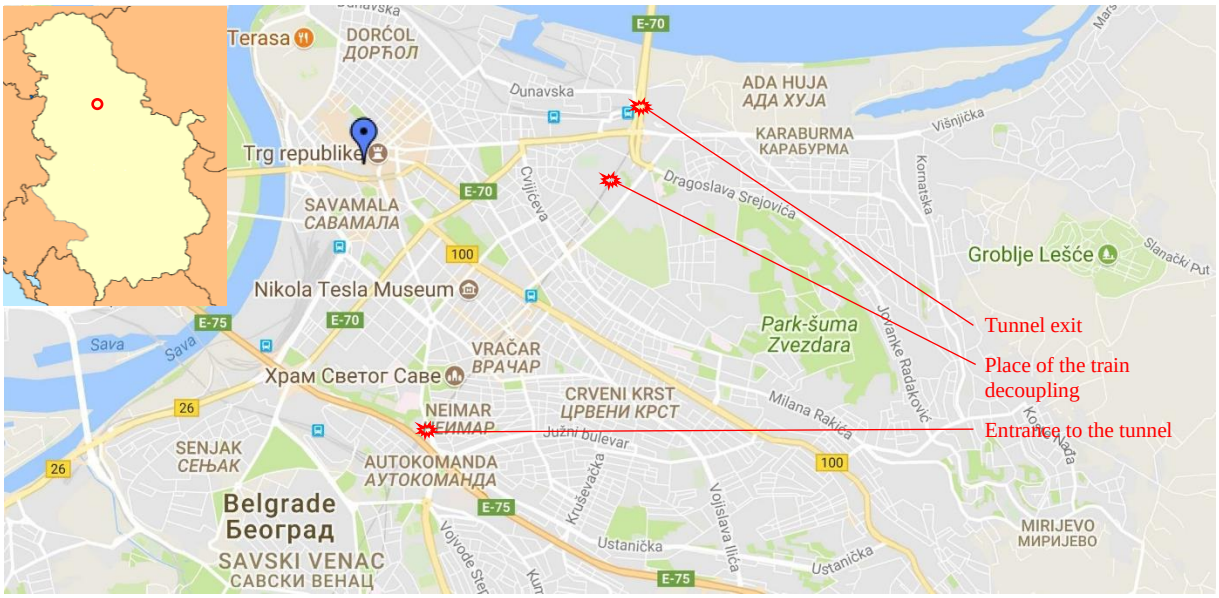
2. Direct facts about the incident

2.1. Basic incident data

2.1.1. Date, time and place of the incident

The accident occured on August 03, 2017 at 07:55 h, in the city of Belgrade, on the main arterial route *E 66*: Belgrade Centre - Pančevo Main Station - Vršac - State border - (*Stamora Moravita*), in the area of the junction and the stop Pančevački Most at *km* 3+817, the section located in the tunnel below the city center.

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



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

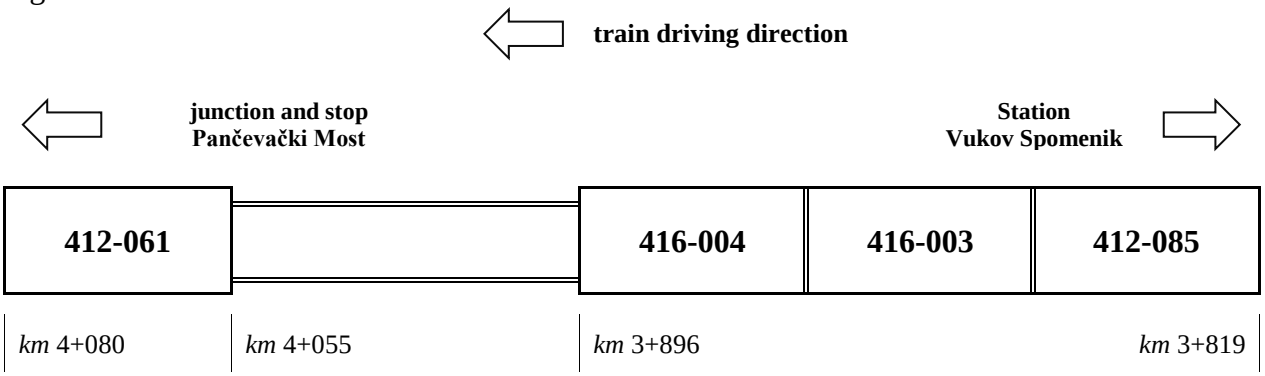
2.1.2. Description of the incident and the incident site and work of rescue and emergency services

On the main arterial route *E 66*: Belgrade Centre - Pančevo Main Station - Vršac- State border - (*Stamora Moravita*), in the area of the junction and the stop Pančevački Most, on the right track of the double-track line, when driving in the direction from the station Vukov Spomenik to the junction and the stop Pančevački Most, after passing beside the protective signal Su 92, the train No. 8011 decoupled (train from BG VOZ system, EMV 412/416-061/085). The incident occured in the city of Belgrade, between the junction and the stop Pančevački Most, on the section located in the tunnel below the city center.

The train No. 8011 operated regularly on the route Batajnica - Ovča. Viewed from the direction of driving, the train consisted of: power car 412-061, trailer 416-004, trailer 416-003 and power car 412-085. The train driver was in the power car 412-061 (driver's cab).

The decoupling occured between the power car 412-061 and the trailer 416-004. After the decoupling, the train No. 8011 stopped, so that the head of the first part of the train (front of the

power car 412-061) was found at *km* 4+080, and the end of the power car 412-061 at km 4+055. The end of the second part of the train (end of power car 412-085) was found at *km* 3+819. The front of the trailer 416-004 was at *km* 3+896, which means that the distance between the end of the power car 412-061 and the front of the trailer 416-004 was 159 *m*. A schematic description of the position of parts of the EMV as they were found on the spot after the incident is given in figure 2.1.2.1.



Picture 2.1.2.1: Position of the stopped units of the train No. 8011 after the decoupling

The place where the train No. 8011 stopped (front of the power car 412-061) after the decoupling is at *km* 4+080, in the tunnel 595 *m* from the tunnel exit (at *km* 4+675). According to the estimation of the train driver, at the moment of the decoupling about 30 passengers were in the train.

After the decoupling, both sections of the split train No. 8011 were secured against un-intented movements of the rolling stock by installing manual brake pads.

Since there were no passengers killed or injured, emergency medical services and police were not alerted.

Due to the aforementioned incident, there was an interruption of traffic between station Belgrade Centre and junction and the stop Pančevački Most on the right track of double-track line. The interruption of traffic on the right track lasted until 13:25. The traffic was organized on the single track, the left track of the double-track railway.

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

The main investigator for railway traffic received the first notification on the incident at 08:18 by phone from Assistant Director of the Sector for operations of "IŽS"a.d. Based on the initial information received, the main investigator decided to go to the place of the incident. On the basis of the facts established by the initial investigation, CINS launched the investigation of the incident in accordance with the Law on Investigation of Air, Rail and Water Traffic Accidents (*"Official Gazette of the RS" No. 66/15*). Composition of the working group for the incident investigation was determined by the Decision 33 no. 02-02-7832/2017 of the Director of CINS, from August 15, 2017 and according to articles 6 and 32 of the Law on Investigation of Air, Rail and Water Traffic Accidents (*"Official Gazette of the RS" No. 66/15*).

2.2. Incident background

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

Train driver and conductor of the train No. 8011, employed at railway undertaking ”Srbija Voz”a.d., Traction Organisational Unit Belgrade and Unit for Traffic and Transport Affairs Belgrade, are the parties involved in the incident.

Staff of the railway infrastructure manager “IŽS”a.d. were not involved in the incident, as well as the contractors, other persons or external witnesses (non-passengers).

2.2.2. Trains involved in the incident and train composition

The train No. 8011 participated in the incident. The train of EMV series 412/416, consisted of: power car 412-061 (in use since October 10, 1986, with autorisation for rolling stock No. 2615/85-31 of October 10, 1986), power car 412-085 (in use since October 18, 1988, with autorisation for rolling stock No. 113/88-78 of October 18, 1988) and trailers 416-003 and 416-004 (in use since April 02, 1981, with autorisation for rolling stock No. 146-8/81 of February 05, 1981). According to the autorisations for rolling stock, power car 412-061 under number 5671, power car 412-085 under number 5674, trailer 416-003 under number 5673 and trailer 416-004 under number 5672 are immatriculated in the National rolling stock register.

The above mentionned composition of EMV 412/416-061/085 is in operation since February 16, 2011. The last regular repair on the EMV has been performed on October 02, 2012. The last regular repair on the EMV was carried out on October 02, 2012. Since the regular repair to July 31, the EMV ran 756746 *km* (power car 412-061), i.e. 756810 *km* (power car 412-085).

