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"AIRCRAFT, MARITIME AND RAILWAY ACCIDENT INVESTIGATION"
DIRECTORATE (AMRAI)

FINAL REPORT

from

technical investigation of a railway accident – derailment of a car from international fast train
№ 465 while passing in transit through the third track of Raduntsi station on 03.09.2013



December 2013

I APPROVE:

TO

**MR. DANAIL PAPAZOV
MINISTER OF TRANSPORT,
INFORMATION TECHNOLOGY AND COMMUNICATIONS**

FINAL REPORT

Regarding: *Technical investigation of a railway accident - derailment of a car № 51 75 5040 012-4 from international fast train № 465 while passing in transit through the third track of Raduntsi station on 03.09.2013 going in direction Bucharest - Istanbul.*

DEAR MR. PAPAZOV,

The Commission for the investigation has performed an inspection of the accident site, which was continued in Train car maintenance shed Gorna Oryahovitsa as well. They conducted personal interviews with everyone involved in the accident, including the conductors in service of the Turkish and Romanian sleeping cars. For the quick clarification and establishing of the facts and circumstances, two external experts have been included in the Commission. In the course of investigation the report presented by the Task Force as analyzed, additional materials and documents were requested, additional technical expert report was prepared by an independent laboratory on determining the speed of the train; there was a new detailed measuring of the railroad parameters in the accident zone and external experts statements were presented.

1. Established facts and circumstances in the course of the investigation.

On 03.09.2013 from Ruse Station leaves international fast train (IFT) № 465 comprising 3 couchette cars with 27 passengers and total mass 145 tons, serviced by electric locomotive № 44085.9, with locomotive crew locomotive driver and locomotive assistant driver and transport crew train master and train conductor. The train runs on schedule for train movement for direction Bucharest-Istanbul.

At 21:03 hrs. IFT № 465 departs from Krastets station, as evident from the decoding and technical expertise of the speedometer tape of the electric locomotive. After the speed has reached 32 km/h three consecutive hold-backs were performed, whereby the speed decreases to 25 km/h, after which the speed increases and reaches 62 km/h. For 3050 m the train moves along 24 ‰ incline in “brake” mode and as a result the speed decreases to 38 km/h. The train moves with this speed for 3.1 km, after three short hold-backs the speed decreases to 20 km/h and then increases to 25 km/h.

At 21:22 hrs. the traffic director in Raduntsi station prepares the route for IFT № 465 to Dabovo station along 3rd entrance-departure track with open entrance and exit signal, without the train stopping at the station.

At 21:28 hrs. while entering 3rd track of Raduntsi station the train is moving with 25 km/h. From km 212+220 before the exit traffic light **B₃**, the locomotive driver feels a pull and the speed abruptly decreases until it reaches 0 km/h. At 21:29 hrs. the train stops at the exit switches of Raduntsi station at km 212+292 without the locomotive driver attempting “quick braking”. Due to climbing of the flange on the rail of axle 1, right wheel of the third car, the car derails with the two axles of the first truck. The locomotive driver and the train supervisor ascertain a derailment of car № 51 75 5040 012-4 and the fact that a part of the switch has punctured the floor of the car and has

penetrated sleeper compartments № 8 and № 9, which were empty of passengers. The locomotive and transport crews immediately inform the authorities and the train passengers of the accident.

At 21:28 hrs., the Traffic Director of Raduntsi station sends the transit train № 465, along the 3rd track without following its departure from the station and starts preparing the route for freight train № 40592, which has been waiting on track 4 to move towards Krastets station. After going back to the hardware room, he sees on the display that train № 456 is still next to the exit switches of the station. Arriving at the spot, he receives information from the locomotive engineer that the train has derailed with the first truck of the third car. After the inspection it was determined that only the first car can continue travelling along its course, about which he informed the train inspector.

At 22:10 hrs. with order № 21 of the senior train dispatcher who was substituted by the Operative transport management in Gorna Oryahovitsa it is ordered the derailed couchette car № 51 75 5040 012-4, property of the Turkish railways, and couchette car № 50 53 7131 006-9, property of the Romanian railways, to be decreased from the international fast train № 465, due to linkage of the buffers between them, after which the train to continue its movement to Istanbul.

At 22:30 hrs. after transferring the passengers and testing the brakes, IFT № 465 departs with one car from Raduntsi station with 86 minutes delay.

At 00:10 hrs. on 04.09.2013 with automobile “Mercedes 207 D” from National Railway Infrastructure Company specialized repair vehicles arrive at the accident site to disconnect the cars and to pick up the derailed car.

At 01:30 hrs. after coordination and permission from the investigative bodies of the MoI, repair works were commenced. The cars were disconnected and the derailed car was lifted up on the rails at 5:05 hrs.

