Ministry of Sustainable Infrastructure and Mobility

DIRECTORATE GENERAL FOR RAIL AND MARITIME INVESTIGATIONS

INVESTIGATION REPORT

DERAILMENT OF TRENITALIA PASSENGER TRAIN 9595, HS/HC MILANO – BOLOGNA LINE, AT PM LIVRAGA, ON 06/02/2020

(IDENTIFIER ERAIL: IT-6182)

28 January 2022

Foreword

This investigation report has been drafted according to the outline defined in Annex V of Italian Legislative Decree No. 162 of 10 August 2007, pursuant to the provisions of Article 31 of Italian Legislative Decree No. 50 of 14 May 2019.

The objective of the report is to prevent future accidents and incidents through the identification of the technical causes that generated the event and the consequent formulation of safety recommendations to operators in the sector.

DiGIFeMa's investigation cannot be used to apportion blame or determine liability for the event analysed and is conducted independently from the Judicial Authority's investigation.

Table of contents

Abbreviations and Acronyms

ACC	Central Computerised Apparatus
AdC	Driver
AG	Judicial Authority
AM	Maintenance Agent
ANSF	National Agency for Railway Safety
ANSFISA	National Agency for Railway, Road Infrastructure and Motorway Safety
AV/AC	High Speed/High Capacity
CdL	Work Centre
CO	Hydraulic Unit
CODIR	Management Committee
CoTAP	Territorial Production Committee
CT	Train Conductor
CST	Train Services Supervisor
CUM	Chief Maintenance Unit
DCCM	Central Manager Movement Co-ordinator
DCO	Central Operations Manager
DiGIFeMa	Directorate General for Railway and Maritime Investigations
DIS	Driver Information System
DM	Movement Manager
DPR	Production Department
DTP	Territorial Production Department
ERA	European Union Agency for Railways
ERAIL	European Railway Accident Information Links
ETCS	European Traffic Control System
FRI	Fatigue and Risk Index
GEPO	Operations Management and Planning
GI	Infrastructure Manager
GSM-R	GSM-Railway
IF	Railway Company
IS	Safety and Signalling Systems
ISD	Diversion Service Instruction
LFM	Light and Power
MdO	Working Equipment
MO	Ordinary Maintenance
MUM	Operation and Maintenance Manual
NTW	Network
OC	Civil Engineering Works
OdL	Work Order
OMH	Hardware Maintenance Operator
OSMI	Infrastructure Maintenance Operator
PC	Central Signalling Centre
PCQ	Quality Control Plan
PdC	Pipeline Personnel
PFC	Manufacturing and Control Plan
PM	Signalling Centre
POQ	Operational Planning and Quality
RFI	Rete Ferroviaria Italiana SpA
RSMS	Rolling Stock Management System

RUT	Head of Territorial Unit
SAMAC	Skills Acquisition and Maintenance System
SCC-M	Multi-station Command and Control System
SCMT	Train Running Control System
SIDAC	Dynamic Conduct Training Simulator
SIGS	Integrated Safety Management System
smt	Train Running Direction
SO	Hydraulic Shunting Subsystem
SON	National Operations Centre
SRM	Entity Responsible for Maintenance
STF	Technical Specifications of Supply
TA	Needle Frame
TE	Electric Traction
TLC	Telecommunications
UM	Maintenance Unit
UO	Operating Unit
UT	Territorial Units

1. Summary

1.1. Brief description of the event

On 06/02/2020, at about 05:30 a.m., on the Milano-Bologna HS line, passenger train 9595 of the RU Trenitalia SpA, composed of eight cars, coming from Milan and bound for Salerno, derailed near PM Livraga (km 166+252), at a speed of 298 km/h.

Twenty-eight passengers were travelling on the train at the time of the derailment, in addition to the on-board staff.

1.2. Direct, indirect and upstream causes

The derailment began at switch 05 (km 166+756): the train was not on the correct track (normal position), and its incorrect positioning (diverted position) was the direct cause of the event.

The indirect causes can be summarised as follows:

1. internal wiring error in the control circuit of actuator no. 2 of the leading frame of switch 05;

2. failure to check the correspondence between the physical configuration of switch 05 on the yard and that returned remotely, at the end of the maintenance activity;

3. failure to immobilise switch 05 (the actuator no. 2 on the leading frame of which had shown clear signs of malfunctioning) in the correct track position;

4. inadequacy and ineffectiveness, in the specific event, of the control of the production process of the frame-needle actuator;

5. absence of a clear and distinct assignment of tasks from the documents defining the procedures relating to the maintenance and operation phases of the switches.

The upstream cause of the accident, on the other hand, can be traced back to the absence of fail-safe functionality of the point's position control circuit, with respect to the actuator's wiring error.

1.3. Summary of the main recommendations

In view of the causes that led to the occurrence of the event, it was deemed necessary to formalise a number of recommendations addressed to the National Agency for Railway, Road Infrastructure and Motorway Safety, aimed at the following:

– requesting railway infrastructure managers to revise the activities foreseen in the Quality Control Plan (PCQ) of the hydraulic switch actuators:

- by introducing, instead of a simple visual inspection of the wiring, a functional test that verifies the correct input-output connection at the different positions of the actuator contact shaft;
- by verifying the completeness of the *"Complete actuator test"* and *"Complete actuator final functional test"* phases;

– requiring railway infrastructure managers to adapt the reference documentation and related training activities so that it is clearly stated that all maintenance activities on switches, which involve work on the relevant command and control circuits, must always conclude with a verification of concordance between the physical configuration of the switch on the yard

and the remotely controlled one, proven by visual documentation of the evidence;

– requiring railway infrastructure managers to adapt the reference documentation and related training activities so that the return to operation of a switch, or any other safety device, at the end of any maintenance activity on it, in cases where anomalous behaviour of the devices is manifested, is carried out by those involved, always drawing inspiration from the precautionary principle, i.e., adopting the most restrictive measure to protect safety;

– requiring railway infrastructure managers to reorganise their internal procedures for the use of switch restraints by maintenance staff;

– requesting railway infrastructure managers to initiate a process aimed at the design, realisation and implementation of hydraulic switches with a control circuit capable of signalling the position of each actuator constituting the switch, as well as the adaptation of the ACC's operating logic aimed at appropriately managing the control parameters that govern the operation of the switch.

2. Facts directly related to the event

2.1. Event

2.1.1. Description of the events and the accident site

On 06/02/2020, at about 05:30 a.m., on the Milano - Bologna HS line, passenger train 9595 of the RU Trenitalia S.p.A. (ETR1000 no. 021), composed of eight cars, coming from Milan and bound for Salerno, with an odd numbered transit route in the direction of Bologna, derailed at km 166+756 while running on switch 05 near PM Livraga, at a speed of 298 km/h.

The entire train derailed but, while the leading car, detached from the others, broke through a fence and stopped its run on its side, close to the opposite side of the PM Livraga building, after colliding with some maintenance equipment stationed on a siding, to the left of the direction of the train (DT), the other seven cars continued their deceleration run off the rails and stopped in the inter-track between the odd-numbered track and the adjacent track, after travelling approximately 700 m from the initial point of the derailment, with the second DT car reversed on its side (*Figures 1, 2, 3 and 4*).

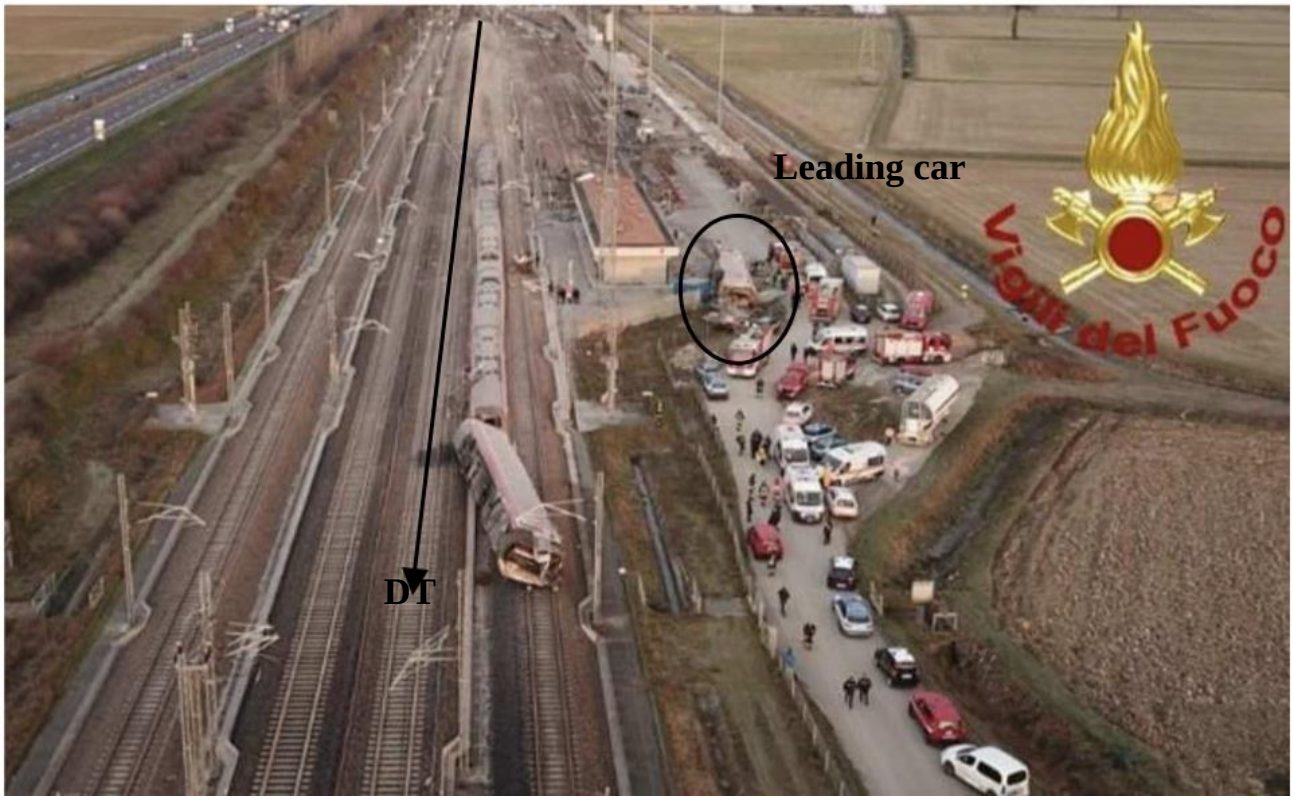


Figure 1 – Static position of the train following the accident (source: web)

Figure 2 – Schematic reconstruction of the dynamics of the accident (source: web)


Figures 3 and 4 – Static position of the leading car, left, and cars no. 2 and following, right (source: web)

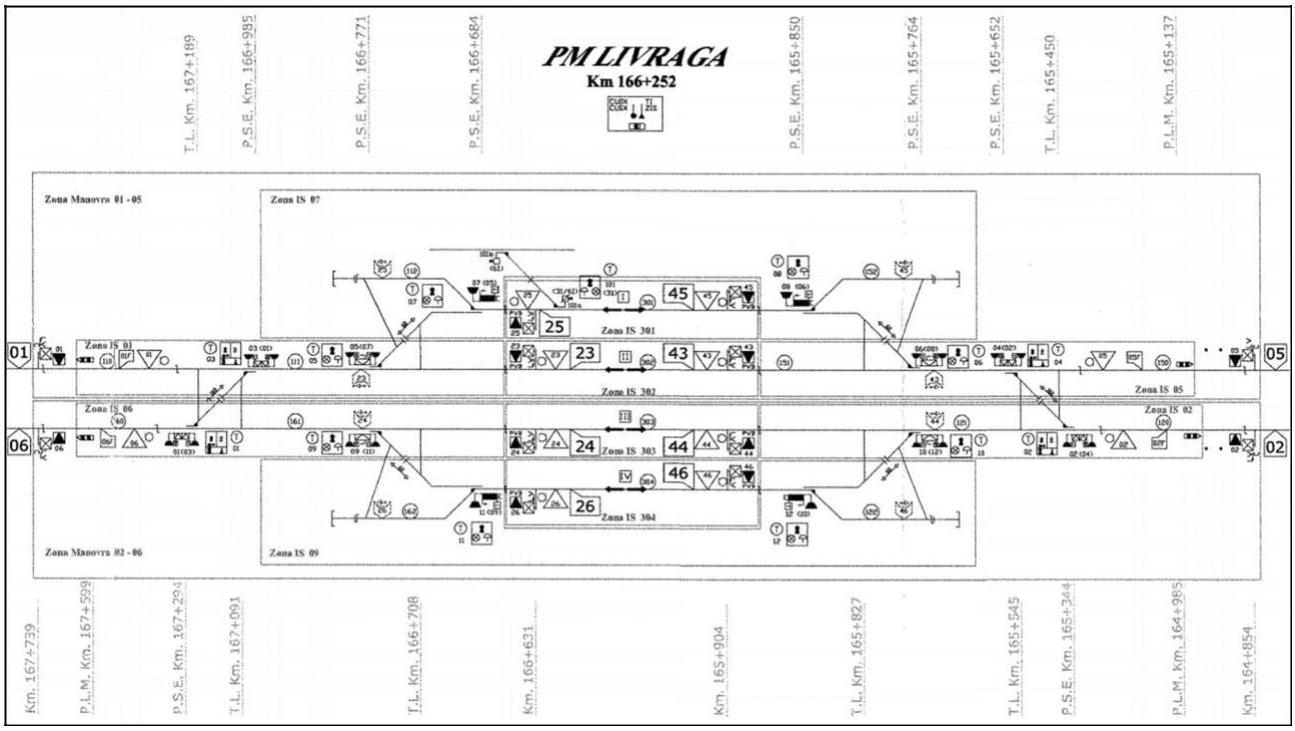


Figure 5 – Schematic plan of the event route (source: RFI)

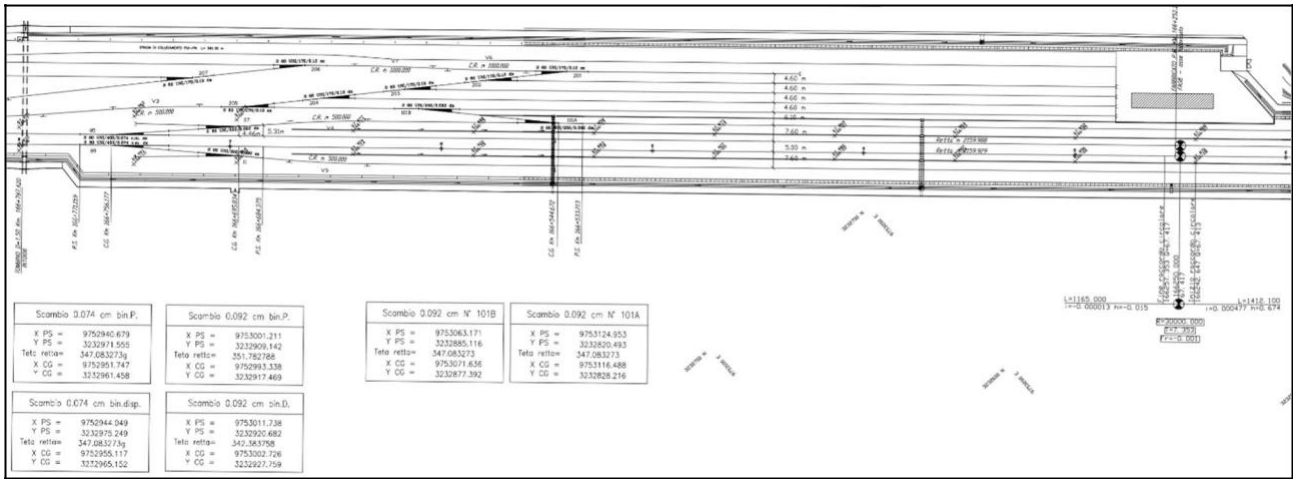


Figure 6 – Planimetry of the event route from the initial derailment point to PM Livraga (source: RFI)

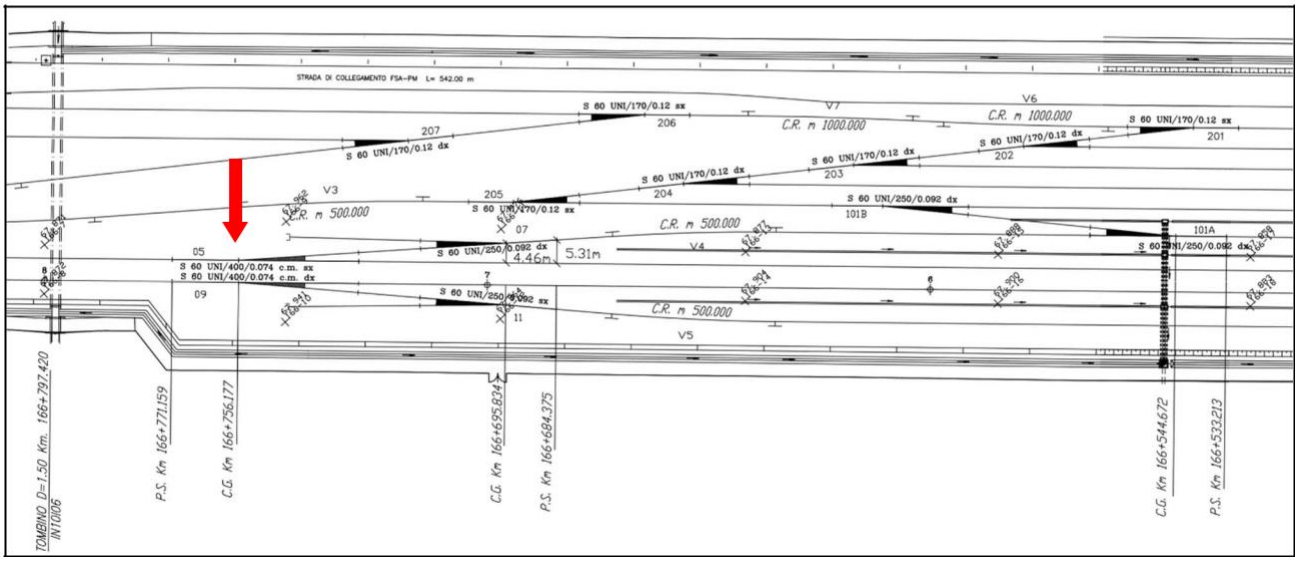


Figure 7 – Planimetry of the event route with evidence of the initial point of derailment: switch 05 at km 166+756 (source: RFI)

The initial point of the derailment on the track structure was located at switch 05, at km 166+756, where, due to the derailment, the rails broke (*Figure 8*).

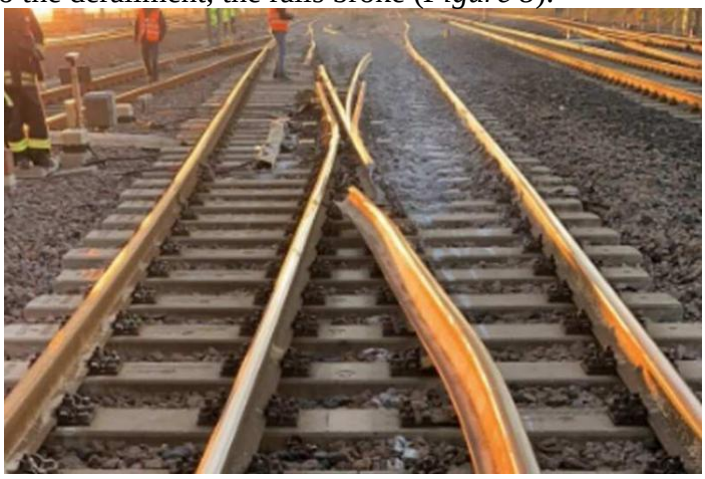


Figure 8 – Initial point of derailment: switch 05 at km 166+756 (source: web)

Starting from the point of derailment and up to the point where the train came to a halt, serious damage was found on the railway equipment (tracks, switches, crossbars, couplings).

At the scene of the accident, RFI and Trenitalia personnel, the Fire Brigade, the Civil Defence, the Railway Police, the Judicial Authority and the emergency medical services attended.

2.1.2. Decision to start the investigation, composition of the investigation team and conduct of the investigation

Following the event, the Directorate General for Rail and Maritime Investigations appointed an Investigation Committee to ascertain the causes of the accident, consisting of:

- Prof. Ciro Attaianese, engineer
- Prof. Roberto Maja, engineer
- Mr. Wolmer Zanella, engineer

The Committee was mandated to ascertain the causes of the accident by carrying out its investigative activities on the basis of the regulations in force on the date of the event and, in particular, Italian Legislative Decree No. 50 of 14 May 2019, which came into force on 16/06/2019.

The mandate was carried out by means of documentary analysis and inspections on the site of the event and in the railway areas where the materials placed under seizure were stored, visits to the area and to the systems used to control and regulate circulation, acquisition of the testimonies of Trenitalia personnel, interviews with RFI and ANSFISA personnel.

First inspection - Date of event

On 06/02/2020, a member of the committee was alerted at 08:06 a.m. and arrived at the accident site at 10:10 a.m. to carry out a first inspection.

At the same time, he contacted the manager of the Territorial Production Department of Bologna, informing him of his presence and the need to go to the site of the accident to carry out an initial survey.

At 10:26 a.m., after having been accredited by the Railway Police and the Local Police, he reached the station of Livraga and informed DiGIFeMa of his availability to carry out the inspection.

At 10.30 a.m. he received from DiGIFeMa the Letter of Assignment for Investigative Activities, the Notice of Commencement of Investigation to the Lodi Public Prosecutor's Office and the DiGIFeMa-Lodi Public Prosecutor's Office Agreement necessary to obtain from the Public Prosecutor's Office the authorisation to access the site of the derailment.

At 10.40 a.m., accompanied by a Polfer agent, he went near switch 05, waiting to be accredited by the Deputy Prosecutor and thus carry out the inspection. Although he was unable to access the point of the derailment, he was able to ascertain that switch no. 05 was configured for the diverted direction (switch in diverted position), thus making it evident that this condition was the probable direct cause of the derailment.

At about 11:05 a.m. the investigator was able to confer with the Deputy Prosecutor, who prevented him from carrying out the inspection by inviting him to leave.

He then went near the station building, where he was able to observe some of the damage caused by the derailed cars.

At 11:39 a.m. he updated the DiGIFeMa manager on the situation and what he had observed.

At approximately 11:50 a.m., a police officer ordered all persons present within the station area to leave, making it impossible to carry out further inspections.

No further activities relevant to the investigation could be carried out later on 6 February.

Second inspection - 10 February

At 2:10 p.m. on 10 February, the same investigator went to PM Livraga to carry out an inspection authorised by the Lodi Public Prosecutor's Office. As it appears from the Polfer report, he carried out the following operations accompanied by the Commissioner of the same Polfer:

- at 3:10 p.m. visual and photographic survey of switches 05 (odd track) and 09 (even track), during which the actual diverted configuration of switch 05 was verified;
- at 3:30 p.m. visual and photographic survey of switch 07, during which its actual configuration towards the direction of the safety section located at the end, on the Milan side, of the odd-numbered passing track was verified; visual and photographic survey of the yard, the track equipment and the debris present there;
- at 3:40 p.m. visual and photographic survey of the rolling stock.
  The inspection ended at 3:50 p.m.

Attendance at the repeatable and unrepeatable controls on 12 February.

At 9:00 a.m. on 12 February, the same investigator went to PM Livraga to attend the repeatable and unrepeatable checks carried out by the Forensic Police and RFI personnel at switches 05 and 09.

The inspection began at approximately 10:30 a.m. The exact time of the operations is reported in the report drawn up by the Polfer and filed with the Lodi Public Prosecutor's Office. During the course of the inspection, it was possible to witness the following operations:

- repeatable checks on switch 09 on the even-numbered track to observe the way in which it was controlled by the Bologna Central Signalling Centre and to verify its correct configuration, as well as the actions taken by the safety apparatus in the event of failure to control it;
- unrepeatable checks on switch 05 on the odd-numbered track to verify the efficiency of the new actuator installed on the night of 6 February and the control signal returned by it to the safety apparatus.

During the course of the above-mentioned operations, it emerged that the actuator installed on switch 05 returned the normal configuration control even when it was in diverted configuration. This circumstance also results from official statements made by the Director of the National Agency for Railway Safety on the evening of 10 February.

The inspection ended at approximately 3:00 p.m.

Presence at the repeatable and unrepeatable inspections on 22 and 23 February

This paragraph describes the methods used and the results of the technical inspections carried out on 22 and 23 February 2020 at the accident site by RFI maintenance staff and the Forensic Police in the presence of the Deputy Public Prosecutor of Lodi, which were witnessed by an investigator from the Investigation Committee.

The inspections aimed at highlighting the anomalies that caused train 9595 to derail are listed below:

1. verification of switch 10 with electric manoeuvring device,
2. verification of switch 10 with manual manoeuvring device,
3. verification of switch 10 with electric manoeuvring device and reversed control,
4. verification of switch 10 with manual manoeuvring device and reversed control,
5. verification of switch 10 with electric manoeuvring device and control restored,
6. verification of switch 10 with switch 05 actuator and electric manoeuvring device,
7. verification of switch 10 with switch 05 actuator and manual manoeuvring device.

Day 22 February

Inspection 1

The inspection consisted of the following operations:

- request, by recorded telephone communication, to the Signaller (RC) of the Central Operations Manager (DCO) of Bologna to exclude switch 10;
- disconnection of the switch from the control circuit and connection to the portable power supply device, for manual shunting of the switch *(baraccotto)*;
- execution of a reverse manoeuvre and a subsequent normal test manoeuvre;
- execution of a calibration check of the needles by inserting calibrated shims between the needles and the shunts at the actuators, as follows:
    - insertion of the 2 mm shim into the needle of the deviated branch and diverted manoeuvre with the shank: the shim returned the diverted check as expected;
    - insertion of the 2 mm shim into the needle of the correctly traced branch and normal manoeuvre with the slide bar: the disc returned the normal check as expected;
    - insertion of the 4 mm shim into the needle of the diverted branch and diverted manoeuvre with the slide bar: the diskette returned, no control;
    - insertion of the 4 mm shim into the needle of the correctly traced branch and normal manoeuvre with the slide bar: the disk did not return, any control;

  the above checks confirmed the correct calibration of the needles;

- performance of a calibration check on the needles by inserting calibrated shims between the needles and the counter-needles in correspondence with the tie-rod located in an intermediate position between actuators 1 and 2, in the same way as the previous check, with the insertion of a 7 mm shim instead of 4 mm, as provided for in the protocol; the check confirmed the correct calibration of the tie-rod;
- carrying out a calibration check on the mobile core in a manner similar to that adopted for the needles: the check confirmed the correct calibration of the heart;
- control check of the core against forcing with a pry bar; following forcing the indicator disk returned no control, as expected;
- disconnection of the switch from the shunt and connection to the control circuit;
- return of switch 10 to the Central Operations Manager's control;
- carrying out a check for consistency between the control visible on the Central Operations Manager's desk and the actual configuration of the switch:
  - diverted manoeuvre for the diverted branch by the Central Operations Manager: presence of concordance between the diverted configuration of the switch, the control on the indicator disk and the control on the Central Operations Manager's desk;
  - normal shunting for the correct branch by the Central Operations Manager: presence of concordance between the normal configuration of the switch, the control on the indicator disk and the control on the Central Operations Manager's bench.

Inspection 2

The inspection consisted of carrying out the same operations as in inspection 1, but operating switch 10 with manual manoeuvring device: the verification confirmed the presence of concordance between the normal and diverted configurations of the switch, the control on the indicator disk and the control on the Central Operations Manager's desk.

Inspection 3

The inspection consisted of carrying out the concordance checks between the normal and diverted configurations of switch 10, the check on the indicator disk and the check on the Central Operations Manager's desk following the reversal of the electrical connections in the terminal box of actuator 2 as follows:

- opening of terminal box CT2/DEV10;
- reversal of terminals 13 and 14;
  - carrying out the concordance check:
  - diverted manoeuvre: return of normal control,
  - normal manoeuvre: return of normal control;
- execution of the concordance check with the insertion of the 2 mm shim between the needles and the counter needles:
  - diverted manoeuvre: return of normal control,
  - normal manoeuvre: return of normal control;
- execution of the concordance check with the insertion of the 4 mm shim between needles and needle points:
  - diverted and normal manoeuvre: no control.

Subsequently, the same checks as described above were carried out by manoeuvring switch 10 from the bench of the local Signalling Centre, obtaining the same result. In summary, during the repeatable technical inspection 3 it was verified that the manoeuvre of switch 10 in the normal configuration by the Central Operations Manager gave the following result:

- the switch maintained the diverted configuration,
- the indicator disk returns normal control,
- the Central Operations Manager sees normal control.

Inspection 4

The inspection of switch 10 with manual manoeuvring device and reversed control was not carried out as it was considered unnecessary.

Inspection 5

The inspection consisted of carrying out the concordance check between the normal and reverse configurations of switch 10, the check on the indicator disk and the check on the Central Operations Manager's desk after the correct connection of terminals 13 and 14 in the CT2/DEV10 terminal box had been restored. The concordance check was positive in both configurations, normal and diverted, of switch 10.

Day 23 February

Inspection 6

The purpose of the inspection was to assess the efficiency conditions of actuator 2 of switch 05 and the operating and control conditions of switch 10 controlled by actuator 2 of switch 05. The inspection was carried out as follows:

- opening of terminal box CT2/DEV05;
- verification of continuity between connectors 13 and 14 and the respective contacts 43 and 44 of the VEAM connector: the verification was positive, highlighting that the connection is not inverted, therefore the box returns the same control that it receives from the actuator;
- verification of continuity and correspondence between the VEAM connector and the free terminals of the device which replaces the whip, to be used for the verification of the control returned by actuator 2 (in railway jargon, the term "whip" refers to the cable which connects the actuators to the terminal boxes): the verification has given a positive result
- removal of the actuator cover;
- disconnection of the whip connected to the terminal box on the heel side of the actuator;
- verification of continuity between the free terminals of the whip replacement device corresponding to the internal contacts of the actuator and used to return the switch configuration control; the verification gave the following result:
  - correspondence between terminals A and A: negative
  - correspondence between terminals B and B: negative,
  - correspondence between terminals C and C: negative,
  - correspondence between terminals D and D: negative,
  - correspondence between terminals A and B: positive,
  - correspondence between terminals B and A: positive,
  - correspondence between terminals C and D: positive,
  - correspondence between terminals D and C: positive,

verification of the neutral short-circuit of the branch not affected by the configuration: correct.

The result of the check shows that the actuator, configured for the deviated branch, returns a normal control instead of a diverted control, i.e., it is defective.

Subsequently, the actuator 2 of switch 05 (referred to as “intermediate needle frame actuator” and identified with the last two digits 83 of the serial number) was removed, after protecting the seals to prevent breakage, and mounted on switch 10. The purpose of this operation was to analyse the operation and control of switch 10 operated by actuator 2 of switch 05 in order to simulate the conditions that led to the train 9595's derailment on 6 February. The assessment was carried out as follows:

- installation of switch actuator 2 of switch 05 (serial no. 83) on switch 10;
- disconnection of the switch from the control circuit and connection to the local shunting switch;

- preliminary execution of two diverted manoeuvres and two normal manoeuvres in succession;
- calibration check of the needles and verification of the control returned by the actuator:
  - diverted manoeuvre: the indicator disk returned normal control,
  - normal manoeuvre: the indicator disk returned normal control;
- disconnection of the switch from the shunt and connection to the control circuit;
- return of switch 10 to the Central Operations Manager's control;
- performing a check for consistency between the control visible on the Central Operations Manager's desk and the actual configuration of the switch:
  - diverted manoeuvre for the deviated branch by the Central Operations Manager: no concordance; the switch is in diverted configuration, while the control on the indicator disk returns the normal configuration for the correct track (*the manoeuvre caused the positioning of the switch in diverted position but returned the normal control; the system logic caused the switch to be disconnected for failure to reach the commanded position*);
  - the switch on the Central Operations Manager's desk was restored; after re-powering the control on the Central Operations Manager's desk returned the normal configuration for the correct track (*when the switch was restored, it signalled a normal position control although it remained in the diverted position*);
- carrying out a route formation check from point 2 to point 24, corresponding to free transit on the correct even track layout:
  - the route is correctly formed for free transit, however switch 10 is configured for the diverted branch,
  - the indicator disk and the Central Operations Manager's desk both return normal control.

    (The correct routing could be achieved because the switch was signalled with normal control while physically remaining in the diverted position due to the malfunction).

Once the above operations were completed, switch actuator 2 of switch 05 (serial no. 83) was opened to examine the connection of the conductors inside it. The inspection was carried out as follows:

- breaking of the original seals bearing the Alstom mark of the box corresponding to the point;
- visual inspection of the connection of the conductors to the terminals:
  - conductor 18 is dinged at terminal 16,
  - conductor 16 is dinged at terminal 18;
- verification of electrical continuity between the conductors connected to the actuator terminals and the free terminals of the device replacing the whip:
  - conductor 16 is connected to terminal A instead of terminal B,
  - conductor 18 is connected to terminal B instead of terminal A,
- breakage of the original seals bearing the Alstom mark of the box corresponding to the heel;
- visual check of the connection of the conductors to the terminals: the conductors appear to be correctly sheathed;
- electrical continuity check between the conductors connected to the actuator terminals and the free terminals of the device replacing the whip:
  - conductor 21 is correctly connected to terminal A,
  - conductor 23 is correctly connected to terminal B.

The outcome of the checks described above shows that the actuator 2 of switch 05 (serial no. 83) has anomalous behaviour, due to which on the morning of 6 February the switch was positioned in diverted position despite being signalled for correct routing on the Central Operations Manager's desk. The signalling of the correct routing position allowed the system to create the correct routing on the odd-numbered track for the transit of train 9595.

Inspection 7

The verification of switch 10 with manual manoeuvring device and control restored by the switch actuator 05 was not carried out as it was considered unnecessary.

Inspection 8

The inspection consisted of verifying the internal connections of the actuators seized by the Magistracy in order to ascertain the existence of any anomalies.

The checks carried out on all the actuators were negative.

From the position the investigator was in, he could also easily see that switch 07, which is conjugate to switch 05, was configured for the direction of the safety siding. If switches 05 and 07 are indeed conjugate, since they realise communication between the odd-numbered running track and the odd-numbered passing track, they must assume the same configuration, i.e., 05 on the correct track and 07 towards the safety switch or 05 and 07 in diverted position. This circumstance suggests that at the time of the derailment, the safety equipment of the system was configured to give the two switches the normal direction on the correct track.

Pursuant to Article 23, paragraph 4, of Italian Legislative Decree No. 50 of 14 May 2019, in order to delve into certain technical and procedural aspects and acquire observations and opinions on the investigation within its competence, the Investigation Committee deemed it appropriate to conduct the following meetings by remote videoconference:

- on 20/05/2020 with representatives of the National Agency for Railway Safety;
- on 22/12/2020 with representatives of the infrastructure manager RFI.