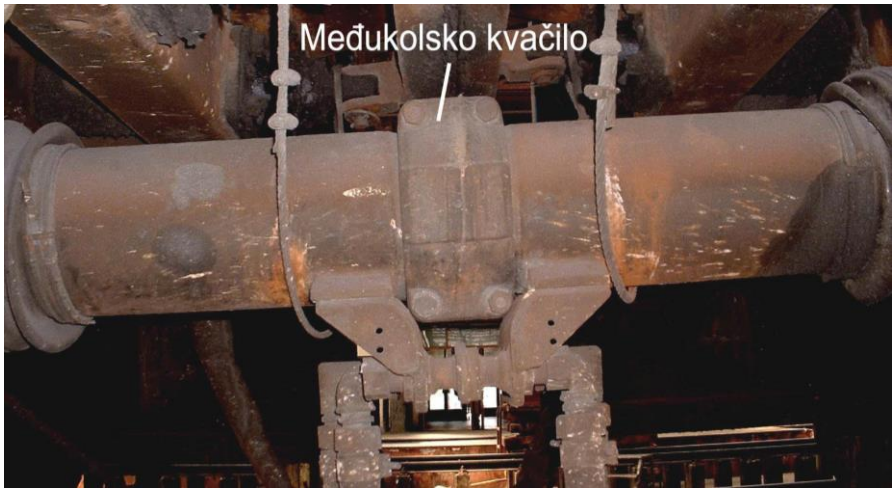
EMV series 412/416 was manufactured for the traffic on standard-gauge railway track of 1435 *mm*, with the single-phase voltage system electrification of 25*kV*, 50 *Hz*. Trains were produced in the Union of Soviet Socialist Republics in the city of Riga, today's Latvian Republic, at the Riga Wagon factory. For the needs of the JŽ, this factory has delivered several sets of this train since 1980.

The appearance of EMV series 412/416 is shown in picture 2.2.2.1.

Picture2.2.2.1: Appearance of the EMV series 412/416

One train is consisted of two identical parts. One part is consisted of a power car and the trailer. The vehicles between them as well as the two parts of the train are connected with the coupling, manufacturer *Scharfenberg* type 10, number 40-1075(1). Coupling provides mechanical conections between vehicles and connection of air pipes, while connestion of electrical cables is done separately. Technical characteristics of the coupling and the procedures for regular repairs are given in Instruction for repairs of couplings between vehicles, that is drafted in 2004 by the Institute Kirilo Savic from Belgrade within the Project of technical overhaul documentation for the train EMV series 412/416.

Appearence of the coupling between vehicles installed in EMV series 412/416 is shown in the picture 2.2.2.2.



Picture 2.2.2.2: Appearence of the coupling between vehicles installed in EMV series 412/416

The train is equiped with the electro-pneumatic brake system.

The basic technical data on EMV series 412/416 are given in the table 2.2.2.1

Table 2.2.2.1: Basic technical data on EMV series 412/416

Basic train composition	M-P-P-M	Weight of the train in its basic composition	217,2±6,5 *t*
Capacity of the train	441 passenger	Weight of the power car	60,1±1,8 *t*
Length of the train over axle of the automatic coupling	102160 ±500 *mm*	Weight of the trailer	48,5±1,46 *t*
Length of the vehicle's body	25092 *mm*	Weight of the bogie with motors	13900 *kg*
Length of the trailer's body	25080 *mm*	Axle load of the power car	18 *t*
Width of the vehicle's body	2810 *mm*	Braked weight of the train	322 *t*
Height of passenger compartment	2227 *mm*	Braked weight percentage	130%
Height between the upper edge of the rail to a dropped pantograph	4633 *mm*	Continous power of the train	1360 *kW*
Distance of the axles in the bogie	2600 *mm*	One-hour power rating of all traction motors	1680 *kW*
Diameter of the new wheel by rolling circle	1050 *mm*	Exploitation speed	120 *km/h*

2.2.3. Infrastructure and signalling system

The main arterial route E 66: Belgrade Centre - Pančevo main station - Vršac - State border - (Stamora Moravita), between the station Belgrade Centre and junction and stop Pančevački Most is a double-track line. At the section of the railway line between the stop Karađorđev Park (the beginning of the tunnel), station Vukov Spomenik and the junction and stop Pančevački Most (the end of the tunnel), each track of the double-track line is located in a separate tunnel tube. The speed at this section of the line, according to the timetable booklet 0.1, is as follows: at the left track, between the station Belgrade Centre to the stop Karađorđev Park *70 km/h* and from the stop Karađorđev Park to junction and stop Pančevački Most 100 km/h; at the right track, between station Belgrade Centre to stop Karađorđev Park *70 km/h*, and between stop Karađorđev Park to junction and stop Pančevački Most *80 km/h*. At this section, according to the timetable booklet, there are three speeds which are limited to: at the left track from *km 1+300* to *km 1+500* it is 70 *km/h* and from *km 4+170* to *km 5+189* it is 75 *km/h* and at the right track from *km 4+170* to *km 5+292* it is *75 km/h.*

On the section between the station Belgrade Centre and junction and the stop Pančevački Most, the traffic is regulated with APB devices. This section of the line is fit out for the two way traffic.

Although the traffic on this section is regulated with APB devices, it is stipulated to ask and issue the permission.

For the purpose of the traffic regulation, on the section of the railway line between the station Belgrade Centre and junction and the stop Pančevački Most, spatial and protective signals that show two-way signs were built. In order to protect the train, the active track balises have been installed in addition to the signal.

2.2.4. Communication tools

On the section between the station Belgrade Centre and junction and the stop Pančevački Most, communication between personnel in charge of traffic regulation and the personnel in traction vehicles is performed by phone via local TT connection. The line of communication includes all the official positions on the line and telephones alongside all the main signals. Communication on this line is recorded on the registrar device located in the TT section Belgrade Centre, so this type of communication is considered as evidence-based communication.

This line is equipped with RDV devices, which are working and which enables the communication between the personnel in locomotive and the personnel who regulate the traffic (BG VOZ dispatcher). Communication performed by the RDV is recorded on the register device situated in TT section Belgrade Centre, so this type of communication is considered as evidence-based communication.

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. 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 Voz"a.d. established a joint investigation commission that conducted an investigation of the incident in accordance with applicable regulations. Upon completion of the investigation, the Investigation Report U-318/17 was drafted.

Immediately after notification from the station inspector of junction and the stop Pančevački Most, the Vukov Spomenik stationmaster came out on the spot. Assisted by the Vukov Spomenik stationmaster and the conductor of the train No. 8011, passengers from the front part of the train (power car 412-061) were moved to the back part of the train (the secont part of the decoupled EMV). EMV, that arrived in the station Vukov Spomenik at 08:05 as train No. 8013, after receiving the dispatch order, was routed to the rear of the decoupled train No. 8011 due to evacuation of passengers. All passengers from the train No. 8011 were safely moved to the arrived EMV, which was returned to the station Vukov Spomenik at 08:55. After arriving at the station Vukov Spomenik, EMV was routed as a train No. 8022 at 09:01 to station Batajnica.

After receiving the dispatch order, shounting locomotive 621-302 was routed from the station Belgrade Centre, as a train No. 78003, and it arrived in the station Vukov Spomenik at 10:06, and at 10:07 it was routed from the station Vukov Spomenik, to the place of the accident, to the end of the decoupled train No. 8011 to pull out the second part of the decoupled train.

The second part of the decoupled train was pulled out to the station Vukov Spomenik and, as a train No. 38034, was routed to Technical - passenger station Zemun, to Depo for maintenance of EMV 412/416.

The rest of the decoupled train No. 8011 (power car 412-061) from the station Zemun, as the train No. 38037 the shounting locomotive 621-302 was returned to the junction and the stop Pančevački Most, where it arrived at 12:01. From the junction and the stop Pančevački Most it was routed at 12:18, as a train No. 38030, to the front of the power car 412-061 and, after coupling of the power car, it continued to Technical – passenger station Zemun, in the Depo for maintenance of EMV 412/416, as a pushed train.

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

In this incident 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 incident.

2.3.2. Goods, luggage and other assets

In this incident there was no damage to goods, luggage and other property.

2.3.3. Railway cars, infrastructure and environment

In the incident the railway vehicles (EMV 412/416-061/085) and installations on infrastructure were damaged. No material damage has been caused to the property of third parties.

The structure of the material damage is as follows:

Concerning EMV 412/416-061/085:	1250000,00	RSD
Concerning SS devices (*UTD-DM* sensor for the system *BROS*):	184500,00	RSD
Total direct material damage:	**1434500,00**	**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 03, 2017, which is 1 EUR (Evro) = *119,8397 RSD (Dinara*), the total material damage caused in the respective incident amounts to 11970,17 *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 Voz"a.d that confirm the stated damage amounts.

2.3.4. External conditions – weather conditions and geographic characteristics

The site of the incident is located in the area of Belgrade, on the section located in a tunnel beneath the city center.

The geographic coordinates of the place of incident are: 44º 48' 49,1" *N* and 20º 29' 15,2" *E*.

At the time of the incident, the sky was clear, it was sunny and without any wind. Vision was not impaired by anything. The air temperature was 31°C. In the tunnel, where the incident occured was dark. The air temperature was 17°*C*.

Since the incident occurred in the tunnel, the investigation was carried out under difficult conditions.

3. Minutes on 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 Traffic from CINS;
- Additional examination of the EMV carried out by the investigation team of the CINS in the presence of representatives of "Srbija Voz"a.d.
- Materials delivered by the infrastructure manager "IŽS"a.d. and
- Materials delivered by the railway undertaking "Srbija Voz"a.d.

The preliminary investigation of the accident on site and the investigation were done by a joint investigation committee of the infrastructure manager "IŽS"a.d. and the railway undertaking "Srbija Voz"a.d.

