HARSIA
Hellenic Air & Rail
safety Investigation Authority

ΕΛΛΗΝΙΚΗ ΔΗΜΟΚΡΑΤΙΑ

Εθνικός Οργανισμός Διερεύνησης
Αεροπορικών & Σιδηροδρομικών Ατυχημάτων
& Ασφάλειας Μεταφορών (ΕΟΔΑΣΑΑΜ)

Σιδηροδρομικός Τομέας

Rail Accident Report

Head-on collision between a passenger train and a freight train in Tempi, 28 February 2023

RL01-2025, 27 February 2025

IN MEMORIAM

Out of respect for the victims and their relatives, the investigation team lists all the names and ages of the persons who lost their live in the Tempi accident.

Giorgos Bournazis, aged 15
Thomai Plakia, aged 20
Anastasia Plakia, aged 20
Maria-Thomai Psaropoulou, aged 21
Giorgos Papazoglou, aged 22
Iordanis Adamakis, aged 22
Aphrodite Tsioma, aged 23
Iphigenia Mitska, aged 23
Denis Ruci, aged 23
Nikitas Karatheodorou, aged 23
Anastasia Adamidou, aged 24
Dimitra-Evangelia Kapetaniou, aged 25
Dimitris Aslanidis, aged 26
Sotiris Karageorgiou, aged 28
Giannis Karasavvas, aged 28
Panagiotis Chatzicharalambous, aged 29
Dimitris Massalis, aged 32
Athena Katsara, aged 34
Spyros Voulgaris, aged 35
Elena Dourmika, aged 39
Ebrahim Masri, aged 42
Andreas Pavlidis, aged 49
Vasilis Kottas, aged 51
Vasiliki Chlorou, aged 55
Giannis Tzovaras, aged 55
Maria Miari, aged 56
Giorgos Koutsoumbas, aged 59
Giannis Kariotis, aged 63
Giorgos Kyriakides, aged 67

Anastasia Papaggeli, aged 19
Chryssa Plakia, aged 20
Anastasios Koutsopoulos, aged 21
Francesca Beza, aged 21
Eleni Tsintza, aged 22
Klaudia Latta, aged 22
Agapi Tsaklidou, aged 23
Angelos Tilkeridis, aged 23
Kyprianos Papaioannou, aged 23
Erietta Molcho, aged 23
Kalliopi Porfyridou, aged 24
Elizabeth Chatzivassiliou, aged 26
Nikos Nalmpantis, aged 27
Elpida Choupa, aged 28
Dimitris Oikou, aged 29
Sofia-Eleni Tachmazidou, aged 32
Vaios Vlachos, aged 34
Mohammad Edris Mia, aged 34
Ionel Culea, aged 35
Vaia Bleka, aged 42
Giannis Voutsinas, aged 48
Maria Mourtzaki, aged 51
Vangelis Bournazis, aged 54
Maria Egout, aged 55
Chrysoula Koukarioti, aged 56
Giorgos Fotopoulos, aged 57
Pavlini Bozo, aged 62
Evangelia Koukarioti, aged 63

Photo extracted from a media video

https://www.ertnews.gr

Legal notice

This investigation has been carried out in accordance with:

- Directive (EU) 2016/798 of the European Parliament and of the Council of 11 May 2016 on railway safety
- Commission Implementation Regulation (EU) 2020/572 of 24 April 2020 on the reporting structure to be followed for railway accident and incident investigation reports.
- Law 5014/2023 of the Greek Parliament of 23/1/2023 on the 'Institutional framework for the investigation of air and rail accidents for transport safety and other provisions'.

Any use of this report for a purpose other than accident prevention – for example, for determining responsibilities and a fortiori individual or collective guilt – would be completely contrary to the objectives of this report and the methods used in its preparation, the selection of facts collected, the nature of the questions asked and the concepts it uses and to which the concept of responsibility is alien. The conclusions that could then be drawn would therefore constitute an abuse in the literal sense of the word.

The judicial context of the no-blame, openness, and improvement approach for this investigation refers to the Railway Directive EU2016/798 applicable to all EU Member States, and in particular the whereas (38) to (41) and the Articles 20 and 26, from which we highlight the following extracts.

- The investigation shall in no case be concerned with apportioning blame or liability.
- The safety investigation should be kept separate from any judicial inquiry into the same incident, and those conducting it should be granted access to evidence and witnesses. The investigating bodies should have timely access to the site of an accident, where necessary in good cooperation with any judicial authority involved in the matter.
- The investigation after a serious accident should be carried out in such a way that all parties are given the possibility to be heard and to share the results. And such consultation should in no case lead to apportioning blame or liability but, rather, to collecting factual evidence and learning lessons for the future improvement of safety.
- The reports on investigations and any findings and recommendations provide crucial information for the further improvement of railway safety and should be made publicly available at Union level. Safety recommendations should be acted upon by the addressees and actions reported back to the investigating body.
- Safety recommendations shall in no case create a presumption of blame or liability for an accident or incident.

The regulation (EU) 2020/572 offers the possibility to anonymise the names of persons and organisations who contributes to the NIB investigations.

The documented findings of this report constitute the expression of an impartial opinion as a result of scientific, technical and organisational evaluations of all elements and data made available.

This document/publication is also available at:

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This report is published by EODASAAM.

Dr Christos Papadimitriou

Georgios Dritsakos, Εγκρίνεται το πόρισμα ... ΕΟΔΑΣΑΑΜ.

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Valaris Christos.

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V. Fouseki

Head-on collision between a passenger train and a freight train in Tempi, 28/02/2023

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Foreword

The Railway Branch of EODASAAM is the independent National Investigating Body for Greece. It is responsible for investigating accidents and incidents on the national rail network. EODASAAM was established by Part D of Law 5014 in January 2023, with a view to fulfilling Greece's obligation to establish an independent railway accident investigation body as provided for in Article 20 of the European Railway Safety Directive 2016/798/EC; confirming the obligation that was already introduced with Directive 2004/49/(EC). Law 5014/2023 has been amended by Law 5167/2024.

EODASAAM investigates all serious accidents, defined as any train collision or train derailment resulting in: a) death of one person, b) serious injuries to five or more people and c) extensive damage to rolling stock, infrastructure or the environment. EODASAAM may also decide to investigate accidents and incidents which under different circumstances may have led to serious accidents.

The purpose of the investigations performed by EODASAAM is to improve railway safety by highlighting the causes and contributing factors and issuing recommendations to avoid similar accidents in the future. The objectives of EODASAAM's investigations and the resulting reports is not about apportioning blame or liability. This is reflected in the methods used to prepare it, the choice of facts collected, the nature of the questions asked and the concepts it uses. Also, any safety recommendation issued reflects responsibilities for improving the railway system does not create a presumption of fault or liability for the investigated accident or incident.

1. Summary

1.1. The accident on 28 February 2023

1 On the evening of February 28, 2023, passenger train IC-62, with 352 persons on board and en route from Athens to Thessaloniki, departed Larissa station at 23:05, with a delay of 48 minutes. At almost the same time, freight train 63503 left the station Neoi Poroi towards Larissa, also with a delay on the planned schedule.

2 Shortly after 23:18 both trains collided head-on, with the freight train registering a speed of almost 90 km/h while the passenger train was travelling at an estimated speed of 150 km/h, both well within the allowed speed restrictions. The shock was violent and while the two locomotives of the freight train were pushed to the adjacent track to come to a crash against the vertical retaining wall, the locomotive and the first-class passenger car of the passenger train were catapulted to the other side of the track, where they landed on the ground below, completely destroyed.