On 16/07/2021, DiGIFeMa submitted the Draft Final Investigation Report, prepared by the Commission in charge, to the parties involved (ANSFISA, RFI, Trenitalia). At the request of the parties, meetings were held by video conference, on 15/09/2021 and 12/10/2021 with representatives of RFI (during which the infrastructure manager provided DiGIFeMa with two annexes: the first consisting of a table of comments on the Draft Report, and the second entitled "Shunting scenarios of the Livraga switch 05") and on 04/10/2021 with representatives of ANSFISA. This document also takes into account what emerged during the aforementioned meetings and the comments transmitted by the aforementioned Bodies.

2.2. Circumstances of the event

2.2.1. Personnel involved

On train 9595 were travelling the two Drivers, the Train Conductor and the Train Services Supervisor of the Trenitalia RU, three operators of the catering company Itinere and an on-board cleaner.

2.2.2. Train and its composition

The Trenitalia RU train departed from Milan as train 9595 and bound for Salerno on 06/02/2020 consisted of 8 cars:

- vehicle No 1:93 83 3400 121-2 I-TI (train head);
- vehicle No 2:93 83 0400 221-6 I-TI
- vehicle No 3:93 83 5400 321-3 I-TI
- vehicle No 4:93 83 0400 421-2 I-TI

- vehicle No 5:93 83 0400 521-9 I-TI
- vehicle No 6:93 83 6400 621-4 I-TI
- vehicle No 7:93 83 0400 721-5 I-TI
- vehicle No 8:93 83 4400 821-5 I-TI

The train had the following characteristics:

- type of composition ETR 1000 021;
- braking mass 501 t;
- % braking mass 145%;
- maximum vehicle speed 300 km/h;
- speed rank C;
- length 202 m;
- safety equipment ERTMS/ETCS Level 2 with STM/SCMT;
- continuous travellers-type brake.

The entire train is owned by Trenitalia S.p.A., which is also its keeper and SRM (Subject Responsible for Maintenance). From the train sheet (*Figures 9/a and 9/b*) and from the File line 82 bis, section 6.1.2 FL (**Figure 14**) it can be deduced that the maximum speed allowed for the train on the section where the derailment occurred is 300 km/h and the line has braking degree Ia.

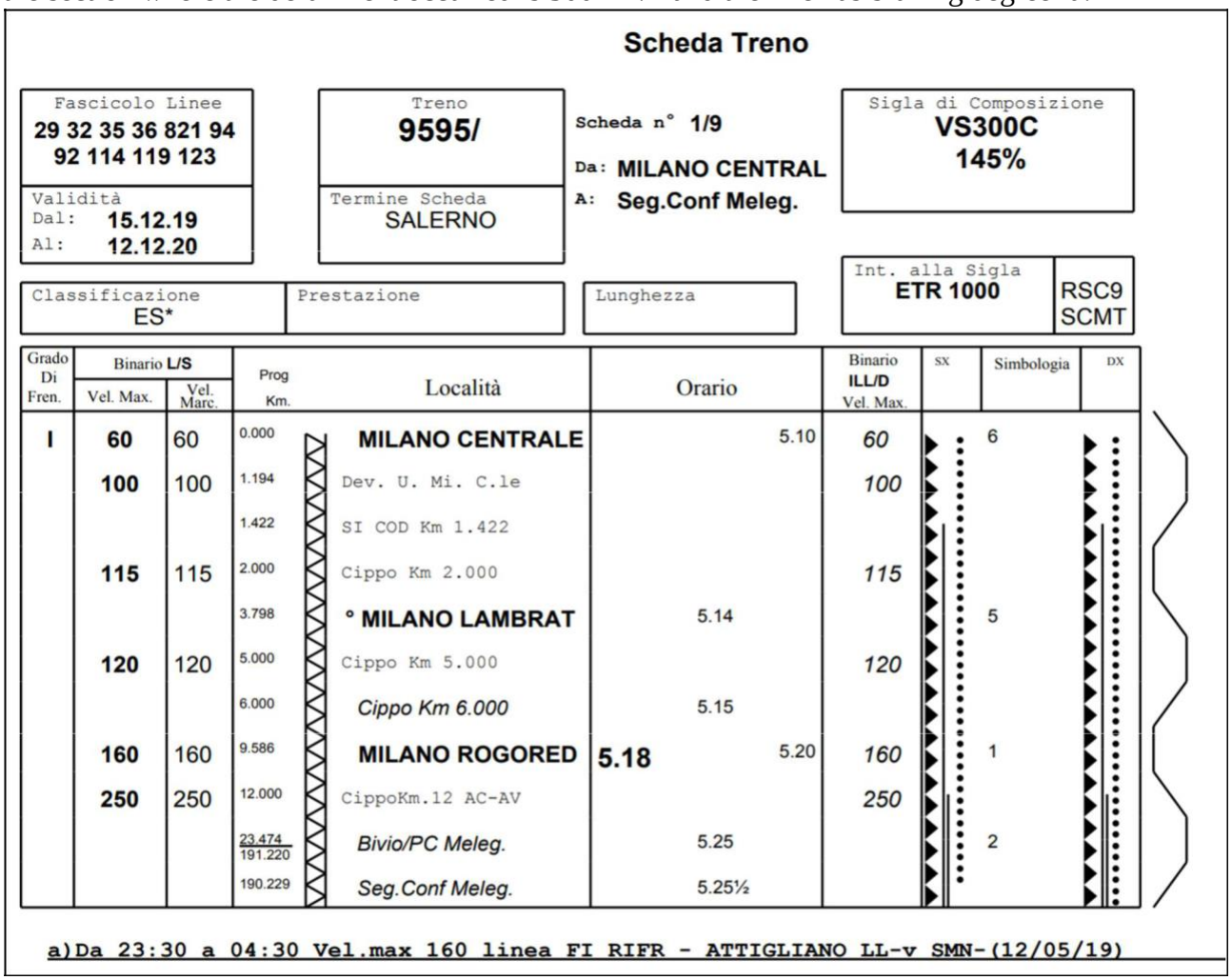


Figure 9/a - Train sheet 9595 of 06/02/2020: Milano C.le - Bivio/PC Melegnano route (source: Trenitalia)

Scheda Orario

Fascicolo Linee	Treno	Scheda n° 2/9	Sigla di Composizione
Validità Dal: 15.12.19 Al: 12.12.20	9595/	Da: SEG.CONF MELEG A: PDE MONTE BIBE	
	Termine Scheda SALERNO		Int. alla Sigla

Classificazione	Prestazione	Lunghezza
ES*		

Località	Orario	
SEG.CONF MELEG.	5.25½	
P.M. LIVRAGA	5.31	
BIVIO PIACENZA O	5.33½	
1°BIV.PIACENZA E	5.36	
P.C. PIACENZA	5.36½	
1°BIV FIDENZA O.	5.40	
P.C.FONTANELLATO	5.42	
1°BIVIO PARMA E.	5.47	
P.M. CAMPEGINE	5.50½	
REGGIO E. AV MP...	**5.54**	5.56
P.C. RUBIERA	6.05	
BIVIO MODENA O	6.07	
BIVIO CF EST	6.13½	
P.M. ANZOLA	6.15	
P.M. RENO	6.18	
BIVIO VENEZIA	6.19	
BOLOGNA C. LE.....	**6.22**	6.25
PDE SAVENA	6.29	
PDE MONTECALVO	6.30½	
BIVIO EMILIA	6.31	
PDE RIOSTO	6.32	
PDE LAURINZIANO	6.33	
PDE RIO DEI CANI	6.34½	
PDE QUINZANO	6.36½	
PM IDICE	6.37	
PDE MONTE BIBELE	6.37½	

a)Da 23:30 a 04:30 Vel.max 160 linea FI RIFR - ATTIGLIANO LL-v SMN-(12/05/19)

Località di stampa SKT-M3M40
Data di stampa 04/02/2020 22:24:10 Valida per il treno del 06/02/2020

PPC - Vers. 94

Figure 9/a - Train sheet 9595 of 06/02/2020: Milano C.le - Bivio/PC Melegnano route (source: Trenitalia)

The train was prescribed the speed reductions (sheet M3) shown in *Figure 10.*

Richiamato in scheda treno ▶
M3

RFI - Rete Ferroviaria Italiana

LINEA MILANO CENTRALE - SALERNO IL 06/02/2020 N.2199379

STAZIONE DI: MILANO CENTRALE

SI ORDINA ALL'AGENTE DI CONDOTTA DEL TRENO 9595/9597 **DI OSSERVARE I SEGUENTI RALLENTAMENTI**

N. Progressivo	Se instradati sul binario di sinistra o legale TRA LE LOCALITA' (o nella località)		Se instradati sul binario di destra o illegale TRA LE LOCALITA' (o nella località)		Fisso con inizio dopo cippo chilom.	Spostabile fra i cippi chilometrici		Velocità km/h	Lunghezza metri	Prescrizioni specifiche
1	1°Biv.Orte N	PC Gallese	-		66	-	-	115	2100	A/J/K/L
2	-		PC Gallese	PC Capena	62	-	-	115	2100	A/L/M
3	ROMA TIB.NA		-		6	-	-	40	100	A/N/O/P
4	ROMA TERMINI		-		1	-	-	60	400	A/Q/R
5	-		ROMA TERMINI		1	-	-	60	400	A/S/T
6	ROMA TERMINI		-		0	-	-	60	400	A/Q/R/U/V
7	-		ROMA TERMINI		0	-	-	60	400	A/S/T/W/X/Y
8	-		NAPOLI CENTRALE		219	-	-	60	900	A/Z/AA
9	NAPOLI CENTRALE		-		221	-	-	60	900	A/Z/AA
10	B.S.LUCIA	SALERNO	-		-	10	14	80	2100	A
	***	***	***	***	***	***	***	***	***	***

A)da rispettare con tutto il treno (per treni viaggiatori)

J)Il rallentamento interessa anche il 1° Bivio Orte Sud.

K)I treni provenienti da 1° Bivio Orte Nord incontreranno due segnali di inizio rallentamento; il secondo segnale di inizio rallentamento è riferito ai treni provenienti dall´interconnessione dispari.

L)I segnali di rallentamento sono di formato ridotto.

M)Il rallentamento interessa anche il PC Gallese.

N)Il rallentamento interessa il binario VII di Roma Tiburtina binario di corsa dispari linea Lenta Attigliano - Roma.

O)Segnali di avviso rall.to non preceduti da tavole distanziometriche.

P)Treni dispari istradati su linea Locale trovano segnale di fine rallentamento posto a terra.

Q)Il rall.to interessa il binario 19 di corretto tracciato (dispari)linea Cassino di Roma Termini.

R)I segnali di avviso rall.to non sono preceduti da tabelle distanziometriche e sono posti a terra.

S)Il rallentamento interessa il binario 21,di corretto tracciato linea Grosseto.

T)Segnali di rall.to sono posizionati a terra e i segnali d´avviso rall.to non sono preceduti da tavole distanziometriche.

U)I treni in partenza da Roma Termini non incontrano segnali di avviso rallentamento.

V)I segnali di fine rallentamento sono esposti solo per i treni percorrenti la linea Cassino.

W)I segnali di fine rall.to sono esposti solo per i treni diretti linea Grosseto sul binario di sinistra.

X)I treni in partenza dai binari dal 11 al 20 e dai binari dal 25 a 29 di Roma Termini e diretti linea Grosseto, se istradati sul binario di SX, incontrano segnale di fine rall.to che per loro non ha significato.

Y)I treni in partenza da Roma Termini non incontrano segnale di avviso rall.to.

Z)I segnali di avviso rallentamento non sono sussidiati da tavole di orientamento.

AA)I treni in partenza dai binari dal 2 al 15 non incontreranno il segnale di avviso rallentamento.

IL DIRIGENTE **L'AGENTE DI CONDOTTA**

SKT-M3M40

04/02/2020 11:11:40

Figure 10 - Train 9595 slowdowns on 06/02/2020 (source: Trenitalia)

The technical prescriptions received by the train at the station of origin in Milano C.le (Mod. M40 no. 47 of 06/02/2020) are shown below (*Figure 11*).

M.40 N° 47

TRENITALIA Stazione di MILANO CENTRALE Lì 04/02/2020

Tratta: MILANO CENTRALE - SALERNO

PRESCRIZIONI TECNICHE

Si ordina/dà avviso al macchinista e al capotreno del treno 9595/9597N del 06/02/2020

****

PRESCRIZIONI TECNICHE SUL PERCORSO D'ORARIO

Non Sono Presenti Limitazioni di Circolabilità

PRESCRIZIONI TECNICHE SU LINEE AFFIANCATE

1) Tratta: MILANO LAMBRATE - PM TRECCA

Se Vostro treno ha in composizione od è effettuato con ETR 450, ETR 460, ETR 463, ETR 470, ETR 485, ETR 600, ETR 610, ETR 500, ETR 700, ETR1000 sia in semplice sia in multiplo attacco, non superate velocità 30 km/h da Milano Lambrate a P.M.Trecca. [MI42D]

Figure 11 - Technical prescriptions train 9595 (source: Trenitalia)

2.2.3. Infrastructure and signalling system

The train, which left Milano Centrale at 5:10 a.m. on 06/02/2020, after having regularly stopped at Milano Rogoredo, proceeded towards Reggio Emilia.

The event took place on the Milano Rogoredo - Firenze Castello section.

The line is electrified with electric traction at 25 kV ac from Bivio/PC Melegnano to Bivio Castelfranco Est and from Bologna C.le to Firenze Castello and electric traction at 3 kV dc from Milano Rogoredo to Bivio/PC Melegnano and from Bivio Castelfranco Est to Bologna C. le, equipped with an ETCS Level 2 system and operation is managed with a Central Manager from Milano Rogoredo to Bivio/PC Melegnano (Milano Greco Headquarters) and with a Central Operations Manager from Bivio/PC Melegnano to Firenze Castello (SCC - Bologna C.le Headquarters).

The maximum speed allowed near PM Livraga, on the Bivio/PC Melegnano - Bivio Piacenza Ovest section for odd-numbered trains is 300 km/h (*Figure 14*).

At km 166+756, where switch 05 is located, the initial point of the train's derailment, the track is straight and slightly uphill. Switch 05 is of type SO 8 with tg 0.074 with a movable point core, year of installation and activation 2008 (*Figure 12).*

Figure 12 - Infrastructure equipment near the point of derailment (Source: DiGIFeMa)

Recorded verbal communication between the signaller and the driver is permitted on the route.

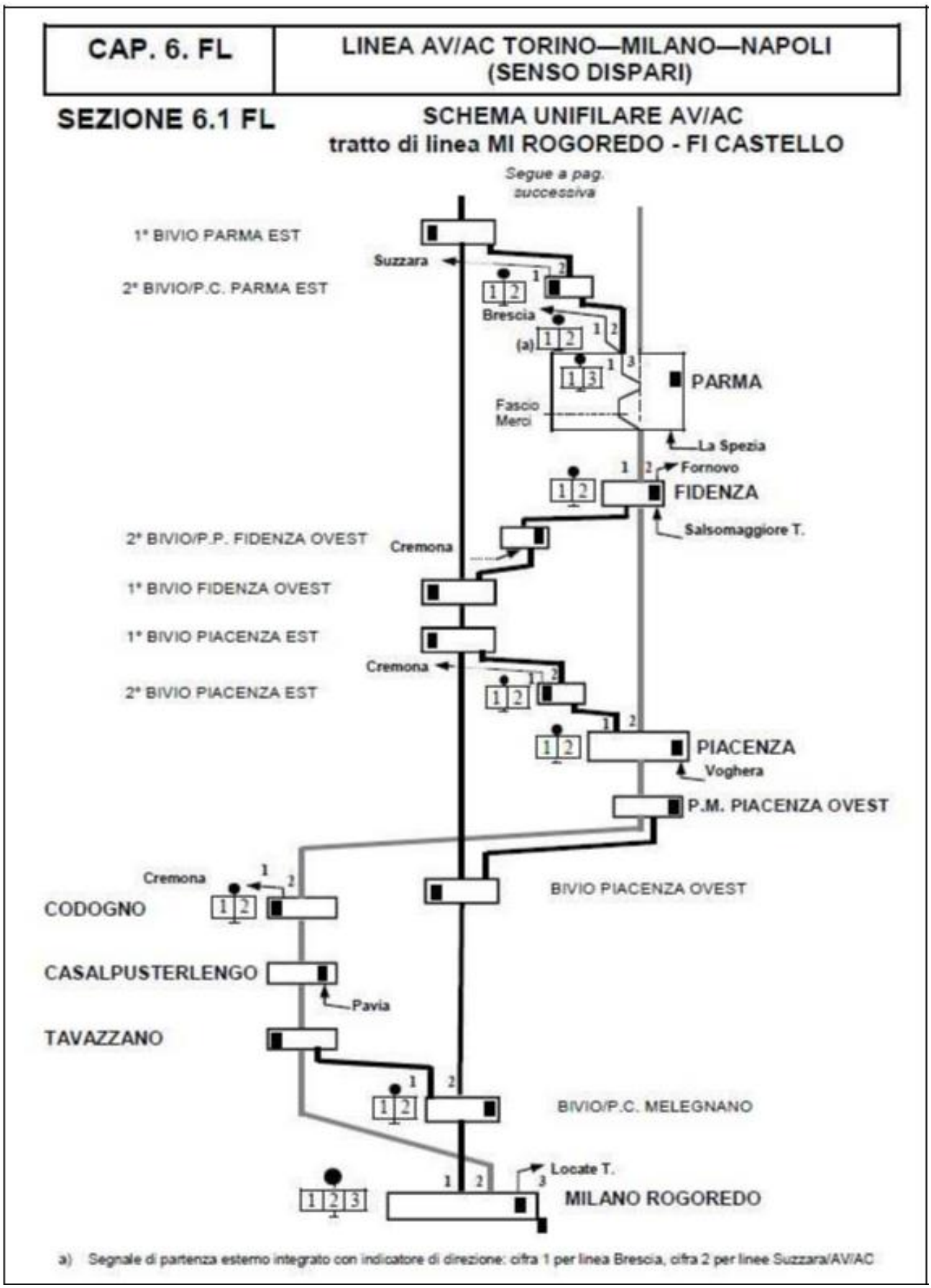


Figure 13 - Single-line diagram of the HS/HC Torino - Milano - Napoli line (odd train direction) – MI Rogoredo - FI Castello line section (source: File Line 82bis, RFI)

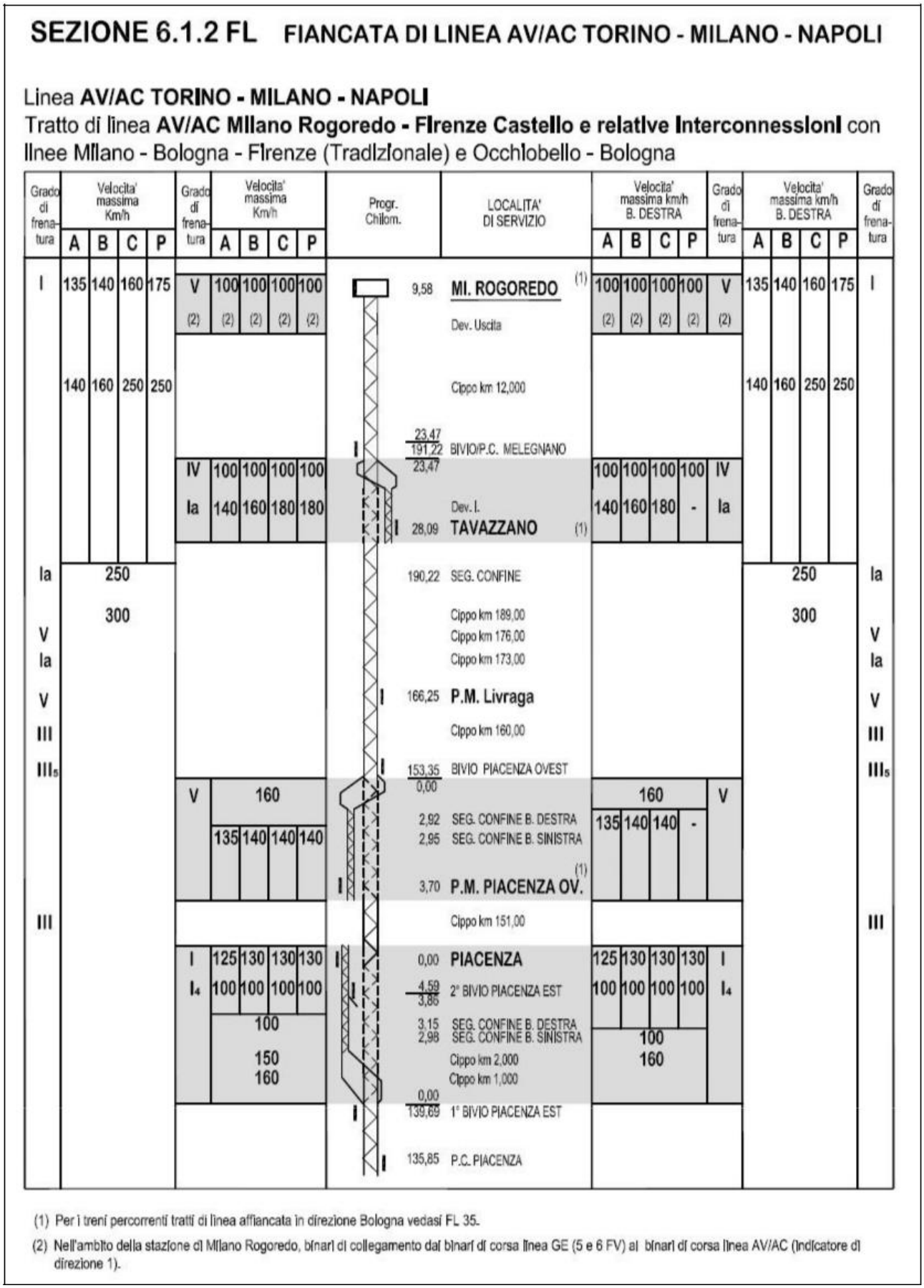


Figure 14 - Single-line diagram of the HS/HC Torino - Milano - Napoli line (odd train direction) – MI Rogoredo - FI Castello line section (source: File Line 82bis, RFI)

SEZIONE 6.1.3 FL FIANCATA PRINCIPALE LINEA AV/AC TORINO - MILANO - NAPOLI

Binario di sinistra

Linea **AV/AC TORINO - MILANO - NAPOLI** tratto di linea **Milano Rogoredo - Firenze Castello e relative interconnessioni**
Trazione elettrica a corrente continua. Esercizio con Dirigente Centrale da Milano Rogoredo a Bivio/PC Melegnano (sede Milano Greco), con Dirigente Centrale Operativo da Bivio/PC Melegnano a Firenze Castello (SCC - Sede Bologna C.le)

Grado di prestazione	Ascesa ‰	Progressive chilometriche	Distanze parziali	LOCALITA' DI SERVIZIO	Posti di blocco	INDICAZIONI DI SERVIZIO E PROTEZIONE PL	Numero e capacità binari
				(da Mil Lambrate, Mil P. Romana, Mil P. Vittoria e PM Trecca)			
1	2	9,586		**MILANO ROGOREDO** *(per Tortona, Melegnano)*	907	1 (1) (2)	—
10	16	9,567				(3)	
		11,229	1,643	Dev. U.			
		12,000	2,414	Cippo			
10	7	12,037	0,037		P909		
		13,064	1,027		P911		
		14,454	1,390		P913		
		15,994	1,540		P915		
		17,607	1,613		P917		
		19,207	1,600		P919		
		20,981	1,774		P921		
8		23,474 / 191,220	2,493		209	2	
10	13	23,474		BIVIO/P.C. MELEGNANO	923	1 30 (5)	
		24,612	1,138		P925		
		26,976	2,364	Dev. I. *(da Melegnano)*		60 (5)	795 - 635
		28,095	1,119	**TAVAZZANO** *(per Piacenza L.T.)*		(2) (4)	
		190,654	0,566	Limite giurisdizione Direzioni Compartimentali Movimento			
		190,229	0,425	SEG. CONFINE			

(1) La stazione di Milano Rogoredo è munita, per i treni provenienti da Milano C.le di due successivi segnali di partenza. Lato Piacenza è munita di segnalamento plurimo di protezione.

(2) Per i treni percorrenti tratti di linea affiancata in direzione Bologna, vedasi FL 35.

(3) Nell'ambito della stazione di Milano Rogoredo, binario di collegamento dal binario di corsa dispari linea Genova (6 FV) al binario di corsa dispari linea AV/AC (indicatore di direzione 1).

(4) A Tavazzano i treni ricevuti sul binario di precedenza dispari incontrano due segnali di partenza; il primo interno comanda le partenze per Codogno e per il binario di precedenza; il secondo, esterno, comanda le partenze dal binario di precedenza. Il segnale di partenza dal binario di corsa è interno solo per i treni diretti al binario di precedenza. Lato Piacenza la stazione è munita di segnalamento plurimo di protezione.

(5) 100 solo se tale velocità è consentita dall'aspetto segnali.

Figure 15/a - Main diagram of the HS/HC Torino - Milano - Napoli line (odd train direction) Part 1 - (Source: File Line 82bis, RFI)

Binario di sinistra

Linea **AV/AC TORINO - MILANO - NAPOLI**

Tratto di linea Milano Rogoredo - Firenze Castello e relative interconnessioni
Alimentazione 25 KVca da B°/P.C. Melegnano (e) a B° Castelfranco Est (e) e da BO Centrale (e) a FI Castello (e) - 3KV cc da MI Rogoredo a B°/P.C. Melegnano (i), da B° Castelfranco Est (i) a BO Centrale (i) e interconnessioni - DCO sede Bologna - ETCS Livello 2

Grado di prestazione	Pendenza ‰	Progressive chilometriche		Località di servizio	Numerazione segnali	Segnalamento e blocco	Indicazioni di servizio	Giurisdizione RBC	Numero e Capacità Binari
8	-4	190,229	0,425	SEG. CONFINE				IT 256 - ID RBC: 30 Tel. 908301	
		189,260	0,969	**POC 3→25** 148m					
		189,000	0,260	Cippo					
		188,003	0,997		1207				
		186,579	1,424		1205				
		185,108	1,471		1203				
		183,700	1,408		1201				
		182,224	1,476		1199				
		180,118	2,106		1197				
		179,740	0,378	**PCF** 147m					
		178,948	0,792	**RTB**					
		177,515	1,433		1195				
	+14	176,107	1,408		1193				
		176,000	0,107	Cippo					
		174,682	1,318		1191				
	-14	174,548	0,134						
	-2	173,057	1,491		1189				
		173,000	0,057	Cippo					
		171,502	1,498		1187				
		169,896	1,606		1185				
		168,924	0,972	**PCF** 147m					
		167,739	1,185		1183				
9	+14	166,252	1,487	**PM Livraga**					747
		165,904	0,348	PVB	1181				
		164,455	1,449		1179				

Figure 15/b - Main diagram of the HS/HC Torino - Milano - Napoli line (odd train direction) Part 1 - (Source: File Line 82bis, RFI)

2.2.4. Work performed at the site of the event

On the section under examination, at the time of the event, no work was being carried out on the track or other parts of the infrastructure, but in the previous hours, during the period of night-time service interruption, the following work had been carried out, which later proved to be related to the accident

- renewal of the three hydraulic actuators frame + core of switch 05;
- renewal of the hydraulic actuator of the frame of switch 06;
- renewal of the hydraulic actuator of the frame of switch 10.

2.2.5. Activation of the railway emergency plan, public emergency services, police, medical services and the associated chain of events

Following the derailment, the following chain of events concerning traffic was adopted:

- 05:30 a.m.: train 9595 arrived at PM Livraga in Full Supervision status and stopped on the arrival route;
- 05:32 a.m.: after several attempts to contact the on-board staff, the operations room was notified to divert the accompanying train 9601;
- 05:36 a.m.: the National Operations Room advised of a probable diversion of train 9595;
- 5:40 a.m.: Central Executive Movement Coordinator in Milan was notified to send help;
- 5:41 a.m.: warnings were issued as per Territorial Production Department P SE 43.1.0:
  - alerted Available Operational Programming and Quality
  - alerted Available Territorial Production Department
  - alerted Polfer
  - notified company protection.

Traffic was therefore interrupted on both directions of the Milan-Bologna HS line and diverted to the "conventional" line, with delays of up to 60 minutes.
The emergency management following the accident therefore did not reveal any criticalities. The entire area and the train were placed under seizure by the Judicial Authority, which decreed its restitution on 12/02/2020, at the end of the surveys and technical investigations.

2.3. Deaths, injuries, material damage

2.3.1. Passengers and third parties, staff

As a result of the event, the two train drivers died and 30 persons, including on-board personnel and passengers, were injured.

2.3.2. Rolling Stock and Infrastructure

Rolling stock and infrastructure suffered considerable damage.

The railway undertaking incurred costs of approximately € 1,915,000.00 for recovering and fixing the rolling stock alone.

The damage to the rolling stock, the seat and the Electric Traction between the point of derailment and the point where the train stopped was quantified by the infrastructure manager at a total cost of approximately € 8,211,190.00 as follows:

- € 4,844,490.00 for track structure;
- € 909,900.00 for Safety and Signalling Systems, Telecommunications, Light and Driving Force;
- € 586,100.00 for Electric Traction;

€ 1,870,700.00 for Civil Engineering Works.

2.4. *External Circumstances*

At the time of the accident the weather conditions and external visibility at night were good.

3. Report of the investigation

3.1. Summary of testimonies (respecting the protection of the identity of the persons concerned)

The testimonies reported in this paragraph were given by the staff of the railway undertaking involved in the accident (§ 3.1.1. and § 3.1.2.) and by that of the infrastructure manager (§ 3.1.3.).

3.1.1. Train Conductor

The Train Conductor stated that, after departing from Milano C.le, the train made a stop in Milano Rogoredo where a few travellers boarded, bringing the total number of passengers present to about 30, in addition to the Train Conductor and the Train Services Supervisor train crew and the catering team, consisting of three people plus a cleaner.

After departing from Milano Rogoredo, once the scheduled announcements had been made and the few customers in Business had been checked, the Train Conductor went to the part of car no. 3 where the Bar is located, to view and sign the digital list in the possession of the Brigade Chief, in the presence of the Train Services Supervisor.

Suddenly, following a strong jolt of the car, he found himself on the ground and, remaining in a crouched position, he banged on various points of the Bar carriage until the train came to a complete halt.

Reopening his eyes and ascertaining that he was not seriously injured, he got up again, trying to check the condition of the other people inside the car, which was completely dark. At the moment, he was unable to locate his equipment (triple key, tablet and GSM-R service phone) as well as the Train Services Supervisor, who, unable to find his service phone, asked for help from a passenger in the adjacent carriage, who provided his personal phone by activating the torch. Once the room was illuminated, the Train Services Supervisor' service phone was retrieved and some panels were noticed to be detached. A strong acrid smell was perceived in the air.

After activating the information flow to the HS Operations Centre, he and the Train Services Supervisor walked through the entire train, starting from car no. 3 towards the rear, breaking the glass panes of the intercom doors that had remained closed to check the health of the travellers present. Most of them had managed to get off the train on their own initiative, while on board, inside car no. 8, the cleaner was lying on the ground with a sore leg. In the meantime, the Train Services Supervisor was continuously contacted by the Operations Room and the emergency services (Fire Brigade, National Health Service and Police).

Once on the ground, he walked with the Train Services Supervisor towards the head of the train, noticing the inclined position of car no. 2 and realising that car no. 1 was missing.

He then walked towards a group of passengers in a lay-by in the locality and noticed the presence of car no. 1 detached from the rest of the train.

Once he reached the car with the Train Services Supervisor, he attempted to gain access to the driver's cab by trying to force the front window without success. In the meantime, emergency vehicles (Fire Brigade, Ambulances and Police) arrived.

After conferring with the intervening police and carrying out a quick count of those on the ground, he returned with the Train Services Supervisor and a policeman to car no. 3 to retrieve trolley bags and jackets in the compartment of the Train Conductor.

He was then attended to by medical personnel together with the Train Services Supervisor, immediately after the aid had been given to the travellers.

He boarded the Ambulance and made the appropriate statements to a policeman while awaiting transfer to hospital. Once transported to the hospital in Pavia, he was admitted to the emergency room.

3.1.2. Train Services Supervisor

After the departure of the train from Milan Central Station and the stop at Milano Rogoredo, after about 10 minutes, the Train Services Supervisor, who was in the bar area of car no. 3 with his back to the counter, felt a strong impact due to which he was thrown over the counter, ending up on the inside, where the operator administers the food.

Immediately perceiving the seriousness of the event, he crouched down to wait for the train to stop, which happened shortly thereafter.

He smelled an acrid odour in the air but was unaware of what had actually happened. In the collision he lost both telephones (personal and service) which he could not locate due to the darkness and the commotion caused by moving objects on board.

In the same carriage were two food service operators and the Train Conductor, who were also in a state of shock.

Noticing that in the intercom between cars no. 3 and no. 4, a traveller was using the torch on his phone, he asked if he could use this device to retrieve the mobile phones on board. He then managed to retrieve both his personal and service mobile phones, through which he immediately alerted the Operations Centre, giving the Train Conductor the opportunity to provide any further information he had at the time regarding the incident.

He then decided to walk with the Train Conductor through the entire train, “armed” with a glass-breaking hammer, from car no. 3 to car no. 8, finding only three passengers who needed help to get out of the train, while all the other passengers had already got out. In car no. 8, the only person in need of care at the time was found, a cleaner, lying on the ground in pain in one leg.

He got out of car no. 8 and went, together with the Train Conductor, towards the head of the train in continuous telephone communication, through his service mobile phone, with the Operations Room, the Fire Brigade, the National Health Service and the Police.

At the head of the train, he noticed that car no. 1 was missing and that car no. 2 was lying on its side.

Once inside car no. 2, he checked that there was no one inside, after which he went, again with the Train Conductor, in search of car no. 1, which he found behind the building of PM Livraga, a long way from the rest of the train, which had remained between the tracks.

After reaching car no. 1, completely in the dark, he tried to access it without success, trying to force the front window of the cab.

In the meantime, help arrived.

Together with the Train Conductor and a policeman, he then re-entered the train, in car no. 3, to retrieve luggage and coats in the compartment of the Train Conductor, after having broken the glass of the access door.

He was then transported by ambulance to Lodi hospital and admitted to the ER.

3.1.3. Infrastructure maintenance staff and Central Operations Manager

On the basis of the documentation acquired, the Committee did not deem it necessary to interview the infrastructure manager's staff, considering as sufficient the reconstruction elaborated

on the basis of the command log, the event log and the recordings of voice communications between the Central Operations Manager and the RFI maintenance staff, as described in paragraph 4.2.2.

3.2. Security Management System

3.2.1. Organisational framework and methods for assigning and performing tasks

The organisational model defined by the infrastructure manager is specified in Organisational Communication No. 390/AD “Organisational model for the governance of RFI's Integrated Safety Management System” (Level I document).

Figure 16 shows the outline of the organisational model, consisting of documents establishing the security policy, roles and responsibilities of the company organisation (Level I), documents defining the system processes (Level II), documents defining the rules of the operational processes (Level III) and local operational rules (Level IV).