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

3.1. Summary of the testimonies

Written statements from "IZS"a.d. and station inspectors' reports on irregularities during operation (S-23) in the station Vukov Spomenik and the junction and the stop Pančevački Most who performed the service at the time of the incident (personnel regulating traffic on that sectionof the railway line) were obtained.
Written statements of "Srbija Voz"a.d. were obtained as well as Reports on irregularities in the train driver's (EV-38) and conductor's (K-91) work in the train No. 8011.

3.1.1. Railway staff

Train driver stated: "on the section Vukov Spomenik - Pančevački Most rapid discharge of the main brake pipe of the EMV 412/416-061/085 happened. Immediately after the event I applied speed braking and after the train stopped the situation was such that EMV was broken and separated into two parts. saw that there were no injured passengers, I secured the EMV of self-rolling, and then I reported on the incident to the district control office of "Srbija Voz"a.d.

The report on irregularities in work (*EV-38*) that the train driver provided on the accident and the statement he gave after the accident coincide in all essential facts.

Conductor stated: "after the departure of the train No. 8011 from the station Vukov Spomenik, the EMV decoupled in the tunnel tube. I went to the train driver and in accordance with him I secured both parts of the decoupled broken EMV of self-rolling by installing pads. I informed the worker on duty and the control office in Belgrade. In the train No. 8011 There were about 30 passengers. In agreement with the dispatcher of BG-VOZ, the train No. 8013, the train that was in the station Vukov Spomenik, came to the broken EMV. I led safely the passengers from both parts of the broken EMV to the EMV that arrived, ant which transported them back to the station Vukov Spomenik. After the arrival of shounting locomotive, as it arrived without the manoeuvring personnel, I coupled the part of the broken EMV, that was routed to the technical – passenger station Zemun, in the Depo for maintenance of EMV 412/416. We did the same with the other part of the EMV".

Report on irregularities during operation (*K-91*), that the conductor sent regarding the accident and the statement he gave after the accident coincide in all essential facts.

Vukov Spomenik Station inspector stated: "the train No. 8011 was routed from the station Belgrade Centre at 07:46, from the station Vukov Spomenik at 07:53, 6 minutes delayed train No. 8013 from Belgrade Centre at 08:01, to Vukov Spomenik arrived at 08:05. Meantime, the station inspector of the junction and the stop Pančevački Most is informing me that the train No. 8011 is on the trac kat the protective signal *Su 92*. Around 08:11 the station inspector Pančevački Most is informing me that the decoupling of the train 8011 (EMV 412/416-061/085) occurred. At 08:49 I am receiving order from the Belgrade Centre dispatcher to route the EMV from train 8013 to the back part of the train 8011 in order to move passengers in the station Vukov Spomenik, that I immediately did, and when the EMV is back with the passengers, to route it as train No. 8022 by the next track in regular time".

Station inspector of the junction and the stop Pančevački Most stated: "rain driver of the train 8011 informed me at 07:57 that the train EMV 412/416-061/085 decoupled. At 07:58 I am closing for traffic he right track and the trains run on the next, left track".

Reports on irregularities (*S-23*) submitted by Vukov Spomenik and the junction and the stop Pančevački Most station inspectors in relation with the incident and the statements that they gave after the incident coincide regarding all relevant facts.

3.1.2. Other witnesses

The witnesses of this accident (passengers in the train No. 8011) were not interviewed and no statements were obtained from them.

3.2. Safety Management System

3.2.1. Organisational frame and manner of issuing and executing orders

According to the Safety Management System, "IŽS"a.d. informed all interested parties on the accident.

Railway infrastructure manager "IŽS"a.d. and the railway operator "Srbija Voz"a.d, according to the Law on railway safety and interoperability ("*Official Gazette RS No. 104/13, 66/15 - other law and 92/15*), established a joint investigating commission that carried out an investigation of the event. After the investigaton, they drafted a Report on investigation U-318/17.

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

"Srbija Voz"a.d. insured through its Safety Management System (SMS) management of competencies, i.e, that all the employees participating directly in railway traffic are trained and competent, as well as the planning of the work load.

Regarding the accident, where the train driver and the conductor employed in "Srbija Voz"a.d, all the activities related to the professional training, competencies and the planning of working time were carried out in accordance with applicable regulations.

3.2.3. Procedures for internal audits and controls and their results

"Srbija Voz"a.d, as a railway operator has established Safety Management System. The general purpose of the Safety Management System (SMS) is to ensure that "Srbija Voz"a.d. achieve its business objectives in a safe way.

The purpose of establishing a safety management system (SMS) in the company "Srbija Voz"a.d. is ensuring safe management of their own activities in accordance with the provisions of the Law on railway safety and interoperability ("*Official Gazette RS No. 104/13, 66/15 - other law and 92/15*) and the Statute of the Join Stock Company for rail passenger transport "Srbija Voz" Belgrade (*"Official Gazette RS" No. 60/15*).

Planning in the safety management process in certain elements, that are relevant to the safety management process, by adoption of other plans: Railway maintenance plans in order to increase

technical safety and achieve bigger safety level in traffic, the Framework plan and the program for training of executives in the company "Srbija Voz"a.d. and their proficiency checks, Plans for checking the health skills of executive officers and operational workers.

Rolling stock must maintain the prescribed technical level of accuracy and must follow the maintenance plans (*EV-62*) and its cycles of control and technical inspections and execution of regular repairs, in order to be as reliable as possible in traffic, in accordance with the Rulebook on rolling stock maintenance and other laws and by-laws being part of the Safety Management System of ″Srbija Voz“a.d.

Within the company ″Srbija Voz“a.d. an internal control was organized in all organizational parts, which is particularly noticeable in the field of rolling stock maintenance during the execution of regular tasks, in control-technical inspections, in rolling stock, and especially the control of executive officers in the application of regulations, the use of alcohol, rest between the two services and other. In addition to this type of control, control is also carried out through the Center for Internal Control, which is tasked with controlling at all levels in all organizational parts of the Company, on all relevant issues.

According to the point 4.5.1. (extract) of the Safety Management System of “Srbija Voz“ a.d, the main activity of the company is carrying out public transport of passengers on railways, in domestic and international railway transport, as well as the maintenance of rolling stock and train traction.

As part of its activities “Srbija Voz“a.d. provides services related to maintenance of rolling stock:

...

- rolling stock control and reception from regular and emergency services;
- development of maintenance standards;

...

All mentioned activities and business processes “Srbija Voz“a.d. are the generator of risk in traffic flow. These risks have been identified and quantified through the definition of operational business processes. In the work processes, instructions, rules, technical documentation and legal regulations are applied, which implements instructions as well as the management of defined records and business documentation.

3.3. Relevant international and national regulations

3.3.1. Law on Railway Safety and Interoperability (*“Official Gazette of RS“ No. 104/2013, 66/2015 - other law and 92/2015*)

2. Vehicle maintenance, Person in charge of maintenance, Article 80 (extract):

The vehicle holder shall determine for every vehicle that it is using a person in charge of its maintenance.

The person in charge of maintenance can be a railway undertaking, infrastructure manager or vehicle holder.

...

Apart from the responsibility that the railway undertaking and infrastructure manager have for the safe operation of trains, the person in charge of maintenance is responsible to ensure, with the help of the maintenance system, that the vehicles for whose maintenance it is responsible are in such condition that enables them to move safely.

...

The person in charge of maintenance shall ensure that the vehicles are maintained in accordance with this law, the vehicle maintenance file and TSI provisions. The maintenance file for every vehicle is prepared and kept by the person in charge of maintenance. Elements of the maintenance file and the file keeping method are specified by the Directorate.

...

3.3.2. Rulebook on Rolling Stock Maintenance no 340-382-7/2015 as from 04/12/2015 (*"Official Gazette of RS", No 101/15*)

Article 16 (extract):

...

The cycles, time periods and the volume of works for regular repairs are defined in the maintenance file.

...

Article 34 (extract):

...

The preparation of the maintenance file is based on the initial technical documentation as produced by the railway vehicle manufacturer, which is enclosed with the request for the issuance of the authorisation to place the railway vehicle in service.

...

Article 35 (extract):

The maintenance file consists of the following elements:

...

(3) documentation containing a description of the maintenance and method of maintenance, including in particular:

...

(4) limit values for components that must not be exceeded during the use of the railway vehicle, ...

...

(6) maintenance plan consisting of:

...

- Maintenance criteria and time periods,

...

Article 36 (extract):

...

2) proposing changes to the railway vehicle maintenance system, including deadlines for maintenance, by taking into account the results of the risk evaluation and risk assessment and by integrating accepted changes in the maintenance file.

When updating the maintenance file the following is taken into account:

(1) Limit values that need to be preserved in order to ensure the interoperability of the vehicle, and which are listed in the initial technical documentation and in any potential change of such documentation;

...

Annex 5

Maintenance of traction and buffer equipment (extract):

...

9. During a regular repair of the draw gear, regardless of the kind and type, the draw gear is disassembled, all worn parts are repaired or replaced with functional parts, complete anti-corrosion protection is applied and final testing is done.

...

3.3.3. 241 Rulebook on Rolling Stock Maintenance *("Official Gazette of the ZJŽ", No. 2/84, 2/88, 7/88 and 13/88*), not applicable since December 08, 2015

Important note: for the EMV 412-061/416-004/416-003/412-085, which was involved in the respective incident, in the sense of maintenance and deadlines for regular repairs (the last regular repair on the respective EMV was performed on October 02, 2012), this Rulebook was applicable.