3 In the meantime, a second, near head-on collision occurred between the restaurant car of the passenger train and the first flat car, loaded with steel plates, which were the first following vehicles in the passenger and freight train respectively. Following the direction of the vehicles ahead, the restaurant car and the subsequent second-class car of the passenger train also ended up on the lower ground. Meanwhile, a enormous fireball had formed that appeared to move with the passenger train. In the resulting fires on the lower ground, the restaurant and the second-class car were completely burned out.

4 In total, 57 people, of which 11 staff members or subcontractors working for Hellenic Train, lost their life in the accident, 81 people were seriously injured, and 99 had minor physical injuries. A substantial number of people, directly or indirectly involved with the accident, suffered shock and/or emotional trauma.

1.2. Conclusions of the analysis

5 The collision between passenger train IC-62 and freight train 63503 could happen because both trains were travelling in opposite directions on the same track between the stations of Larissa and Neoi Poroi.

1.2.1. Causal factors

6 The station master did not use the automated method to set the route for train IC-62 to leave Larissa station to the north, towards Neoi Poroi, which would have positioned all switches correctly. Instead, he commanded the individual switches manually and, while doing so, forgot to place the switches 118 A/B in the “main” position, herewith guiding train IC-62 towards the opposite direction of normal travel. This mistake went further unnoticed by the station master.

7 These actions and decisions of the station master need to be understood in the difficult operational context he was confronted with that night. Given the available evidence, it is very unlikely that the station master had the intention to put train IC-62 on the opposite track. The control panel he had to use to remotely operate the switches maybe easy to operate by more experienced station masters but can certainly lead to confusion when this experience has not yet been sufficiently acquired. This was certainly the case for the station master on duty that evening as the control panel contained relevant information in different places, different ways of operating switches were used interchangeably, and clearly written instructions were not available.

8 Moreover, his normal workload was severely strained by a series of aggravating factors. There were a series of technical failures, both temporary and not so temporary, which created additional tasks or made existing tasks more difficult. He had to deal with an unprecedented number of communications, many of which were not directly related to his task of controlling the train traffic. In addition, the design of the working environment, due to the positioning of the various resources to be used, did not allow for conversations to be held and at the same time keeping an eye on the train traffic. Finally, his attention, both cognitive and emotional, was occupied by the correction of an earlier error he made, when setting the route for another incoming, local train.

9 In a following sequence, the authorisation for train IC-62, to leave Larissa station towards the north, was given verbally by the station master of Larissa and was not confirmed through read-back by the train drivers of IC-62. This stayed without reaction by the station master, leaving it uncertain how the message was understood by the train drivers.

10 This sequence of activities was highly affected by a general lack of strict application of the prescribed structured communication methodology. Furthermore, the methodology prescribed by the Greek rules is outdated compared to more recent international standards and the use of an open radio communication channel, which is common in Greek railways, does not allow for direct, uninterrupted safety-related communications between station masters and train drivers.

11 Ultimately, the potential barrier, where the train drivers of IC-62 could react to the conflicting information between the position of the switches and the granted movement authority, was missed. Although they would be expected to stop in front of the wrongly positioned switches 118 A/B and contact the station master to get clear instructions, there is no indication that the train drivers of train IC-62 reacted on the position of the switches not being compatible with the received order. The main factor that can explain this, is that it was not an unusual occurrence for train drivers to be directed to the opposite track. This had also happened earlier in the day on the section in question, between Larissa and Neoi Poroi, and for the train drivers involved even in the section they were driving on to get to Larissa station, from Paleofarsalo.

1.2.2. Underlying factors

12 The Greek railway sector suffered highly from the economic crises that started in late 2009 and reached a peak in 2010. This resulted in poorly maintained and increasingly degrading infrastructure and a structural shortage of staff to continue to provide the usual service. The railway system had not recovered from this situation by the beginning of 2023.

13 The infrastructure manager, OSE, does not provide in any preventive maintenance of its main assets for control, command and signalling. Interventions only take place when (critical) assets fail, even for renewal projects that are partly put in service. Furthermore, the way OSE is managing the competence of its station masters does not guarantee that they are competent in the safety-related tasks for which they are responsible, under all conditions. Also, no structured monitoring of the performance of any of the station masters was performed, leaving OSE unaware of any deterioration in the performance of safety-related tasks.

14 The necessary interactions between humans and other elements of a socio-technical system, whether technical or organisational, were not taken into account by OSE. This resulted in the equipment used, demanded tasks, available work environment and overall organisational arrangements stretching the limits of the operational staff beyond what is humanly acceptable in a sustainable way. A strong belief reigned that all operational risks can be controlled by strictly applying rules, under all conditions.

15 This had also an impact on the train drivers, who were confronted with changes due to ongoing works and/or failing assets on a daily basis, which required a continuous alertness and high level of resilience. In that context, Hellenic Train could not demonstrate that they had put in place an on-going training of their train drivers, in particular for safety-related communications and relevant non-technical competencies (skills, behaviours or attitudes). Also, no process was available within Hellenic Train to systematically monitor the performance of their train drivers regarding the quality of safety-related communications or other safety-critical activities.

16 Finally, by lack of a National Investigating Body to perform the independent analysis of accidents and events, the capability of the Greek railway sector to learn from adverse events relied entirely on the investigations performed by the operators as part of their SMS. These internal investigations, however, by focusing on the errors made by individual front line staff, systematically lacked the necessary depth to introduce sustainable changes, herewith limiting the learning potential to an extreme minimum. This situation was further reinforced by the way RAS focused on non-compliance in its investigations, analyses and recommendations.

1.2.3. Factors affecting the severity of consequences

17 Most of the victims of this accident are due to the impacts that took place after the collision of both trains. Railway vehicles are not designed for a collision with a speed above 36 km/h, so active safety measures should be in place to reduce the severity of consequences. It appears that no criteria nor arrangement existed within OSE to adapt the maximum allowed line speed to the condition of the signalling system.

18 Based on the observations that could be made, there is no indication that the technical equipment of the rolling stock that was used, gave rise to the formation and expansion of the enormous fireball that arose after the impact, and subsequently resulted in the secondary fires. With the existing evidence is impossible to determine what

exactly caused it, but simulations and expert reports indicate the possible presence of a hitherto unknown fuel.

19 Although there was no explicit legal obligation to do so, it remains to be evaluated whether equipping the rolling stock with better fire-retardant materials could have played a role in the survival chance of the few victims that had survived the initial collision and lost their lives from the fire.

20 There was/is a high risk of aggravation of the initial consequences related to the Post-Traumatic Stress Disorder, especially for all the ones who did not have the possibility to access this support in time. We note that there are at least still at least 22 persons at a 'severe' level or above, as revealed by a survey conducted by the investigation team (in fact, more than 1/4th of the survey sample).

1.2.4. Safety observations

21 Although not linked to causes of the accident or the severity of the consequences, the investigation has identified a series of additional elements that are relevant for a safe management of incidents on the Greek railways.

22 There was no actual coordination, whether at operational or strategical level, of the different services at the scene of the collision. Each service continued to operate under its own orders, initiatives, and personnel without any interaction at the organisational level. One particular result of this is the fact that no proper mapping of the accident investigation site was performed.

23 Knowledge for the correct application of "Human Loss Management Plan" was missing with several of the emergency services. No exercises to prepare for its coordinated implementation in a railway context have ever been organised, neither was any initiative taken afterwards to learn from the experience of the Tempi accident.

24 The initial collection of evidence for a further safety investigation shows several flaws, resulting in the loss of potentially vital information for understanding the causal and underlying factors of the accident and ultimately improving the safety of the railway system.