The criteria for the risk control process are set out in the level II procedures RFI PSE 01 1 0 “Hazard identification and risk assessment” and RFI PSE 02 1 0 “Management of infrastructural, operational and organisational changes”.

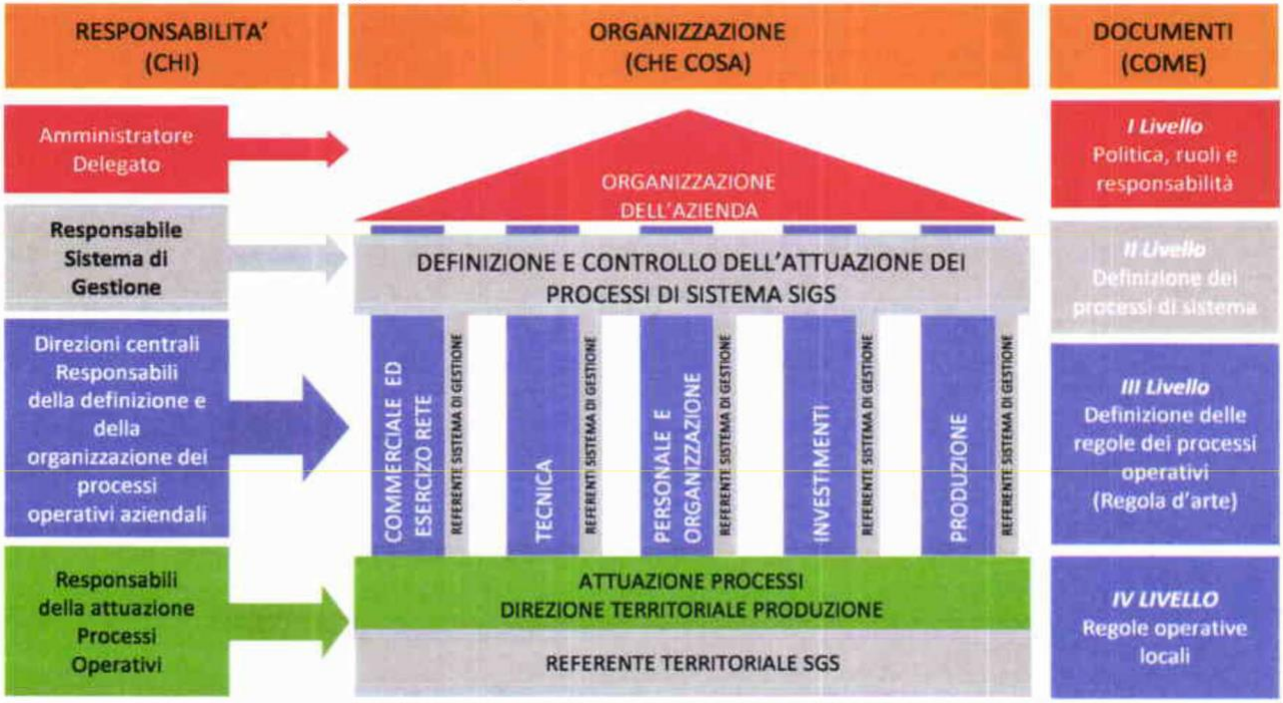


Figure 16 - Diagram of the organisational model for governing the Safety Management System (source: RFI SIGS M 2 0)

The RFI PSE 03 1 0 procedure “Inspections and investigations by RFI in the event of railway accidents or incidents” (2nd level) provides the methods for the assignment and execution of investigations carried out by the Manager in the event of accidents or incidents.

The organisational framework and the procedures for assigning and executing the tasks of the infrastructure manager's personnel in charge of maintenance are set out in Organisational Provision No. 192/AD of 29 December 2015 “Production Management” and Operational Provision No. 36/DPR of 29 December 2015 “Production Management”, which came into force on 01.03.2016. The Operational Provision provides for the organisational and operational structure of the Territorial Production Department shown in *Figure 17*.

In turn, each territorial unit is organised according to the scheme shown in *Figure 18*, and the reference functions of the Territorial Unit are described in the Operational Provision, which is reproduced below in excerpt.

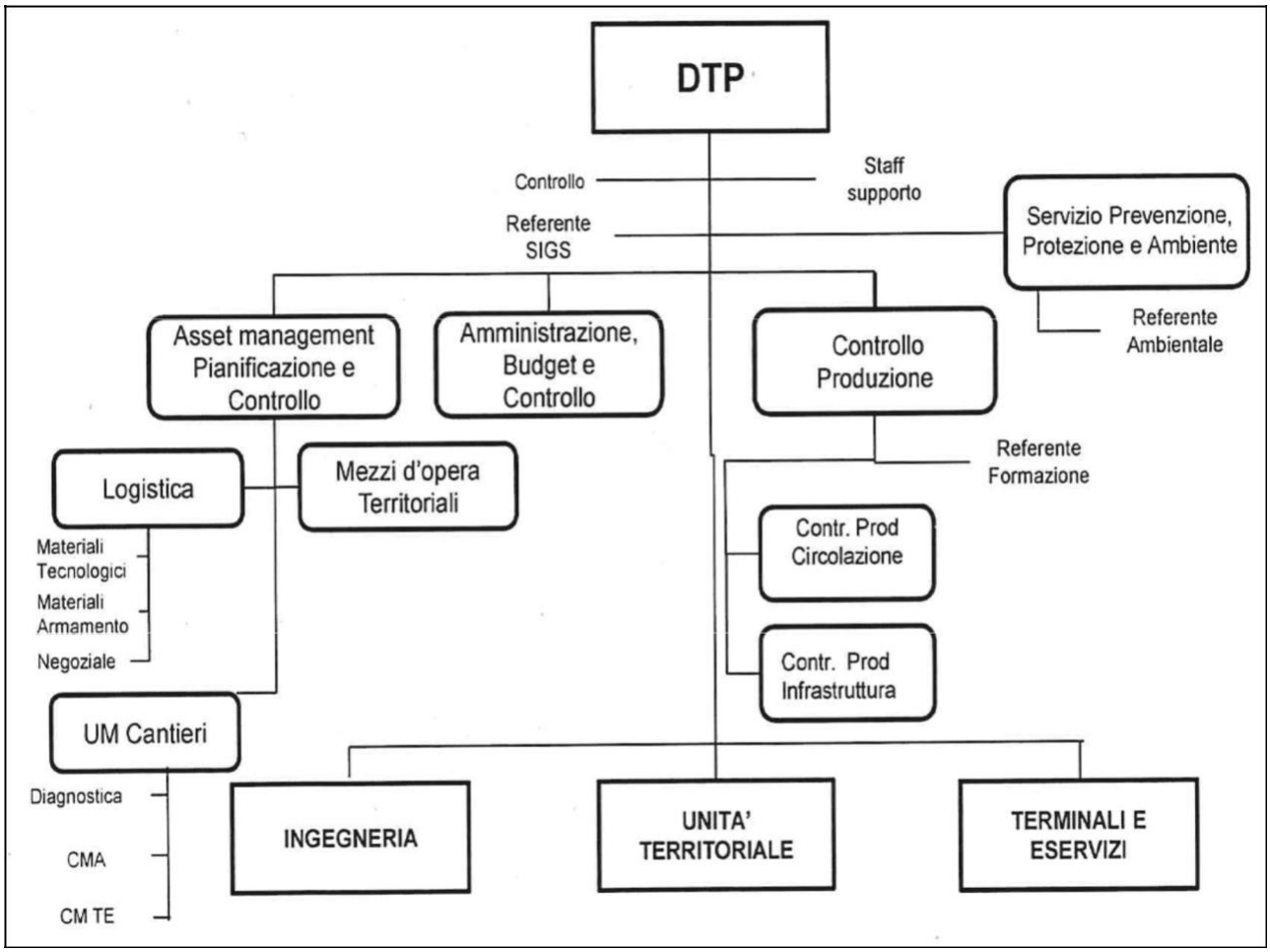


Figure 17 - Organisational and operational structure of the Territorial Production Department (source: RFI)

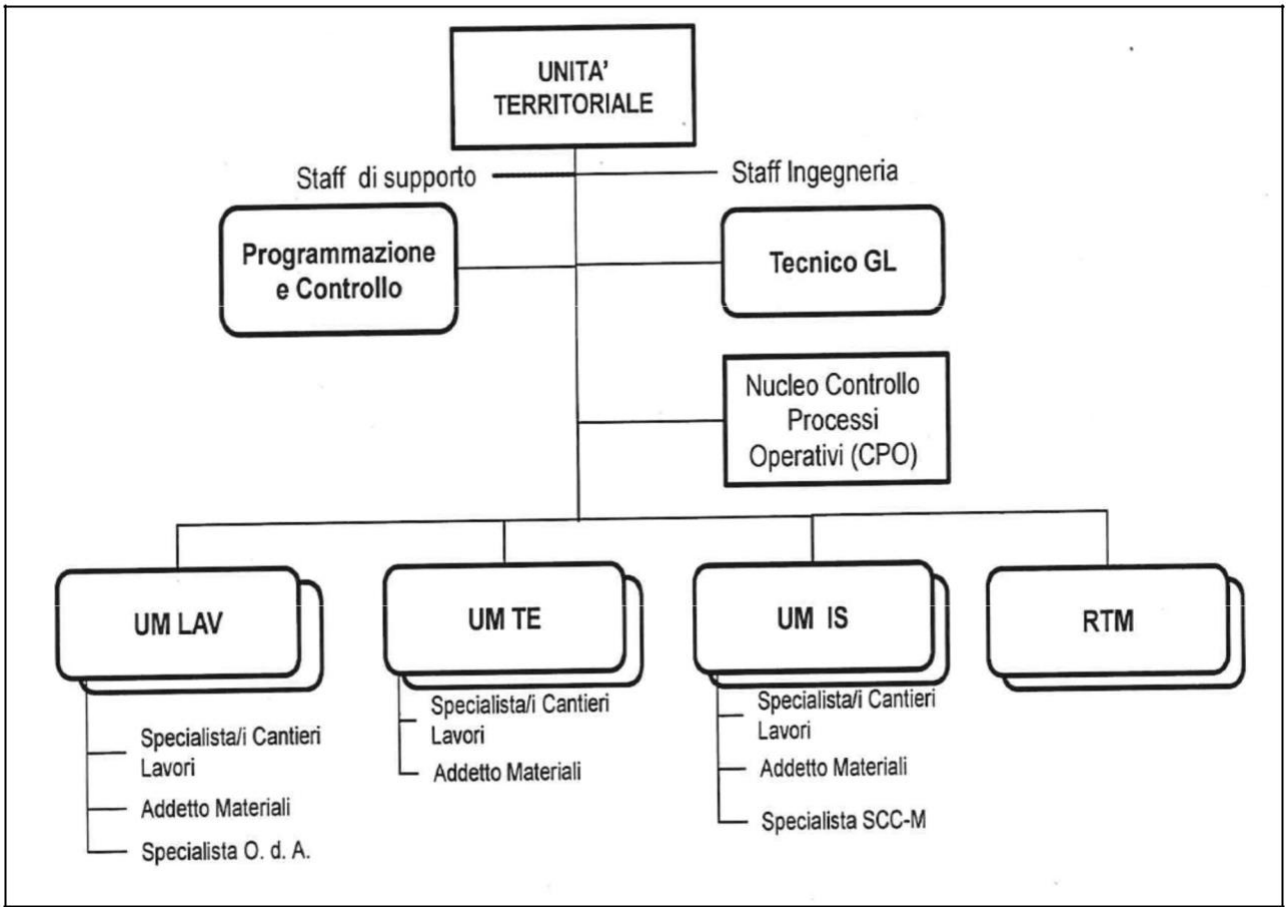


Figure 18 - Organisational and operational structure of the Territorial Unit (source: RFI)

1) PROGRAMMING AND CONTROL
   Activities:
   - Collaborating with the Central Department Maintenance Officer for the drafting of the Annual Planning documentation, identifying, on the basis of the proposals made by the competent structures, the ordinary and extraordinary maintenance operations to be implemented, presenting the priorities to the Territorial Unit Manager for subsequent consolidation;
   - taking care of the drafting of the quarterly and monthly ordinary and extraordinary maintenance schedules, providing for the issuance of the Work Orders and NTWs of the projects within its competence;
   - taking care of the scheduling of activities following the notifications made by the competent National/Territorial Diagnostic structure;
   - guaranteeing the optimisation of the use of human resources, means, materials and interruptions;
   - guaranteeing the procurement of materials for Ordinary Maintenance and internalised activities, on the basis of what is planned by Logistics;
   - monitoring maintenance performance in order to achieve company objectives;
   - seeing to the correct entry and updating of the company information system database regarding maintenance objects, work centre structures and capacities.
2) WORK MANAGEMENT TECHNICIAN
   Activity:
   - Ensuring the executive management of maintenance and infrastructure renewal works entrusted to companies, in accordance with the laws and regulations and internal provisions

by directly carrying out Works Management activities or by providing the necessary cooperation to the persons in charge;

- within the scope of the Works Management assignments entrusted:
  - providing for the verification of the works for the execution in a workmanlike manner, in compliance with the approved plans, the prescriptions of the contracts and the provisions issued by the Works Director;
  - see to the verification or carrying out of the basic layout of the works, the profiles of the ground and the technical surveys necessary for the handover of the works to the companies, pointing out any discrepancies and impediments and proposing the initiatives to be taken to remove them;
  - take care of the implementation of the preliminary initiatives for the delivery of the works, preparing the relevant minutes and proceeding for any suspensions, resumptions and extensions of the works;
  - carry out investigations and take the necessary initiatives to ensure the exact fulfilment by the contractor of all the obligations undertaken, promptly promoting the appropriate measures in the event of delays, irregularities or negligence;
    attend load tests (foundation soils, piles, load-bearing structures, etc.) and prepare the relevant minutes;
  - ascertain the regularity of registration documents by validating, during each on-site visit, the measurements still accessible, dating and signing the documents themselves following the last registration;
- act as the technical secretariat for the infrastructures of jurisdiction;
- to collaborate with the competent structures in the drafting of the annual planning and quarterly programming;
- prepare expenditure proposals for maintenance and renewal works to be carried out by means of a contractor;
- collaborating with the Heritage, Expropriations and Crossings Operating Unit of the Civil Engineering Operating Unit in the activities connected with the protection and asset management of the assets under the Territorial Unit's jurisdiction;
- guaranteeing the correct use of personnel and assigned resources.

3) OPERATIONAL PROCESSES CONTROL NUCLEUS
   Activity:

- Ensuring the performance of control activities at the Maintenance Work Centres of the Territorial Production Department;
- guaranteeing the performance of infrastructure control and supervision activities, provided for by the standards, scheduled or specifically requested;
- providing support during internal or external audits, enquiries and investigations;
- taking part in Internal Inspection Visits and Investigation Committees relating to operating accidents and abnormalities; providing support, where necessary and taking into account the different specialisations, to the Maintenance Units of the Territorial Production Departments with regard to the typical activities of work sites; providing support to the Maintenance Units of the Territorial Production Departments for:
  - the assessment of the skills of operational staff,
  - the identification of training needs,
  - the carrying out of training activities aimed at maintaining skills.

4) MAINTENANCE UNIT
   (Responsible role: Head of Maintenance Unit – Head of Working Centre)

- Ensuring the maintenance of the infrastructure of jurisdiction and the relevant supervision obligations, aimed at the safety and regularity of train movements and the protection of railway assets, in compliance with laws, regulations and internal provisions;
- guaranteeing the execution of the scheduled activities and the scheduling of works in the maintenance information system, assigning the necessary loads to the staff, also ensuring that the activities are accounted for via the information system;
- ensuring the correct use of the assigned staff, means of work, transport and equipment/materials and their efficiency;
- guaranteeing the issue of non-schedulable Work Orders, the opening of failure notices in the maintenance information system and the data entered therein; guaranteeing the activities relating to the management of emergency response (manpower, means and materials) and more specifically:
  - o imposing the necessary traffic restrictions or speed reductions in the event of actual or potentially dangerous situations, also providing for their termination;
  - o intervening when necessary and in any case in the event of abnormalities or operating accidents, in order to ensure the restoration of the infrastructure and the rapid resumption of traffic;
  - o providing for the detection of the first elements that may be useful for ascertaining responsibility for operating incidents and abnormalities; o ensuring the implementation of the activities and tasks envisaged by current legislation on safety, accident prevention and hygiene at work;
- ensuring the organisation of worksite protection;
- ensuring the correct management of waste in compliance with the regulations in force and the regular keeping of loading and unloading registers;
- taking part, if appointed, in committees for the modification and activation of the plants; ensuring that the Maintenance Unit personnel have the requisites required to perform the functions entrusted to them, have complete knowledge of the plants they are responsible for and of the occupational safety and environmental regulations, organising appropriate training meetings;
- guaranteeing the regular execution of the work carried out by the employees;
- guaranteeing the technical assessment of the work carried out, the identification of discarded and used equipment that can be serviced/to be serviced, ensuring that it is properly stored in accordance with the provisions in force and the physical/accounting alignment of its stocks;

Territorial Unit
Maintenance Unit
Works Site Specialist
Activities:

- Providing for the execution in a workmanlike manner of the works carried out with railway personnel within the jurisdiction of the Maintenance Unit;
- Providing for the organisation of the work sites, organising the availability of resources, means and materials; taking care of the weekly allocation of resources, also checking the correct accounting of the activities, using the maintenance information system; providing for the coordination of the internalised works that require the amalgamation of several teams;

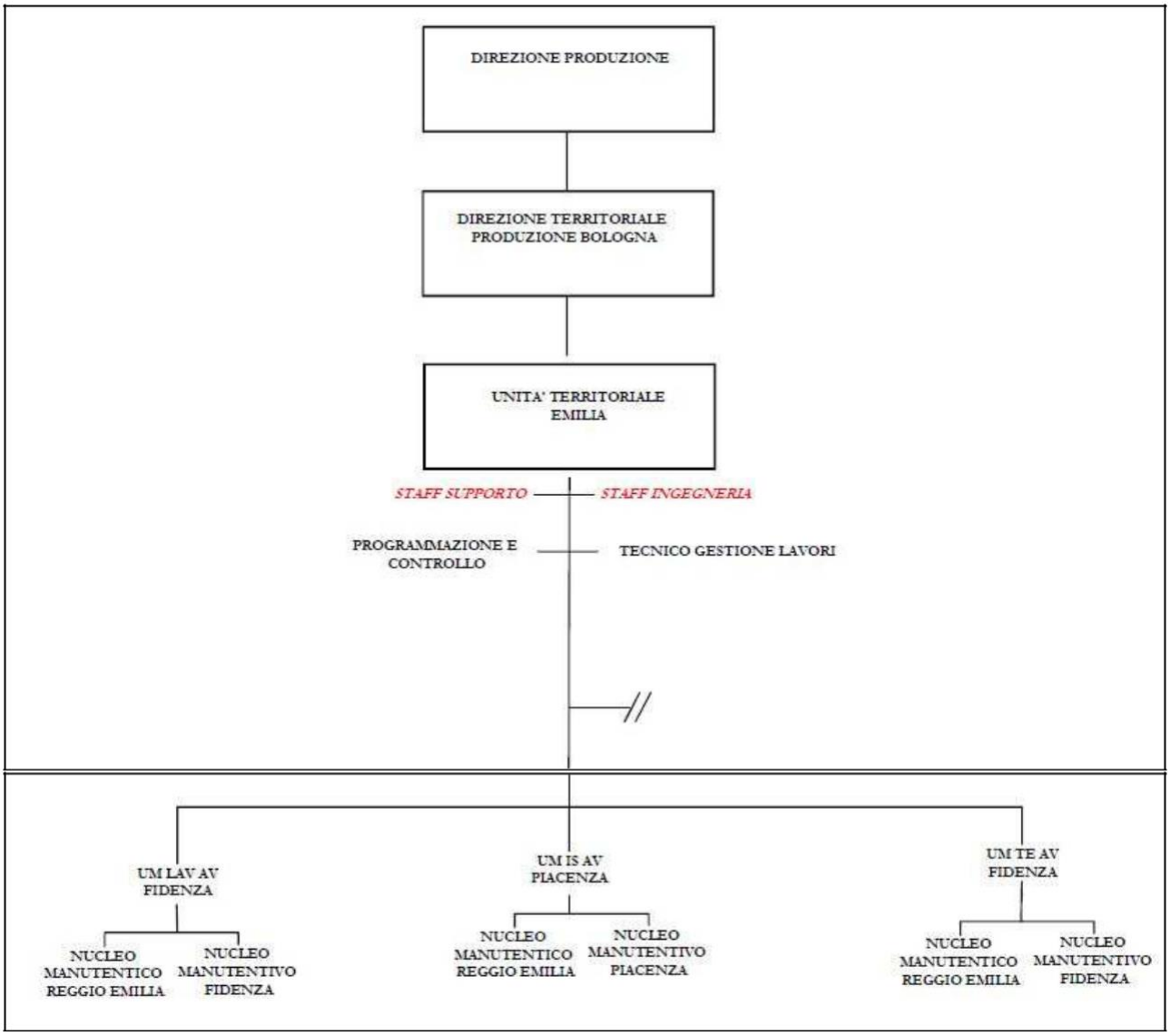
- provide for the adoption of the necessary precautions in order to safeguard the movement of trains and safety in the execution of works, including those under contract;
- with reference to the plants of jurisdiction and with regard to the works to be carried out, provide for:
  - the drafting of briefing and coordination minutes;
  - make available, where not managed in the system, the technical documentation;
- participate, if appointed, in the plant modification and activation committees;
- take care of the issue of non-programmable Work Orders, the opening of failure notices in the maintenance information system and the data entered therein.

Territorial Unit
Safety and Signalling Systems Maintenance Unit
Multistation Control System Specialist
Activities:

- Providing for the perfect execution of works carried out with railway personnel within the jurisdiction of the Maintenance Unit;
- seeing to the organisation of the work sites, organising the availability of resources, means and materials;
- taking care of the weekly allocation of resources, also checking the correct accounting of the activities, using the maintenance information system;
- ensure that the necessary precautions are taken to safeguard the movement of trains and safety in the execution of works, also under contract;
- with reference to the plants of jurisdiction and with respect to the works to be implemented, provide for:
  - the drafting of briefing and coordination minutes;
  - make available, where not managed in the system, the technical documentation;
- participate, if appointed, in the plant modification and activation committees;
- take care of the issue of non-programmable Work Orders, the opening of failure notices in the maintenance information system and the data entered therein.

Extract of Operating Provision No. 36/DPR of 29 December 2015 "Production Department" (source: RFI)

The Milano – Bologna HS line falls within the scope of the Territorial Unit Emilia of the Territorial Production Department of Bologna and is articulated according to the diagram below (Figure *19)*.



Organisational and operational structure of the Territorial Unit Emilia (source: RFI)

3.2.2. Personnel requirements and guarantee of their application

Infrastructure Manager

The RFI Production Department oversees and monitors the process of acquiring and maintaining the competences of its personnel working in Safety Activities provided for by Annex C of the ANSF Decree No. 4/2012 "Rules for the qualification of personnel employed in railway traffic safety activities", through the issuance of specific level III procedures called SAMAC (Systems for Acquiring and Maintaining Competences). These documents, which are an integral part of RFI's Safety Management System, define: the roles, operating contexts and training programmes necessary for the acquisition of the skills required to carry out safety activities, as well as the procedures for issuing individual safety authorisations and professional qualifications and the maintenance of their validity over time.

The granting of a security authorisation requires the possession of specific physical and professional requirements:

- the possession of specific physical and psychological (where applicable) and toxicological prerequisites;

- participation in the specific qualifying course, normally divided into three different training phases (theory, training and apprenticeship) and three related examination sessions to assess the skills acquired in "knowing", "knowing how to do" and "knowing how to be".

Completion of all the training phases and maintenance of the physical requirements allows the issuance of the qualification (*Abilitazione*). Below is a summary of the training pathway for the acquisition of safety qualifications in RFI (*Figure 20*).

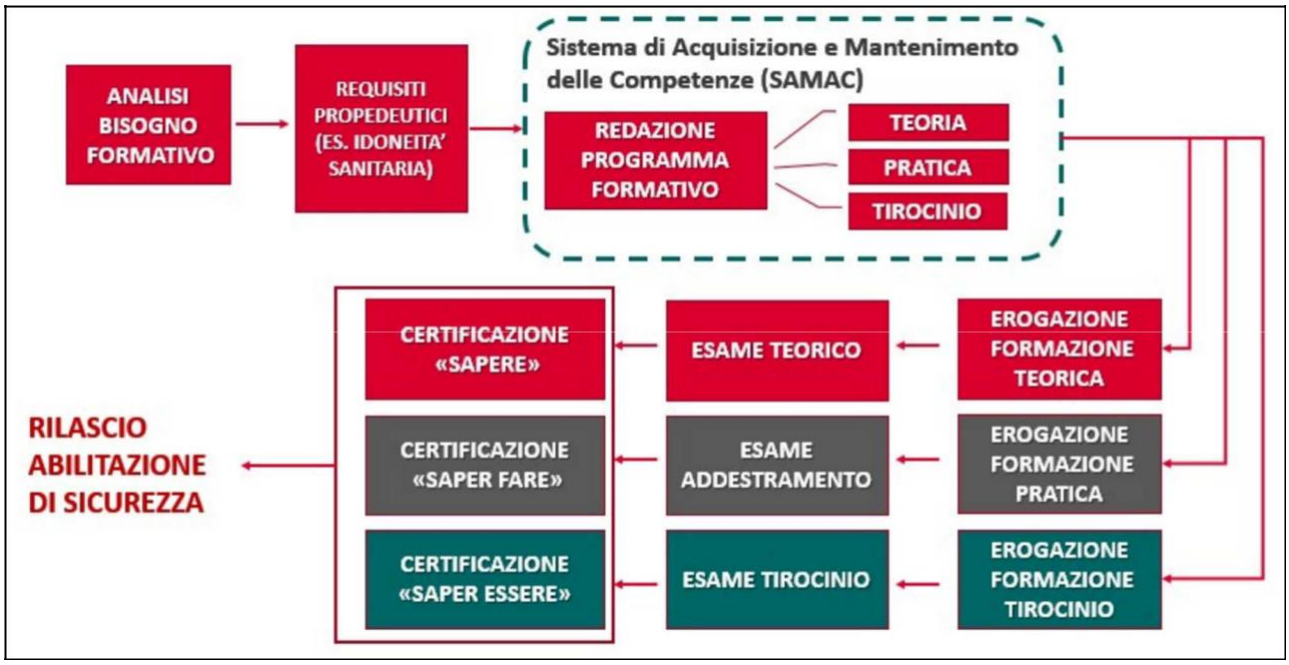


Figure 20 - Outline of the training course for the acquisition of security qualifications in RFI (source: RFI)

Following the acquisition of the entitlement, the agent is entered into a process of maintaining the skills acquired.

The holder of the authorisations, in RFI, corresponds to the Head of the Production Unit, who is responsible for guaranteeing the maintenance of personnel authorisations/qualifications if the requirements for their issue remain in force.

In particular, the authorisation remains valid over time if the following requirements are met:

- specific health aptitude for the qualification role (*medical examinations with varying frequencies depending on the qualifications possessed and age)*;
- exercise of the role (*performance of the work activities covered by the qualification)*;
- maintenance of skills (*attendance at refresher courses).*

The loss of even one of the prerequisites results in immediate termination of employment on the role and suspension of the licence. The holder of the licence is assisted by the Head of the User Work Centre in verifying the above-mentioned requirements.

The courses useful for the issue of enabling certifications as per the IIIrd level procedures mentioned above and the relative examination sessions are carried out exclusively by Instructors and Examiners certified respectively in compliance with ANSF Decree No. 14/2009 "Rules for the Recognition of Instructors and Examiners of personnel carrying out safety activities".

Within the scope of the 3rd level procedures regulating the qualification process in RFI, the RFI procedure DPR SIGS PO 10 1 1 of 1/4/2014 "Maintenance qualification system - Professional qualification system for personnel involved in maintenance and safety activities of railway traffic" implements the provisions of ANSF Decree No. 4/2012 for the specific competences of the maintenance specialist areas. This document describes in detail the procedures for the acquisition of the authorisations (and relative professional qualifications) also for the Safety and Signalling Installations area, with the relative roles and operating contexts,

programmes, minimum times and prerequisites for the acquisition of the qualifications.

The procedure, for the IS specialist area, defines three safety roles functional to the skills possessed:

1. Infrastructure Maintenance Operator
2. Safety and Signalling Systems Maintenance technician
3. Safety and Signalling Systems Activator

The following (*Figure 21*) shows the planned pathway for obtaining the qualifications held by the Security and Signalling Installations operators.

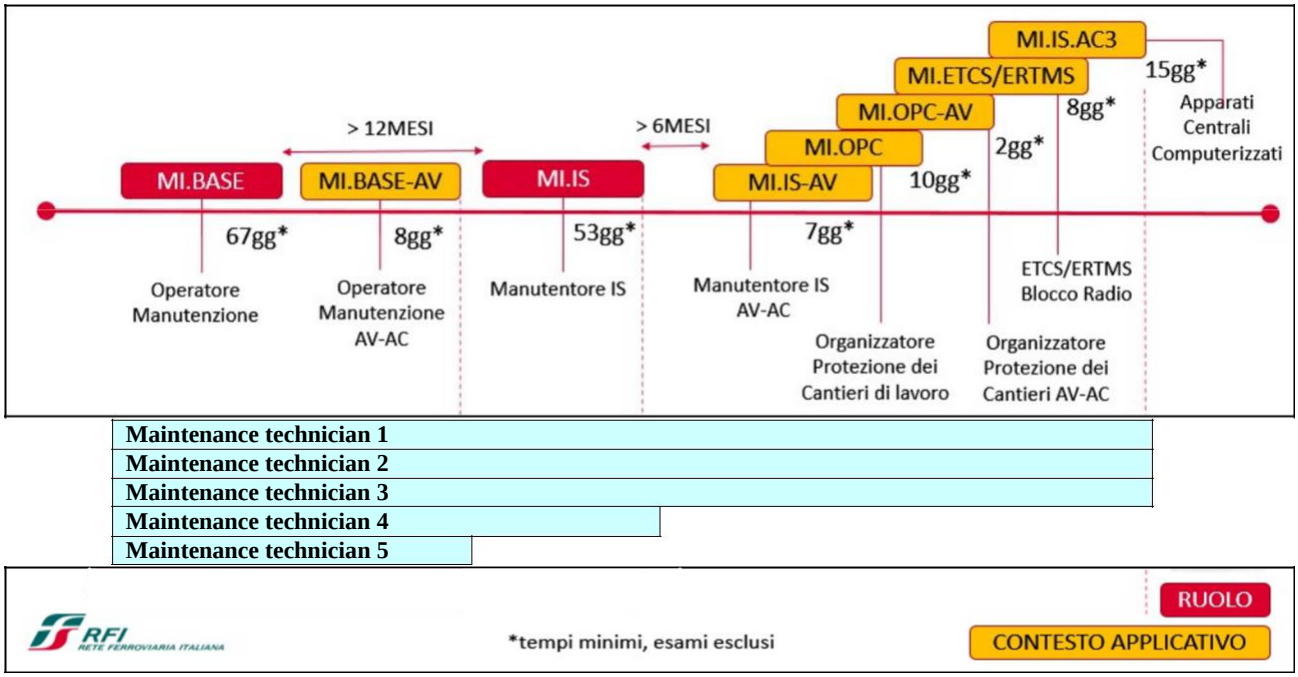


Figure 21 - Outline of the training course for the acquisition of safety skills in RFI (Source: RFI)

The analysis shows that all five operators possessed the necessary skills to collaborate in the performance of the planned work activity. Three agents also had a high level of qualification for the safety activities to be carried out on the section affected by the event.

The personnel of the UMIS AV Piacenza Maintenance Unit of RFI (Territorial Production Department of Bologna), who operated on the section where the accident occurred, possessed the qualifications and underwent the competence maintenance activities indicated in Table 1.