Article 29 (extract):

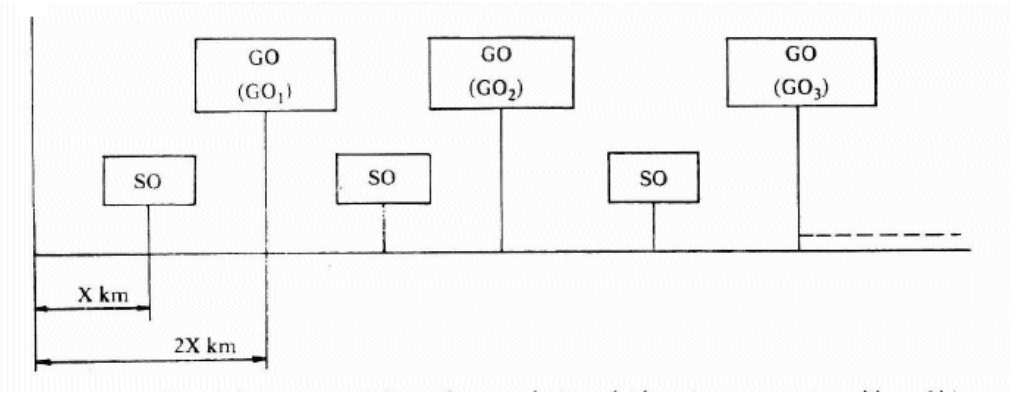
1. Types of regular repairs of electric and diesel units are:
   - Intermediate repair SO
   - Main repair GO
2. The intermediate repair of electric and diesel traction vehicles includes the inspection, control and repair or replacement of certain parts, sets and units of the vehicle so as to bring the vehicle into the technical condition that is specified for this type of repair and it consists of the following:

   ...

   - repair, partial or complete, of single sets and units that cannot operate without failures until the next regular repair;

   ...

CYCLE
OF REGULAR REPAIRS OF ELECTRIC AND DIESEL VEHICLES



Annex 2

Note: for certain series of traction vehicles there are small differences with regard to the volume of works performed during regular repairs ranked as main repairs, which depends on the vehicle's operation expressed in total kilometres crossed, or age of vehicle since the beginning of its operation.

GO –main repair; SO – intermediate repair

Article 31 (extract):

...

The stipulated kilometres of operation of locomotives and motor train sets between two regular repairs, that is, until the intermediate or main repair, are presented in tables per series for all electric and diesel vehicles in Annex 4 to this Rulebook.

6. The maximum time period between two successive repairs of a diesel vehicle and electric vehicle is 5 years, regardless of how many times such a vehicle is repaired on this time basis. The aforementioned maximum time period cannot be prolonged on any basis.

7. There are permitted exceptions from the specified deadlines for certain types of regular maintenance of traction vehicles and these are:

- for control inspections ± 20%
- for regular repairs ± 15% (only based on kilometres)

...

DEADLINES FOR
REGULAR REPAIRS OF ELECTRIC AND DIESEL VEHICLES

TRACTION TYPE	VEHICLE TYPE	DEADLINE FOR REPAIRS (km) intermediary/main										
		100.000 / 200.000	120.000 / 240.000	150.000 / 300.000	200.000 / 400.000	250.000 / 500.000	300.000 / 600.000	350.000 / 700.000	400.000 / 800.000	450.000 / 900.000	500.000 / 1.000.000	600.00 / 1.200.000
Electric	Locomotives							341 362		342		363 441 461
	Motor train sets					311/315 320/315				410/414 411/415 412/416		

Annex 4

3.3.4. Instructions for the Maintenance of Traction Vehicles of "Srbija Voz"a.d. No. 4/2016-16-4 as from February 23, 2016

3. Periodic inspection, Article 4 (extract):

...

The criterion for periodic inspections can be reduced or increased by 15%. Depending on the series of the traction vehicle, the criterion for the periodic inspection is:

...

Series 412/416

Type of inspection	P1	P3	P6	P12
Time criterion (days)	30	90	180	360

...

4. Regular repair, Article 5 (extract):

The regular repair of traction vehicles produced before 2010 can be as follows:

- Intermediate repair (SO),
- General Repair (VO).

The intermediate repair (SO) of a traction vehicle includes the inspection, control and repair or replacement of parts and sets on the vehicle in order to bring the vehicle into a technically safe condition as specified for that type of repair.

...

- The criterion based on kilometres crossed between two regular repairs for vehicles produced before 2010 is:

...

Electric multiple units of the series 412/416 - 1000000 *km*

...

The person in charge of maintenance may make a decision that the *km* crossed between two regular repairs can amount to more or less, depending on the technical condition of the vehicle, whereby the maximum time period between two successive regular repairs of the traction vehicle must not exceed 15 years.

...

3.3.5. Instructions for the Maintenance of Couplings between Vehicles, Institute "Kirilo Savić", 2004

Note: These instructions are part of the maintenance documentation for the EMV and/or part of the maintenance file, based on which the coupling between vehicles is maintained in a condition that makes it safe for use. These Instructions were prepared based on the request submitted by the ŽTP "Beograd", whose legal successor in charge of maintaining the EMV is "Srbija voz"a.d.

(Extract)

...

6. Tests to be performed in order to determine the quality

The functioning should be checked during a slow start of movement. Before testing the operation of the entire system, first the fixing of screws, nuts, the tightness etc. should be checked.

When controlling the coupling between the vehicles the following should be checked, if possible:

- the tread of the coupling in traction and under pressure,

- radius of movement in the horizontal plane of the coupling and

- if possible, the traction force should be tested.

7. Overview of activities of the KPO of the ŽTP during the repair

During the repair of the coupling between vehicles, the KPO of ŽTP needs not check the coupling. The KPO will perform an inspection according to item 6 after the completion of the repair of the gear.

...

3.3.6. Working Instructions for Control and Receiving bodies of the JŽ *("Official Gazette of the ZJŽ", No. 1/03*);

Note: Pursuant to Article 152 of the Law on Railway Safety and Interoperability ("*Official Gazette of RS" No. 104/2013, 66/2015 - other law and 92/2015*), these Instructions were integrated into the safety system (Annex 4 to the Rules of Procedure of the Safety Management System of "Srbija Voz"a.d.) and are still in application in "Srbija Voz"a.d.

(Extracts)

...

1.2.1 The basics for the work of KPO are as follows:

...

Structural documentation, technical requirements for the production and delivery and measurement sheets

...

3.2.3 The KPO checks the works performed in accordance with the applicable regulations and technical documentation from the field of railway vehicle maintenance

...

3.4. Functioning of railway vehicles and technical installations

3.4.1. Control, command and signalling

On the part of the railway line between the station Belgrade Centre and the junction and the stop Pančevački Most, the control, command and signalling devices were safe and operational.

3.4.2. Infrastructure

The condition of the infrastructure on the part of the railway line between the station Vukov Spomenik and the junction and the stop Pančevački Most was good and in that sense there were no irregularities that could have had a negative impact on rail traffic safety.

3.4.3. Means of communication

At the time of occurrence of the respective incident, the means of communication were safe and operational. No malfunctions or failures of communication devices were documented.

3.4.4. Railway vehicles

At the time of occurrence of the respective incident, the train No. 8011 was moving in the direction from the station Vukov Spomenik to the junction and the stop Pančevački Most (from the beginning towards the end of the railway line, in the direction of increasing mileage).

The appearance of parts of the EMV at the point where it decoupled is shown in figures 3.4.4.1. and 3.4.4.2.

Figure 3.4.4.1: Appearance of a part of the decoupled coupling on the trailer 416-004

Figure 3.4.4.2: Appearance of a part of the decoupled coupling on the power car 412-061

In the EMV 412/416-061/085 speed meters of the manufacturer *Hasler* are installed. In the driver's cab of the power car 412-061 a registering speed meter of the type *RT12*, serial number *E10.361* is installed, and in the driver's cab of the power car 412-085 a registering speed meter of the type *RT12*, serial number *E02.109* is installed. Both speed meters were certified on July 04, 2017, with the certification being valid until July 04, 2018.

The speed measuring tape was removed from the speed meter of the power car 412-085 on August 21, 2017. By processing the registered data (Data from the speed-measuring tape No. 3-536 from August 22, 2017), it was determined that the last movement of the EMV 412/416-061/085 with the power car 412-085 was registered in the train No. 8002 that finished its ride on August 03, 2017 at 07:10 at the station Batajnica. Since then until the removal of the speed-measuring tape, no movement with the power car 412-085 was registered.

The speed measuring tape was removed from the registering speed meter of the power car 412-061 on site. By processing the registered data (Data from the speed-meausring tape no. 3-488 as from August 04, 2017) it was determined that the train No. 8011 (EMV 412/416-061/085), after departing from the stop Karađorđev Park (August 03, 2017 at 07:40), crossed 1584 *m* without stopping at a speed of up to 66.5 *km/h*, after which it stopped in the station Vukov Spomenik at 07:42. After departing from the station Vukov Spomenik (at 07:43) the train No. 8011 accelerated and after moving for 594 *m* it reached the speed of 68.5 *km/h*. The train continued its ride and after crossing 148 *m* the speed went down to 62 *km/h*. At that moment, on the registering tape, on lines "A" and "B" - symbols of operation of the auto stop device - were registered, which are not listed in Table No. 4 of the Instructions on the Use of Speed Meters in Traction and Other Vehicles and Processing of the Registering Tape (Instructions 230 *"Official Gazette of the ZJŽ", No 6/80 and 8/90*) and after driving for 297 *m* the train No. 8011 stopped at 07:44.