At 16:20 hrs. on 04.09.2013 after performed accident repair works on the railroad of 3rd track and 3rd switch, the train traffic was restored according to schedule.

By order of the Commission for the investigation on 04.09.2013 car № 51 75 5040 012-4 and car № 50 53 7131 006-9 were directed towards Gorna Oryahovitsa station and after their arrival car № 51 75 5040 012-4 was delivered to the train car repair shed for inspection and technical parameters' measurements.

2. Officials involved in the case.

2.1 Locomotive crew:

2.1.1. “Locomotive driver” of electric locomotive № 44085.9 from locomotive depot Gorna Oryahovitsa, “BDZ – Passenger services” EOOD – 32 years of service;

2.1.2. “Assistant locomotive driver” of electric locomotive № 44085.9 from locomotive depot Gorna Oryahovitsa, “BDZ – Passenger services” EOOD – 7 years of service;

2.2. Transport crew:

2.2.1. “Train master” from Transport service Ruse, “BDZ – Passenger services” EOOD – 1 year of service

2.2.2. “Train conductor” from Transport service Ruse, “BDZ – Passenger services” EOOD – 15 years of service

2.3. Train station staff:

2.3.1. “Traffic director” Raduntsi station, employee in "Train Traffic and Station Activity Management" (TTSAM) Gorna Oryahovitsa, National Railway Infrastructure Company – 5 years of service

2.3.2. “Assigned switch-man” Raduntsi station, employee in TTSAM Gorna Oryahovitsa, National Railway Infrastructure Company – 26 years of service

2.4. Other staff

2.4.1. “Railway section chief” – Railway section, Gorna Oryahovitsa, National Railway Infrastructure Company – 21 years of service

2.4.2. “Train car mechanic inspector” (TCMI) – Car inspection division (CID), Ruse - 5 years of service;

2.4.2. TCMI-CID Ruse - 27 years of service;

2.4.3. TCMI-CID G. Oryahovitsa - 28 years of service;

2.4.4. TCMI-CID G. Oryahovitsa - 3 years of service.

3. Physical status of the officials involved in the case.

All officials involved in the case were provided with the necessary period of rest before starting work, according to the provisions of the Labour code and Ordinance № 50 of 28.12.2001 for the work hours of managerial and operational staff, employed in the service of transporting passengers and freight in the railway transportation system (renewed in State Gazette (SG), issue 4 of 2002, amended in SG, issue 46 of 2004, amended and supplemented in SG, issue 99 of 2006.

All officials involved in the case received a pre-shift instruction and have declared that are alert, well-rested and are not under the influence of alcohol or other intoxicating substances.

The officials involved in the case have valid psychological examination certificates, which have not expired.

4. Competence and qualification documents.

All officials involved in the case possess the necessary documents for competence, professional qualification for their respective position and a certificate for holding said position.

5. Actions of the officials before and during the accident.

All officials immediately before and during the accident were acting in accordance with the approved regulations and internal rules, governing the safety of transport by rail.

The locomotive and transport crews have undertaken all measures to inform the relevant authorities for the railway accident and to move the passengers from the two cars into the third, which continued along its direction.

6. Circumstances preceding the accident in terms of railroad, safety equipment, overhead contact lines, rolling stock, etc.

Meteorological weather data affecting the visibility of the signals:

- air temperature +18 °C;
- weak wind with a speed of 4 m/s;
- during night time.

Railroad: **Intact by documents.**

Condition of station safety equipment (SSE) and semi-automatic blocking between the stations (SAB): intact, no relation to the occurred railway accident.

Overhead contact line: intact, no relation to the occurred railway accident.

Train forming station: Bucharest.

Communications technology and telecommunications: technically intact.

Profile, geometry and situation of the railroad: The train has stopped in a flat sector with a profile of the 3rd track 0 ‰, a curve with a radius R = 200m and cant of H = 45 mm.

Rolling stock:

Electric locomotive № 44085.9 was technically intact, with technically intact undercarriage, brake system, light and sound signalling equipment, in accordance with the technical standards and requirements, as evidenced by the entries in the relevant logs, presented in the report of the Task Force.

Coaches – 3:

- № 51 75 5040 012-4 – owned by the Turkish railways;
- № 50 53 7131 006-9 – owned by the Romanian railways;
- № 51 52 1340 117-8 – owned by the Bulgarian railways.

7. Compliance with the procedures and technologies employed by the State Enterprise "National Railway Infrastructure Company" before and during the accident.

The procedures and technologies of work in the unit "Train Traffic and Station Activity Management" (TTSAM) – Gorna Oryahovitsa, which is in the structure of the SE "NRIC", before and during the accident have been met, as evidenced by the report of the Task Force and the appendices thereto, as well as by the additionally requested materials and the conducted line-ups on the spot with the persons involved in the accident by the Commission for the investigation.