Table 1 - Qualifications acquired and maintenance of skills of RFI maintainers (source: RFI)

Tabella 1 – Abilitazioni acquisite e mantenimento delle competenze dei manutentori di RFI (fonte: RFI)

Descrizione U.O.	Mansione	Qualifica	Figura Professionale	Abilitazioni acquisite	Aggiornamenti sulle competenze
BO-UTEM-UMIS AV Piacenza	Specialista Settore IS	Quadro	Professional	MI.IS.ETCS - ERTMS/ETCS-Blocco Radio QP MI.IS.ETCS. PP. Ansaldo MI BASE - Operatore Manutenzione Infrastruttura MI BASE AV/AC - Operatore Manutenzione Infrastruttura MI OPC - Organizzazione Protezione Cantieri MI OPC AV/AC – Organizzazione Protezione Cantieri QP MI MDO MI.IS - Manutentore IS MI.IS.AV/AC	Risulta effettuato mantenimento competenze su attività specifiche di settore nel 2019, in particolare: IMP Mantenimento competenze Abilitazioni Specialistiche Impianti Segnalamento IMP-SIC.LAV Aggiornamento DPI IMP-SIC.LAV Aggiornamento DVR IMP-SIC.LAV - Utilizzo sostanze pericolose/schede di sicurezza sostanze IMP - problematiche esercizio-analisi guasti

				MI.IS.AC2 - ACEI MI.IS.AC3 – ACC QF MI.IS.AC3. Ansaldo MI.IS.AS1 - RTB/RTF QF MI.IS.AS1. Bombardier	IMP - Aggiornamento sulla manutenzione attrezzature Verifiche di legge - Verifiche di messa a terra
BO-UTEM-UMIS AV-NM Piacenza	Operatore Manutenzione IS	Operaio	Operatore Specializzato Manutenzione Infrastruttura	MI.BASE - Operatore Manutenzione Infrastruttura MI.BASE AV/AC - Operatore Manutenzione Infrastruttura MI.OPC - Organizzazione Protezione Cantieri MI.OPC AV/AC – Organizzazione Protezione Cantieri MI.IS - Manutentore IS MI.IS.AV/AC MI.IS.ETCS - ERTMS/ETCS-Blocco Radio MI.IS.AC3 – ACC MI.IS.SCC - Sistemi Comando e Controllo MI.IS.SCMT - Sistema Controllo Marcia Treno QF MI.IS.ETCS. PF. Ansaldo QF MI.IS.AC3. Ansaldo QF MI.IS.SCC.PF. Ansaldo QF MI.IS.SCMT. Ansaldo	Risulta effettuato mantenimento competenza su attività specifiche di settore nel 2019, in particolare: IMP-SIC.LAV - Utilizzo sostanze pericolose/schede di sicurezza sostanze IMP-SIC.LAV Aggiornamento DVR IMP-SIC.LAV Aggiornamento DPI IMP Mantenimento competenza Abilitazioni Specialistiche Impianti Segnalamento IMP - problematiche esercizio-analisi guasti MI.IS - Mantenimento competenza Istruttori/Esaminatori IMP - Aggiornamento sulla manutenzione attrezzature La competenza metodologiche dell'istruttore - Modulo 1, 2, 3 e 4 Verifiche di legge - Verifiche di messa a terra
BO-UTEM-UMIS AV-NM Piacenza	Operatore Manutenzione IS	Operaio	Operatore Specializzato Manutenzione Infrastruttura	MI.IS.ETCS - ERTMS/ETCS-Blocco Radio QF MI.IS.ETCS. PF. Ansaldo MI.BASE - Operatore Manutenzione Infrastruttura MI.BASE AV/AC - Operatore Manutenzione Infrastruttura MI.OPC - Organizzazione Protezione Cantieri MI.OPC AV/AC – Organizzazione Protezione Cantieri QF MI MDO MI.IS - Manutentore IS MI.IS.AV/AC MI.IS.AC2 – ACEI MI.IS.AC3 – ACC QF MI.IS.AC3. Ansaldo MI.IS.AS1 - RTB/RTF QF MI.IS.AS1. Bombardier	Risulta effettuato mantenimento competenza su attività specifiche di settore nel 2019, in particolare: IMP-SIC.LAV - Utilizzo sostanze pericolose/schede di sicurezza sostanze IMP Mantenimento competenza Abilitazioni Specialistiche Impianti Segnalamento IMP-SIC.LAV Aggiornamento DPI IMP-SIC.LAV Aggiornamento DVR IMP - problematiche esercizio-analisi guasti IMP - Aggiornamento sulla manutenzione attrezzature
BO-UTEM-UMIS AV-NM Piacenza	Tecnico Manutenzione IS	Operaio	Tecnico della Manutenzione Infrastruttura	MI.BASE - Operatore Manutenzione Infrastruttura MI.BASE AV/AC - Operatore Manutenzione Infrastruttura	Risulta effettuato mantenimento competenza su attività specifiche di settore nel 2019, in particolare: IMP-SIC.LAV - Utilizzo sostanze pericolose/schede di sicurezza sostanze IMP Mantenimento competenza Abilitazioni Specialistiche Impianti Segnalamento IMP-SIC.LAV Aggiornamento DPI IMP-SIC.LAV Aggiornamento DVR IMP - problematiche esercizio-analisi guasti IMP - Aggiornamento sulla manutenzione attrezzature Abilitazione degli operatori all'utilizzo delle attrezzature di lavoro: gru per autocarro Gestione dell'emergenza e 1° Soccorso - Antincendio rischio medio Safety - Attenzione Consapevole
BO-UTEM-UMIS AV-NM Piacenza	Operatore Manutenzione IS	Operaio	Operatore Specializzato Manutenzione Infrastruttura	MI.BASE - Operatore Manutenzione Infrastruttura MI.BASE AV/AC - Operatore Manutenzione Infrastruttura MI.IS - Manutentore IS	Risulta effettuato mantenimento competenza su attività specifiche di settore nel 2019, in particolare: IMP-SIC.LAV - Utilizzo sostanze pericolose/schede di sicurezza sostanze IMP Mantenimento competenza Abilitazioni Specialistiche Impianti Segnalamento

					IMP-SIC.LAV Aggiornamento DPI IMP-SIC.LAV Aggiornamento DVR Ruolo Operatore di Cantiere – Teoria Ruolo Operatore di Cantiere – Addestramento IMP - problematiche esercizio-analisi guasti Safety_La Rete della Sicurezza IMP - Aggiornamento sulla manutenzione attrezzature Abilitazione degli operatori all'utilizzo delle attrezzature di lavoro: gru per autocarro MI.IS Manutentore IS TP Abilitazione MI.IS Manutentore IS A

To complete the enabling framework, the number of hours of professional refresher courses carried out for each agent in 2019 (minimum 7.6 h/year) is also shown below.

Table 2 - Professional refresher courses carried out by RFI's maintenance staff (source: RFI)

Tabella 2 – Aggiornamento professionale effettuato dai manutentori di RFI (fonte RFI)

Manutentore	Anni di esperienza nel settore	Aggiornamento abilitazioni di settore: focus 2019 (n. ore)
1	12	39,98
2	11	17,18
3	10	17,18
4	2	17,18
5	2	17,18

Railway Undertaking

The documentation provided by the railway undertaking shows that the drivers of train 9595 were qualified to drive ETR1000 rolling stock on the Milan - Naples HS (*Figures 22 and 23*) and had undergone training and skills maintenance.

CERTIFICATO COMPLEMENTARE DI MACCHINISTA

7. MATERIALE ROTABILE CHE IL MACCHINISTA È ABILITATO A CONDURRE

Data	Descrizione	Note
12/12/2017	ETR500	
12/12/2017	G2000 Classe A e C	
12/12/2017	ETR 1000	
05/06/2019	ETR700	
05/12/2019	ETR 1000 I-F	

CERTIFICATO COMPLEMENTARE DI MACCHINISTA

8. INFRASTRUTTURA SU CUI IL MACCHINISTA È ABILITATO A CONDURRE

Data	Descrizione	Note
12/12/2017	Ancona - Pescara C.le	
12/12/2017	BOLOGNA - FIRENZE (storica)	
12/12/2017	Brescia - VERONA	
12/12/2017	FIRENZE - ROMA (DD LL)	
12/12/2017	MILANO - BOLOGNA (storica)	
12/12/2017	MILANO - Brescia (DD/LL/AV)	
12/12/2017	MILANO - FIRENZE (AV)	
12/12/2017	NAPOLI - Salerno (LMV)	
12/12/2017	nodo BOLOGNA	
12/12/2017	nodo FIRENZE	
12/12/2017	nodo MILANO	
12/12/2017	nodo NAPOLI	
12/12/2017	nodo ROMA	
12/12/2017	nodo TORINO	
12/12/2017	nodo VENEZIA	
12/12/2017	PADOVA - BOLOGNA	
12/12/2017	Rimini - Ancona	
12/12/2017	ROMA - NAPOLI (AV)	
12/12/2017	ROMA - NAPOLI (via Cassino)	

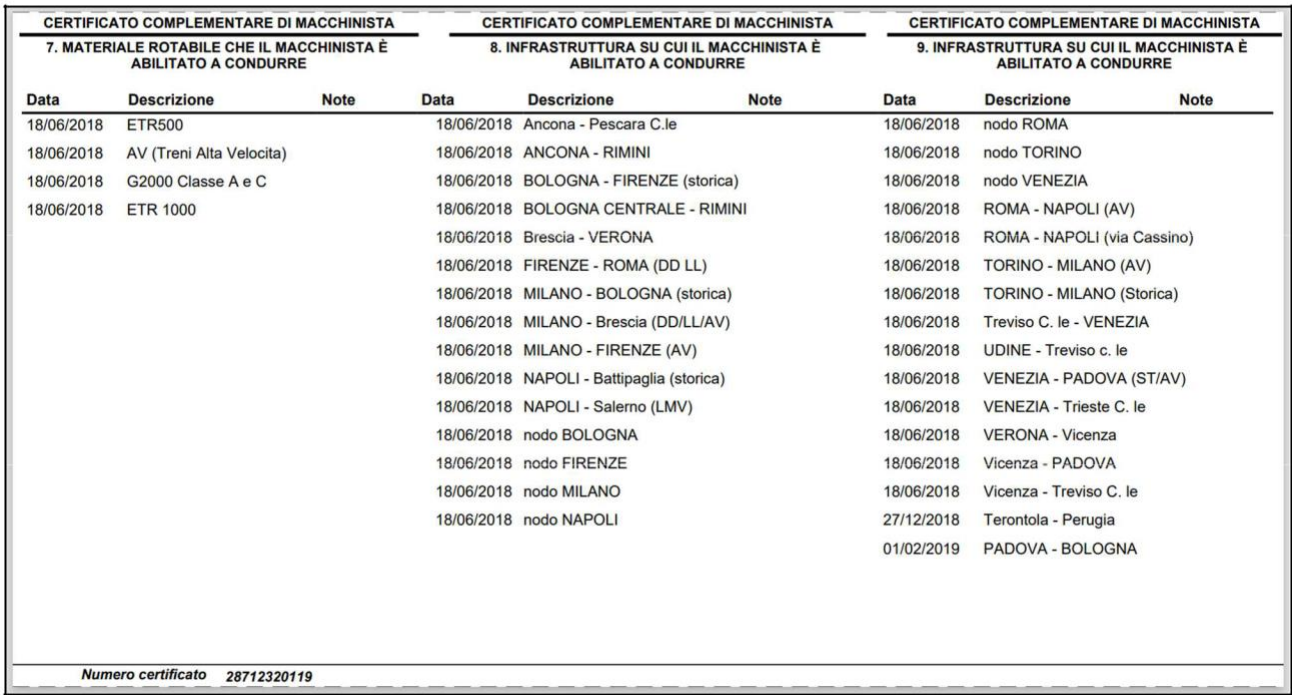
CERTIFICATO COMPLEMENTARE DI MACCHINISTA

9. IIFRASTRUTTURA SU CUI IL MACCHINISTA È ABILITATO A CONDURRE

Data	Descrizione	Note
12/12/2017	TORINO - MILANO (Storica)	
12/12/2017	Treviso C. le - VENEZIA	
12/12/2017	UDINE - Treviso c. le	
12/12/2017	VENEZIA - PADOVA (ST/AV)	
12/12/2017	VENEZIA - Trieste C. le	
12/12/2017	VERONA - BOLOGNA	
12/12/2017	VERONA - Vicenza	
12/12/2017	Vicenza - PADOVA	
12/12/2017	Vicenza - Treviso C. le	
08/02/2018	NAPOLI - Battipaglia (storica)	
03/03/2018	Terontola - Perugia	
10/03/2018	MILANO - GENOVA	
10/03/2018	nodo GENOVA	
26/10/2018	Bergamo - Rovato	
26/10/2018	Treviglio - Bergamo	
23/03/2019	Gallarate - MILANO	
13/10/2019	BOLOGNA - Rimini	
13/10/2019	Bressana B. - Broni	
	Note: solo senso dispari	

Numero certificato ***29108630120***

Figure 22 - Extract from the complementary certificate of driver 1 (source: Trenitalia)



CERTIFICATO COMPLEMENTARE DI MACCHINISTA

7. MATERIALE ROTABILE CHE IL MACCHINISTA È ABILITATO A CONDURRE

Data	Descrizione	Note
18/06/2018	ETR500	
18/06/2018	AV (Treni Alta Velocita)	
18/06/2018	G2000 Classe A e C	
18/06/2018	ETR 1000	

CERTIFICATO COMPLEMENTARE DI MACCHINISTA

8. INFRASTRUTTURA SU CUI IL MACCHINISTA È ABILITATO A CONDURRE

Data	Descrizione	Note
18/06/2018	Ancona - Pescara C.le	
18/06/2018	ANCONA - RIMINI	
18/06/2018	BOLOGNA - FIRENZE (storica)	
18/06/2018	BOLOGNA CENTRALE - RIMINI	
18/06/2018	Brescia - VERONA	
18/06/2018	FIRENZE - ROMA (DD LL)	
18/06/2018	MILANO - BOLOGNA (storica)	
18/06/2018	MILANO - Brescia (DD/LL/AV)	
18/06/2018	MILANO - FIRENZE (AV)	
18/06/2018	NAPOLI - Battipaglia (storica)	
18/06/2018	NAPOLI - Salerno (LMV)	
18/06/2018	nodo BOLOGNA	
18/06/2018	nodo FIRENZE	
18/06/2018	nodo MILANO	
18/06/2018	nodo NAPOLI	

CERTIFICATO COMPLEMENTARE DI MACCHINISTA

9. INFRASTRUTTURA SU CUI IL MACCHINISTA È ABILITATO A CONDURRE

Data	Descrizione	Note
18/06/2018	nodo ROMA	
18/06/2018	nodo TORINO	
18/06/2018	nodo VENEZIA	
18/06/2018	ROMA - NAPOLI (AV)	
18/06/2018	ROMA - NAPOLI (via Cassino)	
18/06/2018	TORINO - MILANO (AV)	
18/06/2018	TORINO - MILANO (Storica)	
18/06/2018	Treviso C. le - VENEZIA	
18/06/2018	UDINE - Treviso c. le	
18/06/2018	VENEZIA - PADOVA (ST/AV)	
18/06/2018	VENEZIA - Trieste C. le	
18/06/2018	VERONA - Vicenza	
18/06/2018	Vicenza - PADOVA	
18/06/2018	Vicenza - Treviso C. le	
27/12/2018	Terontola - Perugia	
01/02/2019	PADOVA - BOLOGNA	

Numero certificato 28712320119

Figure 23 - Extract from the complementary certificate of driver 2 (source: Trenitalia)

Section 2 of the "Instructor's Agendas" of the two drivers (source: Trenitalia) shows the activities and skills checked (chronological list of activities, escorts/escorting, examination of recordings of driving events, sessions at the SIDAC) from which no critical elements emerge.

Similarly, for the train Crew on duty (Train Conductor and Train Services Supervisor), the documentation viewed attests to their suitability for accompanying trains, in compliance with the provisions of the Organisational Communication for the Safety Certificate (COCS 55) of Trenitalia, which acquires the prescriptions of ANSF decree No. 4/2012 and specifies that in order to maintain the aforementioned skills, the accompanying personnel must undergo continuous training processes.

From what we have been able to ascertain, therefore, the staff of the infrastructure manager and that of the railway undertaking appear to have undergone the required training courses, to be in possession of the qualifications and to have undergone competence maintenance activities.

3.2.3. Modalities of the internal controls and checks and their results

On the date of the event, the internal controls and verifications implemented by the infrastructure manager followed the indications of the Document of RFI SpA "The control system of the Production Department. Monitoring, Audit and Improvement" DP R P 02 1 3 (Level III Document) dated 23/12/2019, in force since 16/01/2020, which transposes the principles and criteria established in the Level II documents of RFI's Safety Management System by defining the responsibilities and methods of implementation of the Production Management's control system on the processes required for the safe operation of the railway infrastructure. To date, the document has been updated to version DPR P 02 1 4 of 13/01/2021.

In a nutshell, the document provided for several levels for the periodic control of processes (for details, see § II.5):

- Management Committee (CODIR);
- Territorial Committee on Production Trends of Territorial Production Department (CoTAP DTP);
- Territorial Production Trend Committee of Territorial Unit (CoTAP UT);

The Management Review is then the summary document that collects the information related to all the areas of the management system, in particular the performance analysis, the objectives, the indicators, the audits and any other element related to the functioning of the Integrated Safety Management System, in order to give evidence of the state of adequacy and effectiveness of the Integrated Safety Management System.

In the IV level document "Review of the Bologna 2020 Territorial Production Department Management (ref. year 2019)" of RFI SpA of 30.04.2020, the objectives related to safety are indicated, which consist in aiming at zero operating accidents, accidents at work and environmental impact.

3.2.4. Interface between the various parties operating on the infrastructure

The "interface" procedures applied by the different stakeholders (railway undertaking and infrastructure manager) are outlined below.

Article 8 of Italian Legislative Decree No. 50 of 14 May 2019, Implementation of Directive 2016/798 of the European Parliament and of the Council of 11 May 2016 on railway safety, provides - *inter alia* - the following:

1. Infrastructure managers and railway undertakings shall develop their safety management systems (SMS) in order to ensure that the railway system achieves at least the Train Services Supervisors, complies with the safety requirements contained in the TSIs and that the relevant elements of the CSMs and national rules are applied.

2. The safety management system (SMS) shall be documented in all its relevant elements and shall describe, in particular, the allocation of responsibilities within the organisation of the infrastructure manager or the railway undertaking. […]

In addition, there must be a clear commitment to the consistent application of knowledge and methods for human factor risk assessment. […]

3. The safety management system consists of the following essential elements:

[…]

f) planning of personnel training and systems to ensure that personnel maintain their competence and that tasks are performed in accordance with it, including provisions for physical and psychological fitness;

[…]

8. The safety management system of each infrastructure manager shall take into account the effects of the activities carried out on the network by the various railway undertakings and shall enable railway undertakings to operate in accordance with the TSIs as well as national rules and conditions laid down in their safety certificates.

The Commission's Delegated Regulation (EU) 2018/762 establishes Common Safety Methods (CSM) relating to the requirements of the safety management system in accordance with Directive (EU) 2016/798 of the European Parliament and of the Council.

Annexes I and II "Requirements of the safety management system with regard to railway undertakings/infrastructure managers" provide, inter alia, that:

3. PLANNING

3.1. Actions to address risks

3.1.1.1. The organisation shall:

a) identify and analyse all operational, organisational and technical risks relevant to the character and scale of the organisation. These risks shall include those arising from human and organisational factors, such as workload, work design, fatigue or adequacy of procedures, and from the activities of other interested parties (see 1. Background of the organisation);

[…]

e) recognise the need to collaborate with other stakeholders (such as railway undertakings, infrastructure managers, manufacturers, maintenance providers, subjects in charge of maintenance, railway vehicle keepers, service providers and procurement entities), where appropriate, on shared risks and the implementation of appropriate safety measures.

[…]

4. SUPPORT

4.6. Integration of human and organisational factors

4.6.1. The organisation shall demonstrate that it has a systematic method for integrating human and organisational factors within the safety management system. This method shall: a) include the use of experts and the use of recognised methods from the field of human and organisational factors; b) address the risks associated with the design and use of equipment, tasks, working conditions and organisational measures taking into account human capabilities and their associated limitations and their influence on human performance.

The "Guidelines for the design and implementation of a Safety Management System in the railway sector", published by the European Railway Agency in 2010, on the subject of "Risk Assessment", state that (paragraph 7.2):

The risk could affect basically three areas: finances, time and quality. Safety risks in the form of hazardous events could occur in all three areas, which could be related to technical systems, human factors or organisational factors.

The responsibility for the safe operation of the railway system and the control of associated risks lies with the infrastructure manager and the railway undertakings and obliges them to take the necessary control measures and to apply national safety rules and standards.

To this end, risk management (consisting of the overall process of risk analysis and assessment) is a key element for the effectiveness of any SMS.

3.3. Rules and Regulations

3.3.1. Relevant Community and national rules and regulations

The main national regulations governing railway safety relating to the event in question are listed below.

- Presidential Decree No. 753 of 11 July 1980 "*New rules on police, safety and regulation of the operation of railways and other transport services*", which applies to the entire national railway system;
- Ministerial Decree No. 138-T of 31 October 2000: Deed of Concession to the National Infrastructure Manager;
- Italian Legislative Decree No. 188 of 8 July 2003, transposition of Directives 2001/12/EC, 2001/13/EC and 2001/14/EC;
- Italian Legislative Decree No. 162 of 10 August 2007, "*Implementation of Directives 2004/49/EC and 2004/51/EC on the safety and development of the Community's railways*";
- Italian Legislative Decree No. 50 of 14 May 2019, "*Implementation of Directive 2016/798 of the European Parliament and of the Council of 11 May 2016 on railway safety*";
- Italian Legislative Decree No. 57 of 14 May 2019, "*Implementation of Directive 2016/797 of the European Parliament and of the Council of 11 May 2016 on the interoperability of the rail system of the European Union (recast)*".
- ANSF Decree No. 4/2012 of 9/08/2012 "*Regulations for railway traffic*".

3.3.2. Other regulations (operating rules, local instructions, staff requirements, maintenance requirements and applicable standards)

Infrastructure manager

- Integrated Safety Management System Manual RFI SIGS M 2 0 dated 25/09/2015
- Manual of the Safety Management System for the Traffic of Trains and Railway Operations RFI SGS M 2 0 dated 11/04/2017
- Regulations for the Circulation of Trains of RFI SpA (Updated by ANSF decree No. 12/2009)
- Instruction for the Protection of Yards Operating on the National Railway Infrastructure (1986 Edition - reprinted 2014)
- Instruction for the service of switches in use on the National Railway Infrastructure (1994 edition, reprinted 2019)
- Amendments to the Instruction for the Operation of the Central Computerized Multistation Apparatus (ACCM) of the High Speed/High Capacity (HS/HC) Milan - Florence line equipped with ERTMS/ETCS L2
- Instruction for verifications that must precede the activation of signalling installations (IS 46 - 1971 edition)
- ACC/ACCM installations - Verification, activation and operational modification procedures (RFI DTC STS ST PR PC00 002 A)
- Operation and Maintenance Manual for the Hydraulic Subsystem (RFI DTC STS SS TB EN IS 1 166 C - rev. C of 23/09/2014; ALSTOM G425015013 T - rev. 6 of 24/02/2014)
  6 Hydraulic manoeuvring subsystem - Technical Specification (ALSTOM G425015011R - rev. 6 of 24/02/2014)
- Technical standards for the supply and testing of mechanical and electromechanical equipment for safety and signalling installations (IS 715 - 1991 edition)
- Type and Acceptance Tests for electronic and electromechanical equipment for safety and signalling installations (DI TCSS ST IS 00 402 A)
- Hydraulic system “Manufacturing and Control Plan” (ALSTOM A-0000086016 - rev. B of 01/02/2018)
- Hydraulic operating subsystem “Single fault management procedure” (ALSTOM G41304700AK - rev. 1 of 24/01/2013)
- Principle diagram of simple hydraulic switch tg. 0.074 without accumulation for HS/HC application (RFI DT 04-2008 - ANSALDO SIGNAL S00A.A39001.602.01I)
- Procedure for the technical approval of products (DI TC PS ORG 002 A - rev. A of 06/12/1999)
- Management operating procedure “Requirements for the management of supplies of materials carried out under quality assurance” (RFI DPR PD ORG 020 A - rev. A of 30/10/2015)
- Operating procedure “Replacement of hydraulic switch parts” (RFI MOL TDS22050 C IS Ed. 0 - rev. A of 22/10/2014).

Railway undertaking

- Maintenance Plan ETR1000 V300Zefiro, dated 11/06/2018, Bombardier - Hitachi
- Manual of Trades Conduct, Manual of Trades “Operating Rules for Technological Equipment”
- DEIF 13.3 of 2/05/2017 “"Management of situations related to operational incidents and assistance to customers and train crew”

- CO (Organisational Communication) No. 281.5/DPI dated 31/07/2019 “Rescue system: management of rescue vehicles for the recovery of rolling stock and clearing of the railway infrastructure of the RFI Manager”.

3.4. Operation of rolling stock and technical installations

3.4.1. Signalling and command-control system, recording by automatic recording equipment

Trenitalia train 9595, departing from Milano C.le at 5:10 a.m. with destination Salerno, was the first train of the day to pass near Livraga PM, on the HS/HC Milano-Bologna line, and the wrong position of switch 05 caused it to go off track.

3.4.2. Infrastructure

As mentioned in Section 2.2.3, the line is electrified with 25 kV ac electric traction from Bivio/PC Melegnano to Bivio Castelfranco Est and from Bologna C.le to Firenze Castello and 3 kV dc electric traction from Milano Rogoredo to Bivio/PC Melegnano and from Bivio Castelfranco Est to Bologna C. le, equipped with an ETCS Level 2 system and operation is managed with a Central Manager from Milano Rogoredo to Bivio/PC Melegnano (Milano Greco Headquarters) and with a Central Operations Manager from Bivio/PC Melegnano to Firenze Castello (SCC - Bologna C.le Headquarters).

The maximum speed permitted near PM Livraga, on the Bivio/PC Melegnano - Bivio Piacenza Ovest section for odd-numbered trains is 300 km/h.

3.4.2.1. Periodic checks on the infrastructure

The infrastructure manager has submitted the line maintenance plan for review. The scheduled checking activities are shown in *Table 3*.

The planned frequencies for the various scheduled control activities on the line are shown in *Table 4.*

Table 3 - Extract from the cyclic maintenance plan Safety and Signalling Systems HS/HC Bologna-Milano line - PM Livraga Period 01/01/2019-29/02/2020

Descrizione	Sede Tecnica	Descrizione Sede Tecnica	Data prevista fine esecuzione	Data effettiva fine esecuzione
Manut. Mensile dev. a manovra oleod. SO1			31/01/2019	07/01/2019
Manut. Mensile dev. a manovra oleod. SO1			28/02/2019	05/02/2019
Manut. Trimestrale dev. a manovra oleod. SO1			31/03/2019	01/03/2019
Manut. Mensile dev. a manovra oleod. SO1	LO9121-BC-BC01-DEV-D03-MD1	manovre oleodinamiche	30/04/2019	06/04/2019
Manut. Mensile dev. a manovra oleod. SO1	LO9121-BC-BC01-DEV-D02-MD1 LO9121-BC-BC02-DEV-D03-MD1	dev. tg 0,074	31/05/2019	07/05/2019
Manut. Annuale dev. a manovra oleod. SO1	LO9121-BC-BC02-DEV-D02-MD1	dev. n. 05 - 06 - 09 -10	30/06/2019	25/06/2019
Manut. Mensile dev. a manovra oleod. SO1			31/07/2019	01/07/2019
Manut. Mensile dev. a manovra oleod. SO1			31/08/2019	02/08/2019
Manut. Trimestrale dev. a manovra oleod. SO1			30/09/2019	03/09/2019

Descrizione	Sede Tecnica	Descrizione Sede Tecnica	Data prevista fine esecuzione	Data effettiva fine esecuzione
Manut. Mensile dev. a manovra oleod. SO1			31/10/2019	01/10/2019
Manut. Semestrale dev. a manovra oleod. SO1			30/11/2019	20/11/2019
Manut. Mensile dev. a manovra oleod. SO1			31/12/2019	10/12/2019
Manut. Mensile dev. a manovra oleod. SO1			20/01/2020	14/01/2020
Manut. Mensile dev. a manovra oleod. SO1			29/02/2020	25/02/2020
Manut. Mensile dev. a manovra oleod. SO5	LO9121-BC-BC02-DEV-D04-MD1 LO9121-BC-BC02-DEV-D01-MD1 LO9121-BC-BC01-DEV-D04-MD1 LO9121-BC-BC01-DEV-D01-MD1	manovre oleodinamiche dev. tg 0,022 dev n. 01 - 02 - 03 – 04	31/01/2019	08/01/2019
Manut. Mensile dev. a manovra oleod. SO5			28/02/2019	04/02/2019
Manut. Trimestrale dev. a manovra oleod. SO5			31/03/2019	01/03/2019
Manut. Mensile dev. a manovra oleod. SO5			30/04/2019	05/04/2019
Manut. Mensile dev. a manovra oleod. SO5			31/05/2019	07/05/2019
Manut. Annuale dev. a manovra oleod. SO5			30/06/2019	25/06/2019
Manut. Mensile dev. a manovra oleod. SO5			31/07/2019	02/07/2019
Manut. Mensile dev. a manovra oleod. SO5			31/08/2019	01/08/2019
Manut. Trimestrale dev. a manovra oleod. SO5			30/09/2019	03/09/2019
Manut. Mensile dev. a manovra oleod. SO5			31/10/2019	30/09/2019
Manut. Semestrale dev. a manovra oleod. SO5			30/11/2019	13/11/2019
Manut. Mensile dev. a manovra oleod. SO5			31/12/2019	09/12/2019
Manut. Mensile dev. a manovra oleod. SO5			20/01/2020	13/01/2020
Manut. Mensile dev. a manovra oleod. SO5			29/02/2020	25/02/2020
LO9121-BC - Verifica annuale CDB AF su Binari di Corsa	LO9121-BC-BC01-CDB-C01 LO9121-BC-BC01-CDB-C02 LO9121-BC-BC01-CDB-C03 LO9121-BC-BC01-CDB-C04 LO9121-BC-BC01-CDB-C05 LO9121-BC-BC02-CDB-C01 LO9121-BC-BC02-CDB-C02 LO9121-BC-BC02-CDB-C03 LO9121-BC-BC02-CDB-C04 LO9121-BC-BC02-CDB-C05	cdb su BC cdb n. 110 - 111 - 302 - 151 - 150 - 160 - 161 - 303 - 121 – 120	31/03/2019	19/03/2019
Verifica annuale CDB AF su altri Binari	LO9121-AB-AB01-CDB-C01 LO9121-AB-AB01-CDB-C02 LO9121-AB-AB01-CDB-C03 LO9121-AB-AB02-CDB-C01 LO9121-AB-AB02-CDB-C02 LO9121-AB-AB02-CDB-C03	cdb su AB cdb n. 112 - 301 - 152 - 162 - 304 – 122	31/03/2019	15/03/2019
Man. Annuale dev. P80/L90 intall. mecc. diagn.	LO9121-AB-AB01-DEV-D01-MD1 LO9121-AB-AB01-DEV-D03-MD1 LO9121-AB-AB02-DEV-D01-MD1 LO9121-AB-AB02-DEV-D02-MD1	manovre dev. tg 0,074 dev. n. 08 - 07 - 12 - 11	30/06/2019	05/06/2019

Descrizione	Sede Tecnica	Descrizione Sede Tecnica	Data prevista fine esecuzione	Data effettiva fine esecuzione
Man. Semestrale dev. P80/L90 intall. mecc. diagn.			30/11/2019	07/11/2019
Man. dev. Manovra a mano tirant. a ganci	LO9121-AB-AB01-DEV-D02	dev n. 101a	30/06/2019	05/06/2019
Man. dev. Manovra a mano tirant. a ganci	LO9121-AF-AF01-DEV-D01 LO9121-AF-AF01-DEV-D02 LO9121-AF-AF01-DEV-D03 LO9121-AF-AF05-DEV-D01 LO9121-AF-AF05-DEV-D02 LO9121-AF-AF07-DEV-D01 LO9121-AF-AF07-DEV-D02 LO9121-AF-AF07-DEV-D03 LO9121-AF-AF08-DEV-D01	dev. n. 101b - 205 - 208 - 201 - 206 - 202 - 203 - 204 - 207	30/06/2019	28/06/2019

Table 4 - Summary of the maintenance plan cycles ca IS HS/HC Bologna-Milan line - PM Livraga loc

Tipologia	Attività	Periodicità
Manut. dev. a manovra oleod. SO1	MN-Manut. dev. manovra oleod. SO1	mensile
	TR-Manut. dev. manovra oleod. SO1	trimestrale
	SM-Manut. dev. manovra oleod. SO1	semestrale
	AN-Manut. dev. manovra oleod. SO1	annuale
Manut. dev. a manovra oleod. SO5	MN - Manut. dev. manovra oleod. SO5	mensile
	TR - Manut. dev. manovra oleod. SO5	trimestrale
	SM - Manut. dev. manovra oleod. SO5	semestrale
	AN - Manut. dev. manovra oleod. SO5	annuale
Man. dev. P80/L90 intall. mecc. diagn.	SM-Man. dev. P80/L90 intall. mecc. diag	semestrale
	AN-Man. dev. P80/L90 intall. mecc. diag	annuale
Man. dev. Manovra a mano tirant. a ganci	AN-Man. dev. Man. a mano con tir. ganci	annuale
Verifica annuale CDB AF	AN-Verifica CDB AF diagnos. Comp.	annuale

3.4.2.2. Checks on the infrastructure following the accident

The checks carried out on the infrastructure following the accident, in which the Committee took part, were described in section 2.1.2.

3.4.3. Communication equipment

As far as communication equipment is concerned, the railway line is covered by the *GSM-R* system and all station and driving personnel are equipped with mobile telephones operating on the same *GSM-R* network.

Service communications following the derailment were carried out with service mobile phones.

3.4.4. Rolling stock, recording by automatic recording equipment

The Investigation Committee, considering the dynamics of the accident and the causes that determined it, described in detail in § 4.2, did not deem it necessary to acquire the DIS equipment and related recordings seized by the Judicial Authority immediately after the event.

It was not possible to take a reading of the Electronic Tachograph Zone because the DISW system, on the basis of what was reported by the railway undertaking, reports the zone of a shunting movement carried out from Milano Martesana to Milano Centrale (recording start at 23:20:46 of 05/02/2020, recording end at 04:48:47 of 06/02/2020) as the last unloading.

The last contact with the ground diagnostic room of the ETR 1000 021, recorded at 05:30:20 on 06/02/2020, a few moments before the train wreck, revealed that the train was proceeding at a speed of 298 km/h *(Figure 24)*.

Stato	Veicolo	Ultimo Aggiornamento	Ultima posizione disponibile	km/h
	etr1000cst001	07/07/2020 - 16:39:46	Gr.Sc.Mestre AC (0.07 km)	0
	etr1000cst002	07/07/2020 - 16:39:34	P.C. CAPENA (5.59 km)	176
	etr1000cst003	07/07/2020 - 16:39:35	BIVIO TURRO (0.13 km)	0
	etr1000cst004	02/07/2020 - 14:52:13	NAPOLI TRACCIA (0.15 km)	0
	etr1000cst005	07/07/2020 - 16:39:36	MONZUNO (12.86 km)	279
	etr1000cst006	07/07/2020 - 16:37:04	ZDE_MilanoMartesana (0.32 km)	0
	etr1000cst007	07/07/2020 - 16:39:44	BIVIO AGUCCHI (0.34 km)	141
	etr1000cst008	07/07/2020 - 16:39:35	P.C. S.DONATO (1.63 km)	247
	etr1000cst009	07/07/2020 - 16:39:34	BIVIO TURRO (0.24 km)	0
	etr1000cst010	07/07/2020 - 16:37:16	2B.ORVIETO S. (0.59 km)	249
	etr1000cst011	07/07/2020 - 16:39:46	VAIRANO C. (2.94 km)	302
	etr1000cst012	07/07/2020 - 16:39:40	ZDE_Napoli (0.06 km)	0
	etr1000cst013	07/07/2020 - 16:38:40	Napoli Gianturco (0.25 km)	0
	etr1000cst014	07/07/2020 - 16:39:45	ROMA TIBURTINA (0.05 km)	0
	etr1000cst015	15/06/2020 - 15:04:36	ZDE_VadoLigure (0.05 km)	0
	etr1000cst016	04/07/2020 - 20:25:01	P.C.ALLERONA (0.08 km)	236
	etr1000cst017	07/07/2020 - 16:39:28	GALLIERA (1.63 km)	165
	etr1000cst018	07/07/2020 - 16:39:36	Napoli Gianturco (0.33 km)	0
	etr1000cst019	07/07/2020 - 16:37:05	P.C.ASCIONE (0.46 km)	248
	etr1000cst020	07/07/2020 - 16:39:36	PONTENURE (3.14 km)	300
	etr1000cst021	06/02/2020 - 05:30:20	Ospedaletto L. (3.20 km)	298
	etr1000cst022	07/07/2020 - 16:39:48	PM S.P. Sieve (0.61 km)	249
	etr1000cst023	07/07/2020 - 16:39:40	NAPOLI C. (0.03 km)	0
	etr1000cst024	07/07/2020 - 16:39:39	Gr.Sc.Mestre AC (0.06 km)	0

Figure 24 - Last contact with the diagnostic ground server of ETR 1000 021 (source: Trenitalia)

3.4.4.1. Periodic checks on rolling stock

The ETR 1000.21 train, which left the IMC AV of Milan at 23:36 of 05/02/2020 to run commercial service no. 9595 the following day, had regularly carried out the scheduled maintenance operations in compliance with the km and time schedules set out in the current Maintenance Plan.

The notices that, as of 06/02/2020, were open and postponed (by IW28) concerned items of furniture/decorating to be replaced or restored.

Based on the information provided by the railway undertaking, the maintenance history of the trainset is summarised below *(Figure 25)*.