Since this stopping until the removal of the speed-measuring tape, no movements of the train were registered. The speed-meter tape was removed when the front of the power car 412-061 was at *km* 4+080.

Based on the data from the speed-meter tape of the train No 8011, it was concluded that the maximum permitted speed on this part of the railway line (80 *km/h*) was not exceeded.

At the point of decoupling, on site, it was noticed that the vehicle coupling decoupled with the overhead line and electric connections between the power car 412-061 and the trailer 416-004. On parts of the decoupled coupling no traces of breakage or tearing of parts of the coupling were noticed.

By performing a control of the dimensions at the point of decoupling of the vehicle's coupling, which was done in the Technical and Passenger Station Zemun at the Maintenance Depo for EMV 412/416, it was determined that the dimensions at the point of the joint between the housing and the set of ring-forming springs are exceeding the specified limits.

3.5. Traffic operation and management

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

The operation of the train No. 8011 from Belgrade Centre - Pančevački Most was performed at block section lengths. Before the dispatch of the train No. 8011 from the station Belgrade Centre, clearance was obtained regularly for the train and in that sense there were no disturbances.

The train crew received in the accompanying documents all required 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 incident

Immediately before and during the respective incident, 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 incident in order to provide information that an incident occurred. The train driver of the train No. 8011 notified the train dispatcher at the junction and the stop Pančevački Most and the dispatcher at the operational centre of BG-VOZ.

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

After the incident happened, on the main arterial route on the railway line *E 66*: Belgrade Centre - Pančevo Main Station - Vršac - State Border - (*Stamora Moravita*), between the station Belgrade Centre and the junction and the stop Pančevački Most, the right track of the double-track line was closed for train traffic. Traffic on that part of the railway line was organised on one track, on the left track.

Due to the fact that the train No. 8011 stopped after the respective incident on the part of the railway line where the inclination amounts to 1.5‰ (a decline of 1.5‰, when looking in the direction of the train movement), parts of the decoupled train were secured so as not to move alone by placing manual braking stop blocks.

The evacuation of passengers from the train No. 8011 was performed as follows: on the same track (right track of the double-track line) behind the end of the train No. 8011, an empty EMV series 412/416 arrived, into which the passengers from the train No. 8011 moved, after which the EMV series 412/416 was moved to the station Vukov Spomenik. Until the arrival of the EMV series 412/416 with which they were evacuated from the site, passengers were in the EMV series 412/416 of the train No. 8011 under the supervision of the train conductor.

No other measures were taken to secure the place of incident.

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 and the conductor of the train No. 8011 had the legally stipulated rest before going to work and that they 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 effects on the incident, including the presence of physical or mental stress

For the railway staff, information was submitted based on which it is clear that the train driver and the conductor of the train No. 8011 were qualified and bodily and mentally fit to

perform their work. For the train driver of the train No. 8011 a certificate was issued by the Railway Directorate to confirm that his application was submitted and conditions were fulfiled that are required to issue the licence for the operation of a traction vehicle.

With the inspection on site and after an interview it was determined that the train driver was not physically 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 main arterial railway line *E 66*: Belgrade Centre - Pančevo Main Station - Vršac - State Border - (*Stamora Moravita*), between the station Belgrade Centre and the junction and the stop Pančevački Most was designed such that it satisfies, with regard to all parametres, the criteria for the safe operation of trains at speeds specified in the timetable booklet.

The railway line is equipped with APB devices, where train traffic is regulated in block sections.

For the purpose of traffic management, on the part of the railway line between the station Belgrade Centre and the junction and the stop Pančevački Most automatic block and protective signals are installed that show binary signalling signs. To protect the train, next to the signals active rail line balises are installed.

On the part of the railway line between the station Vukov Spomenik and the junction and the stop Pančevački Most, communication between the staff managing the traffic on the railway line and the staff in the traction vehicle is done by telephone via a local TT connection.

This railway line is equipped with RDV devices that are operational and with the help of which communication between the staff of the traction vehicle and the staff in the dispatch centre of BG VOZ is enabled.

The EMV is operated by a train driver by way of commands from the driver's cabs of the power car, which were designed when the EMV was manufactured. During its use, all defects noticed in the EMV on systems and operating gear were removed, so that in that sense no remarks or defects were registered.

In the designed technical and operating characteristics of the EMV series 412/416 and during its maintenance no remarks or defects were registered. In the accompanying documentation issued after the last regular repair, irregularities were determined in the sense that the dimensions on certain parts of the equipment were not within the specified limits, not even after the performed overhaul.

3.7. Previous incidents of similar nature

No data were obtained from the infrastructure manager “IŽS“a.d and from “Srbija Voz“a.d. about any decoupling of EMV of the series 412/416 in the previous period.

4. Analysis and conclusions

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

According to the Information no 2/2017-278 as from August 04, 2017 as submitted by "IŽS"a.d, on August 03, 2017 at 7:55, after passing the protective signal *Su 92* (*km* 3+717), on the main arterial railway line *E 66*: Belgrade Centre - Pančevo Main Station - Vršac - State Border - (*Stamora Moravita*), on the right track, in the tunnel, in the area of the junction and the stop Pančevački Most, the train No. 8011 from the system BG-VOZ decoupled (EMV 412-061/416-004/416-003/412-085).

The decoupling occurred between the power car 412-061 and the trailer 416-004, when the air hoses broke and both parts of the train had to force brake due to the emptying of the main overhead line. The position of the decoupled train in which the train was found is shown in figure 4.1.1.

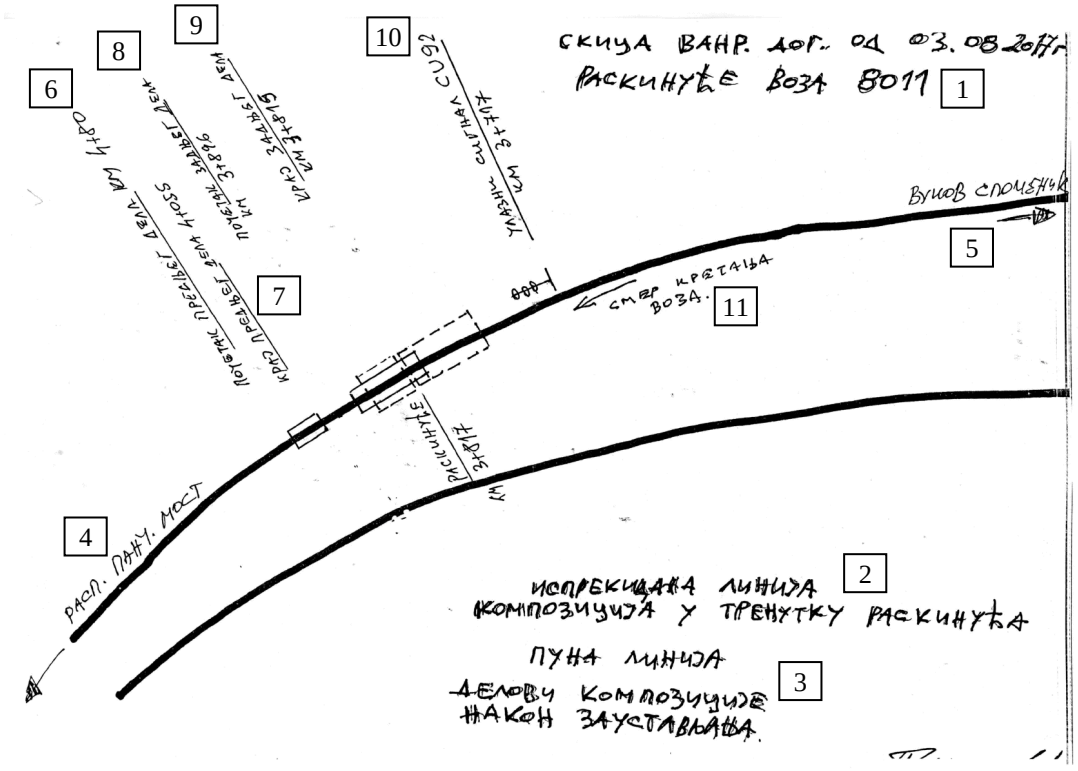


Figure 4.1.1: Sketch of the condition found at the place of the incident (source "IŽS"a.d.)