8. Compliance with the procedures and work technologies for servicing of the rolling stock in the system of the transport operator before and during the accident.

The international fast train № 465 was provided with the necessary brake mass and was equipped with the necessary train documents. The locomotive and transport crews were equipped with business mobile phones.

In the inspection of the technical documentation, no violations of the regulations for factory and maintenance shed repairs and maintenance of electric locomotives and of the organization, procedures and technologies of repairs works related to the derailment were identified and registered.

In the inspection of the technical documentation, it was found that couchette coach № 51 75 5040 012-4 of Bcm series, owned by the Turkish railways (TCDD) had been produced in 1989 at the factory TUVASAS, Turkey, and it had passed revision REV Ada on 04.11.11.

9. Condition of the railway infrastructure and the rolling stock before, during and after the accident.

In the protocol № 08/23.08.2013 prepared by a six-month inspection committee for performed technical inspections of railway facilities and devices in the Raduntsi station under Art. 402 of the "Rules of Technical Operation of the Railway infrastructure" of the SE "NRIC" following results were recorded:

1. Tracks

- track № 1 – technically intact;
- track № 2 - technically intact;

- track № 3

- **fixed element, broken coach screws before the exit signal – at the side of Dabovo;**
- **responsible person: head of railroad section;**
- **deadline for removal: 05.09.2013 – executed on 04.09.2013**

- track № 4 - technically intact;
- track "Stopping" - technically intact.

2. Switches

- switch № 1 – technically intact;
- switch № 2 – technically intact;
- switch № 3 – technically intact;
- switch № 4 – technically intact;
- switch № 5 – technically intact;
- switch № 6 – technically intact;
- pre-performed manual measurements of tracks and switches – they meet the technical standards – 08.22.2013, signed;
- transitional bridges – present

It was found that the railway infrastructure before and during the accident was intact in accordance with the documentation.

As a result of the accident, multiple damages on the track were found, as detailed in p. 10 below.

Before the accident, the electric locomotives № 44085.9 and the coaches of IFT № 465 were intact.

As a result of the accident, damages to couchette coach № 51 75 5040 012-4 were found, as detailed in i.10.

10. Consequences of the accident.

10.1. Casualties – none;

10.2. Injured with traumas – none;

10.3. Faults and damages caused to the rolling stock:

10.3.1. Coaches:

Passenger coach № 51 75 5040 012-4, type Bcm – owned by TCDD:

- broken welds and deformed buffer mounted on the car body at axle bearings № 5 and № 6 /bogie at the side of the handbrake/;

- deformed transitional bridge, at the side of the handbrake;

- broken and deformed plate of the guide, at the side of the handbrake;

- deformed front wall along the entire height, at the side of the handbrake;

- broken and deformed crossbeam under the car body of the coach under compartments № 8 and № 9;

- deformed crossbeam under the car body of the coach under compartments № 8 and № 9;

- deformed longitudinal beam and side wall of the car body /about 45 mm/ under compartment № 9;

- broken and deformed bar and mount of the drive for the cabinet for high power electrical heating;

- pierced in the floor of the coach under seats with numbers № 91, № 93 and № 95 in compartment № 9;

- deformed and torn off heater under seats № 91, № 93 and № 95 in compartment № 9;

- deformed and torn off mount, bed and seats with numbers № 91, № 93 and № 95 in compartment № 9;

- deformed and broken bed above seats № 91, № 93 and № 95 in compartment № 9;

- pierced separating wall between compartments № 8 and № 9;

- deformed and broken bed above seats № 82, № 84 and № 86 in compartment № 9;

- broken mirror in compartment № 8;

- on the surface of the spherical part of the slider of the coach, dints can be observed, resulting in damage of its geometry;

- there are also dints on the upper part of the slider to the car body of the coach.

The damages to the passenger coach amount to 4711 BGN without VAT.

10.3.2. Electric locomotive:

Electric locomotive № 44085.9 – owned by „BDZ – Patnicheski prevozi” EOOD: no damages.

10.4. Faults and damages caused to the railway infrastructure

10.4.1. Railroad and facilities:

As a consequence of the derailed coach in Raduntsi station before switch № 3, the following materials and facilities have been damaged and replaced, as follows:

- semi-tongue part RL 300 S49 at switch № 3 – 1 piece;

- intermediate rail type S 49 at switch № 3 – 11 m;

- normal wooden traverse – 5 pieces;

- fastening kit GEO – 50 pieces;

- fish bolts and nuts – 50 pieces;

- coach screws - 100 pieces.

The damages to the railway and the facilities amount to 2,465.23 BGN without VAT.

10.4.2. Safety equipment and communications, radio connections, power supply: no damage.

- 10.4.3. Contact network: no damage
 10.4.4. Other damages and losses: no damage.