From RSMS there are no anomalies or salt replacements relating to DM1 (train head) after maintenance R1.

- **R1** eseguita a marzo 2019. Ad oggi percorsi **468.707 km** da R1, 1.893.165 km da messa in servizio.
- Scadenza **F4** effettuata il 21/05/2019, percorsi **368.231 km** (passo da PM 500.000 km)
- Ultima **tornitura** eseguita il 13/10/2019, percorsi **160.250 km** (passo da PM 300.000 km)
- Ultimo controllo **US Assili e Ruote** (+ F3) eseguito il 24/11/2019, percorsi **106.913 km** (passo da PM 250.000 km)
- Ultima scadenza **F1+84k** eseguita il 23/01/2020, percorsi **23.446 km** (passo da PM 42.000 km)
- Ultima scadenza **I0** eseguita il 31/01/2020, percorsi **10.363 km** (passo da PM 14.000 km)

Figure 25 - Train maintenance history (source: Trenitalia)

I0 - 1st Level Scheduled Maintenance - Visual Inspections (step 14,000 km)
F1 - 1st Level Scheduled Maintenance - Checks and interventions (step 42,000 km)
F3 - 1st Level Scheduled Maintenance - Checks and servicing (step 250,000 km)
F4 – 1st Level Scheduled Maintenance - Checks and servicing (step 500,000 km)
R1 – 2nd Level Scheduled Maintenance - General overhaul type 1 (step 1,250,00 km)
84k – 1st Level maintenance intervention to be carried out at every second F1 (step 84,000 km)

There were no alarms of any kind prior to the incident from the Teledia download.

In the hours before departure, the following self-tests were carried out correctly: DNRA (locked axle), HABD (hot axle boxes), IMS (serpentine), Brake and General Piping seal.

3.5. Documentation of the operating system

3.5.1. Measures taken by traffic control and signalling staff

The Central Operations Manager (DCO) of Bologna, having become aware of an abnormality after the passage of train 9595 due to the loss of control of the switches near PM Livraga, at 5:36 a.m. informed the Central Operations Manager of train 9601 that it had been diverted onto the "historical" line; at 5:53 a.m., the Central Operations Manager of train 9907 was also informed that it had been diverted onto the "historical" line, as well as for all trains of the odd-numbered block, as communicated to the DM of Piacenza at 5:39 a.m.

In the meantime, the officers of the UMIS AV Piacenza intervening during the night were also informed by the Central Operations Manager that train 9595 had been diverted at Livraga and that there was no other news on the matter at the moment, since the Driver and Train Conductor were still unaccounted for.

3.5.2. Exchange of verbal messages in relation to the event

For the record.

3.5.3. Measures taken to protect and safeguard the site of the accident

The railway line and the entire train involved in the accident were placed under seizure by the Public Prosecutor's Office at the Court of Lodi.

3.6. Man-machine-organisation interface

3.6.1. Working time of the personnel involved

The shifts worked by the drivers of train 9595 on the days of the week preceding the date of the event were examined.

The shifts were analysed by calculating two indicators: Fatigue and Risk Index (FRI), one related to fatigue and the other related to risk.

The Fatigue Index is calculated by assigning a score ranging from 0 to 100 and represents the average probability, expressed in perceptions, of having high levels of sleepiness. A value of 20.7% corresponds to the average value achieved in studies of people working 12-hour shifts on a 2-day, 2-nights, 4-rest schedule in the railway industry.

Similarly, a Risk Index of 1 indicates the average accident/error risk achieved in studies of people working 12-hour shifts on a 2-day, 2-nights and 4-rest schedule in the rail sector. Consequently, a risk score of 2 can be interpreted as a doubling of the risk on this particular shift schedule.

The indicators were calculated using the Fatigue Index Calculator (© Crown Copyright 2005), a methodology proposed by The Health and Safety Executive (HSE).

This analysis makes it possible to assess the workloads to which workers are subjected and was used to make a rough estimate of the fatigue and risk indices resulting from the work performed by the RU's Flight Attendants and the IM's Maintenance Workers.

In particular, the shifts worked by Driver 1 produced a maximum Fatigue Index value of 3.5% and a maximum Risk Index value of 0.90 *(Figure 26)*.

Fatigue Index Calculator

Read the manual before using! Go to http://www.hse.gov.uk/RESEARCH/rrpdf/rr446g.pdf

Company: Trenitalia | Location: Agente di condotta 1 | Shift ID: | Date: 16/10/2020 | Mode: Fatigue | Assessor: | Display schedule | Display charts | Defaults | Reset Index | Calculate Index | © Crown Copyright 2005 Version 2.3 | About

Day	On Duty	Off Duty	Job type / breaks	Commuting Time	Duty Length	Rest Length	Average duty per day	Cumulative component	Duty timing component	Job type / Breaks component	Fatigue Index
29/01/2020	13:45	18:58	Default	Default	5h 13m	Fully Rested	5h 13m	0,1	0,5	0,0	**0,5**
30/01/2020	03:40	09:40	Default	Default	6h	**8h 42m**	5h 37m	1,5	2,1	0,0	**3,5**
02/02/2020	15:15	22:15	Default	Default	7h	3d 5h 35m	3h 39m	0,2	1,0	0,0	**1,2**
03/02/2020	16:45	23:18	Default	Default	6h 33m	18h 30m	4h 8m	0,8	1,5	0,0	**2,3**
04/02/2020	08:20	14:45	Default	Default	6h 25m	**9h 2m**	4h 27m	2,0	0,5	0,0	**2,5**

Risk Index Calculator

Read the manual before using! Go to http://www.hse.gov.uk/RESEARCH/rrpdf/rr446g.pdf

Company: Trenitalia | Location: Agente di condotta 1 | Shift ID: | Date: 16/10/2020 | Mode: Risk | Assessor: | Display schedule | Display charts | Defaults | Reset Index | Calculate Index | © Crown Copyright 2005 Version 2.3 | About

Day	On Duty	Off Duty	Job type / breaks	Commuting Time	Duty Length	Rest Length	Average duty per day	Cumulative component	Duty timing component	Job type / Breaks component	Risk Index
29/01/2020	13:45	18:58	Default	Default	5h 13m	Fully Rested	5h 13m	0,89	0,75	1,11	**0,74**
30/01/2020	03:40	09:40	Default	Default	6h	**8h 42m**	5h 37m	0,96	0,77	1,11	**0,82**
02/02/2020	15:15	22:15	Default	Default	7h	3d 5h 35m	3h 39m	0,90	0,80	1,11	**0,79**
03/02/2020	16:45	23:18	Default	Default	6h 33m	18h 30m	4h 8m	0,99	0,82	1,11	**0,90**
04/02/2020	08:20	14:45	Default	Default	6h 25m	**9h 2m**	4h 27m	1,04	0,71	1,11	**0,82**

Figure 26 - Fatigue Index and Risk Index for Driver 1 (data: Trenitalia - elaboration: DiGIFeMa)

The shifts worked by Driver 2 produced a maximum Fatigue Index value of 8.5% and a maximum Risk Index value of 0.88 *(Figure 27)*.

Both indicators show values well below the average values, thus confirming the absence of fatigue problems, for both Drivers, due to shift work.

Fatigue Index Calculator

Read the manual before using! Go to http://www.hse.gov.uk/RESEARCH/rrpdf/rr446g.pdf

Company: Trenitalia | Location: Agente di condotta 2 | Shift ID: | Date: 16/10/2020 | Mode: Fatigue | Defaults | Reset Index | Calculate Index

Assessor | Display schedule | Display charts

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Day	On Duty	Off Duty	Job type / breaks	Commuting Time	Duty Length	Rest Length	Average duty per day	Cumulative component	Duty timing component	Job type / Breaks component	Fatigue Index
30/01/2020	07:10	14:03	Default	Default	6h 53m	Fully Rested	6h 53m	0,1	0,7	0,0	**0,8**
01/02/2020	15:10	23:20	Default	Default	8h 10m	2d 1h 7m	5h 1m	0,2	1,4	0,1	**1,7**
02/02/2020	06:25	13:50	Default	Default	7h 25m	**7h 5m**	5h 37m	7,7	0,9	0,0	**8,5**
04/02/2020	15:45	00:20	Default	Default	8h 35m	2d 1h 55m	4h 26m	0,6	2,2	0,2	**3,0**

Risk Index Calculator

Read the manual before using! Go to http://www.hse.gov.uk/RESEARCH/rrpdf/rr446g.pdf

Company: Trenitalia | Location: Agente di condotta 2 | Shift ID: | Date: 16/10/2020 | Mode: Risk | Defaults | Reset Index | Calculate Index

Assessor | Display schedule | Display charts

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Day	On Duty	Off Duty	Job type / breaks	Commuting Time	Duty Length	Rest Length	Average duty per day	Cumulative component	Duty timing component	Job type / Breaks component	Risk Index
30/01/2020	07:10	14:03	Default	Default	6h 53m	Fully Rested	6h 53m	0,89	0,72	1,12	**0,72**
01/02/2020	15:10	23:20	Default	Default	8h 10m	2d 1h 7m	5h 1m	0,89	0,81	1,12	**0,80**
02/02/2020	06:25	13:50	Default	Default	7h 25m	**7h 5m**	5h 37m	1,04	0,72	1,12	**0,85**
04/02/2020	15:45	00:20	Default	Default	8h 35m	2d 1h 55m	4h 26m	0,94	0,84	1,12	**0,88**

Figure 27 - Fatigue index and risk index for Driver 2 (data: Trenitalia - elaboration: DiGIFeMa)

Using the same methodology, the shifts worked by the five members of the maintenance team operating on the infrastructure were also examined, based on the data provided to the Committee by RFI, in the ten days preceding the event.

The shifts worked by Maintenance Agent 1 produced a maximum Fatigue Index value of 19.1% and a maximum Risk Index value of 1.07 *(Figure 28)*.

Fatigue Index Calculator

Read the manual before using! Go to http://www.hse.gov.uk/RESEARCH/rrpdf/rr446g.pdf

Company: Rete Ferroviaria Italiana | Location: Addetto manutenzione 1 | Shift ID: | Date: 20/01/2021 | Mode: Fatigue | Defaults | Reset Index | Calculate Index

Assessor | Display schedule | Display charts

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Day	On Duty	Off Duty	Job type / breaks	Commuting Time	Duty Length	Rest Length	Average duty per day	Cumulative component	Duty timing component	Job type / Breaks component	Fatigue Index
27/01/2020	07:35	16:41	Default	Default	9h 6m	Fully Rested	9h 6m	0,1	0,7	0,0	**0,7**
28/01/2020	07:35	16:41	Default	Default	9h 6m	14h 54m	9h 6m	1,4	0,7	0,0	**2,1**
29/01/2020	07:35	16:41	Default	Default	9h 6m	14h 54m	9h 6m	3,3	0,7	0,0	**4,0**
30/01/2020	07:35	16:41	Default	Default	9h 6m	14h 54m	9h 6m	5,5	0,7	0,0	**6,2**
31/01/2020	07:35	16:41	Default	Default	9h 6m	14h 54m	9h 6m	7,6	0,7	0,0	**8,2**
03/02/2020	07:35	16:41	Default	Default	9h 6m	2d 14h 54m	6h 49m	1,0	0,7	0,0	**1,7**
04/02/2020	07:35	16:41	Default	Default	9h 6m	14h 54m	7h 5m	2,7	0,7	0,0	**3,4**
05/02/2020	07:35	13:05	Default	Default	5h 30m	14h 54m	6h 55m	4,9	0,7	0,0	**5,6**
05/02/2020	22:00	05:36	Default	Default	7h 36m	**8h 55m**	6h 59m	9,6	9,9	0,6	**19,1**

Risk Index Calculator

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Company: Rete Ferroviaria Italiana | Assessor:
Location: Addetto manutenzione 1
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Mode: Risk | Defaults | Reset Index | Calculate Index | Display schedule | Display charts | © Crown Copyright 2005 Version 2.3 | About

Day	On Duty	Off Duty	Job type / breaks	Commuting Time	Duty Length	Rest Length	Average duty per day	Cumulative component	Duty timing component	Job type / Breaks component	Risk Index
27/01/2020	07:35	16:41	Default	Default	9h 6m	Fully Rested	9h 6m	0,89	0,78	1,13	**0,78**
28/01/2020	07:35	16:41	Default	Default	9h 6m	14h 54m	9h 6m	0,94	0,78	1,13	**0,82**
29/01/2020	07:35	16:41	Default	Default	9h 6m	14h 54m	9h 6m	0,98	0,78	1,13	**0,87**
30/01/2020	07:35	16:41	Default	Default	9h 6m	14h 54m	9h 6m	1,03	0,78	1,13	**0,91**
31/01/2020	07:35	16:41	Default	Default	9h 6m	14h 54m	9h 6m	1,08	0,78	1,13	**0,95**
03/02/2020	07:35	16:41	Default	Default	9h 6m	2d 14h 54m	6h 49m	0,95	0,78	1,13	**0,84**
04/02/2020	07:35	16:41	Default	Default	9h 6m	14h 54m	7h 5m	1,00	0,78	1,13	**0,88**
05/02/2020	07:35	13:05	Default	Default	5h 30m	14h 54m	6h 55m	1,05	0,73	1,13	**0,86**
05/02/2020	22:00	05:36	Default	Default	7h 36m	**8h 55m**	6h 59m	1,10	0,86	1,13	**1,07**

Figure 28 - Fatigue Index and Risk Index for Maintenance Agent 1 (data: RFI - elaboration: DiGIFeMa)

The shifts worked by Maintenance Agent 2 produced a maximum Fatigue Index value of 21% and a maximum Risk Index value of 1.12 *(Figure 29)*.

Fatigue Index Calculator

Read the manual before using! Go to http://www.hse.gov.uk/RESEARCH/rrpdf/rr446g.pdf

Company: Rete Ferroviaria Italiana | Assessor:
Location: Addetto manutenzione 2
Shift ID:
Date: 20/01/2021
Mode: Fatigue | Defaults | Reset Index | Calculate Index | Display schedule | Display charts | © Crown Copyright 2005 Version 2.3 | About

Day	On Duty	Off Duty	Job type / breaks	Commuting Time	Duty Length	Rest Length	Average duty per day	Cumulative component	Duty timing component	Job type / Breaks component	Fatigue Index
03/02/2020	06:59	13:05	Default	Default	6h 6m	Fully Rested	6h 6m	0,1	0,8	0,0	**0,8**
03/02/2020	21:46	05:36	Default	Default	7h 50m	**8h 41m**	6h 58m	4,5	10,1	0,6	**14,7**
05/02/2020	06:59	11:23	Default	Default	4h 24m	1d 1h 23m	6h 7m	9,2	0,8	0,0	**9,9**
05/02/2020	21:36	05:36	Default	Default	8h	**10h 13m**	6h 35m	11,0	10,6	0,7	**21,0**

Risk Index Calculator

Read the manual before using! Go to http://www.hse.gov.uk/RESEARCH/rrpdf/rr446g.pdf

Company: Rete Ferroviaria Italiana | Assessor:
Location: Addetto manutenzione 2
Shift ID:
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Day	On Duty	Off Duty	Job type / breaks	Commuting Time	Duty Length	Rest Length	Average duty per day	Cumulative component	Duty timing component	Job type / Breaks component	Risk Index
03/02/2020	06:59	13:05	Default	Default	6h 6m	Fully Rested	6h 6m	0,89	0,72	1,13	**0,72**
03/02/2020	21:46	05:36	Default	Default	7h 50m	**8h 41m**	6h 58m	0,96	0,84	1,13	**0,92**
05/02/2020	06:59	11:23	Default	Default	4h 24m	1d 1h 23m	6h 7m	1,09	0,73	1,13	**0,90**
05/02/2020	21:36	05:36	Default	Default	8h	**10h 13m**	6h 35m	1,17	0,84	1,13	**1,12**

Figure 29 - Fatigue Index and Risk Index for Maintenance Agent 2 (data: RFI - elaboration: DiGIFeMa)

The shifts worked by Maintenance Agent 3 produced a maximum Fatigue Index value of 24.8% and a maximum Risk Index value of 1.11 *(Figure 30)*.

Fatigue Index Calculator

Read the manual before using! Go to http://www.hse.gov.uk/RESEARCH/rrpdf/rr446g.pdf

Company: Rete Ferroviaria Italiana
Location: Addetto manutenzione 3
Shift ID:
Date: 20/01/2021
Mode: Fatigue

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Day	On Duty	Off Duty	Job type / breaks	Commuting Time	Duty Length	Rest Length	Average duty per day	Cumulative component	Duty timing component	Job type / Breaks component	Fatigue Index
27/01/2020	07:35	16:41	Default	Default	9h 6m	Fully Rested	9h 6m	0,1	0,6	0,0	**0,7**
28/01/2020	07:41	16:48	Default	Default	9h 7m	15h	9h 7m	1,4	0,6	0,0	**2,1**
29/01/2020	07:34	13:09	Default	Default	5h 35m	14h 46m	7h 56m	3,3	0,7	0,0	**3,9**
29/01/2020	21:52	05:45	Default	Default	7h 53m	**8h 43m**	7h 55m	8,7	10,1	0,6	**18,5**
30/01/2020	21:55	06:11	Default	Default	8h 16m	16h 10m	7h 59m	12,6	11,1	0,7	**22,9**
03/02/2020	07:32	13:05	Default	Default	5h 33m	3d 1h 21m	5h 41m	2,1	0,7	0,0	**2,8**
03/02/2020	21:37	05:36	Default	Default	7h 59m	**8h 32m**	5h 57m	8,1	10,0	0,6	**17,9**
05/02/2020	07:33	13:05	Default	Default	5h 32m	1d 1h 57m	5h 54m	12,1	0,7	0,0	**12,7**
05/02/2020	21:51	05:43	Default	Default	7h 52m	**8h 46m**	6h 5m	15,8	10,1	0,6	**24,8**

Risk Index Calculator

Read the manual before using! Go to http://www.hse.gov.uk/RESEARCH/rrpdf/rr446g.pdf

Company: Rete Ferroviaria Italiana
Location: Addetto manutenzione 3
Shift ID:
Date: 20/01/2021
Mode: Risk

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Day	On Duty	Off Duty	Job type / breaks	Commuting Time	Duty Length	Rest Length	Average duty per day	Cumulative component	Duty timing component	Job type / Breaks component	Risk Index
27/01/2020	07:35	16:41	Default	Default	9h 6m	Fully Rested	9h 6m	0,89	0,76	1,13	**0,76**
28/01/2020	07:41	16:48	Default	Default	9h 7m	15h	9h 7m	0,94	0,76	1,13	**0,81**
29/01/2020	07:34	13:09	Default	Default	5h 35m	14h 46m	7h 56m	0,98	0,72	1,13	**0,80**
29/01/2020	21:52	05:45	Default	Default	7h 53m	**8h 43m**	7h 55m	1,05	0,84	1,13	**1,01**
30/01/2020	21:55	06:11	Default	Default	8h 16m	16h 10m	7h 59m	1,16	0,85	1,13	**1,11**
03/02/2020	07:32	13:05	Default	Default	5h 33m	3d 1h 21m	5h 41m	0,92	0,72	1,13	**0,74**
03/02/2020	21:37	05:36	Default	Default	7h 59m	**8h 32m**	5h 57m	0,99	0,84	1,13	**0,95**
05/02/2020	07:33	13:05	Default	Default	5h 32m	1d 1h 57m	5h 54m	0,98	0,72	1,13	**0,80**
05/02/2020	21:51	05:43	Default	Default	7h 52m	**8h 46m**	6h 5m	1,05	0,84	1,13	**1,00**

Figure 30 - Fatigue Index and Risk Index for Maintenance Agent 3 (data: RFI - elaboration: DiGIFeMa)

The shifts worked by Maintenance Agent 4 produced a maximum Fatigue Index value of 26.3% and a maximum Risk Index value of 1.48 *(Figure 31)*.

Fatigue Index Calculator

Read the manual before using! Go to http://www.hse.gov.uk/RESEARCH/rrpdf/rr446g.pdf

Company: Rete Ferroviaria Italiana
Location: Addetto manutenzione 4
Shift ID:
Date: 20/01/2021
Mode: Fatigue

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Day	On Duty	Off Duty	Job type / breaks	Commuting Time	Duty Length	Rest Length	Average duty per day	Cumulative component	Duty timing component	Job type / Breaks component	Fatigue Index
27/01/2020	07:17	13:05	Default	Default	5h 48m	Fully Rested	5h 48m	0,1	0,7	0,0	**0,8**
27/01/2020	21:43	05:36	Default	Default	7h 53m	**8h 38m**	6h 51m	4,3	10,1	0,6	**14,6**
29/01/2020	07:16	13:06	Default	Default	5h 50m	1d 1h 40m	6h 30m	9,0	0,7	0,0	**9,7**
29/01/2020	21:38	05:43	Default	Default	8h 5m	**8h 32m**	6h 54m	14,3	10,6	0,7	**24,0**
31/01/2020	07:16	16:41	Default	Default	9h 25m	1d 1h 33m	7h 24m	17,0	0,7	0,0	**17,6**
03/02/2020	07:13	13:05	Default	Default	5h 52m	2d 14h 32m	5h 22m	2,4	0,7	0,0	**3,1**
03/02/2020	21:37	05:36	Default	Default	7h 59m	**8h 32m**	5h 39m	8,7	10,0	0,6	**18,5**
05/02/2020	07:13	13:05	Default	Default	5h 52m	1d 1h 37m	5h 40m	12,7	0,7	0,0	**13,4**
05/02/2020	21:35	05:37	Default	Default	8h 2m	**8h 30m**	5h 53m	17,0	10,6	0,7	**26,3**

Risk Index Calculator

Read the manual before using! Go to http://www.hse.gov.uk/RESEARCH/rrpdf/rr446g.pdf

Company: Rete Ferroviaria Italiana
Location: Addetto manutenzione 4
Shift ID:
Date: 20/01/2021
Mode: Risk

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Day	On Duty	Off Duty	Job type / breaks	Commuting Time	Duty Length	Rest Length	Average duty per day	Cumulative component	Duty timing component	Job type / Breaks component	Risk Index
27/01/2020	07:17	13:05	Default	Default	5h 48m	Fully Rested	5h 48m	0,89	0,72	1,13	**0,72**
27/01/2020	21:43	05:36	Default	Default	7h 53m	**8h 38m**	6h 51m	0,96	0,84	1,13	**0,92**
29/01/2020	07:16	13:06	Default	Default	5h 50m	1d 1h 40m	6h 30m	1,09	0,72	1,13	**0,89**
29/01/2020	21:38	05:43	Default	Default	8h 5m	**8h 32m**	6h 54m	1,17	0,84	1,13	**1,12**
31/01/2020	07:16	16:41	Default	Default	9h 25m	1d 1h 33m	7h 24m	1,69	0,78	1,13	**1,48**
03/02/2020	07:13	13:05	Default	Default	5h 52m	2d 14h 32m	5h 22m	0,98	0,72	1,13	**0,79**
03/02/2020	21:37	05:36	Default	Default	7h 59m	**8h 32m**	5h 39m	1,06	0,84	1,13	**1,01**
05/02/2020	07:13	13:05	Default	Default	5h 52m	1d 1h 37m	5h 40m	1,36	0,72	1,13	**1,10**
05/02/2020	21:35	05:37	Default	Default	8h 2m	**8h 30m**	5h 53m	1,44	0,84	1,13	**1,37**

Figure 31 - Fatigue Index and Risk Index for Maintenance Agent 4 (data: RFI - elaboration: DiGIFeMa)

The shifts worked by Maintenance Agent 5 produced a maximum Fatigue Index value of 25.1% and a maximum Risk Index value of 1.18 *(Figure 32)*.

Fatigue Index Calculator

Read the manual before using! Go to http://www.hse.gov.uk/RESEARCH/rrpdf/rr446g.pdf

Company: Rete Ferroviaria Italiana
Location: Addetto manutenzione 5
Shift ID:
Date: 20/01/2021
Mode: Fatigue

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Day	On Duty	Off Duty	Job type / breaks	Commuting Time	Duty Length	Rest Length	Average duty per day	Cumulative component	Duty timing component	Job type / Breaks component	Fatigue Index
27/01/2020	07:26	16:41	Default	Default	9h 15m	Fully Rested	9h 15m	0,1	0,7	0,0	**0,7**
28/01/2020	07:31	16:41	Default	Default	9h 10m	14h 50m	9h 12m	1,5	0,6	0,0	**2,2**
29/01/2020	07:29	16:54	Default	Default	9h 25m	14h 48m	9h 17m	3,5	0,7	0,0	**4,2**
30/01/2020	07:21	16:41	Default	Default	9h 20m	14h 27m	9h 17m	5,8	0,7	0,0	**6,4**
31/01/2020	07:22	16:41	Default	Default	9h 19m	14h 41m	9h 18m	8,1	0,7	0,0	**8,7**
03/02/2020	07:25	13:05	Default	Default	5h 40m	2d 14h 44m	6h 31m	1,0	0,7	0,0	**1,8**
03/02/2020	21:37	05:36	Default	Default	7h 59m	**8h 32m**	6h 41m	6,6	10,0	0,6	**16,5**
05/02/2020	07:26	13:05	Default	Default	5h 39m	1d 1h 50m	6h 35m	10,9	0,7	0,0	**11,5**
05/02/2020	21:35	05:37	Default	Default	8h 2m	**8h 30m**	6h 43m	15,6	10,6	0,7	**25,1**

Risk Index Calculator

Read the manual before using! Go to http://www.hse.gov.uk/RESEARCH/rrpdf/rr446g.pdf

Company: Rete Ferroviaria Italiana
Location: Addetto manutenzione 5
Shift ID:
Date: 20/01/2021
Mode: Risk

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Day	On Duty	Off Duty	Job type / breaks	Commuting Time	Duty Length	Rest Length	Average duty per day	Cumulative component	Duty timing component	Job type / Breaks component	Risk Index
27/01/2020	07:26	16:41	Default	Default	9h 15m	Fully Rested	9h 15m	0,89	0,77	1,13	**0,77**
28/01/2020	07:31	16:41	Default	Default	9h 10m	14h 50m	9h 12m	0,94	0,76	1,13	**0,81**
29/01/2020	07:29	16:54	Default	Default	9h 25m	14h 48m	9h 17m	0,98	0,78	1,13	**0,86**
30/01/2020	07:21	16:41	Default	Default	9h 20m	14h 27m	9h 17m	1,03	0,77	1,13	**0,90**
31/01/2020	07:22	16:41	Default	Default	9h 19m	14h 41m	9h 18m	1,08	0,77	1,13	**0,94**
03/02/2020	07:25	13:05	Default	Default	5h 40m	2d 14h 44m	6h 31m	0,91	0,72	1,13	**0,74**
03/02/2020	21:37	05:36	Default	Default	7h 59m	**8h 32m**	6h 41m	0,99	0,84	1,13	**0,94**
05/02/2020	07:26	13:05	Default	Default	5h 39m	1d 1h 50m	6h 35m	1,16	0,72	1,13	**0,94**
05/02/2020	21:35	05:37	Default	Default	8h 2m	**8h 30m**	6h 43m	1,24	0,84	1,13	**1,18**

Figure 32 - Fatigue index and risk index for Maintenance Agent 5 (data: RFI - elaboration: DiGIFeMa)

The analysis carried out on the ten days preceding the date of the event shows that, for all the members of the maintenance team, the highest values of the fatigue index and the risk index were reached at the end of the work shift carried out on the night of 5 to 6 February, exceeding, albeit slightly, the average values of fatigue and risk reported above (FI equal to 20.7% and RI equal to 1). In fact, the data provided by the infrastructure manager show that the five maintenance workers had worked a shift on the morning of 5 February (from 7 a.m. to about 1 p.m.) to resume in the evening around 10 p.m. with the night shift, which ended shortly after 5.30 a.m. on 6 February. Evidently this workload resulted in fatigue and a slightly higher than average risk exposure factor, but presumably not such as to compromise the operators' skills and role awareness of the work activities and procedures followed during and especially at the end of the maintenance work carried out.

3.6.2. Personal and medical circumstances that may have influenced the accidental event

The analysis of the examined documentation shows that there are no elements ascribable to physical and/or psycho-attitudinal disorders attributable to the personnel driving the train involved in the accident, the infrastructure maintenance personnel or the traffic control personnel at the time of the accident.

3.6.3. Architecture of the equipment affecting the human-machine interface

In order to classify the components of the working system, analysing the interactions between them, and order the elements collected during the investigation within the chain of events, it is possible to use the SHELL method, characterised by four fundamental elements *(Figure 33)***:**

- the Software, is the non-physical part of the system, and includes organisational policies, procedures, manuals, check-list diagrams, charts, maps, notices/directives and computer software;
- the Hardware, including machines and systems, equipment and facilities;
- the Environment i.e., the working environment, understood as the physical and social environment;
- the Liveware (human element) which constitutes the most important and flexible element of the system, so called to assimilate it to the designations of the other system components, and is placed at the centre of the model. It represents the contribution of each person, with their capabilities and limitations, whether physical, physiological, psychological, or psychosocial. This component can be applied to each person involved in the activity, or support to it. The subject under consideration interacts directly with each of the other four elements. Each person and each interaction, or interface, constitutes a potential area of investigation into human performance;
- the Liveware (peripheral element) which refers instead to the human-human interactions present in the system, and includes factors such as management, supervision, interactions between operators and communications.

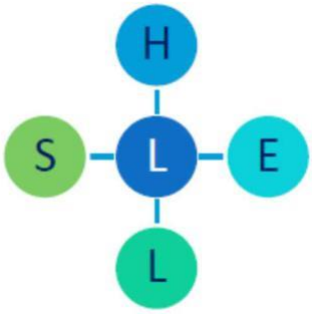

Figure 33 –SHELL method

Based on these principles, a systemic representation of the context in which the accident occurred can be schematised as follows:

Software
- Railway standards and regulations;
- Computer applications for use by railway personnel;
- Paper-based tools, such as train cards or train prescription forms;
- Recorded Minutes Reports (CVRs);
- Plans of maintenance activities and controls with safety implications.

Hardware
- Central Operations Manager's workstation;
- Driver's workstations;
- Maintenance Officers' workstations;
- Signalling equipment;
- Equipment for carrying out maintenance checks.

Environment
- Central Operations Manager Hall
- PM Livraga;
- Railway line.

Liveware
- Central Operations Manager based in Bologna;
- Drivers and train crew;
- Maintenance staff;
- Travellers and third parties.

3.7. Previous events of the same type

The following are some significant excerpts from the DiGIFeMa investigation report carried out following the derailment of Trenitalia train 2885, at PM Lavino, on 14/07/2012, published on the institutional website digifema.mit.gov.it, which shows some similarities with the event in question.

On 14 July 2012, at 9:25 a.m., the regional train 2885 of Trenitalia, coming from Voghera and bound to Rimini, in transit on the second track of the PM of Lavino, with the signals provided for the correct track and in free transit (Warning, protection and departure: Green - Green - Green), deviated at the speed of 140 km/h, at the switch no. 09 of the same post, was in diverted position instead of being on the correct track. The head of the train travelled about 800 metres before coming to a halt. Near the switch, the presence of maintenance staff was detected.

As a result of the derailment, extensive damage was caused to the infrastructure and rolling stock. Approximately 250 passengers were travelling on the train, 30 of whom were injured, one seriously and 29 slightly.

The switches in the area affected by the train 2885's derailment are equipped with an electric shunting box in the crossbar, which can be rolled up on command, and since the PM is normally unmanned, the switches are equipped with devices for on-site hand manoeuvring by the train crew.

On the evening of 13 July 2012, the day before train 2885 went off the track, a loss of control of switch no. 09 of the PM at Lavino had occurred in rest conditions, without any manoeuvring of the switch itself. This anomaly was recorded on the INRete 2000 system with a failure warning.

Following the anomaly ... the Infrastructure Operations Coordinator, in order to promptly solve the anomaly, extended the warning to the Maintenance Agents on duty in Zone IS2, who were contacted by the Coordinator at 22:20 and 22:25 respectively.

The Maintenance Agents immediately went to the site, the first one to the switch no. 09 to verify its integrity, while the other one remained in the Movement Office at the ACC manoeuvring desk to ensure the protection of the colleague operating in the yard and to carry out the necessary operations to regain control of the switch by enabling the functional keyboard.

From 22:52:07 to 22:53:26 nine tests were then carried out, using the Functional Keypad, of switch 09 in Normal and Diverted positions, obtaining control of the switch itself.

The above-described operations were carried out without involving in any way the Central Operations Manager of Bologna, having jurisdiction in the PM of Lavino, except for the conclusion of the intervention through the dispatch on model M100b with which the Maintenance Agent at 22:55 communicated the successful restoration of the normal operation of the switch.

At the conclusion of the above operations, the Maintenance Agents, having verified the nature of the fault, deemed it necessary to carry out a further intervention during the daytime period, consisting in the replacement of some micro-switches, in order to definitively solve the anomaly found.

On the morning of 14 July at about 8:00 a.m., the two Maintenance Agents and the Maintenance Operator, after switching off the intrusion alarm, found themselves in the premises of the PM in Lavino. The Maintenance Agent, acting as supervisor, organised the intervention, assigning the Maintenance Operator the task of operating in the cabin, to act as "scout" in order to guarantee his protection and that of the other Agent who would have operated on the yard, warning them of the approach of the trains.

The Maintenance Operator in charge, who was operating on the yard, without taking into account that switch no. 09 was in a diverted position due to the passing of freight train 47002 [coming from the "Cintura" line and directed to Piacenza, which regularly passed at 9:08 a.m. engaging switch no. 09 "calcio", thus leaving it in a deviated position] asked the Maintenance Operator operating in the cab to simulate the control condition of switch no. 09 in normal position and to confirm the switch in such position with the relevant control.

The Maintenance Operator operating in the cab, without considering the position of the switch as displayed by the ACC Light Panel, proceeded to simulate the operation of switch 09 in the normal position, disconnecting the plugs from the switch terminal board and inserting the capacitors to obtain the control of the box and of the switch electromagnet and finally to recover the concordance control from the apparatus by means of the TcD function from the Functional Keypad previously enabled. Once the operation to recover the normal control had been carried out, the Maintenance Operator operating in the cab confirmed to the Agents operating in the yard, the switch in the normal position.

… from the Chronological Event Recorder of ACC at Lavino it is "read" that at 09:14:53" there was a loss of control of switch 09 in diverted position, the last one in which the switch had been commanded to allow the passage of freight train 47002 at 9:08.

The Maintenance Agents operating on the yard, having obtained the confirmation that switch 09 was in the normal position with the relative control, unfastened the "whip" of switch 09 in order to prevent an orderly and separate contact from causing an undue manoeuvre of the switch and subsequently the electrical contacts of the switch stops were removed in order to replace them.

With regard to the above operations, deduced from the statements of the Maintenance Agents and Maintenance Operator, it is appropriate as of now to point out the incorrectness of such operations in that, without taking into account that switch 09 was in an inverted position, following the passage of freight train 47002 at 9.08 a.m. coming from the "Cintura" line and bound for Piacenza, the plugs were disconnected, the capacitors inserted and, by operating the TcD function of the Functional Keypad, control of the switch was restored to the normal position, but without the switch needles being able to move, as there was no longer any connection between the cab and the switch.