1 --- Sketch of the extraordinary occurrence on August 03, 2017 Braking loose of the train No. 8011
2 --- Dashed line – composition at the moment of decoupling
3 --- Full line – parts of the composition after stopping.
4 --- Junction Pančevački Most
5 --- Station Vukov Spomenik
6 --- Beginning of the front part, km 4+080
7 --- End of the front part, km 4+055
8 --- Beginning of the end part, km 3+896
9 --- End of the end part, km 3+819
10 --- Entrance (protective) signal Su92, km 3+717
11 --- Direction of movement of the train

4.2. Analysis of facts determined during the investigation

4.2.1. Analysis based on speed-meter tape records

Based on the letter no 3-488 dated August 04,.2017 "Information from the speed-measuring tape" of the Belgrade Train Traction Section from "Srbija Voz"a.d, it can be concluded that the decoupling of the EMV happened at a speed of 62 *km/h*, after which the power car 412-061 crossed 297 *m* until stopping (note: the assumed point of decoupling shown in figure 4.1.1. does not match the information from the speed meter tape and therefore it is not relevant). According to the position of the EMV after the incident, the rest of the train stopped 159 *m* behind the power car 412-061. The big difference in the stopping distances is partly the consequence of the smaller percentage of the braked weight of the power car in relation to the two trailers and power car that remained in the other part of the decoupled EMV. The other factor is the fact that from the moment of decoupling of the train until the moment when the train driver placed the brake valve into the position for fast braking, the main overhead line used the main tank to supplement air, which could have contributed to the prolongation of the stopping distance.

4.2.2. Review of the maintenance documentation

Pursuant to the Law on Safety and Interoperability (see item 3.3.1), "Srbija Voz"a.d, as the vehicle holder, is registered in the National Rolling Stock Register as the entity in charge of maintenance of the EMV series 412/416 and is therefore authorised to maintain itself its vehicles.

"Srbija Voz"a.d. laid down the method for maintaining EMV in its Instructions on the Maintenance of Traction Vehicles (see item 3.3.4).

Based on the records delivered by "Srbija Voz"a.d. it can be seen that periodic inspections were performed in the following time periods:

P1 – 13.09.2016
P1 – 12.10.2016
P12 – 14.11.2016
P1 – 22.12.2016 (Note: The P12 period includes works over several days in P12. The 30 days term ±15% for P1 was adhered to.)
P1 – 24.01.2017
P3 – 24.02.2017
P1 – 24.03.2017
P1 – 25.04.2017
P6 – 24.05.2017
P1 – 26.06.2017
P1 – 26.07.2017

Based on the documentation delivered, the following was determined for the main repairs:

- Section 412-061/416-004 has been in operation, after the performed regular repair, since October 02, 2012 and it has crossed 756746 *km*. The deadline for the regular repair has not expired.

- Section 412-085/416-003 has been in operation, after the performed regular repair, since October 02, 2012 and it has crossed 756810 *km*. The deadline for the regular repair has not expired.
- The regular repair of both sections of the EMV set was performed in the company "ŽELVOZ" Smederevo, which was, at that time, listed in the workshops' register.

Based on all above it is clear that the maintenance was done within the deadlines specified in the Instructions for the Maintenance of Traction Vehicles of "Srbija Voz"a.d. No. 4/2016-16-4 dated February 23, 2016.

4.2.3. Inspection and analysis of the decoupled coupling

After the incident, members of the working group have inspected the decoupled coupling, which belongs to the trailer 416-004, in the EMV Maintenance Depo in Zemun. It was determined that the entire set of the traction shaft with the nut onto which the external thread is placed, got out from the housing of the spring, in which the internal thread is fixed. Traces of deformation due to shear or other damage were not found on the internal and also not on the external thread (figures 4.2.3.1. and 4.2.3.2.).

Figure 4.2.3.1: Pulled out set of the draw bar (the thread part is encircled) demounted from the trailer 416-004

Figure 4.2.3.2: Thread of the housing of the coupling's spring from trailer 416-004

On the nut of the draw bar set, pins remained that serve to prevent self-unscrewing, which indicates that it did not unscrew itself. In the letter No. 19/2017 -1270 dated October 16, 2017, "Srbija Voz"a.d. submitted the Report on Determined Facts on the EMV 412/416-061/085. In the appendix to the records of the commission from the Sector For Rolling Stock Maintenance of "Srbija Voz"a.d, which was submitted to the working group, by performing measurements in four planes it was determined that the middle catch (wrap) of the threaded joint has a radius of less than 0.2 mm, which explains why traces of thread shear cannot be noticed.

In figure 4.2.3.3 the set of the tight coupling is shown. In the middle of the figure the correctly mounted coupling is shown in accordance with the Instructions for the Repair of Couplings Between Vehicles, which was prepared by the Institute "Kirilo Savić" in 2004, that is, such that the nut - 8 is tightened until the axial clearance of the draw bar with the spring in the housing of the spring -33 disappears. With the help of pins - 9 and screws - 20, 21 the nut -8 is protected from unscrewing itself.

Detail A shows the corresponding seating of the threaded joint, which is then practically unloaded or insignificantly loaded. If the set of the coupling during the train ride is exposed to the force of pressure, the nut - 8 is completely freed of load and is positioned anywhere in the space of the small mounting clearance (figure 4.2.3.3 down). If during motion the coupling is exposed to the tension force, the thread is touching the surface "a" and transfers the entire tension force (figure 4.2.3.3 up). Therefore, the threaded joint during its use is exposed to an unidirectional variable contact load that slowly causes its wear.

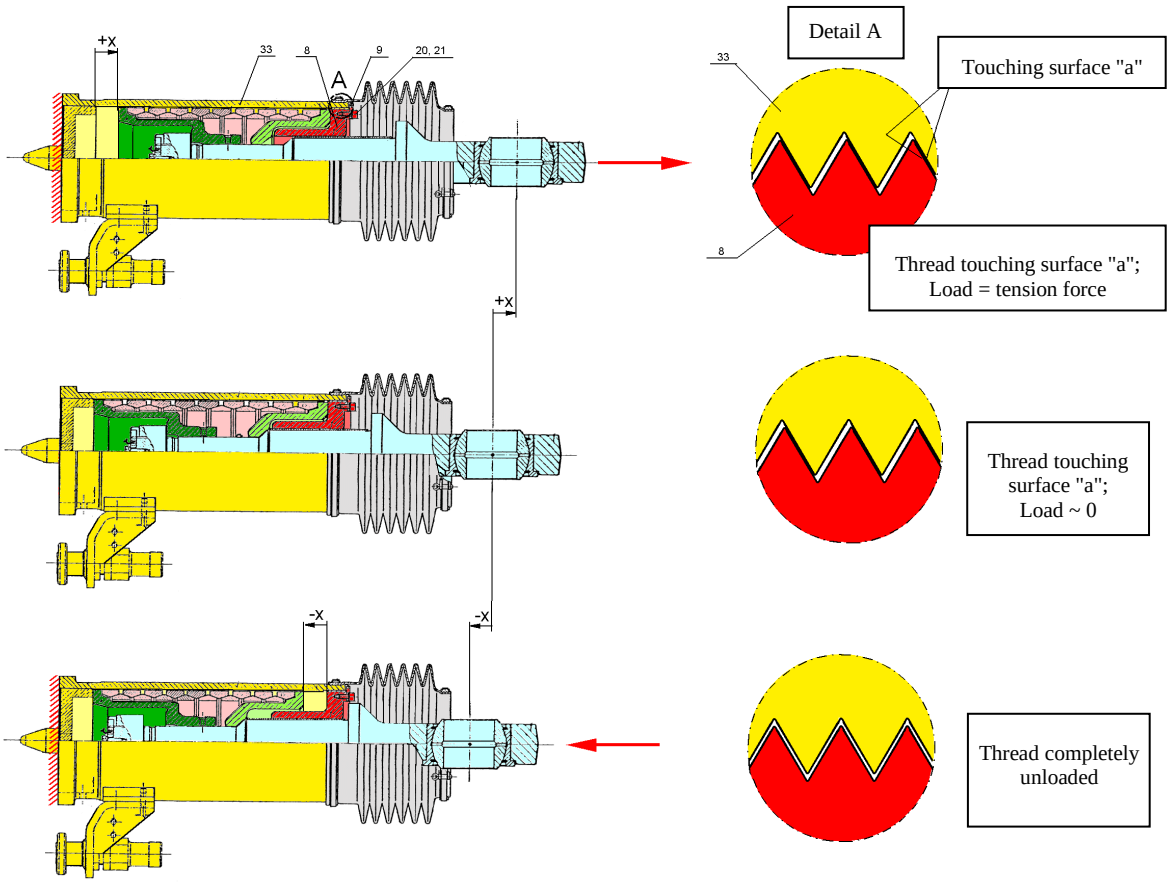


Figure 4.2.3.3: Operation of the threaded joint in use

If with the passing of time the thread is so worn that it does not have sufficient catch (wrap) of the external and internal threaded part, the entire set of the draw bar with the nut -8 can get out of the housing -33.

The existing constructive solution has no alternative way to transfer force (disassembly delimiter, catcher, protective plugs and similar), so the separation of the threaded connection leads directly to the breaking loose of the EMV, as has happened in the observed case. The other theoretical possibility to prevent the wear of the thread would be to preload it with a counter-nut in order to prevent the periodical complete unloading of the threaded joint and to eliminate thus its wear. The potential increase of thread pitches could also be a measure to increase the catch of the thread and to reduce the risk to break the connection due to wear.

With the records of the commission from the Sector for Rolling Stock Maintenance also measurement sheets IV: 594 244 were submitted for the control of the thread of the cylinder set and of the nut of the coupler from the last regular repair done in June 2012. In figure 4.2.3.4 the filled measurement sheet for one side of the trailer 416-004 is shown.