10.5. Interruption of traffic:

Due to the derailment of coach № 51 75 5040 012-4 from train № 465 in the Raduntsi station before switch № 3 and covered distances on the side of Dabovo station, the traffic on all tracks was suspended from 21:29 hrs. on 03.09.2013 to 05:15 hrs. on 09.04.2013.

10.6. Caused delay of trains:

10.6.1. Cancelled trains:

- train № 40623, Gorna Oryahovitsa – Tulovo
- train № 40702, Tulovo – Gorna Oryahovitsa;
- train № 40669, Gorna Oryahovitsa – Tulovo

10.6.2. Diverted trains:

- train № 40669 /DB Schenker/, Gorna Oryahovitsa – Polikraishte – Resen – Yasen.

10.6.3 Assigned trains:

- train № 40992 /loc. № 06127/ Dabovo – Raduntsi;
- train № 40953 /loc. № 06127/ Raduntsi – Dabovo.

10.7. Traffic of restoration vehicles:

10.8.1. Restoration train: no traffic.

10.8.2. Other restoration vehicles:

At 0:10 on 09.04.2013, a specialized vehicle GAZ and a specialized vehicle "Mercedes 207 D" of SE "NRIC" arrive on the site of the accident to lift the derailed coach.

11. Analysis of the causes that led to the railway accident.

From the inspections, the additionally provided materials and the additional measurements of the railroad and the derailed coach, it is evident that the derailment of a passenger coach № 51 75 5040 012-4 from the composition of the IFT № 465 happened at 21:29 at km 212+220 during a transit passing on the 3rd track of the Raduntsi station in the direction of Dabovo station with standard route prepared.

The technical parameters, the mechanical characteristics and the bearing capacity of the railroad change during operation and should be checked in laden condition with a track recording laboratory in accordance with the "Rules for Ongoing Maintenance of Railroad" established in the SE "NRIC". As it can be seen from Section III of the Statement of Findings of 09.04.2013 of the Task Force on the condition of the railroad, no measurements made by a track recording laboratory on the 3rd track have been registered. In the attached photocopies of handwritten entries and of a notebook – Controller’s calendar from Gorna Oryahovitsa Railway Section on the parameters of the railroad at the Raduntsi station and the Scheme of the Raduntsi station, differences were established in the data on the situational and the vertical alignment position of the railroad. According to the submitted Statement of Findings on the condition of the railroad, the longitudinal slope of the track is 0 ‰, while in the plan, the elevation point (km 212 +220) is located in a circular curve with a radius R = 200 m and an cant of H = 45 mm.

The upper structure of the railroad is of the joint type with rails S49, in a combination of wood and concrete traverses - CT 3 and CT 4 with fastenings of K type.

Pursuant to the requirements of p. 3.1.3 of the Tolerances in the wheel-gauge of a railroad from the "Technical Standards for Planning and Maintenance of the Upper Structure of Normal Railway Lines (1435 mm)", the following tolerances shall be allowed in wheel-gauge of railway lines, depending on the speed:

Speed, km/h	Tolerance, mm
V ≤ 100	- 4 +13
from 100 to 120	- 4 + 8
from 120 to 140	- 4 + 5
from 140 to 160	- 4 + 4

V > 160	- 2 + 2
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In the curves of the railroad, the wheel-gauge increases (amplification is given) according to the radius of the curve. The data for amplification for curves R < 300m are given in the following table:

Amplification of curves					
Radius, m	R = 125 to R < 150	R = 150 to R < 180	R = 180 to R < 250	R = 250 to R < 300	R > 300
Amplification, mm	20	15	10	5	0

In this case, the railroad at the elevation point is in a circular curve with a radius R = 200 m and it is therefore necessary to give an amplification of the inner rail string of 10 mm. The results presented by the Task Force with the Statement of Findings on the measurements show that in the same, variations in the tolerance in the amplification and narrowing of the wheel-gauge have been allowed.

Pursuant to the requirements of i 3.2.4.10. Tolerances in the cant from the "Technical Standards for Planning and Maintenance of the Upper Structure of Normal Railway Lines (1435 mm)":

"3.2.4.10. Variations of the mutual arrangement of the rail strings with respect to one another in the straight sections and to the **prescribed cant in the railway curves** may be allowed as a result of the operation."

These variations shall not exceed the following limits:

for $V_{\max} \leq 60$ km/h	± 15 mm
for $V_{\max} \leq 100$ km/h	± 10 mm
for $V_{\max} > 100 \div 130$ km/h	± 6 mm
for $V_{\max} > 130$ km/h	± 4 mm

In this case, the variation from the prescribed rail cant in the railway curve at $V_{\max} \leq 60$ km/h is ± 15 mm and cant of H = 45 mm, the permissible difference in the levels of both rail strings is 60 mm. The results of the measured values of the mutual position of the two rail strings at a level 20 m before and after the elevation point show that the same do not exceed the tolerances of the said cant, taking into account a constant speed limit of 25 km/h.