1.2.5. The role of the controlling authorities

25 In the beginning of 2023, as in the decade before, Greece had no functioning National Investigating Body that could independently investigate railway accidents and incidents. As a result, by lack of independent investigations, no sector wide lessons were learned from previous accidents and incidents. This is reinforced by the general accepted belief that a safe functioning of the railway system, under all circumstances, can be obtained by strict rule compliance, even if no supporting equipment or protection systems are in place.

26 The National Safety Authority, RAS, when issuing the safety authorisation for OSE, did not identify the above critical weaknesses in the Safety Management System. Several of these weaknesses in the implementation of OSE's Safety Management System were later identified during the supervision phase and notified to OSE for corrective measures, without leading to any noticeable change.

27 Relevant issues were identified by the European Railway Agency, either during the safety certification of railway undertakings or during the audit of NSA activities These did not lead to the necessary improvement quickly enough, which in turn may lead to a deterioration of railway safety in the long term.

1.3. Recommendations

28 During the investigation, an urgent safety recommendation was made, with the intent to address the combined risk of safety-related messages lacking structure and methodology as well as the use of an open communication system where safety-related communications cannot be prioritised over all other communications.

29 In addition, EODASAAM has made 17 more recommendations as a result of this investigation in the Tempi accident. Several of these recommendations go beyond the remit and powers of individual organisations and can therefore not be implemented without the support of the Greek Government. The Ministry for Transport and Infrastructure is therefore recommended to continue and enhance the implementation of the initiated Action Plan to create a context in which the different responsible railway actors have the human, financial and organisational means at their disposal to meet the demands placed on them to develop and maintain a sustainable and safe railway system.

30 OSE needs to better understand the risks related to the operational reality of the current railway system in Greece and to improve the way it is controlling these risks. Furthermore, OSE needs to optimise the performance and

reliability of its physical assets and manage the safety risks associated with, throughout their life cycle. OSE needs to regularly assess the competence of staff performing safety related tasks and needs to maintain them. This includes the set of competencies related to non-technical skills and arrangements regarding physical and psychological fitness, not only when recruiting staff but also during their entire career. OSE should develop a system for performance monitoring, to become aware of any deterioration in the performance of safety-related tasks by station masters or other staff performing safety critical tasks. Moreover, the potential for OSE to learn lessons from incident and accidents needs to be created. This should lead to implementing structural improvement measures that can create an environment that supports the work of operational staff. Finally, OSE should maximise the availability of recorded data which could assist accident and incident analysis and should reflect on the possibility to use these technologies for continuous monitoring of safety performance in a non-blaming context.

31 Hellenic Train is recommended to strengthen its competence management system, in order to ensure that train drivers (and other staff, whenever relevant) performing safety related tasks are prepared for this, that their competence is regularly assessed and maintained and that tasks are carried out accordingly, including the set of competencies related to the non-technical skills and arrangements regarding physical and psychological fitness. Furthermore, a system for monitoring the performance of train drivers should be developed, to create the capacity to become aware of any deterioration in the performance of safety-related tasks.

32 To strengthen the potential of the Greek railway sector to learn from adverse event, the National Safety Authority, RAS, should develop an occurrence reporting system that provides the necessary structure and taxonomy for the mandatory reporting of safety related occurrences by the infrastructure manager and all railway undertaking operating on the Greek network. At least as important, and even more urgent, is the need for RAS to strengthen its capacity for supervision with the aim of establishing a view on the level of safety performance of the Greek railway system.

33 The European Union Agency for Railways is recommended to take measures in order to generate a quicker implementation of on the one hand, SSC action plans, and on the other hand, NSA action plans in relation to identified deficiencies that prevent the NSA from effectively performing the monitoring of Safety Management Systems of railway actors. Linked to this, the European Commission is recommended to implement a framework to enforce Member States to adequately and timely satisfy the EU requirements on safety policy setting, the functioning of National Safety Authorities and National Investigating Bodies, and the system of national rules. In addition, a view should be generated on the adequateness of implementing EU specified operational safety rules within the national framework of Member States, at all levels.

34 Finally, the Greek Ministry for Climate Crisis and Civil Protection is recommended to develop, in collaboration with the different emergency services (Fire Brigade, Medical and Psychosocial Support, Police, Civil Protection) and based on international recognised good practice, detailed instructions for an Emergency Response and Crisis Management Plan that will enable rapid and, above all, coordinated assistance during an emergency situation. This plan should include clear instructions for the coordination of emergency situations at the operational and at the strategic management level, for setting up the perimeters, for the adequate mapping of the accident site, and for preventing and reducing the risks of Post-Traumatic Stress Disorder.

2. The investigation and its context

2.1. Decision

35 The EODASAAM Board took office on 18/09/2023. EODASAAM officially undertook the investigation of the tragic accident of Tempi on 15/03/2024, with the appointment of the first railway investigators and the establishment of the three-member committee for the investigation of the railway accident of Tempi (decision 783/15-3-2024).

2.2. Motivation

36 This investigation is motivated by Article 20.1 of Directive 2016/798 on railway safety that requires the independent investigation of any serious accident on the European Union rail system with the objective of improving, where possible, railway safety and the prevention of accidents.

2.3. Scope and limits

37 This investigation aims at identifying the sequence of events leading up to the accident as well as the activities that took place in the aftermath of the accident, with a separate focus on:

a. The activities for setting the route and authorising the movement of the two trains that ended up driving in opposite direction on the same track,
b. The mechanism of the collision and the impact it generated,
c. The deflagration that took place immediate after the collision and the propagation of the consecutive fires,
d. The immediate emergency response to the accident,
e. Post-emergency activities.

38 This information, for each of the above elements, is then the starting point for examining contributing and systemic factors that can explain the decisions and actions taken as well as the capacity of the different parties involved to fulfill their role in managing the risks of operating the railway system.

39 It should be noted that this investigation, from its start, was facing a series of limitations that undoubtedly affected the course and possibly the depth of the analysis. The most important element is that EODASAAM, as independent railway accident investigating body under Article 22 of Directive 2016/798, was not operational at the time of the accident. This resulted in the official launch of this investigation more than 1 year after the accident, which had an impact on (all forms of) data collection.

40 Therefore, this report is based on information that has been collected by various services and investigators and from direct investigation from EODASAAM (gathering of technical information, interviews and site visits). It has to be pointed out that a lot of information that should have been collected in a timely manner in a proper investigation, has been lost due to the different scope of the various investigating organisations. This is notably the case for: the judicial investigation (only dealing with legal compliance), some of the expert reports (ordered with a specific scope), the management and partial mapping[1] of the accident site (4.5.2, 4.5.3), the medical examination (4.5.4.4, 538). Furthermore, a series of actions were only undertaken after specific demands of the families of the casualties (e.g. the sampling and chemical analysis happened 29 days after the accident). Moreover, 3 videos that show the train 63503 were made available to the judicial authorities in the concluding stage of the investigation and are still being checked on their authenticity. Also the analysis of seat samples is still pending (451).

41 Other elements that certainly influenced the context in which this accident could take place (e.g. evolution of contract 717, funding of investment projects, national and EU control mechanisms on investment projects,…) were considered but after initial evaluation it was decided not to further analyse them in this investigation because they are less relevant for the direct improvement of the railway system as such, at short and medium term.

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1 Mapping: process of producing a map. In the context of an investigation, we mean to make a detailed cartography, with ex. drawings – photos – videos – in 3D or aerial – persons, objects, measurements and samples positioning, of all the relevant information that will be useful during the subsequent steps of the investigation, once the site will have been restored. Due to the complexity or the length of investigations, for the investigator, mapping is to the site of the accident what the forensic pathologist sees in an autopsy of a deceased person.