This circumstance was not even noticed by the Maintenance Agents on the yard who were working on a "loose and diverted" switch.

In the meantime, at 09:20:38", the formation of itinerary 01 → 03b for the transit of train 2885 coming from Piacenza and bound to Bologna, starts in automatism, on the 2nd track of the PM in Lavino. The Maintenance Operator who was operating in the cab, became aware of this through the display on the ACC QL and therefore warned the Maintenance Agents who were operating on the yard. From 09:20:38" to 09:21:12" the formation of the free passing route 01 → 03b with the arrangement of the free way signals (green - green - green) is regularly completed, because, despite the position of switch 09 was in the "diverted" position and therefore incompatible with the correct route, but compatible with the ACC signalling system of Lavino and the Central Operations Manager, the switch was "read" in the "normal" position due to the simulated control in this position.

The train 2885 therefore met the protection signal of the ACC of Lavino provided for transit at a speed of 140 Km/h, picking up with the equipment of the Track Signal Repeater the code 270 (clear) and at that speed approached the switch 09, provided in a diverted position for the routing on the "Cintura" line. Due to the speed of 140 km/h at which switch 09 was engaged, much higher than the maximum permitted speed of 60 km/h on that type of switch, train 2885 was diverted onto the diverted track, causing the occupation of track circuits not pertinent to the planned route and the loss of control of switch 11, which is the communication link with switch 09 for the routing of trains on the "Cintura" line.

The direct cause of the derailment is [was] the non-compliant position of switch no. 09 with respect to the signalling, which caused the switch, placed in a diverted position, to be engaged at an improper speed.

The indirect cause of the derailment is [was] the manner in which the maintenance work was organised and carried out on the switch, which did not comply with the provisions issued for the execution of maintenance and repair work on safety equipment.

The report concluded with the following safety recommendations.

It is recommended that the National Agency for Railway Safety:

1) take action so that RFI sensitises the structures and the personnel concerned, to the respect of the rules and provisions concerning the maintenance of the yards, with particular regard, to the cases in which it is necessary, due to the particularity of the interventions, the exclusion of the section subjected to maintenance care, from operation;

2) see to it that RFI verifies and ensures the operational and management consistency of the maintenance and traffic management activities and systems, also in order to be able to have evidence of the operating conditions that correspond to each maintenance operation carried out;

3) assess the appropriateness of the application of more effective automatic recommendations to the Central Operations Manager that intervene in the case of operations (such as, for example, enabling the Functional Keypad or manipulating the safety keys) that normally require the consent of the same Manager.

As shown in the above summary, the incident of 6/02/2020, which is the subject of this investigation report, despite the different type of apparatus (mechanical in 2012, hydraulic in 2020), shows similarities with that which occurred on 14/07/2012 in the direct cause and some similarities in the procedures for the restarting of the switchboard (indirect cause) which, as a result of the faulty behaviour of the component, returned a control signal of the switchboard that was not congruent with the actual position of the same.

While in the Lavino episode the erroneous control returned in apparatus by the position of the switch was originated by incorrect maintenance interventions, in the Livraga episode it was instead originated by a manufacturing error of the actuator of the top frame of the switch.

4. Analysis and Conclusions

4.1. Final account of the chain of events

On the basis of what is indicated in chapter 3, the data and results of the investigations carried out, the inspections performed and the documentation examined, the chain of events that characterised the event can be reconstructed.

During the night between 5 and 6 February 2020, during the interruption of railway traffic, the following scheduled maintenance works were carried out at the PM of Livraga, at km 166+252 of the Milano-Bologna HS/HC line, which ended around 4:30 a.m.:

- renewal of the three hydraulic actuators frame + core of switch no. 5 (km 166+756);
- renewal of the hydraulic actuator of the frame of switch no. 6;
- renewal of the hydraulic actuator of the frame of switch no. 10.

On the morning of 06/02/2020, train FR9595, belonging to the RU Trenitalia S.p.A., the first train of the day departing from Milan and bound for Salerno, on the Milano-Bologna HS/HC line, operated with ETR1000 no. 021 material and composed of eight cars, derailed, at a speed of 298 km/h, during transit at km 166+756. The leading car, detached from the others, broke through a fence and stopped its run on its side, close to the opposite side of the PM Livraga building, after colliding with some maintenance equipment stationed on a siding, to the left of the direction of the train (DT), the other seven cars continued their deceleration run off the rails and stopped in the inter-track between the odd-numbered track and the adjacent track, after travelling approximately 700 m from the initial point of the derailment, with the second DT car reversed on its side.

4.2. Discussion

4.2.1. Analysis concerning the direct cause of the accident

Following the findings of the on-site inspections (see § 2.1. 2), of the simulations carried out by the Board of Technical Consultants of the Public Prosecutor's Office at the station of the Central Operations Manager of Bologna and of the examination of the documentation acquired by the RFI IM and the Trenitalia RU, the direct cause of the accident is to be attributed to the wrong positioning of the switch 05 (km 166+756) that instead of being returned to the traffic in the correct position (normal position), was in diverted position.

4.2.2. Analyses concerning indirect causes of the accident

4.2.2.1. Indirect cause No. 1

<u>Internal wiring error in the control circuit of actuator no. 2 of the leading frame of switch 05</u>

In order to better understand the causal link between the internal wiring error of the control circuit of actuator no. 2 of the leading frame of switch no. 05, highlighted by the investigations described in paragraph 2.1.2 above, and the accident which occurred, it is necessary to analyse, albeit briefly, the configuration and the corresponding implementation methods of the control circuit of the switch in question. The notional support for such analysis is provided by the following documents supplied by RFI:

1. Hydraulic SIMPLE Hydraulic TG: 0.074 WITHOUT ACCUMULATION FOR HS/HC APPLICATIONS, dated January 2008 (file name transmitted "SO 0,074 ASF AV–Schema approv.11_04_08")
2. PRINCIPLE ELECTRICAL SCHEME Integrated Hydraulic Shunting Subsystem Tg 0.074 Cogifer - CMI - MOT, dated July 2016 (file name transmitted "attachment 14")
3. TECHNICAL SPECIFICATION FOR CMI OLEODYNAMIC POWER PLANT, dated April 2006 (file name transmitted "attachment 12")

From this documentation it can be seen that switch 05 is of the hydraulic type with a movable point core. Its operation is entrusted to 4 hydraulic actuators identified as follows:

- leading actuator 1 for the unburstable switch stop;
- actuator 2 for the movement of the needle frame;
- actuators 3 and 4 for the movement of the movable point core.

The energy required to manoeuvre the actuators is supplied by a hydraulic power unit in which an electric motor drives a hydraulic pump.

In each actuator there is a double-acting hydraulic cylinder which is the moving organ of the various internal elements which are in turn connected, by means of a suitable linkage, to the elements of the switch to be moved.

For each actuator, information on the position of the switch elements to be moved is provided by the opening and/or closing of certain contacts positioned inside the actuator and reported outside the actuator by means of a suitable wiring harness, which allows the connection between the different actuators. The unambiguous correspondence between the state of these contacts and the position of the switch elements being moved is obtained by means of a mechanical device (contact shaft), which, as shown in Figure 34, is integrally connected to the element to be moved and allows the opening or closing of sliding contacts corresponding to the control contacts.

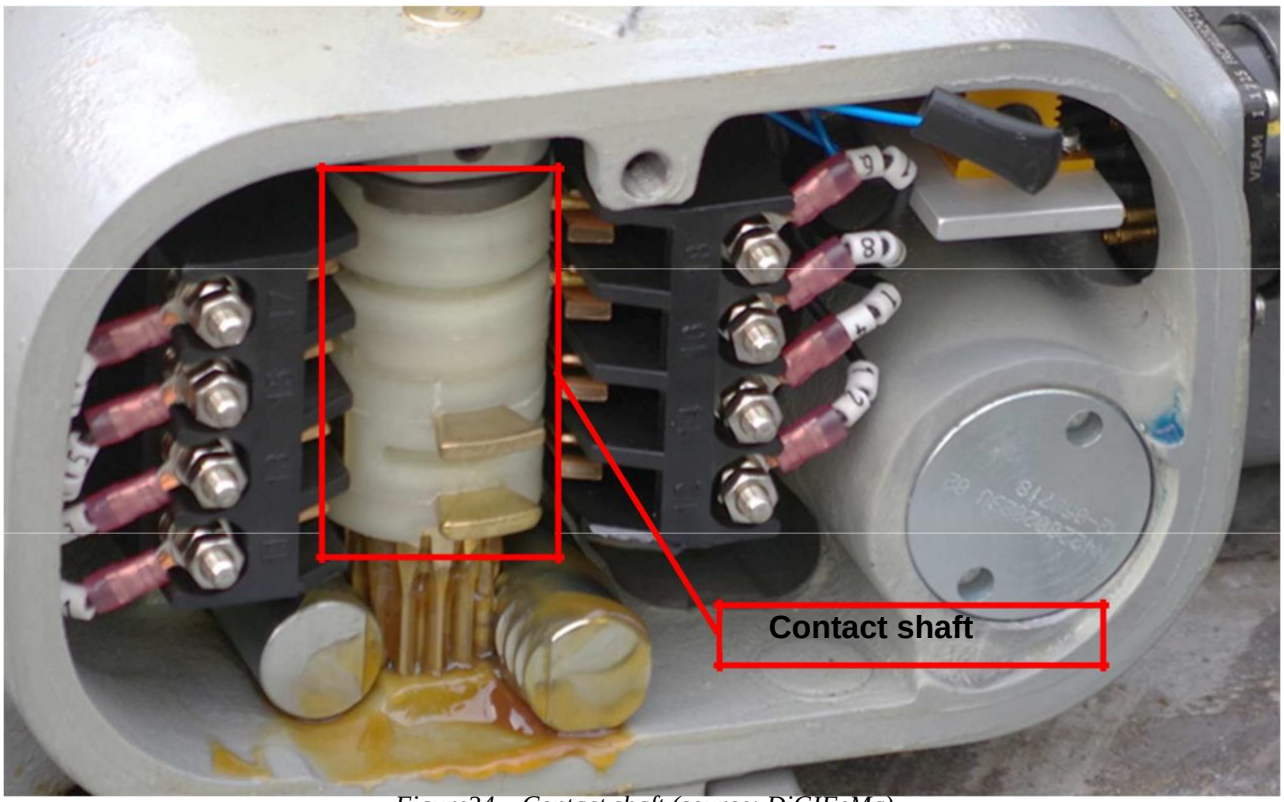

Figure34 – Contact shaft (source: DiGIFeMa)

For example, in the case of switch actuator 2, the electrical circuit that provides the position is shown in the following picture *(Figure 35)*.

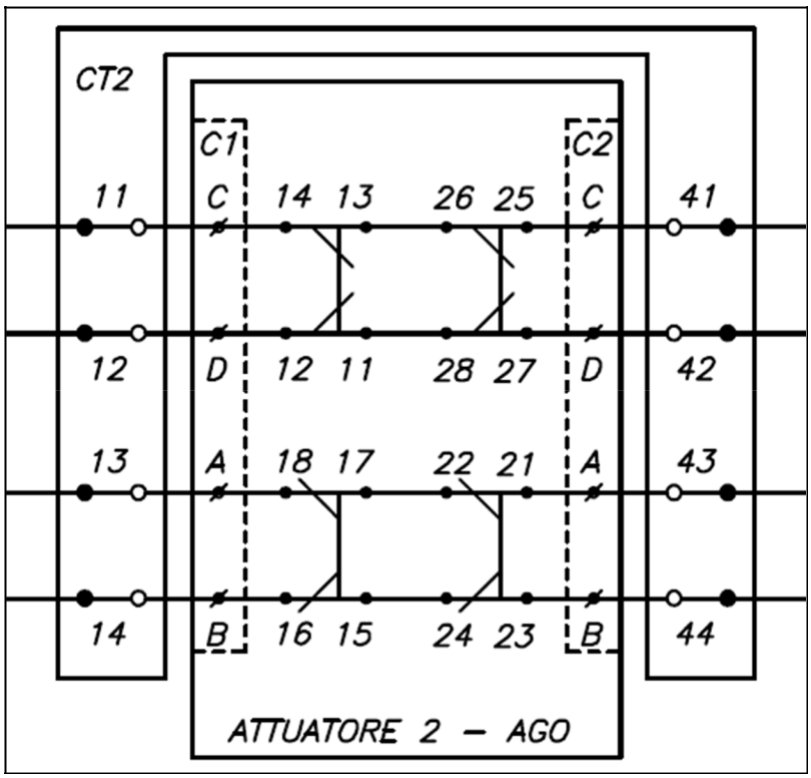

Figure 35 - Needle actuator position control circuit (source: RFI)

In this case, the contact shafts, one for each needle, will establish the following circuit configuration:

in case of normal position:	closing of contacts	13-14, 11-12, 25-26, 27-28
	opening of contacts	17-18, 15-16, 21-22, 23-24
in case of diverted position:	closing of contacts	17-18, 15-16, 21-22, 23-24
	opening of contacts	13-14, 11-12, 25-26, 27-28

The switch control circuit, shown in *Figure 36*, has the task of transmitting information from the yard to the cab and to the Central Operations Manager's desk regarding the configuration assumed by the entire switch from the position information provided by the individual actuators. This is achieved by means of a 48V dc powered circuit that connects in series the outputs of the devices described above that provide the position of the individual elements of the switch moved by each actuator, and that returns a voltage to the contacts of the control relay KDi always equal to 48V dc, but with a positive or negative polarity depending on the configuration assumed by the switch. In *Figure 36*, the configuration of the shunter contactor (TM), cascade contactor (TC) and shunter switch contacts is that corresponding to the normal position of the switch. Under these conditions, as shown in *Figure 37*, the voltage at the contacts of the control relay KDi is +48V. On the other hand, at the end of the manoeuvre which takes the switch from the normal position to the diverted position, the configuration of the contacts of the control circuit will be as shown in Figure 38, which corresponds to a voltage at the contacts of KDi of -48V.

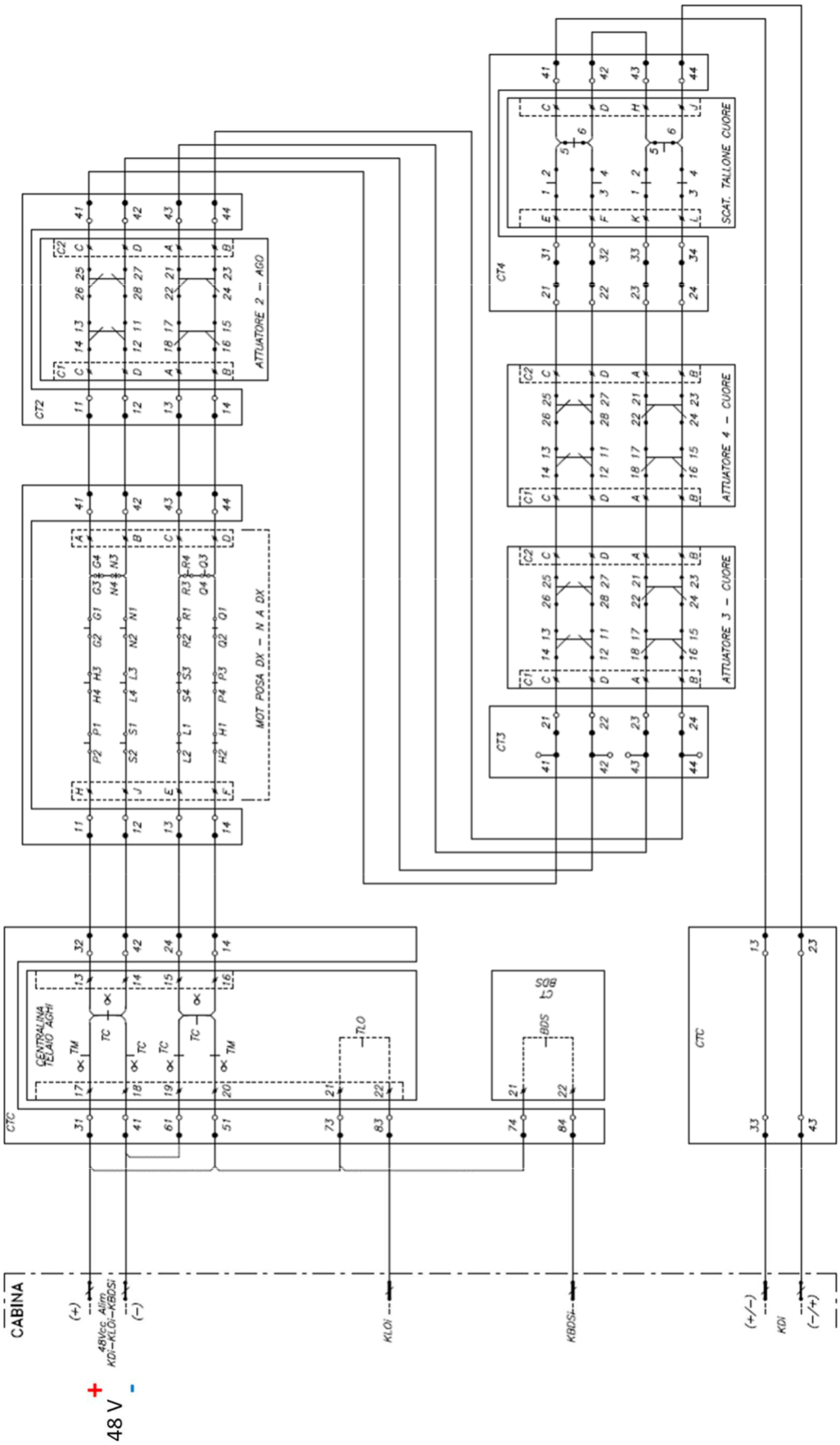

Figure 36 – Switch control circuit (source: RFI)

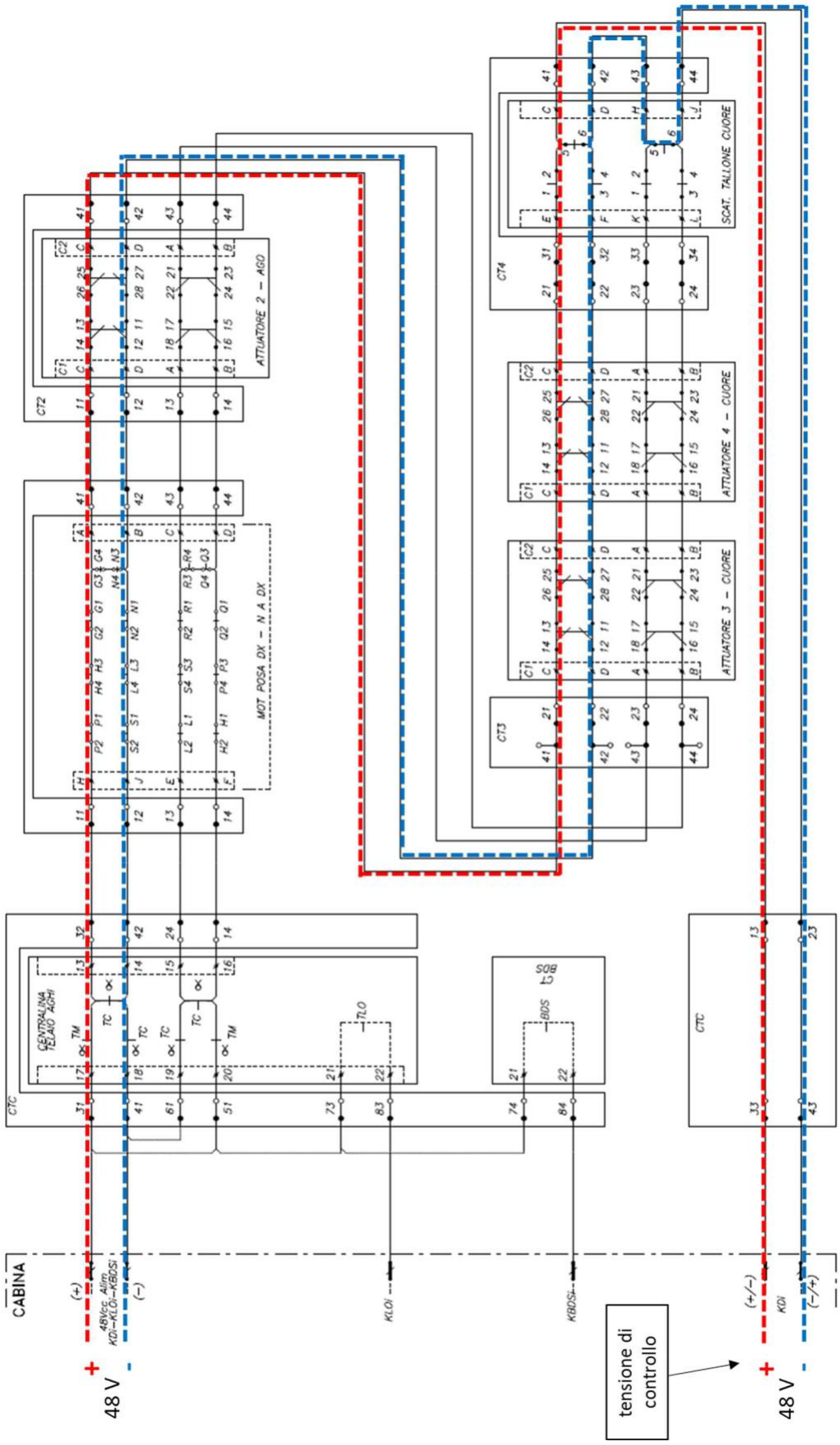

Figure 37 – Switch control circuit: circuit configuration corresponding to normal position (elaboration: DiGIFeMa)

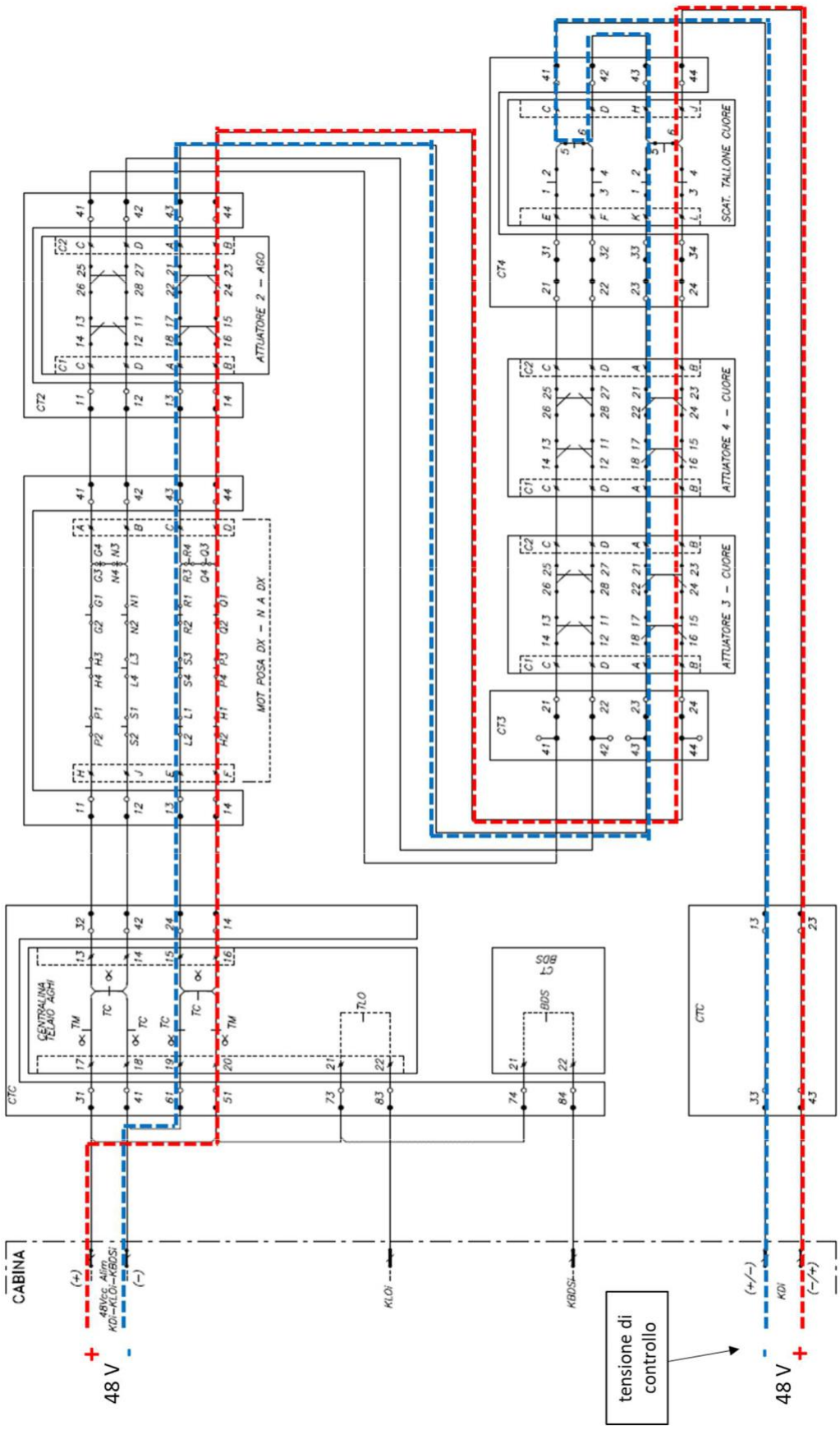

Figure 38 – Switch control circuit: circuit configuration corresponding to diverted position (elaboration: DiGIFeMa)

During the manoeuvre to change the position of the switch, following the supply of power to the motor which drives the hydraulic power unit, the following occurs:

1) loss of the control initially possessed, caused by the rotation of the contact shaft with consequent absence of the control signal. The contact shaft is designed in such a way that control is lost when the kinematic organ on which the application of the change-over stop no longer guarantees stability;
2) closing of the control relay KDi in neutral closed circuit: the control voltage is zero (see *Figure 39*) and the position of the switch is, therefore, indefinite;
3) removal of the switch stop;
4) movement of the needles from one position to another;
5) reapplication of the change-over stop;
6) resumption of position control: the control voltage is + 48 V if the switch is in the normal position, - 48 V if it is in diverted position.

It should be pointed out that the solution adopted to obtain the position control of the switch by connecting in series the circuit elements which provide the position information of the single actuators, is equivalent, from a logical point of view, to performing an AND operation between such information.

From a technical point of view, this solution allows a considerable simplification of the wiring of the control circuit, but it is not fail-safe in the event of wiring errors in the control circuit, as in fact occurred inside actuator no. 2 of switch 05 (serial no. 83).

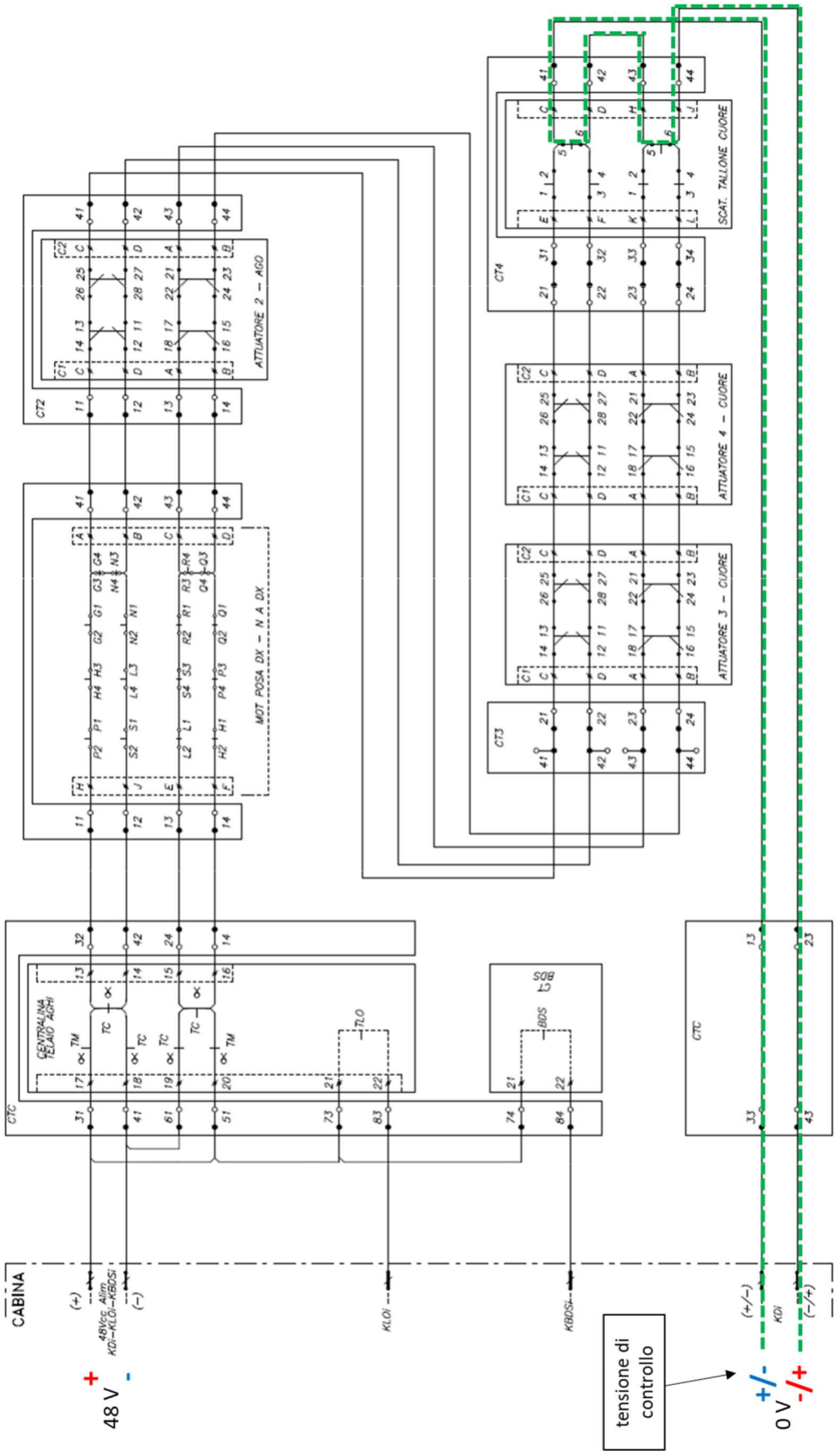

Figure 39 - Switch control circuit: undefined position (elaboration:DiGIFeMa)

As also reported in paragraph 2.1.2 above, an examination of the electrical connections inside one of the actuator 2 boxes of switch 05, carried out immediately after the removal of the sealed cover, showed that:

- the contact shaft is in the configuration corresponding to the diverted position (closing contacts 17-18 and 15-16, opening contacts 13-14 and11-12);
- the lugs marked with the numbers 16 and 18 are connected in an inverted manner to the corresponding contact shaft connection contacts (Figure*40)*.

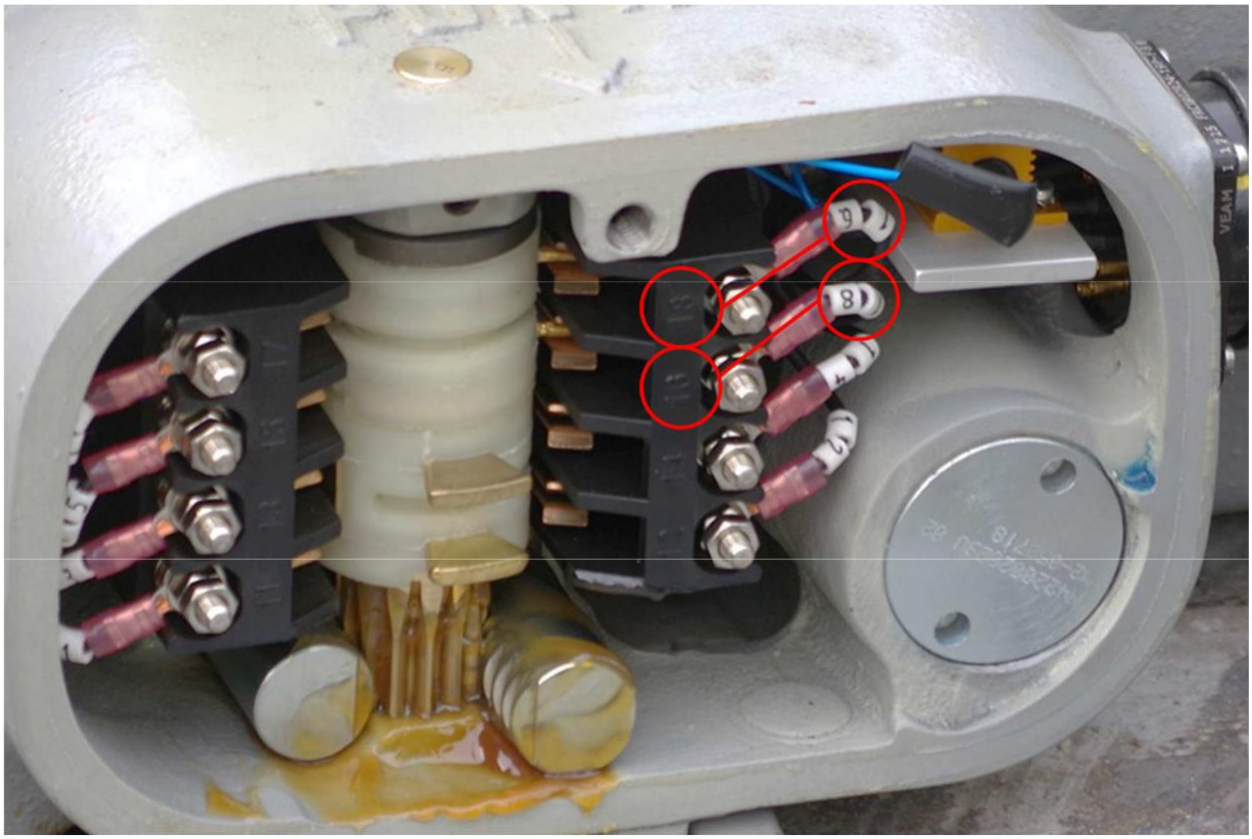

Figure 40 - Actuator box no. 2 of switch 05 after the accident (source: DiGIFeMa)

It should be pointed out that this situation led to the abnormal operation of actuator no. 2 of switch 05 after it was replaced in the early hours of 06/02/2020. The wiring error within the actuator obviously changed the structure of the control circuit and, consequently, its operation. The following figures show the polarity assumed in this case by the position control relay from the yard (KDi) at the normal position (*Figure 41*) and diverted position (*Figure 42*) of the switch. Ultimately, the wiring error corresponding to the reversal of the connections in the actuator box causes the voltage applied to the position control relay to always have the same sign, corresponding to the normal position, regardless of the actual configuration of the switch.