The dimension sheet in figure 4.2.3.4, as well as other five submitted measurement sheets, have several irregularities:

- the sheet contains only the nominal catch (wrap) of the threaded joint (d-D1=3.248 mm) per diameter (corresponds to 1.624 mm per radius), and the column ”*Measurement limit*“ is not defined, which is why it is not clear when the parts should be regenerated, so that such a measurement sheet is practically not usable;

- the measured value is entered into the wrong column ”*Measurement limit*“;

- instead of the required six measurements in different axial sections, only one measurement is entered (in all six sheets);

- the value of the measurement A1 is larger than A, which is impossible, because the coupling would already have arrived to the repair shop disassembled (this is the case in five out of six submitted sheets!);

- in the column “Needs repair“ in all six sheets the sign “+“ was entered, which means that the threaded joint should have been regenerated, and the column “measurement of the regenerated part” is empty, which means that the regeneration or replacement of parts of the joint has probably not been performed.

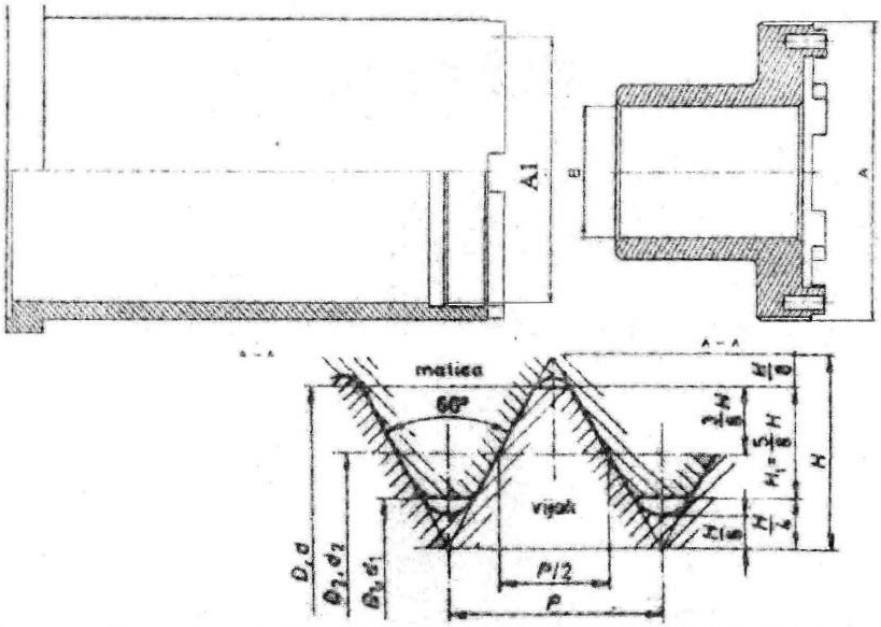
Based on these facts it can be assumed that the thread was not even measured, but that the sheet was only formally filled. The control did not determine incorrect data in five measurement sheets, and it also did not determine the fact that there are no data about measurements of the regenerated part, although in the column “Needs repair“ all sheets contain the sign “+“.

The observed EMV crossed ca. 757000 *km* since the last regular repair in 2012 until the incident, according to the data submitted by “Srbija Voz“a.d. It is not possible to determine what was the catch of the critical threaded joint after the repair, but it is clear that it was not enough for the threaded joint to safely perform its function until the next regular repair.

Smederevo	MEASUREMENT SHEET	IB: 594 244
	CYLINDER AND NUT SET (Coupling between vehicles) M – 12	Vehicle series and number 416-004

Evaluation of the repair need	
Safe and operational	
Needs repair	+
New	

1 Br : 2. 013



Designation of the measurement	Nominal measurement	Measurement limit	Actual measurement 1	2	3	4	5	6
Measurement of the new part								
A(d)	M 175	175						
A1 (D1)	171,752	175,7						
B	Ø 80 $^{+0,030}_{0}$	Ø80,01						
Measurement of the regenerated part								
A(d)	M 177							
A1 (D1)	173,752							
B	Ø 80 $^{+0,030}_{0}$							

Measurement of the new part

d – D1 = 175- 171,752 = 3,248

Measurement of the regenerated part

d – D1 = 177-173,752 = 3,248

Measured	Date	Controlled	CRB
	11. 6. 12		

Figure 4.2.3.4: Filled measurement sheet for the threaded joint of the tight coupling of the trailer 416-004

4.2.4. Analysis of cycles and periods between regular repairs of the EMV 412/416

According to the original documentation of the manufacturer (EMV series 412/416, Usage Instructions, book 1, Energomaseksport), the maintenance cycle and maintenance periods were specified as shown in figure 4.2.4.1 (left). On the right side of figure 4.2.4.1 the cycle and deadlines were shown as modified based on the practice in the JŽ and as defined in Rulebook 241 from 1984 (see item 3.3.3).

It has been observed that the original overhaul TP-3 at 350000 *km* could not be included in the inspection P12, and the Rulebook 241 introduced intermediate repairs at 450000 *km* ±15% only based on kilometres crossed, however at the latest five years after the previous repair, based on the time criterion. The intermediate repair, based on the definition from Rulebook 241 (see item 3.3.3), means partial or complete repairs of sets and units that are not capable of operating without failures until the next regular repair.

The now applicable Rulebook on the Maintenance of Traction Vehicles (see item 3.3.4) defines intermediate repair in a similar way. The tight coupling and the threaded joint, which is the cause of the incident dealt with in this report, belong to this category. So, in accordance with the previously applicable Rulebook 241 it should have been disassembled at every 450000 *km*, measured following the measurement sheet from figure 4.2.3.4 and overhauled or replaced as necessary. The obligation to disassemble and replace worn parts of the coupling during repairs is defined also in the applicable Rulebook on Rolling Stock Maintenance (see item 3.3.2).

Original documentation:

Type of overhaul		Deadline or km crossed
Technical maintenance	TO-1	At the handover of the train and during use
	TO-2	Not less than 48 hours
	TO-3	5 days
Current overhaul	TP-1	50 days
	TP-2	175000 km
	TP-3	350000 km
Factory overhaul	intermediary	700000 km
	general	2100000 km

Rulebook 241 from 1984 (additionally printed in 1995):

Type		Time span or km
Service inspection		Every day
Inspection	P1 P3 P6 P12	30 days 90 days 180 days 360 days
Repair	Intermediary	450000 km, maximum 5 years
	General	900000 km, maximum 5 years since the intermediate repair

Figure 4.2.4.1: Maintenance cycles for EMV 412/416 according to the original documentation and according to Rulebook 241

With the communication no. 109-67/87 dated 25.09.1987 the Sector for Mechanical Affairs of the ŽTO Beograd submitted to the Sector for Rolling Stock of the ZJŽ a proposal for the amendment of the Rulebook 241, with which it was requested to increase the deadlines for repairs from **450000** *km* ±15% to **600000** *km* ±15%.

With the communication No. 115/87-50 dated November 23, 1987 the Sector for Mechanical Affairs of the ŽTO Beograd, a Commission was formed for the technical inspection of the EMV

412/416 for a trial extension of the deadlines for main repairs. In the accompanying communication no. 115/47-99 dated November 23, 1987 it is stated that the commission should perform a technical inspection during some of the control inspections and create a proposal based on that. The task of the commission was to monitor the condition and the behavior of the EMV in use and to submit, five days following the crossing of 600000 *km* ±15%, a report so that a final decision could be made with regard to the change of intervals for regular repairs in the Rulebook 241.

With the decision No. 175/88-2 dated January 28, 1988, the Sector for Mechanical Affairs of the ŽTO Beograd, referring to the consent given by the ZJŽ (letter No. 29-57/87 of the ZJŽ dated October 13, 1987, which was not known to this commission for incident investigation), and referring to the minutes of the commission No. 2985 dated January 18, 1988 about the performed technical inspection (this letter was also not provided to this commission), adopted a decision to implement a trial extension of the deadline for intermediate repairs for EMV 412/416-033/034, this being **600000** *km* ±15%.

Further submitted documentation and letters:

- Communication No. 19/98-1047 of the Sector for Rolling Stock Maintenance of ŽTP "Beograd" dated February 12, 1998.
- List from inspection P6 dated June 14, 1995 for EMV 412/416- 061/062
- Minutes from the Commission's technical inspection of the EMV 412/416-061/062 dated August 14, 1995.
- Communication no. 0028/95-1111 of the Sector for Rolling Stock Maintenance of ŽTP "Beograd" dated June 15, 1995.

refer to the trial extension of the deadline for the main repair of the EMV 412/416-085/086 and EMV 412/416- 061/062 after **700000** ***km*** ± 15% in 1992.

Based on the communication it can be seen that the decision on the extension of the deadline was made based on inspection P6, during which the tightness of the main line and tank was checked, the functionality of the brake was tested and a test ride on the route Zemun - Batajnica - Zemun was performed.

In the communication No. 19/17-1213 dated October 02, 2017 submitted by the deputy director of the Sector for Rolling Stock Maintenance of "Srbija Voz"a.d, it is stated that according to the Instructions of the manufacturer of EMV 412/416 the time period between two regular repairs must not exceed 700000 *km*, and that according to the new Instructions on the Maintenance of Traction Vehicles of "Srbija Voz"a.d. dated February 23, 2016, the deadline between regular repairs amounts to a maximum of **1000000** *km* ±15%.