42 Furthermore, this catastrophic accident has understandably had a social impact, resulting in a continuous media stream that has given rise to a taken-for-granted 'mental model' of the accident and its causes. It cannot be ruled out that this has influenced the statements obtained and even the perceived true memories of some of those persons we have met and questioned.

43 Finally, while no presumption of blame should be drawn from the safety recommendations that are issued through this report, it is to be noted that the ongoing judicial investigation casted its shadow on the investigation, by leading several of the parties involved to share some documents only after strict scrutiny by their legal service and/or senior management. This practice could lead to a situation where the learning potential from the accident through this investigation is not fully exploited, either by delaying the delivery of information or even the retention of important information. About the cooperation, specifically with the stakeholders who were more directly involved, it must be noted that the investigation had to deal with long delays (between 2 and 4 months in general) since the formal request of evidence and their eventual release to the investigation team. In some cases, the requested evidence was not made available at all. This potential defensive culture is to be deplored, given the legal duty of continuous improvement and objective investigation.

2.4. The team of investigators and resources

44 By EODASAAM Board Decision No 783 of 15 March 2024, the initial investigation team consisted of an investigator in charge, who is a member of EODASAAM (engineer) with extensive knowledge of the Greek railway system, and two experts (engineer and industrial and organisational psychologist) of the European Union Agency for Railways (ERA), with expertise in rail operations, accident analysis methodology, human and organisational factors and the European legal framework.

45 This support from ERA to provide assistance in supplying expertise and carrying out technical inspections, analyses or evaluations was requested by EODASAAM on 19th October 2023, in application of Article 22.5 of (EU) 2016/798.

46 By decision A/732 of the Board of EODASAAM of 23/10/2024, the investigation team was reinforced with a deputy investigator, an engineer with an extensive knowledge of the Greek railway system.

47 External expertise was sought, in particular in relation to the possible causes and consequences of the fire that occurred immediately after the collision. This included: an expertise from RI.SE Research Institutes of Sweden, University of Ghent (BE), University of Pisa (IT), RST Labs (DE), and Professor of Chemical Engineering Mr. Konstandopoulos.

48 Furthermore, a specific collaboration was established by the European Union Agency for Railways, to exchange on the factual data, with one of the experts of the investigation team that was appointed by relatives of victims (EDAPO, Επιτροπή Διερεύνησης Ανεξάρτητων Πραγματογνωμόνων Οικογενειών, Committee to Investigate of Independent Family Experts, https://www.edapo.gr/).

2.5. The communication and consultation

49 In September 2024, initial results of the investigation were presented to RAS, OSE and Hellenic Train and the list of the required, still pending evidence was communicated. Regular written and oral reminders of the evidence required were given as and when necessary, and additional evidence was requested throughout the investigation whenever needed.

50 At the end of the investigation period, a major consultation was organised, with a presentation to each stakeholder concerned and the handing over of the parts of the investigation report relating to their own organisation. The objective of this consultation phase was to gather their opinions on the points described and the facts reported concerning them, as well as to verify their understanding of and agreement with the recommendations, to facilitate their correct implementation.

2.6. Levels of cooperation

51 Since November 2023 and throughout the investigation on request, the investigation team had access to all evidence, documents and statements of witnesses as well as accused persons that were obtained through the judicial investigation.

52 Furthermore, during the investigation, the investigation team contacted and consulted the following organisations and interviewed more than 60 individuals or groups of concerned persons:

- Special Court of Appeal of Larissa, running the judicial investigation;
- Hellenic Railways Organisation (OSE), sole infrastructure manager in Greece- executives and employees at all hierarchical levels within the organisation;
- Hellenic Train SA, main passenger and freight railway undertaking- executives and employees at all hierarchical levels within the organisation;
- Regulatory Authority for Railways (RAS), National Safety Authority (NSA) in Greece- executives and employees of the Rail Safety Unit and Department;
- Relatives of the victims and lawyers of the relatives of the victims that reached out to EODASAAM;
- Independent experts investigating the incident appointed by the victim families;
- Experts appointed by the Examining Magistrate of Larissa (Report 19/6/2023);
- Police Directorate of Larissa;
- Traffic police of Larissa;
- OATHYK, the special police force for Disaster Victims' Identification (DVI);
- Fire Brigade of Larissa area;
- The National Emergency Center (EKAV);
- Ministry of Climate Crisis & Civil Protection, General Directorate Civil Protection;
- Hellenic Federation of Railway Employees: Fixed-track railway employees unions;
- Hellenic Union of Traction Personnel: The union of train drivers;
- European Union Agency for Railways (ERA);
- Directorate-General for Mobility and Transport (DG MOVE).

53 In terms of external cooperation, the investigation team would like to thank all the operational staff and the management who had to answer questions from the investigative team, and who were, for the most part, willing to tell the truth in an open and detailed manner. In addition, the extra effort that specific individuals have put into providing all the requested evidence in a structured and efficient manner, has been very appreciated.

54 It should be noted that the investigation team has not been able to interview one of the main persons involved, the Station Manager who was working the night shift at Larissa station on the evening of the accident, despite several attempts (in Athens, in Larissa, online), on several dates over several months. And this, without any reason or motivation given. The facts reported and the elements of analysis on his performance are therefore based on judicial statements, recordings and other documentary evidence.

55 Important information for this report was also obtained from the pre-existing reports and findings which were drawn up immediately after the accident and during this investigation by different experts, authorities (e.g. RAS, Fire Brigade, Police), operational organisations and family representatives.

56 In terms of internal cooperation, within the team of investigators, risk control measures were taken to assure the independence of the members of the committee since they all were working in the railway community. Each one signed a declaration of conflict of interest, to inform the Board of EODASAAM of his previous or current positions.

2.7. Description of the investigation methods

57 This investigation is mainly based on extensive document review, analysis of existing (data, image, video and sound) recordings, existing declarations, additional interviews with all concerned parties, on-site observations, site visits at Larissa, Tempi and Koulouri, substitutions (which allow to compare what happened in the accident with what is happening in similar conditions elsewhere in the organisation) for both train operations and traffic management related activities (train cab journey, traffic control rooms), questionnaires and external expertise on specific topics. The list of the sets of evidence and their source is in the Appendix E.

58 The applied analysis techniques, always relying on a strong evidence-based approach, allowed to further deepen the investigation with the objective of ensuring a systematic analysis of all the influencing circumstances for actions and/or decisions, and a systematic analysis of the feedback and control mechanisms, including risk and safety management as well as monitoring processes.

3. Description of the occurrence

3.1. Description of the occurrence type

59 The occurrence under investigation is a head-on collision between a passenger train and a freight train, both operated by Hellenic Train.

3.2. Date, exact time and location

60 On 28/02/2023, shortly after 23:18, passenger train IC-62 collided head-on with freight train 63503. Both were travelling in opposite direction on the descending track between the station of Larissa and Neoi Poroi.

61 The estimated point of collision is km 371+600 on the descending track (Thessaloniki to Athens), about 80 meters north of the tunnel that guides the Aegean Motorway over the railway lines.