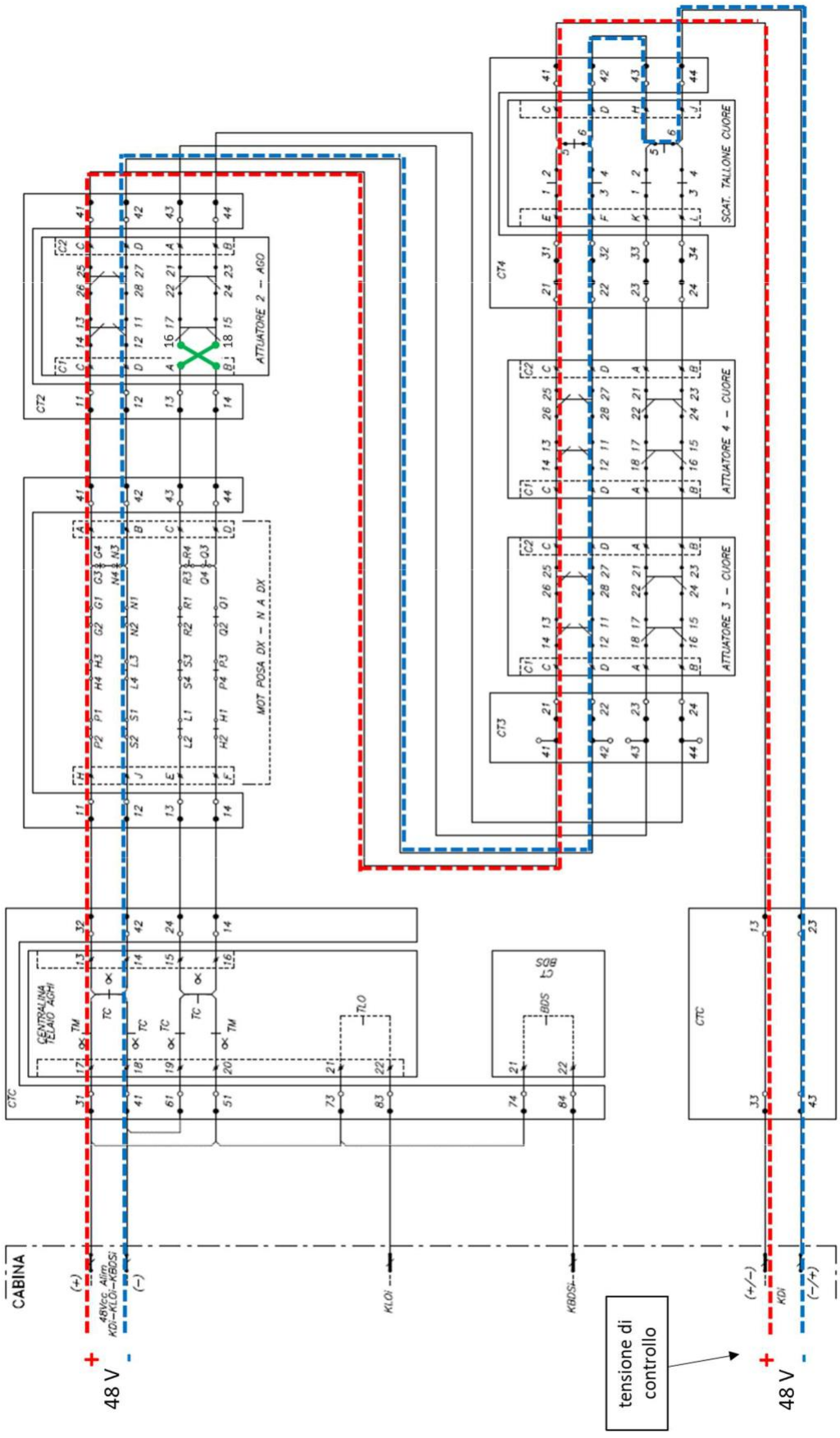

Figure 41 - Control circuit: normal switch position after actuator no. 2 replacement (elaboration: DiGIFeMa)

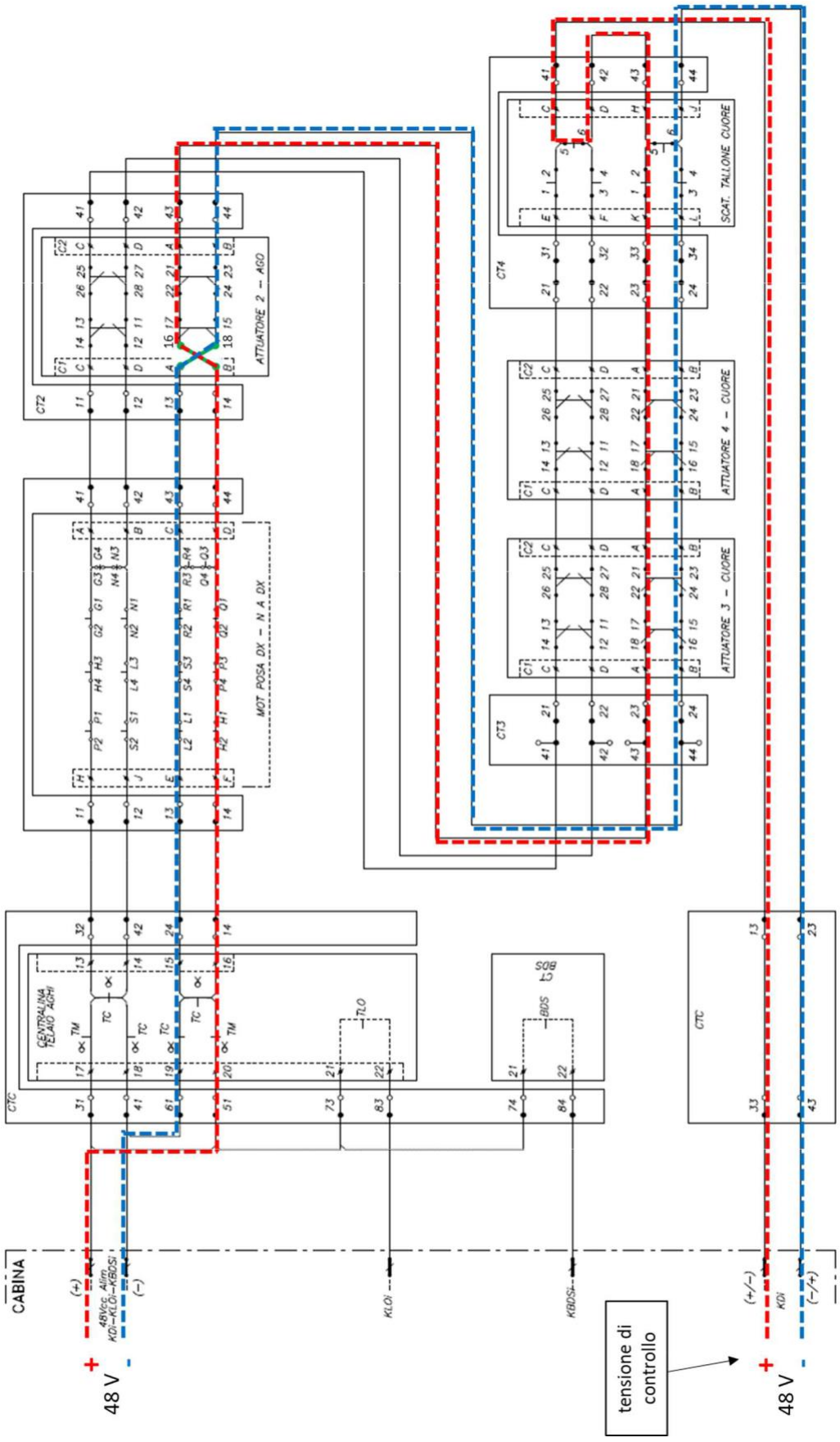

Figure 42 - Control circuit: diverted switch position after replacement of actuator 2 (elaboration: DiGIFeMa)

Table 5/a below summarises the behaviour of the switch and its position control signal when the commanded position and the switch start position change as a result of a manual command given on the switch.

Table 5/a - Switch behaviour following manually given command

		Posizione deviatoio prima del comando	
		Normale	**Rovescia**
Posizione comandata	**Normale**	Il deviatoio resta in posizione normale. L'elettrovalvola che governa il passaggio in posizione normale è disalimentata. Il relé di controllo KDi indica posizione normale.	Il deviatoio si porta in posizione normale. La posizione indicata dal relé di controllo Kdi passa da normale a indefinita e poi di nuovo normale.
	Rovescia	Il deviatoio si porta in posizione rovescia. La posizione indicata dal relé di controllo KDi passa da normale a indefinita e poi di nuovo normale.	Il deviatoio resta in posizione rovescia. L'elettrovalvola che governa il passaggio in posizione rovescia è disalimentata. Il relé di controllo Kdi indica posizione normale.

This was questioned by RFI for the case in which the switch is controlled by the ACC's desk. RFI has not provided any documentation on the relevant electric or logic circuits, although repeatedly requested to do so by the undersigned. In this respect, RFI has produced a two-page document, in pdf format, called "*Annex 2 - Scenarios for switch manoeuvre 05 Livraga*", from which it can be inferred indirectly (i.e. without the counter-evidence provided by the analysis of the corresponding circuit documentation) that the behaviour of the switch is characterised not only by the status of relay KDi, which provides the position of the switch coming from the field (indicated with KD in the above-mentioned document), but also by the following control quantities:

- M: which indicates the logical position of the switch generated by the switch command itself. It can take on two values: Normal or Diverted;
- D: which represents the secondary concordance control of the switch, and is the quantity reported on the QL of the DM/DCO. Its value is provided by the logical AND operation between the control quantities KD and M. It can take on three values: Normal/Diverted/Indefinite. When D takes on an Undefined value, the switch is disconnected, which occurs when there is no agreement between the values taken on by KD and M. Recalling that KD can also take on three values (Normal/ Diverted/Indefinite), table 5/b below summarises the values that D can take on as a function of the values taken on by M and KD:

Table 5/b - Values assumed (in light blue) by the control gravity D as a function of M and KD

		KD		
		Normale	Indefinito	Rovescio
M	Normale	Normale	Indefinito	Indefinito
	Rovescio	Indefinito	Indefinito	Rovescio

Since the contact shaft of the actuator which moves the switch is designed in such a way that control fails (undefined KD) when the kinematic organ on which the application of the change-over stop depends no longer guarantees its stability, it is evident that when KD takes on the value Normal or Diverted it means that the change-over stop is applied to the switch, while the undefined value of KD indicates that the change-over stop is not applied.

Since an error in the control quantity M is highly unlikely, since it is determined directly by the command given to the switch by TO DM/DCO, it is immediate to deduce that the combination of values D-KD-M equal to Indefinite-Normal-Diverted is surely a symptom of a malfunction either of the actuator (the switch did not move from its normal initial position), or of the switch position control circuit coming from the yard (the switch moved from normal to diverted, but KD remained normal). A similar argument can be made for the combination of D-KD-M values equal to Indefinite-Diverted-Normal. In essence, any switch command that results in D being undefined without KD being undefined is an indication of a switch malfunction.

With reference to the incident in question, on the occasion of the restarting of switch 05 (see command no. 37 in the control register, reproduced below) the first manoeuvre carried out by the Central Operations Manager's desk was the command from the normal position to the diverted position, which resulted in the combination D-KD-M equal to Indefinite-Normal-Diverted and the disconnection of the switch. The document produced by RFI also shows that from this state:

- if the DM/DCO restores the switch and gives it a Normal command, then the switch remains fed in diverted position while the D-KD-M combination becomes equal to Normal-Normal-Normal after a time equal to 2 s;
- if the DM/DCO restores the switch and issues a Diverted command to it, then the switch remains energised in diverted position while the combination D-KD-M becomes equal to Indefinite-Normal-Diverted after a time equal to 20 s.

Therefore, as a result of the change in the behaviour of the control circuit of actuator 2, resulting from the internal wiring error, the position control KD of the switch always indicates the normal or undefined position, irrespective of the position actually assumed by the switch, while the quantities D and M can both assume the value Normal even if the switch is in diverted position.

. However, what emerges from the above is the inadequate handling, both by the operators present and by the ACC's control logic, of the information provided by the combination of the control quantities D-KD-M equal to Indefinite-Normal-Diverted, which, as argued above, always corresponds to a malfunction either of the switch actuator or of its control circuit; both circumstances should have prevented the switch from being put into service and, at the same time, required a physical inspection of the switch in order to ascertain and remove the causes of the malfunction.

The foregoing reconstruction, although not supported by logical circuit diagrams, is useful in reconstructing the behaviour of the defective actuator, a circumstance which is in any case established and incontrovertible.

4.2.2.2. Indirect cause No. 2

Failure to check the correspondence between the physical configuration of switch 05 on the yard and that returned remotely, at the end of the maintenance activity.

As previously reported, switch 05 (km 166+756) had been subject to maintenance activity during the night between 5 and 6 February, which ended at around 04:30 on 06/02/2020 and consisted of the renewal of the frame + core hydraulic actuators. From the analysis of the following documentation:

- command log;
- event log;
- recording of conversations between Central Operations Manager and Maintenance Agent,

it emerges unequivocally that, at the end of the maintenance work, the behaviour of switch 05 was completely abnormal.

In support of the above, the following table shows the commands, events and corresponding time-aligned telephone conversations between the Central Operations Manager and the Maintenance Agent that night following the maintenance intervention.

COMANDI					EVENTI				CONVERSAZIONE	OSSERVAZIONI
Ord.	hh.mm.ss.d	CicloNS	Origine	Comando	Ord.	hh.mm.ss.d	CicloNS	Evento		
26	03:30:01.1	[4453802]	BANCO 13	deviatoio 10 am inclusione dev					INIZIO CONVERSAZIONE 2474 DCO: DCO Bologna AV AM: Ciao sono.....(nome AM) da Livraga DCO: Dimmi AM: Allora ti chie... ti faccio la richiesta di inclusione sui deviatoi 10, 5 e 7 DCO: beep....Allora, un attimo che vado a Livraga...Allora vai col primo AM: Allora ti includo il 10..... DCO: Ok	
27	03:30:04.6	[4453812]	BANCO 13	deviatoio 10 am conferma inclusione dev						
28	03:30:09.5	[4453826]	TASTIERA 1	deviatoio 10 dm inclusione is dev	1259	03:30:09.5	[4453826]	Deviatoio (Esclusione) DV.10 Non Escluso		
					1260			Trasmettichiave (esclusione) TRASM.10 Non escluso		
29	03:30:17.2	[4453848]	BANCO 13	deviatoio 05 am inclusione dev					AM: Ok, adesso ti includo il 5.... [rivolgendosi a qualcuno vicino: tu vai di là che vedi dalla scheda se quando lui gira]... DCO: Ok	
30	03:30:21.4	[4453860]	BANCO 13	deviatoio 05 am conferma inclusione dev						
31	03:30:26.6	[4453875]	TASTIERA 1	deviatoio 05 dm inclusione is dev	1261	03:30:26.6	[4453875]	Deviatoio (Esclusione) DV.05 Non Escluso		
					1262			Trasmettichiave (esclusione) TRASM.05 Non escluso		
32	03:30:40.3	[4453914]	BANCO 13	deviatoio 07 am inclusione dev					AM: E ti includo il 7. Si, si bene intanto vai...beep... e ti includo il 7... DCO: Ok	
33	03:30:44.1	[4453925]	BANCO 13	deviatoio 07 am conferma inclusione dev						
34	03:30:49.7	[4453941]	TASTIERA 1	deviatoio 07 dm inclusione is dev	1263	03:30:49.7	[4453941]	Deviatoio (Esclusione) DV.07 Non Escluso		
					1264			Trasmettichiave (esclusione) TRASM.07 Non escluso		
35	03:31:07.2	[4453991]	BANCO 13	deviatoio 06 am esclusione dev					AM: E ti escludo... il 6 che finiam di lavorare sul 6 così... ti escludo il 6... ok...e per piacere mi faresti una manovra sul deviatoio 05?	
36	03:31:13.5	[4454009]	TASTIERA 1	deviatoio 06 dm esclusione is dev	1265	03:31:13.5	[4454009]	Deviatoio (Esclusione) DV.06 Escluso IS		
					1266			Trasmettichiave (esclusione) TRASM.06 Escluso e stabilizzato		

COMANDI					EVENTI				CONVERSAZIONE	OSSERVAZIONI
Ord.	hh.mm.ss.d	CicloNS	Origine	Comando	Ord.	hh.mm.ss.d	CicloNS	Evento		
37	03:31:28.6	[4454052]	BANCO 13	deviatoio 05 manovra leggera in posizione r	1267	03:31:28.6	[4454052]	Deviatoio (Controllo Teleruttore BDSE) DV.05 Eccitato	DCO: Allora 05 rovescio vado....beep.....si è disalimentato lo alimentiamo... AM: Quindi non ti è andato DCO: Lo faccio frullare ancora o torno indietro? AM: Eh prova a tornare... DCO: Normale AM: Eh tornare normale e provo a guardare sul posto la manovra perché devo...ah però ti è tornata subito...è come se non fosse... DCO: Partito prima AM: È come se non fosse partita	E' in posizione normale. Il comando rovescio porta il deviatoio in posizione rovescia. Il segnale di controllo passa da normale a indefinito quindi a normale.
					1268	03:31:30.3	[4454057]	Deviatoio (controllo di posizione) DV.05 Indefinito		
					1269	03:31:49.5	[4454112]	Deviatoio (Alimentazione) DV.05 Disalimentato		
					1270	03:31:51.3	[4454117]	Deviatoio (controllo di posizione) DV.05 Normale		
					1271	03:31:51.6	[4454118]	Deviatoio (Controllo Teleruttore BDSE) DV.05 Diseccitato		
38	03:32:01.8	[4454147]	TASTIERA 1	deviatoio 05 alimentazione deviatoio	1272	03:32:01.8	[4454147]	Deviatoio (Alimentazione) DV.05 Alimentato		
39	03:32:22.8	[4454207]	BANCO 1	deviatoio 05 manovra leggera in posizione n						
40	03:32:42.4	[4454263]	BANCO 1	deviatoio 05 manovra leggera in posizione r						
					1273	03:32:42.4	[4454263]	Deviatoio (Controllo Teleruttore BDSE) DV.05 Eccitato	DCO: Che faccio riprovo? AM: Eh boh. Prova per scrupolo..... DCO: Vedi è ...mente... alimenta... AM: Adesso vi...beep DCO: [parlando fra sé] Deviatoi 5 normale. [riprende a comunicare] Sì, sì non parte AM: È come se non parte...è come se non parte la manovra al rovescio. Adesso provo a darci un'occhiata dai. DCO: Bene allora... AM: Ci sentiamo DCO: Bene AM: Ciao **FINE CONVERSAZIONE 2474**	Comandata posizione normale partendo da posizione rovescia e subito dopo impartito il comando posizione rovescia. Il controllo del deviatoio diventa indefinito per poi tornare normale (con deviatoio in posizione rovescia): il deviatoio si disalimenta. Viene rialimentato e impartito comando normale, per poi essere scluso subito dopo.
					1274	03:32:44.2	[4454268]	Deviatoio (controllo di posizione) DV .05 Indefinito		
					1275	03:33:03.4	[4454323]	Deviatoio (Alimentazione) DV.05 Disalimentato		
					1276	03:33:04.8	[4454327]	Deviatoio (controllo di posizione) DV.05 Normale		
					1277	03:33:05.2	[4454328]	Deviatoio (Controllo Teleruttore BDSE) DV.05 Diseccitato		
41	03:33:12.5	[4454349]	TASTIERA 1	deviatoio 05 alimentazione deviatoio	1278	03:33:12.5	[4454349]	Deviatoio (Alimentazione) DV.05 Alimentato		
42	03:33:19.5	[4454369]	BANCO 1	deviatoio 05 manovra leggera in posizione n						
43	03:46:05.6	[4456558]	BANCO 13	deviatoio 05 am esclusione dev						
44	03:46:11.6	[4456575]	TASTIERA 1	deviatoio 05 dm esclusione is dev	1283	03:46:11.6	[4456575]	Deviatoio (Esclusione) DV.05 Escluso IS		
					1284			Trasmettichiave (esclusione) TRASM.05 Escluso e stabilizzato		

COMANDI					EVENTI				CONVERSAZIONE	OSSERVAZIONI
Ord.	hh.mm.ss.d	CicloNS	Origine	Comando	Ord.	hh.mm.ss.d	CicloNS	Evento		
49	03:47:06.1	[4456731]	TASTIERA 1	deviatoio 05 alimentazione deviatoio	1292	03:47:06.1	[4456731]	Deviatoio (Alimentazione) DV.05 Alimentato	DCO: Adesso l'ho alimentato, comunque AM: Adesso l'hai rialimentato... adesso provo a cambiarti un'altra scheda... DCO: Ok AM: E ce l'hai in controllo normale come l'hai rialimentato no? DCO: No, no è indefinito ... beep..... non ce l'ho né normale né rovescio AM: [parlando a qualcuno in sua prossimità] E proviamo a cambiare anche questo dai..... beep ..... Allora aspetta un attimo... Allora... Adesso lampeggia in con.. mancanza controllo rovescio giusto? DCO: Si giusto	
					1296	03:48:02.1	[4456891]	Deviatoio (controllo di posizione) DV.05 Indefinito		
					1297	03:48:13.0	[4456922]	Deviatoio (controllo di posizione) DV.06 Rovescio		
					1298	03:48:17.2	[4456934]	Deviatoio (controllo di posizione) DV.06 Indefinito		
					1299	03:48:26.3	[4456960]	Deviatoio (controllo di posizione) DV.06 Normale		
					1300	03:48:27.0	[4456962]	Deviatoio (controllo di posizione) DV.05 Normale		
52	03:49:13.5	[4457095]	BANCO 13	deviatoio 05 am esclusione dev					AM: Se io provo a escludertelo e a reincludeterlo così cosa succede? DCO: Eh proviamo..... beep ..... AM: Non succede niente DCO: No, non succede niente AM: Ehhh ....prova a lanciargli la manovra normale..... DCO: Allora... AM: E dovrebbe tornare subito il controllo in teoria, se non faceva come...	Esclusione e poi inclusione del deviatoio 5
53	03:49:19.5	[4457112]	TASTIERA	deviatoio 05 dm esclusione is dev	1301	03:49:19.5	[4457112]	Deviatoio (Esclusione) DV .05 Escluso IS		
					1302			Trasmettichiave (esclusione) TRASM.05 Escluso e stabilizzato		
54	03:49:23.3	[4457123]	BANCO 13	deviatoio 05 am inclusione dev						
55	03:49:26.8	[4457133]	BANCO 13	deviatoio 05 am conferma inclusione dev						
56	03:49:33.5	[4457152]	TASTIERA	deviatoio 05 dm inclusione is dev	1303	03:49:33.5	[4457152]	Deviatoio (Esclusione) DV.05 Non Escluso		
					1304			Trasmettichiave (esclusione) TRASM.05 Non escluso		

COMANDI					EVENTI				CONVERSAZIONE	OSSERVAZIONI
Ord.	hh.mm.ss.d	CicloNS	Origine	Comando	Ord.	hh.mm.ss.d	CicloNS	Evento		
57	03:50:03.9	[4457239]	BANCO 1	deviatoio 05 manovra leggera in posizione r	1305	03:50:03.9	[4457239]	Deviatoio (Controllo Teleruttore BDSE) DV.05 Eccitato		
					1306	03:50:04.3	[4457240]	Deviatoio (controllo di posizione) DV.05 Indefinito		
					1307	03:50:04.6	[4457241]	Deviatoio (controllo di posizione) DV.05 Normale	DCO: No, posso solo mandarla rovescia la manovra AM: Prova a mandarla rovescia allora DCO: Rovescia.....beep....disalimentato.....l'ho rialimentato..... Eh devo rispondere agli altri che mi danno indietro l'interruzione eh AM: E va bene dai, provo a vedere un attimo... Dai prova a sentire poi vediam di....se riusciamo a risolvere DCO: Ok, va bene **FINE CONVERSAZIONE 2544**	Il deviatoio è in posizione rovescia. Il controllo dà posizione normale. Comando rovescio, si disalimenta
					1308	03:50:06.0	[4457245]	Deviatoio (controllo di posizione) DV .05 Indefinito		
					1309	03:50:24.9	[4457299]	Deviatoio (Alimentazione) DV.05 Disalimentato		
					1310	03:50:26.3	[4457303]	Deviatoio (controllo di posizione) DV.05 Normale		
					1311	03:50:26.7	[4457304]	Deviatoio (Controllo Teleruttore BDSE) DV.05 Diseccitato		
					1312	03:50:32.6	[4457321]	Deviatoio (controllo di posizione) DV.05 Indefinito		
58	03:50:37.2	[4457334]	TASTIERA 1	deviatoio 05 alimentazione deviatoio	1313	03:50:37.2	[4457334]	Deviatoio (Alimentazione) DV.05 Alimentato		
					1314	03:51:03.7	[4457410]	Deviatoio (controllo di posizione) DV.06 Indefinito		
					1315	03:51:12.9	[4457436]	Deviatoio (controllo di posizione) DV.06 Rovescio		

COMANDI					EVENTI				CONVERSAZIONE	OSSERVAZIONI
Ord.	hh.mm.ss.d	CicloNS	Origine	Comando	Ord.	hh.mm.ss.d	CicloNS	Evento		
69	04:25:11.1	[4463260]	BANCO 13	deviatoio 06 am inclusione dev					INIZIO CONVERSAZIONE 2746 DCO: DCO Bologna AM: Sono ....(nome AM) DCO: Dimmi AM: Allora ti dovrei restituire l'esclusione sul 6 DCO: Allora deviatoio 6 vai pure...beep.....	
70	04:25:13.9	[4463268]	BANCO 13	deviatoio 06 am conferma inclusione dev						
71	04:25:19.4	[4463284]	TASTIERA 1	deviatoio 06 dm inclusione is dev	1392	04:25:19.4	[4463284]	Deviatoio (Esclusione) DV.06 Non Escluso		
					1393			Trasmettichiave (esclusione) TRASM.06 Non escluso		
72	04:26:18.3	[4463452]	BANCO 1	deviatoio 05 manovra leggera in posizione n					AM: Ah aspetta ce l'avevi te in attesa controllo a rovescio devo fartelo mandare a mano a rovescio allora... aspetta...eh aspetta un attimo...aspetta un attimo..... AM: [rivolgendosi a persona a lui prossima] Lu Lu:Dimmi AM: Chiama Ale digli di girare a rovescio il 6..... Il 5 tu come lo vedi in questo momento? DCO: Senza controllo AM: Senza controllo... ma.... perché io fisicamente ce l'ho normale. Riesci a lanciare una manovra normale o devi... DCO: Sì... aspetta vado a normale AM: Prova a lanciare la manovra normale DCO: E ce l'ho normale ok AM: E sul 5 dovrebbe esserci controllo adesso? DCO: Sì, sì, c'è un controllo normale	Sul deviatoio 05 c'è sempre un controllo normale!
					1394	04:26:41.0	[4463517]	Deviatoio (Livello Olio) DV.06 Assente		
					1395	04:26:49.8	[4463542]	Deviatoio (controllo di posizione) DV.06 Indefinito		
					1396	04:27:08.7	[4463596]	Deviatoio (controllo di posizione) DV.06 Rovescio		
					1397	04:27:16.0	[4463617]	Deviatoio (Livello Olio) DV.06 Presente		
73	04:27:37.4	[4463678]	BANCO 13	deviatoio 06 am esclusione dev						
74	04:27:44.4	[4463698]	TASTIERA 1	deviatoio 06 dm esclusione is dev	1398	04:27:44.4	[4463698]	Deviatoio (Esclusione) DV.06 Escluso IS		
					1399			Trasmettichiave (esclusione) TRASM.06 Escluso e stabilizzato		

COMANDI					EVENTI				CONVERSAZIONE	OSSERVAZIONI
Ord.	hh.mm.ss.d	CicloNS	Origine	Comando	Ord.	hh.mm.ss.d	CicloNS	Evento		
75	04:27:48.2	[4463709]	BANCO 13	deviatoio 06 am inclusione dev					AM: Ok. Adesso allora ti metto a posto il 6, provo a farti una manovra sul 5. Se poi il 5 da ancora problemi lo dobbiamo inibire...perché deve esserci qualche problema sui relè...beep..... [interviene persona prossima: stai partendo rovescio].....Ok, allora adesso ti faccio l'esclusione inclusione sul 6 intanto.....beep...[interviene persona prossima: aspetta un attimo cambio di posizione].....ok e il 6 ce l'hai in controllo rovescio corretto DCO: Rovescio si AM: Se vuoi posso fargli lanciar la manovra sul 6...te lo rimette normale.....[persona prossima: come...] gli faccio lanciar la manovra sul 6 ...[persona prossima: eh chiudi la cassa.....]... Allora ti faccio mettere normale il 6 DCO: Normale il 6.....beep.... AM: Ok DCO: Ok, ce l'abbiamo	
76	04:27:53.5	[4463724]	BANCO 13	deviatoio 06 am conferma inclusione dev						
77	04:28:00.5	[4463744]	TASTIERA 1	deviatoio 06 dm inclusione is dev	1400	04:28:00.5	[4463744]	Deviatoio (Esclusione) DV.06 Non Escluso		
					1401			Trasmettichiave (esclusione) TRASM.06 Non escluso		
78	04:28:29.9	[4463828]	BANCO 1	deviatoio 06 manovra leggera in posizione n	1402	04:28:29.9	[4463828]	Deviatoio (Controllo Teleruttore BDSE) DV.06 Eccitato		
					1403	04:28:32.0	[4463834]	Deviatoio (controllo di posizione) DV.06 Indefinito		
					1404	04:28:34.4	[4463841]	Deviatoio (controllo di posizione) DV.06 Rovescio		
					1405	04:28:35.1	[4463843]	Deviatoio (controllo di posizione) DV.06 Indefinito		
					1406	04:28:46.7	[4463876]	Deviatoio (controllo di posizione) DV.06 Normale		
					1407	04:28:48.4	[4463881]	Deviatoio (Controllo Teleruttore BDSE) DV.06 Diseccitato		

COMANDI					EVENTI				CONVERSAZIONE	OSSERVAZIONI
Ord.	hh.mm.ss.d	CicloNS	Origine	Comando	Ord.	hh.mm.ss.d	CicloNS	Evento		
79	04:29:01.7	[4463919]	BANCO 1	deviatoio 05 manovra leggera in posizione r	1408	04:29:01.7	[4463919]	Deviatoio (Controllo Teleruttore BDSE) DV.05 Eccitato	AM: E adesso provo a farti lanciare la manovra...la manovra sul 5 DCO: Vado a rovescio sul 5? AM: Si, prova a andare a rovescio sul 5..... DCO: Niente, si disalimenta...alimentiamo e lo riportiamo normale AM: Si..... DCO: Orca, non parte proprio AM: Eh sì non...è come se...come se non si muovesse, ma il problema è qua in cabina... il problema è qua in cabina sicuro [si odono voci distanti indistinte] ...Eh niente ascolta allora il 5 lo lasciamo così DCO: Allora il 5 lo confermiamo in posizione normale e lo disalimentiamo e mi fai il fonogramma AM: Si e poi ti faccio il fonogramma. Ti faccio fare due manovre di saggio sul 6 e sul 10 DCO: Ma sul 6 non l'abbiamo già fatta? AM: Beh si abbiam fatto un rovescio normale però adesso c'è... DCO: Allora AM: Se tutti e due da normale li mandi in rovescio DCO: Allora disalimentiamo AM: E poi li rimetti normale DCO: Mettiamo a posto il 5...ok...disalimentato e normale. Poi deviatoio...6 e 10 hai detto vuoi fare le manovre?	Il comando rovescio determina la disalimentazione perché il deviatoio è già in posizione rovescia, mentre il controllo di posizione restituisce normale (è come se non si muovesse...)
					1409	04:29:03.4	[4463924]	Deviatoio (controllo di posizione) DV.05 Indefinito		
					1410	04:29:05.9	[4463931]	Deviatoio (controllo di posizione) DV.05 Normale		
					1411	04:29:06.9	[4463934]	Deviatoio (controllo di posizione) DV.05 Indefinito		
					1412	04:29:22.7	[4463979]	Deviatoio (Alimentazione) DV.05 Disalimentato		
					1413	04:29:24.4	[4463984]	Deviatoio (controllo di posizione) DV.05 Normale		
					1414	04:29:24.4		Deviatoio (Controllo Teleruttore BDSE) DV.05 Diseccitato		
80	04:29:32.9	[4464008]	TASTIERA 1	deviatoio 05 alimentazione deviatoio	1415	04:29:32.9	[4464008]	Deviatoio (Alimentazione) DV.05 Alimentato		
81	04:29:43.3	[4464038]	BANCO 1	deviatoio 05 manovra leggera in posizione n						IL DCO presume che il deviatoio sia in posizione normale. Occorrerebbe verifica di concordanza sul posto
82	04:30:44.6	[4464213]	TASTIERA 1	deviatoio 05 manovra in posizione n	1416	04:30:44.6	[4464213]	Deviatoio (Stato Comando) DV.05 Manuale		
83	04:30:53.7	[4464239]	TASTIERA 1	deviatoio 05 disalimentazione deviatoio	1417	04:30:53.7	[4464239]	Deviatoio (Alimentazione) DV.05 Disalimentato		

COMANDI					EVENTI				CONVERSAZIONE	OSSERVAZIONI
Ord.	hh.mm.ss.d	CicloNS	Origine	Comando	Ord.	hh.mm.ss.d	CicloNS	Evento		
84	04:31:04.9	[4464271]	BANCO 1	deviatoio 06 manovra leggera in posizione r	1418	04:31:04.9	[4464271]	Deviatoio (Controllo Teleruttore BDSE) DV.06 Eccitato	AM: Sì, 6 e 10 le manovre di saggio DCO: 6 rovescio e 10 rovescio...beep...6 andato.....e il 10...non va...è andato AM: Ok, rimetti tutto... DCO: Riporto normale AM: Riportali normale..... DCO: 10 ce l'abbiamo...beep...e il 6 ce l'abbiamo	
					1419	04:31:06.6	[4464276]	Deviatoio (controllo di posizione) DV.06 Indefinito		
85	04:31:07.3	[4464278]	BANCO 1	deviatoio 10 manovra leggera in posizione r						
					1420	04:31:20.3	[4464315]	Deviatoio (controllo di posizione) DV.06 Rovescio		
					1421	04:31:20.6	[4464316]	Deviatoio (Controllo Teleruttore BDSE) DV.10 Eccitato		
					1422	04:31:22.0	[4464320]	Deviatoio (Controllo Teleruttore BDSE) DV.06 Diseccitato		
					1423	04:31:22.7	[4464322]	Deviatoio (controllo di posizione) DV.10 Indefinito		
					1424	04:31:36.4	[4464361]	Deviatoio (controllo di posizione) DV.10 Rovescio		
					1425	04:31:38.1	[4464366]	Deviatoio (Controllo Teleruttore BDSE) DV.10 Diseccitato		
86	04:31:42.3	[4464378]	BANCO 1	deviatoio 10 manovra leggera in posizione n	1426	04:31:42.3	[4464378]	Deviatoio (Controllo Te1eruttore BDSE) DV.10 Eccitato		
					1427	04:31:44.4	[4464384]	Deviatoio (controllo di posizione) DV.10 Indefinito		
87	04:31:44.8	[4464385]	BANCO 1	deviatoio 06 manovra leggera in posizione n						
					1428	04:31:57.7	[4464422]	Deviatoio (controllo di posizione) DV.10 Normale		
					1429	04:31:58.1	[4464423]	Deviatoio (Controllo Teleruttore BDSE) DV.06 Eccitato		
					1430	04:31:59.5	[4464427]	Deviatoio (Controllo Teleruttore BDSE) DV.10 Diseccitato		
					1431	04:32:00.2	[4464429]	Deviatoio (controllo di posizione) DV.06 Indefinito		
					1432	04:32:13.5	[4464467]	Deviatoio (controllo di posizione) DV.06 Normale		
					1433	04:32:15.2	[4464472]	Deviatoio (Controllo Teleruttore BDSE) DV.06 Diseccitato		