Pursuant to the requirements of p. 3.2.4.2. Normal cant and p. 3.2.4.4. Decreased normal cant of from the "Technical Standards for Planning and Maintenance of the Upper Structure of Normal Railway Lines (1435 mm)", **in railway curves of the railway infrastructure where the speed of the trains is up to 50 km/h, the parameters of railway curves require decreased normal cant with a value of 20 mm.**

Based on the "Tables of Technical Parameters and Standards", an appendix to schedules books with effect from 09.12.2012 to 12.14.2013, in Table IV "Permissible Maximum Speed when Passing Through Switches in Stations and Checkpoints", the maximum permissible speed for Raduntsi station in the diverting track is 25 km/h. From 2001 to 2013, the maximum permissible speed in the diverting track at the Raduntsi station is 25 km/h. In this case, assuming the value of the reduced normal cant of 20 mm (including the tolerance) for the curve at the point of rise, the measured values at the level by the Task Force and the Commission for the investigation show that there is **exceeding of the allowable tolerances in most of the legal points, before and after the point of rise.**

Due to missing up-to-date information on the geometry of the 3rd track, in a situation and a longitudinal profile, Gorna Oryahovitsa Railway Section cannot give a specific answer on how the exact cant of H = 45 mm has been determined. In view of this, the actual radius of the curve before and after the elevation point was calculated by the Commission for the investigation.

There is no information on the location for the start and end of the transition of the cant and it cannot be determined whether its slope is within the acceptable limits.

From the presented data on measurement of the railroad in a railroad unloaded condition of 02.07.2013, in the Book of the railway sector, in the "kilometric position" column, only "end of switch (ES) № 3 Raduntsi" is indicated. The points of the measured parameters "wheel-gauge" and "level" are not reflected by kilometres and therefore it cannot be concluded whether the elevation point of the passenger car falls in this section and whether these parameters are within the acceptable limits.

In the Statement of Findings on the condition of the railroad, the measured values of the fatigue of the tracks are shown – vertically and laterally in the point of rise.

Given the requirements of 4.3 "Permissible fatigue of tracks from the "Technical Standards for Planning and Maintenance of the Upper Structure of Normal Railway Lines (1435 mm)", it is found that the data of the fatigue do not exceed limits (S49) for vertical fatigue $a_{Bmax} = 24$ mm and lateral fatigue $a_{Cma} = 13.5$ mm.

The Commission for the investigation made an inspection at the scene on 09.10.2013 and found that repair works of compromised railroad on the 3rd track have been performed, despite the provision of the Commission not to change the condition of the track at the point of derailment, 20m before and after the elevation point and the circumstances in which an accident occurred.

The Commission carried out new measurements of the parameters of the railroad on the 3rd track 20m before and after the elevation point characterizing its position in plan and profile as well as the geometric parameters of switch № 3 .

The following parameters were measured: level, fleshes with a chord with length of 10 meters and hidden slump in the area of the joint.

The instruments used for these measurements were provided by Gorna Oryahovitsa Railway Section, respectively a calibre, profile meter and dens meter as these have undergone a company check in laboratory conditions, as evidenced by the attached protocols.

In order to determine the actual longitudinal slope of the track at the point of rise, a geometric levelling was performed with level "SOKKIA C32", on specific points of the upper edge of the rail head of the inner rail string.

A measurement of the angle of deviation of the axis for the diverting track and for switch № 3 was performed with theodolite "Theo 080".

Parameters measured 20 meters before the elevation point (derailment)

Direction of movement	Point of measurement	Заб. (mm)	Level (mm)	Hidden slumps at basis m (mm)		Wheel-gauge (mm) 1435+	Flesh chord 10 m (mm)	Calculated R (m)
				Left rail	Right rail			
				L	Ll			
1	2	3	4	5	6	7	8	9
Direction of movement of derailed vehicle ← against tongue / in the	20		35			19	63	198,41
	19		36			15	60	208,34
	18		35			12	54	231,48
	17		34			14	62	201,61
	16		32			20	63	198,41
	15		30			24	68	183,82
	14		31			27	70	178,57
	13		30			29	71	176,06
	12		30			29	72	173,61
	11		32			28	70	178,57
10		35			25	69	181,16	

	9		37			23	58	215,52
	8		39			19	57	219,30
	7		37			14	61	204,92
	6		37			14	64	195,31
	5		38			17	73	171,23
	4		35			23	81	154,32
	3		40			14	81	154,32
	2		44			13	73	171,23
	1		43			14	69	181,16
point of rise	0		41			14	65	192,31