Figure 1. Tempi located on a global map of Greece

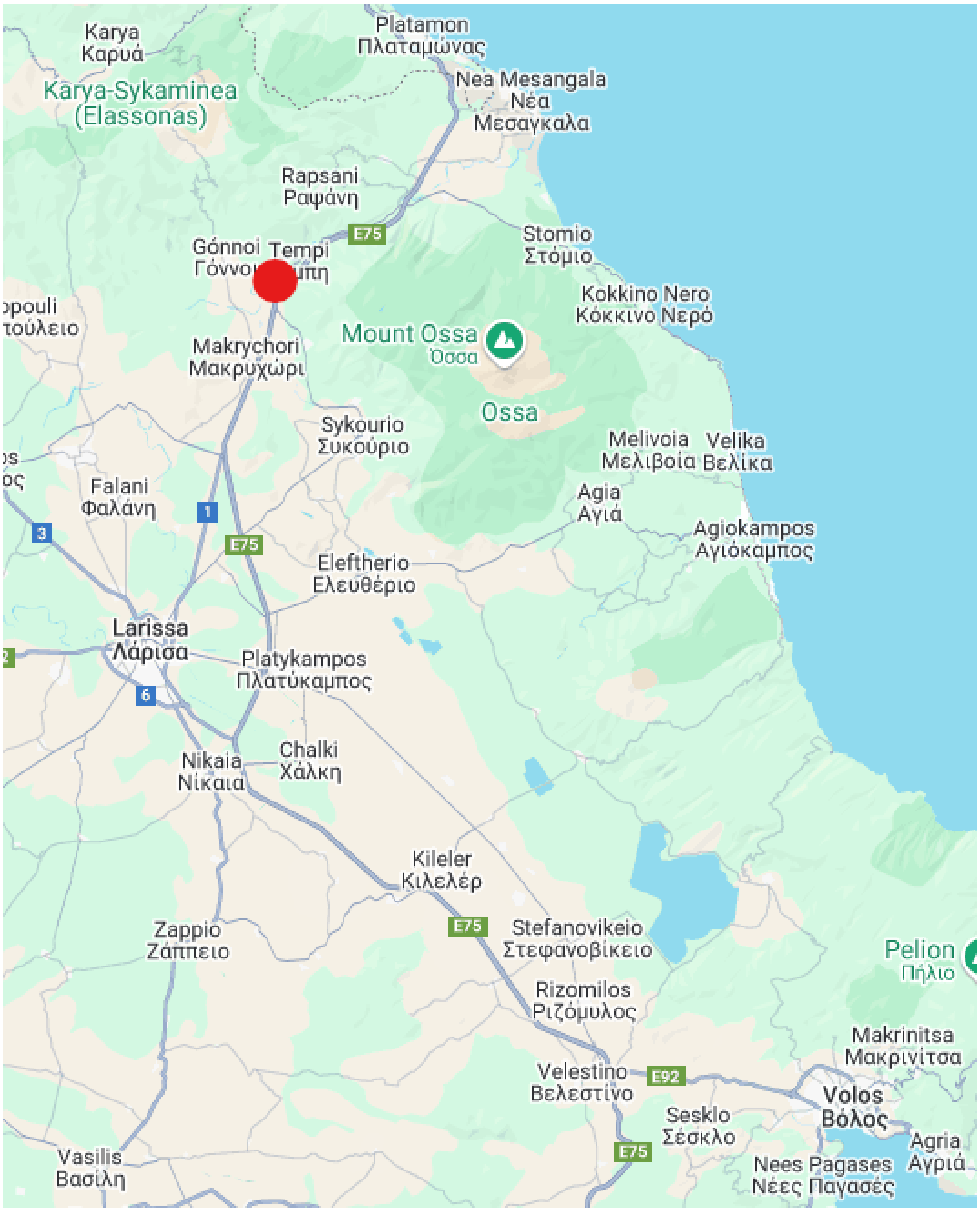


Figure 2. Location of the Tempi accident, near Tempi, after Larissa when coming from Athens

Figure 3. Photos of the tunnels on the site of the accident (left, satellite – right, from the road beside)

3.3. Global description of the occurrence local context

62 The point of impact is located at km 371+600 on the descending track from Thessaloniki to Athens. The track was renovated in 2003 and its condition was good. The tracks were composed of continuously welded UIC 60 rails, B70 sleepers and SKL 14 VOSSLOH couplers. The maximum permitted speed, according to regulations was 160 km/h, while the design speed of the tracks was 200 km/h.

63 At the time of the accident the weather conditions were good: the sky was clear and the prevailing meteorological conditions did not affect the accident.

64 As far as the geography of the accident is concerned, the collision happened as the passenger train had exited to the north the tunnel under the Aegean Motorway. The geometry of the track at this area is a clockwise curve, which, combined with the aforementioned overpass construction, hampers the visibility of train drivers. The previous station is Evangelismos (km 368+974) and the next station is Rapsani (km 381+961).

3.4. Main consequences

3.4.1. Human victims

65 The total number of passengers and staff on both trains was 354[2]. The accident resulted in the direct victims:

	Passengers	HT Staff and subcontractors	Overall
Dead	46	11	57
Seriously physically injured (hospital stay > 24h)	81	0	81
Slightly physically injured	98	1	99

Table 1. Numbers of physically injured and dead passengers and staff

The official Health Ministry records as issued on 26/5/2023 list 180 names of injured passengers. Among these, 7 of them were hospitalized in Intensive Care units and another 3 had serious but not life-threatening injuries. When reporting to RAS on the Common Safety Indicators, Hellenic Train reported 81 persons hospitalised for more than 24 hours.

66 Unfortunately, the number of victims that directly suffered from this accident without physical injury is unknown.

3.4.2. Material damage

67 The following damages had occurred on the rolling stock that was involved in the accident. For more details see Appendix A.

	Electric Locomotives (Siemens Hellas Sprinter)	Passenger wagons	Freight wagons (open type)
Passenger Train IC-62	1 locomotive, totally destroyed and broken into pieces	The first six were completely destroyed, the last two only partly damaged	
Freight Train 63503	1 locomotive totally destroyed and 1 locomotive with heavy damage in front and rear		The first four were completely destroyed, the fifth was damaged, the remaining eight were intact

Table 2. Rolling stock damage

[2] 250 web tickets, 91 station tickets, 4 train drivers, 2 train managers, 1 off duty train driver, 2 off duty train managers, 2 restaurant car staff, 1 cleaning staff, 2 passengers without ticket from Larissa =355 minus 1 who called to say he was not travelling =354 both trains or 352 persons in the passenger train + 2 persons in the freight train.

68 Damage to the electricity infrastructure: As a result of the collision, two support columns of catenary were completely destroyed: 371.19 in normal running direction (Athens to Thessaloniki) and 371.20 (including the pole foundation) in opposite running direction. The overhead power lines (25,000 Volts) on both lines were cut off and the relevant installed equipment. The repair of the damages was done by technical crews of OSE and was completed on both lines at 15/03/2023.

69 Damage to tracks: At the point of initial collision, on both direction the tracks were replaced for 200 m, from km 371+450 up to 371+650. An OSE subcontractor undertook the repairs which included rails UIC 60 and sleepers B70. The track was ready for putting in service on 08/03/2023.

3.4.3. Other consequences

70 All train services were interrupted for a period of one month. The resumption of InterCity passenger services between Athens and Thessaloniki became possible on 03/04/2023. Due to the flood effects of typhoon Daniel (5/9/2023), the section of line Larissa-Domokos suffered large additional damages, which following the accident in Tempi have not allowed the full movement of trains on a double line from Domokos to Larissa. Work to restore the line is being carried out up to the time this report is being written.

71 The accident has drawn widespread criticism for the state's handling of the investigation, raising concerns about the justice system's impartiality and integrity. In Greece, protests, vigils, and riots followed the accident, with some of the largest protests in Greek history and the slogans "Πάρε με όταν φτάσεις" ("Call me when you arrive") and “Δεν έχω οξυγόνο” (“I have no oxygen”) gaining prominence. The Association of Relatives of the Victims launched an online petition, gathering over 1.3 million signatures to push for abolishing ministerial immunity and initiating an inquiry into the ministers responsible for train safety. The media continues to focus on the incident and the legal proceedings to this day, and a major concert that was held on 11th October 2024 in memory of the victims was attended by tens of thousands and streamed to approximately 1.3 million unique viewers. The accident continues to stir public emotions also in 2025, with massive demonstrations in Athens and other cities on January 26.