In the Instructions for the Maintenance of Traction Vehicles it is also specified (see item 3.3.4) that "the person in charge of maintenance can make a decision that crossed *km* between two regular repairs can be more or less depending on the technical condition of the vehicle", whereby no limit whatsoever is given for such deviation in kilometres and also no criteria are mentioned for the assessment of the technical condition, but only a maximum time period is given of as much as 15 years!

In summarising the entire sequence of activities that was presented under this item it can be concluded that the original maintenance cycle as specified by the manufacturer was never applied. With the Rulebook 241 a maintenance cycle was specified that was adjusted to the practice in the JŽ (see figure 4.2.4.1), and which can be deemed to be closest to the original requirements, where, as compared to the original cycle, inspections P1, P3, P6 and P12 were

introduced in shorter time periods than those specified by the manufacturer, and the intermediate repair is introduced after a somewhat longer time period than the overhaul TP3 from the original documentation.

The trial extensions of the time periods between regular repairs were not accepted by ZJŽ as definite and were not changed in Rulebook 241 (see item 3.3.3), so they were applied while bypassing the applicable Rulebook 241.

Also, there was no analysis of extraordinary repairs or of additional works and replaced parts that were not foreseen in periodic inspections.

The end result is that the deadline between regular repairs of 450000 *km* or, expressed in time, a maximum of five years, as defined in Rulebook 241, was increased with gradual internal trial extensions, to 1000000 *km* (according to the decision of "Srbija Voz"a.d. also more kilometres are possible) or a maximum of 15 years. All extensions were adopted based on inspections. However, during the inspections the condition of parts of sets subject to wear or exposed to other damage or ageing could not be determined. Also, no assessment of safety risks that occur by extending the periods between repairs was performed. That can be done only after determining the condition of all safety-relevant sets during the repair, that is, after disassembling, cleaning and performing measurements in according with the measurement sheets, in some cases also after performing tests on a press or similar, or after performing controls as stipulated in instructions for regular repairs.

Therefore, the mentioned practice of extending time periods for regular repairs cannot be accepted.

It is also a fact that no manufacturer allows for maintenance period tolerances such as exist in the analysed regulations and instructions, and data indicate that tolerances were used in practice, practically without any exception, for additional extensions of deadlines between regular repairs.

4.2.5. Analysis of the Instructions for the Maintenance of Couplings between Vehicles

In the submitted Instructions for the Maintenance of Couplings between Vehicles (Institute "Kirilo Savić", Belgrade 2004), in item 7 - "Overview of activities of the KPO of the ŽTP" - it is specified that "during a repair of the coupling between vehicles a check by KPO of the ŽTP is not necessary. The KPO will perform an inspection in accordance with item 6, after the completion of the coupling's repair".

Item 6 foresees the check of the functioning of the mounted coupling after the completed repair.

Such a provision is in conflict with the Working Instructions for Control and Receiving Bodies of JŽ ("*Official Gazette of ZJŽ" No. 1/2003*), which is listed by "Srbija Voz"a.d. in its Rules of Procedure of its Safety Management System, in Annex 4, as a bylaw that it applies. In items 3.2.3 and 1.2.1 of the Working Instructions for Control and Receiving Bodies of JŽ, tasks of the KPO are defined. Among other, one of their tasks is to check the works performed in accordance with the technical documentation, which includes measurement sheets.

4.3. Conclusions about the causes of the incident

4.3.1. Immediate cause of the incident

Based on the analysis performed, it can be concluded that the immediate cause of the incident is the wear of the threaded joint between the nut of the draw bar set and the housing of the tight coupling between vehicles, due to which the threaded joint uncoupled during the ride.

4.3.2. Basic causes resulting from skills, procedures and maintenance

On the occasion of the last regular repair, the inspection of the threaded joint was not properly performed, nor was it properly controlled. The check list for the threaded joint does not have a specified measurement limit value, which means that it is not clearly defined when the threaded joint should be repaired or replaced with a new one.

4.3.3. Causes based on the requirements defined in the legal framework and the application of the safety management systems

The deadlines for regular repairs, which are specified in the then applicable by laws (Rulebook 241) were not abided by.

The maintenance cycle, and in particular the deadlines for the performance of regular repairs were extended in trials without a proper technical justification. Decisions to extend the time periods until the next repair were made based on inspections, not based on measurements of critical dimensions of parts subject to wear and without any control and determination of the condition of parts subject to damage or ageing during the repairs. This led to the situation that the period between two regular repairs was long enough for the threaded joint to experience such wear that exceeds the limit that guarantees safe operation until the next regular repair.

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 respective incident happened, the Director of the Sector for Rolling Stock Maintenance of “Srbija Voz“a.d ordered an extraordinary control of couplings between vehicles on all EMV of the series 412/416 that are used in traffic and a control of the documentation after performed overhauls on all EMV (communication from the Sector for Rolling Stock Maintenance no 19/2017-982 dated August 04, 2017).

The extraordinary control of couplings of vehicles was done in the Rolling Stock Maintenance Section Belgrade, the EMV Maintenance Depo in Zemun, during the day shift on August 05, 2017 and during the night shift on August 05/06, 2017 on all EMV of the series 412/416 that are operational. The Rolling Stock Maintenance Section Belgrade informed with

the communication No. 39/2-717 dated August 07, 2017 the Sector for Rolling Stock Maintenance about the performed extraordinary control of couplings of vehicles. The inspection of the couplings is limited to external elements of the couplings, as their disassembly, as well as overhaul is beyond the possibilities of the workshop and was never done in the rolling stock maintenance workshops of "Srbija Voz"a.d.

The report on the performed control of documentation after the overhaul on all EMV was not submitted to CINS.

After the respective incident occurred, "Srbija Voz"a.d. submitted Measurement Sheets for parts of the coupling between vehicles, as follows: housings, cylinder and nut set, draw bar and axle, issued on October 23, 2017 and Measurement Sheets for the short coupling of EMV 412/416 no. *ZR013*, *ZR014*, *ZR015*, *S011*, *S024* and *S026*, issued on October 30, 2017 in the company "Šinvoz" from Zrenjanin.

The EMV 412/416-061/085 was withdrawn from service after the respective incident for the purpose of inspection and damage repair. It was placed back in service on December 01, 2017 at 15:00 h.

6. Safety recommendations

For potential safety improvement on the railway and prevention of new accidents, CINS issued the following safety recommendations:

"Srbija Voz"a.d:

SR_01/18 "Srbija Voz"a.d. should make changes in the measurement sheet IB:594 244 so that the wording "Measurement limit" is replaced with "Measurement limit *d-D1*" and based on a corresponding analysis (calculation and similar) it should define and enter in the measurement sheet the limit value for safe operation between two regular repairs (explained in item 4.2.3).

SR_02/18 "Srbija Voz"a.d. should consider the possibility to make structural changes on the couplings between vehicles during regular repairs of EMV 412/416 in order to provide for a back-up alternative force transmission in case that the threaded connection is separated, or to apply other measures to reduce the risk of separation of the threaded joint (explained in item 4.2.3).

SR_03/18 "Srbija Voz"a.d. should, in the submitted Instructions for the Repair of Couplings between Vehicles, which was produced within the Project for the preparation of the technical and overhaul documentation for the electric multiple unit of the series 412/416 by the Institute "Kirilo Savic" from Belgrade in 2004, align item 7 with the Working Instructions for the Control and Receiving Bodies of JŽ (*"Official Gazette of the ZJŽ", no 1/03*), (explained in item 4.2.5).

SR_04/18 "Srbija Voz"a.d. should inform the control and receiving bodies about this case and take measures to dedicate special attention during regular repairs to the control of works performed on components that have a significant impact on safety.

SR_05/18 "Srbija Voz"a.d. should harmonize its Instructions for the Maintenance of Traction Vehicles no.4/2016-16-4, dated February 23, 2016, with Article 34, paragraph 2 and Article 36 of the Rulebook on Rolling Stock Maintenance no. 340-382-7/2015 dated December 04, 2015 (*"Official Gazette of RS", no. 101/15*), or to thoroughly reexamine the deadlines for regular repairs by taking the original technical documentation as a basis and to change them only after performing a risk evaluation and risk assessment based on information about the determined condition (especially measurement limits) during previous regular repairs, as well as perform analyses of extraordinary repairs and unplanned works.

SR_06/18 "Srbija Voz"a.d. should perform a risk assessment for passenger transport in EMV of the series 412/416 where the extension of the deadlines for regular repairs was done before a previously performed risk evaluation and risk assessment based on the extension of these deadlines, as specified in paragraph 1, under 2) in Article 36 of the Rulebook on Rolling Stock Maintenance no 340-382-7/2015 dated December 04, 2015 (*"Official Gazette of RS", no.101/15*) and in paragraph 2, item 4.13. of the Rules of Procedure of the Safety Management System of "Srbija Voz"a.d. (due to the incident that occurred).

To the Railway Directorate:

SR_07/18 The Railway Directorate should reexamine the content of the Maintenance File for EMV 412/416 and take measures from its area of competence, as the changes of the maintenance conditions specified by the manufacturer were not performed in accordance with Article 36 of the Rulebook on Rolling Stock Maintenance no 340-382-7/2015 dated December 04, 2015 (*"Official Gazette of RS", no 101/15*).