Parameters measured 20 meters after the elevation point (derailment)

Direction of movement	Point of measurement	Заб. (mm)	Level (mm)	Hidden slumps at basis		Wheel-gauge (mm) 1435+	Flesh chord 10 m (mm)	Calculated R (m)
				m (mm)				
				Left rail	Right rail			
			L	Ll	Lr	L	F	
1	2	3	4	5	6	7	8	9
Direction of movement of derailed vehicle ← against tongue / in the direction of tongue	-1		42			15	57	219,30
	-2		41			22	55	227,27
	-3		40			24	60	208,33
	-4		41			24	57	219,30
	-5		45			20	59	211,86
	-6		47			15	58	215,52
	-7		48			12	60	208,34
	-8		52			10	60	208,34
	-9		55			7	63	198,41
	-10		53			11	59	211,86
	-11		53			12	57	219,30
	-12		50			9	57	219,30
	-13		50			7	56	223,21
	-14		50			7	54	231,48
	-15		47			9	54	231,48
	-16		45			10	63	198,41
	-17		43			9	60	208,33
	-18		39			15	63	198,41
	-19		39			20	64	195,31
	-20		40			25	64	195,31

The results of the measurements performed by the Commission for the investigation of the actual existing condition of the railroad listed in the two tables, relating to the wheel-gauge, the level and the flesh gaps with a chord with a length of 10 m, show that the same are close by value to those measured by the Task Force and are reflected in the mentioned Statement of Findings.

The Statement of Findings of the railroad states that "the railway is not benchmarked".

As a result of many years of operation of the railroad on the 3rd track, the lack of benchmarks and the absence of up-to-date information on the location of the railroad in situation and longitudinal profile, the radius of curve at the elevation point was determined by so called flesh gaps with a chord with length of 10 m ($R \leq 300$ m) in accordance with p. 4.9., Standards for fixing a railroad in plan and p. 4.10, Benchmarking of a railroad from "Technical Standards for Planning and Maintenance of the

Upper Structure of Normal Railway Lines (1435 mm)" and "Instructions for Chaining and Benchmarking of a Railroad".

In the two tables above, the results of the calculated radii corresponding to the measured flesh gaps on the outer rail string are presented.

According to p. 4.9., Standards for fixing a railroad in plan from current technical regulations, the permissible flesh gaps for circular curves are shown in the following table:

Speed km/h	Reception in repairs and new construction		Beginning of the current maintenance		Limit of tolerance	
	Δf_{10}	Δf_{20}	Δf_{10}	Δf_{20}	Δf_{10}	Δf_{20}
>120	1	2	3	6	10	20
80 to 120	1	2	4	8	14	28
60 to 80	2	4	6	10	15	31
to 60	5	10	16	32	24	48

In a section with length of 40 meters (20 m before and 20 m after the elevation point) in the curve of the railroad, the gap between two adjacent fleshs does not exceed the limit values specified in the table.

The Technical Commission for the investigation carried out new measurements of the flesh gaps with chord with length of 10 m along the curve of the 3rd track towards the start of switch № 3 and 50 m before the elevation point. The measured flesh gaps range from 37 ÷ 63 mm and the gap between two adjacent flashes between individual points exceeds that of 16 mm, which means that there is a need for current railroad maintenance. The continuation of the same measurements on the curve to SS № 3 shows that the radius of curve is increased to 700 m with irregular intervals of variation of the radius.

The results from the measurement of flesh gaps with chord with length of 10 m in this section of 40 m in the curve show that the average value of the radius on the outer rail string in this section is about 200 m (20 m before the elevation point it is 189 meters and 20 m after it – 212 m).

With an average value of the radius 20 meters before the point of ascent of 189 meters, the normal cant is 26 mm. Considering the maximum permissible value for $V_{max} \leq 60$ km/h of ± 15 mm, the cant of the outer rail string 20 meters before the elevation point in the curve does not exceed the tolerance as at the elevation point it is 41 mm.

Controlled measurement of hidden slump was done in a laden condition of the railroad at passing of a passenger train serviced by an Electric train bus (ETB) series 32000 in the area of the supported joint before the elevation point on the inner and outer rail string. The values of +8 mm and +2 mm did not show exceeding of the limit tolerance.

At the installation of a supported joint, the axis of the thermal gap of the rails must coincide with the axis of the paired wooden traverse, which in this case is not so. It was found that the binding of the two rails is done at the end of the double threaded tie-plate which is mounted at the end of the paired traverse. This creates a precondition for uneven compaction in laden condition of one of the rail strings compared to the other at the headings in the vertical plane.

From the geometric levelling performed, a certain number of points were selected on the upper edge of the rail head of the inner rail string to determine the longitudinal slope of the railroad. A section from SS № 3 was selected along the curve from Krastets side, with an approximate length of 140 m, including the elevation point. The measured longitudinal slope is 1,4 ‰, which is less than the permissible of 1,5 ‰ for a station area.