3.5. Identification of all roles and entities relevant for the investigation

72 ORGANISATION OF RAILWAYS OF GREECE (OSE) is the only Greek infrastructure manager, responsible for the management of the national railway infrastructure, and the execution of infrastructure development projects (performed by ERGOSE). This is in accordance with Law 3891/10 that specifies the responsibilities of OSE:

- To operate the whole Greek railway network. The current network amounts to 2,552 km (lines in operation), of which 70% concerns standard gauge lines (1435 mm). The main axis is Athens -Thessaloniki (483 km) which includes a double track and is electrically powered.
- For the personnel who conduct traffic, namely the station masters and the switch operators.
- For the maintenance of both the infrastructure and the superstructure and the overhead power line
- To operate in accordance with Regulation (EU) 2021/782 on passenger rights and obligations.

73 OSE has received a safety authorisation to operate as infrastructure manager, from the Greek National Safety Authority (RAS) on 21/6/2022 for its operation as infrastructure manager, which expires on 03/10/2026 (4.2.19.2).

74 Safety-critical tasks that are performed by OSE personnel and that are relevant for this investigation are:

- station masters: responsible for the traffic management of the Railway Station in accordance with traffic regulations and traffic safety.
- switch operators (on site maneuvering personnel): responsible for the onsite maneuvers of the rolling stock on the tracks of the Stations or other assemblies of tracks.

75 In addition, the traffic regulators can be considered having safety-related activities. They are responsible for traffic management according to traffic regulations in a defined geographical area which includes some stations. Additionally, the Regulator is the link between OSE and the Railway Undertakings, regarding everyday information about the specifics of the trains in circulation.

76 HELLENIC TRAIN is the only (to date) provider of rail passenger transport and one of four freight transporters on the Greek network. The Company provides the railway services using the national network and the railway infrastructure in general owned by OSE (paying the corresponding network access charges). The terms under which Hellenic Train provides rail transport services are laid down in the public contract between Hellenic Train and the Greek State, which sets out the specific terms and conditions for the provision of services by the carrier. In addition, they operate in accordance with Regulation 2021/782 on passenger rights and obligations.

- Safety-critical train drivers: responsible for driving passenger and freight trains in accordance with traffic regulations and ensuring the safe and punctual traffic of trains.
- Central traffic monitoring of Hellenic Train: is based at Hellenic Train's headquarters in Athens and, in cooperation with drivers and the central traffic regulator of OSE, regulates the smooth and safe movement of trains and the management of any delays and incidents. He/she also tracks company trains through the GPS-modality of company mobile phones.

77 The company "ERGA O.S.E. S.A." (distinctive title "ERGOSE S.A.") was a subsidiary of the OSE, belonging to the wider public sector. It was established in accordance with the provisions of Article 1(3) of Law 2366/1995 (GG I 256), with the aim of managing the construction of the co-financed by the European Union and the National Resources "Projects" of the investment program of O.S.E. ERGOSE S.A. assigns contracts for studies and construction projects to contractors, who emerge as successful bidders, after the conduct of the relevant public tenders.

78 The Fire Service constitutes an operational structure subordinate to the General Secretariat of Civil Protection of the Ministry of Climate Crisis and Civil Protection, with jurisdiction extending throughout the territory.

79 Traffic Police: An important area of responsibility of the Greek Police is related to traffic and, in particular, to taking the necessary measures, both at a preventive and repressive level, for the safe movement of all vehicles, as well as pedestrians.

80 The General Secretariat of Civil Protection is a department of the Ministry of Climate Crisis and Civil Protection and is responsible for the preparation and implementation of the Human Loss Management Plan, when major disasters occur that lead to the loss of many human lives.

81 The National Emergency Center (EKAV) is a rescue body and operates under the responsibility of the Ministry of Health. Its purpose is to send specialised personnel to the site of an emergency to rescue and provide immediate

assistance and then transport people to the appropriate health facilities (hospitals, health centers). The operations are carried out by ambulances or other means, such as motorcycles, helicopters, boats and special units.

82 OATHYK (DVI): The Disaster Victim Identification Team (DVI) was established by Law 3938/2011 (Government Gazette 61A). DVI belongs to the Hellenic Police Headquarters and has the mission of identifying victims of accidents, disasters, as well as criminal and terrorist acts. The DVI is activated by decision of the Chief of the Hellenic Police following a request from the Preliminary Investigation Authority, to which it is operationally subordinated after its activation. DVI cooperates with the competent Coroner Authority.

83 The European Union Agency for Railways (ERA) is an agency of the European Union, initially established in 2004 by the Regulation (EC) No 881/2004, mainly to provide technical support to the European Commission in developing a Single European Railway Area, without frontiers, guaranteeing a high level of safety. Since 2016, and with the revised Agency Regulation (EU) 2016/796, it also performs authority and control tasks like providing safety certifications, vehicle authorisations and ERTMS approvals services to the railway sector and monitoring National Safety Authorities (NSAs) and Notified Bodies. The two ERA monitoring tasks are performed on behalf of the European Commission. ERA also performs the screening of national safety rules and technical rules.

84 The Directorate-General for Mobility and Transport (DG MOVE) is a Directorate-General of the European Commission responsible for transport within the European Union. DG MOVE is responsible for developing and implementing European policies in the transport field and it carries out these tasks using legislative proposals and program management, including the financing of projects.

3.6. Description and identifiers of all the rolling stock involved

85 The freight train 63503 (total weight 875 ton) was configured with two identical electric locomotives in double traction coupling (the locomotive 120-022 in a first position, and the locomotive 120-012 in the second position). With 13 identical vehicles (platforms): the 3 first loaded with steel plates, the 10 remaining loaded with containers, according to the configuration described in the Appendix A.

86 The passenger train IC-62 (total weight approximately 560 ton) had the usual configuration of Intercity trains of the Athens-Thessaloniki route (Table 3) and used the electric locomotive 120-023, with 8 passenger wagons as described in the Appendix A.

1	Locomotive 120-023		1	Locomotive 120-022
2	A1 (first class coach)		2	Locomotive 120-012
3	Restaurant Car		3	1st wagon with steel plates
4	B2 (2nd class coach)		4	2nd wagon with steel plates
5	B3 (2nd class coach)		5	3rd wagon with steel plates
6	B4 (2nd class coach)		6	Wagon with container of Food Preparations
7	B5 (2nd class coach)		7	Wagon with container of Food Preparations
8	B6 (2nd class coach)		8	Wagon with container of Food Preparations
9	B7 (2nd class coach)		9	Wagon with container of Food Preparations
			10	Wagon with container of beer
			11	Wagon with container of beer
			12	Wagon with container of railway material
			13	Wagon with container of railway material
			14	Wagon with empty container
			15	Wagon with empty container