COMANDI					EVENTI				CONVERSAZIONE	OSSERVAZIONI
Ord.	hh.mm.ss.d	CicloNS	Origine	Comando	Ord.	hh.mm.ss.d	CicloNS	Evento		
						04:35 circa			AM: Ok, adesso se hai tempo prendo subito l'M100 e facciamo il fonogramma per il 5 DCO: Sì, prendo anche io l'M100.....beep... AM: Allora oggi è il... DCO: Allora AM: 6 febbraio 2020. Allora, [inizia a dettare] si dà avviso al DCO AV/AC Milano Bologna che dalle ore...beep...ore..che ore sono? DCO: 4 e 35 AM: 4 e 35 DCO: E fino a nuovo avviso... AM: odierne il deviatoio... DCO: Vabbè scriviamo e fino a nuovo avviso no... AM: Ah beh quello lì lo mettevo alla fine, perché mi stavo copiando uno già fatto DCO: Ok, odierne AM: Il deviatoio 05 di PM Livraga DCO: Il deviatoio 05 di PM Livraga AM: è inibito alla manovra DCO: è inibito alla...beep... manovra AM quindi da utilizzarsi solo per il corretto tracciato DCO: ... da utilizzarsi solo per il corretto tracciato AM: fino a nuovo avviso DCO: fino a nuovo avviso	

COMANDI					EVENTI				CONVERSAZIONE	OSSERVAZIONI
Colonna1	Colonna2	Colonna3	Colonna4	Colonna5	Colonn e6	Colonna7	Colonna8	Colonna9		
Ord.	hh.mm.ss.d	CicloNS	Origine	Comando	Ord.	hh.mm.ss.d	CicloNS	Evento		
									AM: Io sono ...(nome AM) DCO: ...(nome AM) ...beep... AM: e ti do il ...79/81 DCO: Alle 4 e 35....e io ti do....io sono .... (nome DCO) e ti do lo 04 diviso 20 AM: 04...? DCO: diviso 20 AM: diviso 20 DCO: A posto AM: Ok grazie DCO: Vabbè dammi...dammi indietro... AM: Sì, ti do... DCO: Dalle 4 e 35 nulla osta ripresa circolazione AM: Aspetti un attimo eh...aspetta un attimo...[rivolgendosi a persona vicina] [parla con persona vicina: cos'è che c'è? Dici che può essere...] Aspetta un attimo che forse abbiam trovato qualcosa... qualcosa in cabina...aspetta un attimo che facciamo... dobbiamo provare a tirare...a tirare due capicorda e caso mai ti richiamo due minuti dai DCO: Ok AM: Ok FINE CONVERSAZIONE 2746	

COMANDI					EVENTI				CONVERSAZIONE	OSSERVAZIONI
Ord.	hh.mm.ss.d	CicloNS	Origine	Comando	Ord.	hh.mm.ss.d	CicloNS	Evento		
						04:47 circa			INIZIO CONVERSAZIONE 2847 DCO: DCO Bologna AM: Sono ....(nome AM) DCO: Dimmi AM: Ti restituisco l'interruzione 1014 DCO: Ok, dimmi pure AM: Nulla osta ripresa circolazione, binari pari e dispari ambito PM Livraga dalle ore 4...4 e 47. ....(nome AM), trasmette ....(nome AM) DCO: Riceve DCO Allora il 5 lo teniamo così AM Si, il 5 lo teniamo così poi vedremo... quando veniamo a darci un'occhiata fatta bene DCO: Benissimo a posto ciao buonanotte AM Ciao buonanotte ciao FINE CONVERSAZIONE 2847	
					1608	05:28:26.9	[4474106]	Deviatoio (controllo di posizione) DV.05 Indefinito		Svio del treno passeggeri FR9595 dell'IF Trenitalia SpA, proveniente da Milano e diretto verso Salerno.
					1611	05:28:27.6	[44741 08]	Deviatoio (controllo di posizione) DV.07 Indefinito		
					1612	05:28:27.9	[4474109]	Deviatoio (controllo di posizione) DV.07 Normale		
					1617	05:28:29.6	[4474114]	Trasmettichiave (controlli) TRASM.05 in anormalita'		
					1619			Trasmettichiave (controlli) TRASM.07 in anormalita'		
					1621	05:28:30.3	[4474116]	Deviatoio (Livello Olio) DV.05 Assente		
					1627	05:28:30.7	[4474117]	Deviatoio (Controllo Teleruttore BDSE) DV.05 Eccitato		

In particular, from the examination of the log of events and conversations between the Maintenance Agent and the Central Operations Manager after the conclusion of the maintenance intervention, it is immediate to note how the signal controlling the position of switch 05 always assumed the "normal" or "undefined" configuration regardless of whether the command or remotely given by the Central Operations Manager was of normal or diverted configuration. An operation, that of the switch, which was evidently abnormal and not codified, which a management strategy inspired by the precautionary principle should have induced those involved to evaluate with greater attention the recommissioning activities.

Instead, having ascertained that there was a problem in the operation of switch 05, it was decided to leave it *inhibited from shunting and usable for the correct track until further notice*, without, however, having verified the actual physical position of the switch and the concordance between the latter and the position returned remotely by the control circuit. Since, due to the wiring error discussed above, the position of the switch returned remotely by the control circuit was always either normal or undefined, regardless of the actual physical position of the switch, it is clear that the latter was completely erratic and should have been proven by the required on-site concordance check.

The procedures for carrying out the entity verifications and in particular the verifications of concordance between the configuration of the switch in the yard and that resulting on the bench at the Central Signalling Centre are indicated in the following regulatory texts:

- Instructions IS 46 Edition 1971, "Instruction for the verifications that must precede the activation of the signalling equipment" [hereinafter RFI 16], Paragraph 3.03.03, last paragraph: "*The verification of the conditions (omissis) must also extend to the yard in order to ascertain the concordance between the commands given, the controls received and the situation of the field equipment*";
- ISD Instructions Reprinted 2019, "Instructions for the service of switches in use on the National Railway Infrastructure" [hereinafter RFI 10a], Article 24.6: "*The Maintenance Agent has full and exclusive responsibility for the work that it carries out, both with regard to its perfect success and to the repercussions that it may have on the regular operation of other mechanisms or equipment of the same installation*";
- Technical Instruction RFI DTC STS SS TB IT IS 01 166 C of 23 September 2014 [hereinafter RFI 18], issued by Alstom Ferroviaria (G425015013T of 24 February 2014) entitled "Operating and Maintenance Manual for the Hydraulic Shunting Subsystem", Paragraph 7.2.3, Functional checks: "(omissis) *Verify correct operation by performing some test manoeuvres, controlled from the cabin, with the acquisition of the normal/diverted controls; Verify the concordance of the on-site controls with the cabin controls. Verify the correct functioning, by carrying out some test manoeuvres with the acquisition of the normal/diverted controls, of the electrical emergency manoeuvre device*".

Analysing the above documents one can concur that the concordance checks had to be carried out in any case on the yard and that, therefore, the Maintenance Agents adopted an inappropriate behaviour, which did not allow the correct management of the malfunctioning of the switch.

4.2.2.3. Indirect cause No. 3

Failure to immobilise switch 05 (the actuator no. 2 on the leading frame of which had shown clear signs of malfunctioning) in the correct track position.

The Investigation Committee found that, despite the anomalous operation of switch no. 05, in particular the return of the "normal" control despite the "diverted" configuration, it was not immobilised, but only disconnected in the absence of the verification of

concordance between the physical configuration on the yard and that returned remotely.

To define the actual existence of the obligation to immobilise the needles of switch 05, the following documents were examined:

- Alstom Ferroviaria Technical Specification GA4250150011R of 24 February 2014 "Hydraulic System" [hereinafter RFI 19];
- Annex 16 to Alstom Ferroviaria Technical Specification GA4250150011R dated 24 February 2014 "Single fault management procedure" [hereinafter RFI 19-16];
- ISD Instructions Reprint 2019, "Instructions for the service of switches in use on the National Railway Infrastructure" [hereinafter RFI 10a].

As a result of its analysis of the regulatory standards and technical documentation relating to the hydraulic switch, the Committee has identified the following:

- RFI Document 19 (Technical Specification "Hydraulic System") - Section 2.1.2 Description of the Hydraulic Manoeuvring Subsystem:
    - (omissis);
      in the final phase of the operation, once the stop condition has been achieved (overlapping and stabilisation) the electrical contacts are "actuated" which, in line with the position of the moving parts of the switch, realise the acquisition of the electrical position control;
    - *the Hydraulic Shunting Subsystem includes in its electrical control circuit devices called Control Boxes which, depending on the type of switch, are used to realise the following functions: detection of bursting events; control of the approach position of the Movable Core Points;*
    - *(omissis);*
    - *the Hydraulic Shunting Subsystem is equipped, finally, with an apparatus dedicated to the "in-line" signalling of the electric or switch position control, called Switch Indicator Signal. Depending on the installation environment, the hydraulic shunting subsystem will be completed with the switch indicator signal: "SID 50" (ref. PRD. 7) for the installation environment characterised by a 3 kVdc catenary power supply or with the switch indicator signal "SID 365" (ref. PRD. 6) for the installation environment characterised by a 25 kVac 50 Hz catenary power supply.*

- RFI Document 19-16, "Single fault management procedure" - Chapter 1 Introduction:
    - *<u>If on a switch it is not possible to reach the stopping and checking position in a regular manner, current railway procedures require that the entire switch is immobilised (stopped) with appropriate immobilisation devices</u> (Article 8), positioned according to a suitably defined lay-out for each type of switch, along its entire length, as described in the "Technical Instruction for immobilisation devices" (PRD. 7) as referred to on the layout drawings of the switches.*
      <u>In the cab, at this immobilisation, the switch is seen as "not manoeuvrable", and its position (control Normal or Diverted, Right or Left) is simulated, as appropriate.</u>
    - *In the following paragraphs a series of expedients are presented to make it possible to replace the switch stop realised in a shunting point of the hydraulic system, with the switch stop realised by a pair of immobilisation devices (Article 8), while maintaining the view of the real switch controls in the cab.*

- *The main objective of this procedure is to considerably reduce the disruptions caused by an own or induced failure on a shunting point, in particular by shortening the time it takes to restore rail traffic on the shunting point itself.*
- *A further advantage induced by this procedure lies in the considerable reduction in the time required to "replace the shunting point failure" and the subsequent "return to operation" of the switch, since it reduces the preparation time for this activity, which consists of the time required to restore the immobilisation devices placed on the switch when the failure is detected.*

- RFI Document 19-16, "Single fault management procedure" - Section 1.1 Purpose and Scope:
  - *The purpose of this Procedure is to provide the necessary information suitable for the securing of the Hydraulic Shunting Subsystem in the presence of a failure of an individual shunting, stopping and control equipment.*
    In particular, this procedure is to be understood as applicable when a failure of an individual shunting point (see §3.2) of the Hydraulic Shunting Subsystem causes the shunting switch to be unavailable. In this situation, current railway regulations require the immobilisation of the switch by inserting the appropriate locking devices in the positions provided in the "Technical Instruction for Immobilisation Devices" (PRD. 7).
  - *This procedure is not applicable if the fault that makes the hydraulic system unavailable occurs on elements other than those defined as "shunting points" (see §3.2).*

- RFI Document 19-16, "Single fault management procedure" - Chapter 3 Intervention procedure in the event of unavailability of a hydraulic shunting system, Section 3.5 Safety procedure:
  - *The following two safety levels can therefore be classified:*
  - *Level 1. Electrical securing (omissis)*
  - *Level 2. Securing the switch by inhibiting the possibility of shunting - When the Hydraulic Shunting Subsystem is subject to:*
  - *the need to check in greater detail parts or situations that may become necessary as a result of inspection checks.*
  - *routine maintenance (see preventive maintenance sheets - Appendix "A").*

- RFI Document 19-16, "Single fault management procedure" - Paragraph 3.6.1.1 Fault search:
  - *Refer to the Operating and Maintenance Manuals for Hydraulic Shunting Systems (PRD. 6) for the fault-finding phase.*
    If the fault found relates to one and only one switching point described in §3.2, [in this case 3.2.2 Switching point: Frame-needle actuator] or their connecting elements to the switch, the following paragraphs indicate the procedure to secure the switch, inhibiting its manoeuvring, but maintaining the reading of the actual controls from the field in the cab.
  - *Attention: In case of simultaneous presence of more than one faulty shunting point on the switch this procedure is not applicable.*

- Document RFI 19-16, "Single fault handling procedure" - Section 3.6.1.2 Resumption of circulation:

- *Once the faulty shunting point has been identified, the following steps are sufficient to restore train movement:*
- *a. Move the switch to the position where it must remain immobilised.*
- *b. Install a pair of switch immobilisation devices (Items 8) in the position provided for by the installation drawing of the type of switch being worked on, closest to the point of faulty shunting. N.B: At this stage it is important to visually check the correct closure of the needle on the counter needle or on the support blocks. If the presence of obstacles prevents this correct coupling, it will be necessary to remove these obstacles before completing the locking of the switch with article 8.*
- *c, d, f (omissis).*
- *f. Check the presence of the controls in the cab and their concordance with the position of the switch in the field. Once this last operation has been carried out, the switch can be released to traffic, according to normal railway procedures, but keeping the actual control from the field and the switch inoperable.*
- *If this procedure is not applied, the position acquired in the cab must be simulated, but the actual control from the field must be maintained.*

Arrangements for carrying out maintenance and repair work on safety installations "Operations that may affect the safety of operation must be carried out in the manner set out in Art. 24 para. 7" i.e., *inter alia*, under interruption.

- RFI Document 10a (ISD Instructions Reissue 2019) - Article 26 Paragraph 10 Arrangements for carrying out maintenance and repair work on safety and signalling installations at remote service locations:
  - *In the case of temporary use of an electrically operated switch in a remote controlled point, the Maintenance Agent, if able to grant approval, shall proceed as follows.*
  - *a) When the Maintenance Agent is satisfied that the electrical control devices are efficient and that the electrical control is regular, the Maintenance Agent shall grant approval using the following formula: "Permission for train movement ... from ... to ... with signals clear unless other impediments exist. Track switch No. ... in normal/diverted position for left/right with efficient mechanical linkage and stop. Efficient electrical control." and, thus, reinsert the key into the locking unit.*
  - *b) When there is no efficient control, but the mechanical stop of the switch concerned by the work can be ascertained, the Maintenance Agent shall not insert the key in the locking unit and shall grant approval using the following formula: "Permission for train movement ... from ... to ... with signals arranged in an impeded way. switch no. ... in normal/diverted position for left/right with efficient linkage and mechanical stop. Electrical control not efficient - Key withdrawn and guarded.".*
  - *c) When there is no regularity of control and the mechanical stop of the switch involved in the work cannot be established, the Maintenance Agent shall not insert the key in the locking unit and shall grant approval using the following formula "Permission for train movement ... ... from ... to ... with signals arranged in an impeded way. switch no. ... in the standard left/right position with inefficient mechanical linkage and stop. Inefficient electrical control'. (Adding when the switch is on the exit: "secured with vice and wedge/spacer stop - or locking device. Keys withdrawn and guarded.")*

- RFI Document 10a (ISD Instructions Reissue 2019) - Article 8 Switches out of service:
    - *Switches, from which tracks not in service, or tracks used occasionally and exceptionally, branch off, shall be immobilised with special safety devices, of the types established by the competent Central Unit, which bind both the approaching and deviating needle in the predetermined position.*
    - *The application of these devices must be carried out by the Works Agent or the specially authorised Maintenance Agent.*
- RFI Document 10a (ISD Instruction Reprinted 2019) - Article 9 Stops and safety locks, Paragraph 8:
    - *The vice-mounted change-over stop is a portable device which, in the cases provided for by the standards in force, may be used to secure a switch in either of the two positions, if the normal switch change-over stop device is ineffective or the latter is unfastened.*
    - *In any case, the application of the vice-gear interlocking device implies a speed limitation to 30 km/h to the vehicles engaging the switch, both peak and kick-off, and the movement of the trains must always take place with signals maintained at a prevented path.*
- RFI Document 10a (ISD Instructions Reissue 2019) - Article 9 Switch locks and safety locks, Paragraph 8bis:
    - *The switch locking device is a device capable of securing the switch in the normal or diverted position, thus allowing vehicles to travel on the switch, albeit with reduced speed in the event of a lack of electrical control and where it is not possible to ascertain that a mechanical stop has been made.*
    - *This device can be applied permanently, thus constituting an integral part of any type of switch and replaces, in their full functionality, the vice-gear interlocking and the associated wedge or spacing device.*

In the discussions during the sharing of the draft report of this investigation, RFI highlighted the non-applicability of some of the above-mentioned provisions.

- Document RFI 10a (ISD Instructions Reprinted 2019) - Article 26 Paragraph 10 Arrangements for the performance of maintenance and repair works to the safety and signalling installations of remote-controlled service locations;
- RFI Document 10a (ISD Instruction Reissue 2019) - Article 9 Spare parts and safety locks, Paragraph 8 and Paragraph 8bis.

These provisions, according to RFI, are incompatible with the current working regime. Since the application of such procedures (immobilisation of the switch) could have prevented the accident (or limited its consequences) it follows that it would be advisable to promote a reorganisation of the internal procedures to allow, where necessary, the use of the switch immobilisation devices by maintenance staff.

From an examination of RFI document 19-16 “Single fault management procedure”, it can be assumed that the instructions contained therein are sufficiently clear and precise with regard to the operations to be carried out in order to return to operation a single device that is "faulty", in this case actuator 2 of hydraulic switch 05. If this instruction had been applicable not only during operation, but also during interruption, the accident could have been avoided.

When faced with behaviour that has been found to be deficient, fallacious or inadequate, experience from investigations shows that it is often attributable to the following causes:

- the habitual adoption of simplified or incomplete actions, with respect to regulatory requirements, in order to speed up one's work or avoid fulfilments considered annoying and superfluous;
- the failure of subordinate agents to react to the agent in charge who unknowingly or intentionally takes decisions contrary to regulations or otherwise incomplete and inappropriate to the circumstances;
- the execution of incorrect and excessively hasty actions dictated by the anxiety to respect the scheduled time for the completion of maintenance operations and the return of the facilities to circulation;
- the repetition of attempts to restore a component of an installation that is behaving abnormally instead of replacing it;
- insufficient awareness of the risk of causing serious accidents when making critical decisions in the face of unexpected, unforeseeable or extremely rare abnormal events;
- any objective difficulties in interpreting regulatory rules.

It is therefore considered essential to recall the importance of professional training aimed not only at conferring and maintaining technical skills, but also at developing a full awareness of responsibility and of the consequences of one's actions. A management strategy inspired by the precautionary principle, after reordering the various procedures and their scope, could have prevented the occurrence of the accident.

4.2.2.4. Indirect cause No. 4

Inadequacy and ineffectiveness, in the specific event, of the control of the production process of the frame-needle actuator.

From the analysis of the following documentation provided by RFI:

1. Quality Control Plan (PCQ) of the frame-needle actuator, drawn up by Alstom on 05 May 2014 and attached to the supply contract, which describes the production process phases for the specific frame-needle actuator;
2. note addressed by RFI to ALSTOM FERROVIARIA S.p.A., dated 15 July 2014, acknowledging receipt of the aforementioned PCQ, its analysis and its suitability for the control of the production process and the products concerned;
3. declaration of conformity no. 3117/2019 relating to the needle frame actuator subsequently installed for the movement of switch no. 5 during the maintenance work carried out immediately prior to the accident in question. It is acknowledged that RFI, when transmitting the document, has indicated that "*the declaration of conformity contains a typo: the reference to code QC008 is to be understood as QC003*.";

it is noted that the PCQ includes a specific phase called "Cable Wiring Verification", identified with number 18, which covers the following activities for 100% of the sampling:

- Visual wiring inspection,
- Electrical insulation test,
- Electrical test of dielectric strength,

- Labelling of cables,
- Verification of conformity for quantity and type,
- Verification of required certifications.

Therefore, the wiring of the cables is only subject to a visual inspection which, in the present case, proved to be proved to be totally ineffective and, therefore, inadequate to detect the wiring error of the control circuit of the actuator no. 2 of the leading frame of switch 05.

The PCQ phases, identified with the numbers 22 and 23 and called respectively "Complete actuator test" and "Complete actuator final functional test", which were indicated by RFI as potentially capable of detecting the wiring error, proved in the light of the facts to be totally ineffective and, therefore, not suitable for detecting the malfunction of actuator 2 (serial no. 83) of switch no. 05 of PM Livraga.

4.2.2.5. Indirect cause No. 5

Absence of a clear and distinct assignment of tasks from the documents defining the procedures relating to the maintenance and operation phases of the switches.

The documents referred to with reference to Indirect Cause No. 3 are said to be based on a clear separation between the tasks relating to the maintenance and operation phases. However, an analysis of the cited documents does not unambiguously show this separation. The anomalous behaviour of switchboard 05 following its replacement was evident to both the Maintenance Agent and the Central Operations Manager, as shown by the conversations between those figures.

Article 26 of the ISD concerns the "Procedures for the performance of maintenance and repair work on safety installations ..." and paragraph 3 prescribes that "The performance of operations that may jeopardise the safety of traffic operations must be carried out in the manner set forth in Article 24, paragraph 7" i.e., *inter alia*, under the interruption regime. From this it would appear evident that the maintenance personnel should have implemented the actions prescribed by Article 26(10) of that regulation, actions that would have avoided the accident.

It follows that it is appropriate, as already mentioned in reference to indirect case No. 3, to promote a reorganisation of internal procedures.

4.2.3. Analysis concerning the upstream causes of the accident

The upstream cause of the accident was the absence of fail-safe functionality of the switch position control circuit with respect to circuit wiring errors.

The switch position control circuit undoubtedly constitutes a safety-critical system for which design and construction methods are adopted to ensure fail-safe functionality. As already highlighted in the paragraph dedicated to indirect cause No.1, the switch position control circuit has been realised by connecting in series the circuit elements which provide the position information of the individual actuators. This connection is equivalent to performing, from a logical point of view, an AND operation between the position information of the individual actuators. From a technical point of view, this solution allows a considerable simplification of the control circuit wiring, but it is not fail-safe in cases where, like the one in question, wiring errors occur in the control circuit which make the position information of the individual actuator circuit-compatible but not consistent with the actual physical position of that actuator. Paradoxically, if there had been another actuator in the switch with the same wiring error,

the switch position control circuit would have returned the correct information.

4.3. Conclusions

Direct cause

Incorrect positioning of switch 05 which, instead of being returned to traffic in the correct track position (normal position), in accordance with the control signal, was in a diverted position.

Indirect causes

1. Internal wiring error in the control circuit of actuator no. 2 of the leading frame of switch 05.
2. Failure to check the correspondence between the physical configuration of switch 05 on the yard and that returned remotely, at the end of the maintenance activity.
3. Failure to immobilise switch 05 (the actuator no. 2 on the leading frame of which had shown clear signs of malfunctioning) in the correct track position.
4. Inadequacy and ineffectiveness, in the specific event, of the control of the production process of the frame-needle actuator.
5. Absence of a clear and distinct assignment of tasks from the documents defining the procedures relating to the maintenance and operation phases of the switches.

Upstream cause

Absence of fail-safe functionality of the switch position control circuit with respect to circuit wiring errors.

4.4. Additional remarks

For the record

5. Actions taken

The measures brought to the attention of the Investigation Committee are mentioned in the following paragraph.

Following the accident that occurred on 06/02/2020 near PM Livraga, the National Agency for Railway Safety, by note prot. 2878 of 13/02/2020, issued the following Recommendation to railway infrastructure managers regarding the safety of railway operations (first notice):

> *According to the first technical investigations carried out following the derailment in PM Livraga on 06/02/2020, a malfunction has emerged to be attributed to a manufacturing defect of the actuator of the top frame of switch no.5, type S60UNI/400/0.074, with hydraulic manoeuvring with movable core of the brand Alstom S.p.A., in particular an internal inversion of the wiring has been found which determines an anomaly on the position control of the switch.*

It was reported that this anomaly could also occur on actuators of different production batches.

On the basis of this evidence, a Safety Alert was issued to the European Agencies for National Safety.

In light of the above, it is recommended that the Infrastructure Managers and the Operators implement an extraordinary verification activity aimed at checking the correct operation of the newly supplied hydraulically operated switch actuators before their installation.

The aforesaid check shall also be extended to the medical devices already present on the networks under their jurisdiction.

Any anomalies found must be promptly reported to this Agency, also informing it if similar problems have already occurred in its operating context.

This Recommendation will be supplemented with further information as soon as it becomes available to this Agency.

Without prejudice to the need to immediately take all necessary actions to mitigate the problem, these Infrastructure Managers and Operators shall provide feedback on the application of the above recommendations within 30 days of receipt of this Recommendation.

Failure to comply with this recommendation constitutes non-compliance liable to the administrative penalty provided for by Article 30 of Legislative Decree 50/2019.

Shortly afterwards, the National Agency for Railway Safety, in its note prot. 4013 of 28/02/2020, issued the following Recommendation to railway infrastructure managers on railway traffic safety (second notice):

As pointed out by the judicial authority, during the technical inspections completed on 23/02/2020, "it has been definitively ascertained that the hydraulic actuator serial no. SIT 8318681900083 branded ALSTOM S.p.A. mounted on the top frame of switch no. 5 by R.F.I. S.p.A., where Frecciarossa train no. 9595 derailed on 6.2.2010, had an internal inversion of the wiring". Moreover, once "the above-mentioned actuator had been mounted on a switch in regular operation at the PM Livraga and [...] requested [...] to form a route [...] it was found that, although the switch on which the defective actuator was mounted was in diverted position, the signalling system of the Bologna Operations Centre perceived it to be in the normal position, thus authorising, on an experimental basis, the transit of a high-speed train through that switch".

The above confirms the importance of ensuring that concordance tests are carried out with the presence of personnel on site to ascertain the actual state (position or appearance) assumed by the body or apparatus subject to the interventions having an impact on safety.

In view of the above, in application of point 4.33 of the Railway Traffic Regulations and in addition to the recommendation sent with the note under reference, it is provided that these managers transmit the prescriptions aimed at ensuring that:

- *the reactivation of the railway operation of safety bodies or apparatuses on which an intervention with an impact on safety has been carried out only after the positive verification of the concordance between the state assumed by the body or apparatus (such as, for example, orientation or position), as detected on site, and the corresponding control state detected by the operator station of the safety apparatus to which such body/equipment is connected, involving the traffic controller in this latter verification*

- *the verification is carried out with respect to all the states that the entity or apparatus, the object of the intervention, may assume;*
- *the verification operations are recorded in a traceable manner by means of appropriate forms.*

The application of the above must be accompanied by a review of the effectiveness of the procedures currently adopted, implementing all the necessary improvement actions, which must necessarily include a reminder to all the personnel concerned regarding the strict application of the above provisions and the adoption of tools to verify the correct application of the relevant procedures.

The contents of this recommendation refer to all entities or apparatus commanded and/or controlled by a security apparatus.

Without prejudice to the need to immediately take all necessary actions to mitigate the problem, these Infrastructure Managers and Operators must provide feedback on the application of the provisions within 30 days of receipt of this recommendation.

Failure to comply with this recommendation shall constitute non-compliance liable to the administrative penalty provided for by Article 30 of Legislative Decree No. 50/2019.

The Infrastructure Manager RFI, by note prot. 1498 of 05/03/2020 sent the following text to the Territorial Production Departments, in response to the ANSF note prot. 2878 of 13/02/2020 (first notice):

The criteria to be adopted to carry out the aforementioned extraordinary verification are indicated:

- *for each switch in operation equipped with Alstom's hydraulic shunting system a new concordance check must be carried out, recording the sit numbers of the actuators present, the number of the switch where they are installed and the facility where they are located, the positive outcome and the date of the new check;*
- *for newly supplied actuators that have not yet been installed, the Supplier must be interested in their collection, aimed at carrying out the verifications required by the ANSF and their subsequent return with a new declaration of conformity with the construction drawings and with the provisions of the Quality Control Plan in force, with which the Supplier guarantees to RFI the full integrity and suitability for service of the component supplied.*

The Territorial Production Departments must confirm the performance of the checks by sending all the supporting documentation.

The Infrastructure Manager, in note prot. 0176 of 30/03/2020, has notified the National Agency for Railway Safety of the following:

In relation to what has been reported by your Agency with the "second notice" of the note in reference, attached please find the note sent by the competent Production Department to the Territorial Departments containing the indications and measures to be implemented in compliance with the Recommendation in question, as well as the note of the Technical Department that, in transmitting the documents within its competence that deal with the so-called concordance check, also responds to the request concerning the involvement of the Signaller.

It should also be noted that in the RFI memorandum of 19.2.20 (prot. 158) in response to the ANSF request of 14.2.20 (prot. 2967), the provisions relating to the

management of the hydraulic subsystem have already been forwarded (Installation Manual and Operation and Maintenance Manual).

In relation to the standards, technical instructions and procedures relating to the safety maintenance activities of the Safety and Signalling Systems sector, mentioned in ANSF 4013/2020, please note that they can be consulted in the E-Pod and SIGS-Web applications, accessible to this Agency. Lastly, we would like to point out that the verification of the effective application of the foreseen fulfilments will be carried out as part of the control/audit activities to be implemented in accordance with the SMS procedures.

The Manager therefore attached the following two documents to the above-mentioned note.

Note DPR\1757 of 27/03/2020 to all Territorial Production Departments:

In compliance with the requirements of the ANSF recommendation (annexed hereto), the Operational Structures are hereby provided with a reminder of the strict compliance with the rules, technical instructions and procedures relating to safety maintenance activities in the Safety and Signalling Systems sector, which provide for, at the end of the activity and before putting the body or apparatus back into operation, the positive verification of the concordance between the status assumed by the body or apparatus detected on site and the corresponding control status detected by the operator station of the safety apparatus to which said body or apparatus is connected, pointing out that this verification must be carried out for all the statuses that the body or apparatus may assume indicated by the aforesaid standards, technical instructions and procedures. In addition, in relation to the request to specify with "appropriate forms" the verification of concordance, the following indications are provided. Before returning the body or apparatus to the Signaller or before granting the authorisation to resume circulation, the Person in charge identified for the work activity must send a registered communication (form M40) of the concordance check to the Maintenance Agent that handles relations with the Signaller. The person in charge must use the following wording: "... (name of the Maintenance Agent in charge of relations with the Signaller) I confirm that the concordance check has been carried out ... (specify the body or apparatus concerned and its location) with result ... (positive/negative). It is understood that in the event of a negative result of the concordance test, the body or apparatus concerned may be used only in strict compliance with the procedures. It is also provided that the absence of the aforementioned communication from the person in charge prohibits the return of the body or apparatus concerned to operation.

The obligation of the concordance check as well as the communication must be made explicit during the briefing that precedes the work activity. Each Territorial Production Department shall provide evidence of compliance with the above provisions.

Note DTC\0763 of 30/03/2020 to Network Safety and Quality:

The main documents within the competence of this Head Office that deal with the so-called "concordance check" are Technical Instruction IS.46 edit. 1971 (Instruction for checks that must precede the activation of signalling installations) and the Procedure for the verification, activation and change in operation of ACC/ACCM installations (RFI DTC STS PR PC00 002 A of 29/07/2014). These documents, supplemented where appropriate with further indications given in procedures or in the installation, use and maintenance manuals forming part of the SMS, establish the technical operations to be performed for the functional checks to be carried out downstream of the works on the signalling systems and before their formal handing over to the Signaller, a handing over that presupposes the restoration of the normal safety characteristics of the infrastructure.

In this regard, and in particular to the request to involve the Signaller in the execution of the concordance checks, it is emphasised that, on the basis of the rules regulating relations between maintenance staff and traffic personnel, "the maintenance staff is fully and exclusively responsible for the works they carry out, both with regard to their perfect success and the repercussions they may have on the regular operation of other mechanisms or equipment of the same system" (art. 24, subsection 6, ISD). On the basis of this principle, the signaller does not intervene, as such, in the execution of concordance verifications, as well as other verifications preparatory to the handing back of the track or of the entities subject to maintenance or repair (to give an example, the verification of the freedom of the track from "persons, equipment, vehicles or other obstacles" referred to in article 11, paragraph 4, IPC); its possible involvement may instead be envisaged only as operational support to the maintenance officers. Finally, it should be noted that the application of the above-mentioned procedures has so far not revealed any elements that could cast doubt on their effectiveness.

6. Recommendations

Recommendation no. 1

It is recommended that the National Agency for Railway, Road Infrastructure and Motorway Safety request railway infrastructure:

- • introducing, instead of a simple visual inspection of the wiring, a functional test that verifies the correct input-output connection at the different positions of the actuator contact shaft;
- • verifying the completeness of the *"Complete actuator test"* and *"Complete actuator final functional test"* phases.

Recommendation no. 2

It is recommended that the National Agency for Railway, Road Infrastructure and Motorway Safety require railway infrastructure managers to adapt the reference documentation and related training activities so that it is clearly stated that all maintenance activities on switches, which involve work on the relevant command and control circuits, must always conclude with a verification of concordance between the physical configuration of the switch on the yard and the remotely controlled one, proven by visual documentation of the evidence.

Recommendation no. 3

It is recommended that the National Agency for Railway, Road Infrastructure and Motorway Safety require railway infrastructure managers to adapt the reference documentation and related training activities so that the return to operation of a switch, or any other safety device, at the end of any maintenance activity on it, in cases where anomalous behaviour of the devices is manifested, is carried out by those involved, always drawing inspiration from the *precautionary principle*, i.e. adopting the most restrictive measure to protect safety.

Recommendation no. 4

It is recommended that the National Agency for Railway, Road Infrastructure and Motorway Safety require railway infrastructure managers to reorganise their internal procedures for the use of switch restraints by maintenance staff.

Recommendation no. 5

It is recommended that the National Agency for Railway, Road Infrastructure and Motorway Safety request the railway infrastructure managers to initiate a process aimed at the design, realisation and implementation of hydraulic switches with a control circuit capable of signalling the position of each actuator constituting the switch, as well as the adaptation of the ACC's operating logic aimed at appropriately managing the control parameters that govern the operation of the switch.

Prof. Ciro Attaianese, Engineer Prof. Roberto Maja, Engineer Mr. Wolmer Zanella, Engineer