Also, it was found from the measurements in this section that there are bends in the longitudinal slope of the railroad, one of which falls within the elevation point (km 212 +220). The calculated longitudinal slope 20 meters before the elevation point is 0,15 ‰, and 20 m after it – 2,1 ‰.

In a Statement of Findings on the condition of the railroad of 09.04.2013, there are no figures on the parameters of the switches.

By the collection of the necessary documentation required for the technical investigation, it was found that at the time of the derailment, a technical passport for switch № 3 was not developed. In this

case, the performed measurements of the parameters of the switch before the derailment cannot be traced chronologically, which hinders the formation of the final decision on the technical condition of the switch before the accident. From the inspection and the measurements of the restored after the accident switch № 3, it was found that it has an angle of deviation and a radius of respectively 1:9 – 300 with rails 49E1, as the main track has a radius $R \approx 700$ m. A measurement was performed of the restored railway switch by wheel-gauge and level, required by "Standards and requirements for switches type 49 kg/m and heavier", as information about previous measurements was not provided before that.

As a rule, cant is not given in switches, but if the current road passes through the diverting track of a switch, the cant given depends on the speed through the switch and the radius of the curve. If as an exception there is cant, it is the same for the straight and the diverting track. In this case, there is a difference in the levels of the rail strings, respectively in the straight and the diverting track. The measured parameters of the switch by axis and level in this case do not have a direct relation to the derailment of the coach as the derailed wheel pair axle was moving in the direction "end of switch – start of switch" in the wheel-gauge on the traverse grid. The compromised integrity of the rail profiles in the switch and its elements is a result of the already derailed leading wheel pair axle.

On 11.09.2013 in the Carriage maintenance shed in Gorna Oryahovitsa, the Commission for investigation performed measurements of passenger coach № 51 75 5040 012-4 series Bcm with regard to its technical condition and found the following:

- the passenger couchette coach is with a last revision REV Ada 04.11.11

№ measurement	Object of measurement – distance between the inner heading surfaces of the wheels, mm			
	First bogie (derailed) in the direction of movement, measured at		Second bogie in the direction of movement, measured at	
	axle bearings with numbers 4 and 5 (attacking wheel pair axles)	axle bearings with numbers 3 and 6 (second wheel pair axles in the direction of movement)	axle bearings with numbers 2 and 7 (third wheel pair axles in the direction of movement)	axle bearings with numbers 1 and 8 (fourth wheel pair axles in the direction of movement)
1	1360,40	1360,30	1360,10	1360,15
2	1360,45	1360,25	1360,00	1360,05
3	1360,25	1360,30	1360,00	1360,10

- wheel diameters in the circle of rolling

Object of measurement – wheels at axle bearings with numbers, mm							
1	2	3	4	5	6	7	8
923,7	923,4	923,6	922,2	923,0	923,8	923,3	923,7

- parameters of flanges

Type of parameter	Object of measurement – wheel flange at axle bearings with numbers							
	1	2	3	4	5	6	7	8
Thickness, mm	31,8	31,9	31,1	31,4	31,0	32,3	31,4	31,4
Height, mm	28,4	28,0	28,5	28,0	28,4	28,2	28,2	28,3
Vertical undercut, mm	10,0	10,0	9,6	10,0	9,5	10,8	9,7	10,0

The measured parameters of the derailed coach № 51 75 5040 012-4, of Bcm series, reflected in the tables, are within the prescribed limits and in accordance with the requirements of Ordinance

№ 58 of 2 August 2006 on the rules of technical operation, movement of trains and signalling in railway transport and "Agreement on the exchange and use of coaches in international traffic" – RIC, in effect as of 1 January 2001 and "Instruction for wheel pair axles of coaches" of 1977.

- Other findings on the bogies:

a) during the inspection of the sliders of the coach, it was found that the movable spherical part of the slider of the derailed bogie at axle bearings № 5 and № 6 is placed to the extreme left (by axle bearing № 6) in the oil tank located on the bogie frame. On the surface of the spherical part, dints can be observed, resulting in derangement of its geometry. There are also dints on the upper part of the slider (liner) to the car body of the coach where contact with the bottom lower spherical part (lens) is made;

b) there is a difference between the distance "upper rocker – bogie frame" of 21 mm on the side of the axle bearings with № 3 and № 4 and 10 mm on the side of the axle bearings with № 5 and № 6. The difference in the sizes is in result of the derailment;

c) the measured gap between the centre pin and the rubber hub of the central bearing is 2 mm and the gap between the rubber hub and the opening of the central bolt beam is 2 mm;

d) there are no seals and denotations for the performed full revision of the axle bearings on both bogies;

e) there is no entrenching, bedding and thermal coloration of the wheels of the **wheel pair axles**;

f) the automatic brake type KE-GPR is intact and with properly bedded composite blocks.