Table 3. Configuration of the train IC-62 and configuration of the train 63503

3.7. Description of the relevant parts of the infrastructure

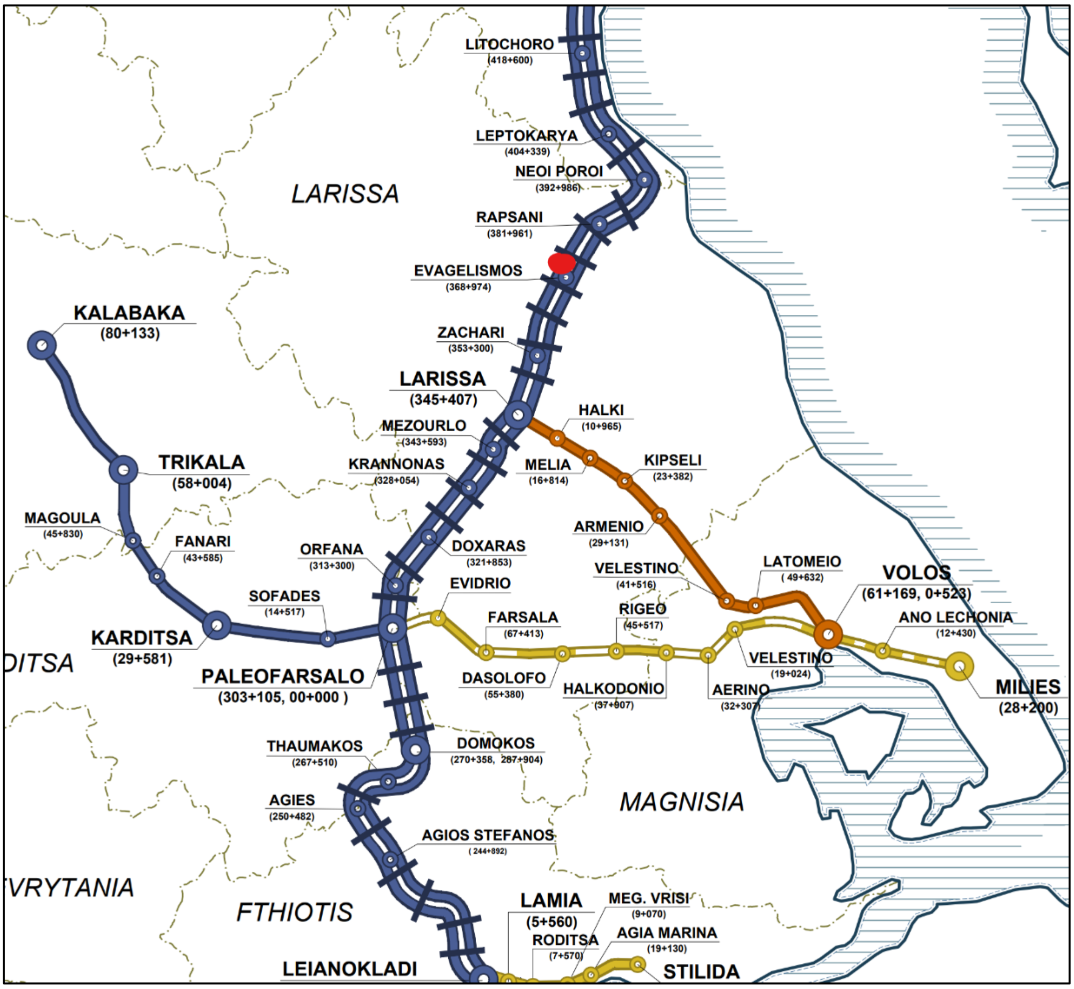


Figure 4. Railway map with Paleofarsalo, Larissa and Neoi Poroi Stations

87 Larissa Railway Station is located at KP 345+407 (measured from the Athens Railway Station). During the accident, the previous manned Railway Station was at Paleofarsalo (KP 303+105) and the next manned Railway Station was at Neoi Poroi (KP 392+936).

88 The station of Larissa has a total of 6 tracks (number 1 to number 6). Tracks 1 and 2 are dedicated to the main traffic (Athens—Thessaloniki). Track 1 is normally used in the geographically descending direction, from Thessaloniki to Athens (called “descending track” further in the text), while track 2 is usually used for traffic going in the other, ascending direction, from Athens to Thessaloniki (referred to as “ascending track” further in the text). Track 3 is used for the local traffic to and from Volos. Track 4, a dead-end track situated between tracks 2 and 3, also called “morta”, is used for the suburban train to and from Thessaloniki. Track 5 is mainly used for freight traffic and track 6 is a bypass, usually used for shunting activities.

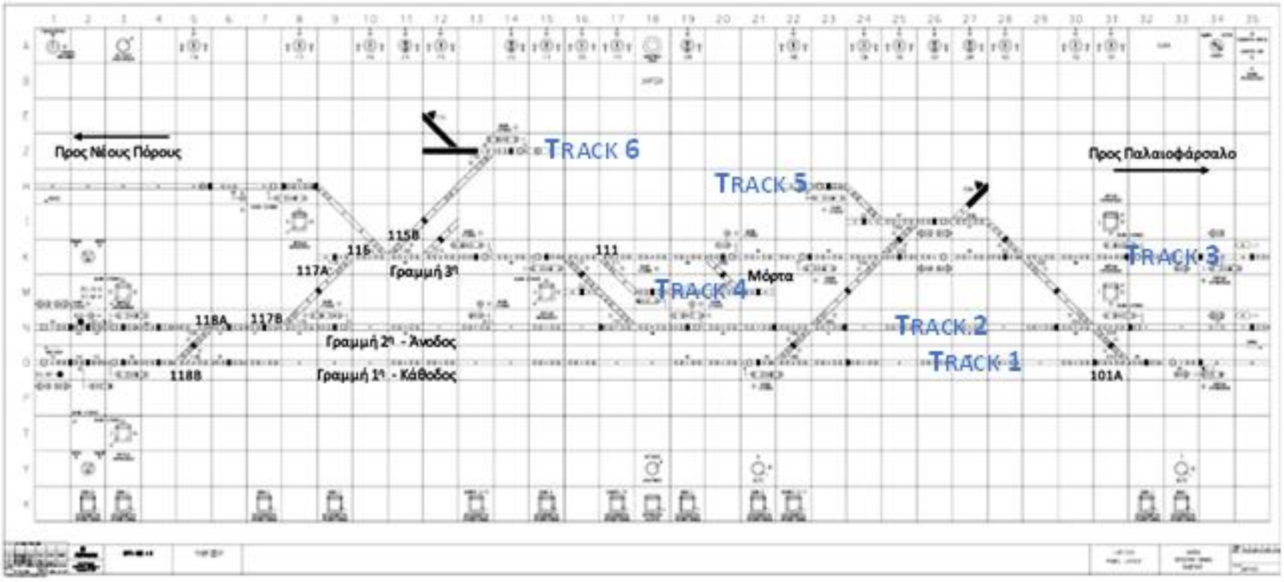


Figure 5. Scheme of the tracks at Larissa station as schematised on the control panel at Larissa Station

89 Within the Larissa station there is a signaling system which is controlled through a Control Panel placed in the station master's office. On the control panel the layout of the lines and switches are shown in a schematic form. It also depicts the indications of the light signals for the station, the position and locking status of the switches, the possible alignment of a route and the presence and position of the trains as soon as their first axle enters the track circuits.

90 The track type is UIC 60, continuously welded. The line is double track with standard gauge (1435 mm). The movement of trains is done via electrification (Airborne System with AC 25 KV). Communication between station masters is done via GSM-R and between station masters and train drivers via radio (VHF). No Train Protection System (ETCS or other) was operational.

3.8. Other relevant information

3.8.1. Related to the local operational context

Figure 6. Railway map of Larissa Station (from Google Maps, 04/2023)

91 The signaling at the exit of Larissa station to Thessaloniki was not operational, because the renewal works (covered by contract 717) were only partly realised. As a result, the signal LAR11 to exit Larissa station towards the north was continuously showing a stop-aspect. Consequently, the station masters working in Larissa had to personally give the order to the train driver (written form 1001 or telegram[3] via VHF-Radio) to pass the red signaling in order to continue towards the next manned station Neoi Poroi.