The established damages on the bogie and the car body are due to the accident – derailment and breaking of the tongue of switch № 3, which dives into the car body of the coach.

12. Reasons for the accident.

As a result of the performed inspections and measurements of the railroad on 3rd track in Raduntsi station and of coach № 51 75 5040 012-4 in the Carriage maintenance shed in Gorna Oryahovitsa and of the analysis of the collected materials and documents and the technical documentation for the coach is provided by Coach Factory TUVASAS in the Republic of Turkey, the report of the Task Force, the additionally prepared technical expertise and the presented opinions of the external experts, the Commission for the investigation considers that:

The direct technical cause of the accident – derailment of coach № 51 75 5040 012-4 with the first bogie, during transit passing with a speed $V = 25$ km/h in the 3rd track, is **the non-radial joint, with sharply pronounced kink in the right rail string that allows the uneven compaction of the joint in laden condition, the connection with the two rails is made at the end of the double threaded tie-plate which is mounted at the end of the paired traverse and allows for unacceptable vertical deviations in the headings of the rails to each other.** The hidden falling through in laden condition of the supported joint before the elevation point to the outer rail string was above the acceptable standards, which has helped to increase the flange of the 1st wheel pair axle, right wheel – 2.50 m after the joint.

Given the above findings and based on previous accidents, the Commission concluded with regard to the **main technical cause** of the accident:

- **the cant of $H = 45$ mm does not meet the parameters of the rail curve in the elevation point.** The tolerances in the cant are allowed as a result of the operation, deviations from the mutual location of the rail strings from one another in straight sections and from the **prescribed cant in railway curves** under p. 3.2.4.9. and p. 3.2.4.10. of the "Technical Standards for Planning and Maintenance of the Upper Structure of Normal Railway Lines (1435 mm)";

- **unevenly expressed in a table form intervals in the change the radius of the curve in plan and profile 20 m before and after the elevation point** according to the requirements of i. 4.9. of the "Technical Standards for Planning and Maintenance of the Upper Structure of Normal Railway Lines (1435 mm)";

- **lack of up-to-date information database on the geometrical position of the railroad on the 3rd track in situation and longitudinal profile to the date of the accident as**

well as data for the start and end of the transition of the cant. The requirements of the Ordinance № 58, Art. 43, on the rules of technical operation, movement of trains and signalling in railway transport and of the Art. 31 and Art. 32 concerning the chaining and benchmarking of a railroad from the "Rules of Technical Operation of the Railway Infrastructure" were not implemented.

13. Recommendations and suggestions for activities preventing other accidents of a similar nature.

In order to prevent future accidents of a similar nature, in connection with Art. 94, paragraph 1 of the Ordinance № 59 of 5.12.2006 on the safety management in railway transport by the Minister of Transport, the "Railway Administration" Executive Agency should order the SE "NRIC" to put into execution the given safety recommendations.

1. The Director General of SE "NRIC" to order an inspection of the railroad in the section from Gorna Oryahovitsa station to Dabovo station, between stations and in the station areas in order to determine where there is no chaining and benchmarking of the railroad or these do not correspond to the actual condition. In these sections to make chaining and benchmarking of the track in accordance with the requirements of the regulations for upper structure and maintenance of the track in order to monitor and optimize its parameters and elements.

2. In order to take appropriate decisions for the maintenance and repair of the railroad, on the grounds of accumulated information from track recording laboratory, the Director General of SE "NRIC" to order examination of the geometry of the railway strings in plan and profile to be done not only on the main tracks but on all arrival and departure tracks in the station areas in which passenger and freight trains move.

3. The Control body of the SE "NRIC" to carry out continuous control of the parameters measured by the ongoing railroad maintenance staff in unloaded condition to be in compliance with the requirements of the legal acts concerning the upper structure of railroads.

In regards to the requirements of the art. 94, paragraph 3 of the Ordinance № 59 of 5.12.2006 on the safety management in rail transport of the Minister of Transport, Information Technology and Communications, the "Railway Administration" Executive Agency and the SE "NRIC" are to notify in writing the AMRAI Directorate in MTITC of the actions taken correspondingly for the safety recommendations implementation given before 17.10.2014.

- Appendix:** 1. *Photographs – 6.*
2. *CD with photos from the accident.*

Chairperson:

..... (Boycho Skrobanski)
State Inspector in AMRAI Directorate in the MTITC

Members:

1. (Boyko Stoilov)
Chief Inspector in AMRAI Directorate in the MTITC

2. (Dobrinka Atmadzhova)
Independent external expert

3. (Kosta Kostov)
Independent external expert