92 On the day of the accident, at 15:55, when the passenger train IC-56 (Athens to Thessaloniki from the ascending track) stopped at the Paleofarsalo station to disembark passengers, the overhead power cable broke because of a defective pantograph and fell onto the train and the track in front of it. As a result, the train was stopped, and the ascending track was blocked until the overhead power line was restored. For this reason, traffic between Paleofarsalo and Larissa was operated on the single descending track, for both directions, between 16:15 on 28/02/2023 and 01:05 on 01/03/2023.

93 On the day of the accident, at 19:12, passenger train 2594 (suburban Larissa-Thessaloniki) reported the inability to move due to a technical failure at location 361+300, while travelling on the ascending track (10 kilometers north of Larissa). As a result, the ascending track on the Larissa-Neoi Poroi section was closed from 19:12 to 21:30, and traffic between Larissa and Neoi Poroi was performed only on the descending track. At 21:30, train 2594 was towed to the Larissa station. Train IC-63 passed the Neoi Poroi station at 21:47 and at 22:12 it entered Larissa from the normal descending track.

94 Switch 101A, at the south entrance of Larissa Station (coming from Paleofarsalo) had a technical problem. It could not be operated from the control panel, and therefore it was requiring manual operation. So when train IC-62 came from Paleofarsalo to Larissa station, the station master had to send the switch operator at the spot to manually operate switch 101A.

95 At the night of the accident, there was a technical problem with the automatic level crossing of Karagatsi street, which is about 1.400m north of the Larissa station. The barrier of the level crossing was stuck with the barriers down and the bells were ringing continuously. As a result, residents have been calling the station master since 22:30 and complaining to him several times. They even filed a complaint with the local police, who in turn called the station master and asked him to fix the level crossing.

96 Around 22:42, the Police Service reported to the station master of Larissa that a man was sitting in the tracks in the area of Mezourlo.

97 At the time of arrival of train IC-62 at Larissa station, there was an issue with a passenger. It was reported that a man, obviously drunk, was moving on the platform and laying down. So the station security officer was looking for him. Just before the departure of train IC-62, he managed to get on the train and the Train Managers were occupied trying to find him.

3.8.2. Related to the wider railway system context

98 The table below presents the evolution of the number of permanent OSE staff from 2010 to date. There are three columns: the first is the number of total staff per year, the second column is the number of permanent station masters per year and the third the number of permanent switch operators (specialties critical to traffic safety). The first line lists the corresponding numbers of personnel that OSE is supposed to have based on its organisational chart.

99 Internal documents of OSE give indication that in the first half of 2021 the state approval was sought for the recruitment of 290 permanent employees through the usual formal process of employment of public sector employees. There was an initial approval to launch the recruitment process at State level for only 119, which was initiated in autumn 2021, but only in January 2023 the evaluation of the applications started in order to employ those 119 people.

[3] A telegram is a concise and formal communication used for transmitting operational or safety-critical messages, delivered either orally via voice communication systems or in written form through delivery of notes, with its structure strictly defined by the General Movement Regulation (GKK) to ensure clarity and standardisation. The two methods (oral telegram or personal delivery of note 1001) are equivalent. The choice of one method or the other is at the discretion of the traffic personnel. Oral telegram delivery is preferred in cases where conditions make personal delivery difficult (platform difficult to access from the traffic office, long train length).

100 During the course of 2022, having understood that the above State process would not lead to direct recruitments and having to deal with ongoing retirements, the Management Board of OSE decided to recruit a number of employees on a fixed-term employment base (to be renewed if fulfilling the requirements). These personnel (some 200+ in total of which around 70 station masters) was employed during the summer of 2022 and undertook duties in January 2023 (after an approximately six-to-seven-months training period).

101 Since then, OSE has continued to hire contractual employees with six-month, renewable contracts, who on 30/09/2024 were approximately 400. We observe that with these contractual employees, OSE is now operating with approximately 45% of the staff it should have according to its organisational chart.

	Total Permanent Staff OSE	*station masters*	*switch operators*
Permanent staff according to the OSE organization chart	*2.097*	*409*	*399*
on 23/9/2024	589	108	57
on 31/12/2023	645	117	64
on 31/12/2022	735	133	69
on 31/12/2021	848	161	88
on 31/12/2020	1.002	195	121
on 31/12/2019	1.107	219	147
on 31/12/2018	1.210	247	168
on 31/12/2017	1.275	251	190
on 31/12/2016	1.368	266	209
on 31/12/2015	1.418	279	214
on 31/12/2014	1.523	298	240
on 31/12/2013	1.735	330	278
on 31/12/2012	2.013	353	321
on 31/12/2011	2.244	387	354
on 31/12/2010	3.445	564	503

Table 4. Evolution of the number of permanent OSE staff from 2010 (Source: OSE)

102 It is unclear whether this number of 2.097 employees, as stipulated by law L3891/2010 and being a number by which OSE was functioning in previous times, is still realistic and reflecting the current, restricted use of the rail network. It must be noted that the required number of personnel for the infrastructure manager has to do with a number of factors which are dynamic and, could change from one year to the next.

103 When compared to the evolution in other European Members States, however, an important decrease in the number of employees employed by the infrastructure manager per line-km from 2015 to 2016 is found, which is in line with the EU figures. But while the latter progressively increases in both 2018 and 2020, Greek values keep constant or even decrease.

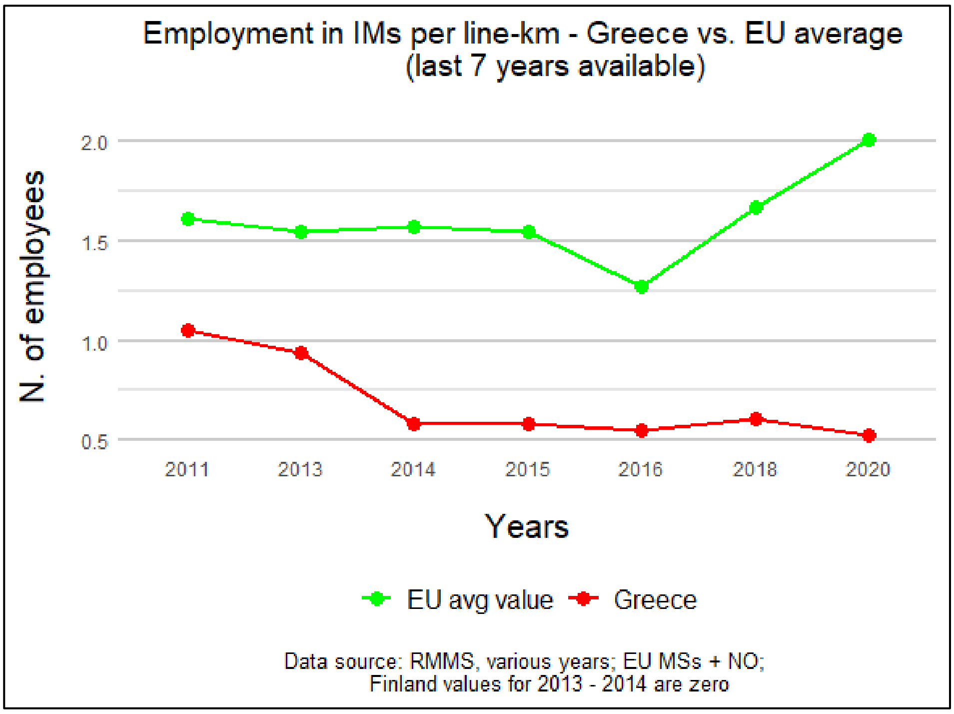


Figure 7. Employment in Infrastructure Managers in Europe and Greece (source: ERA)

104 Furthermore, from 2016 onwards, Greece has the lowest level of expenditure on maintenance, renewal and enhancement per line-km in Europe, being the EU minimum value of the indicators for the last 5 years available (hence the dotted line).

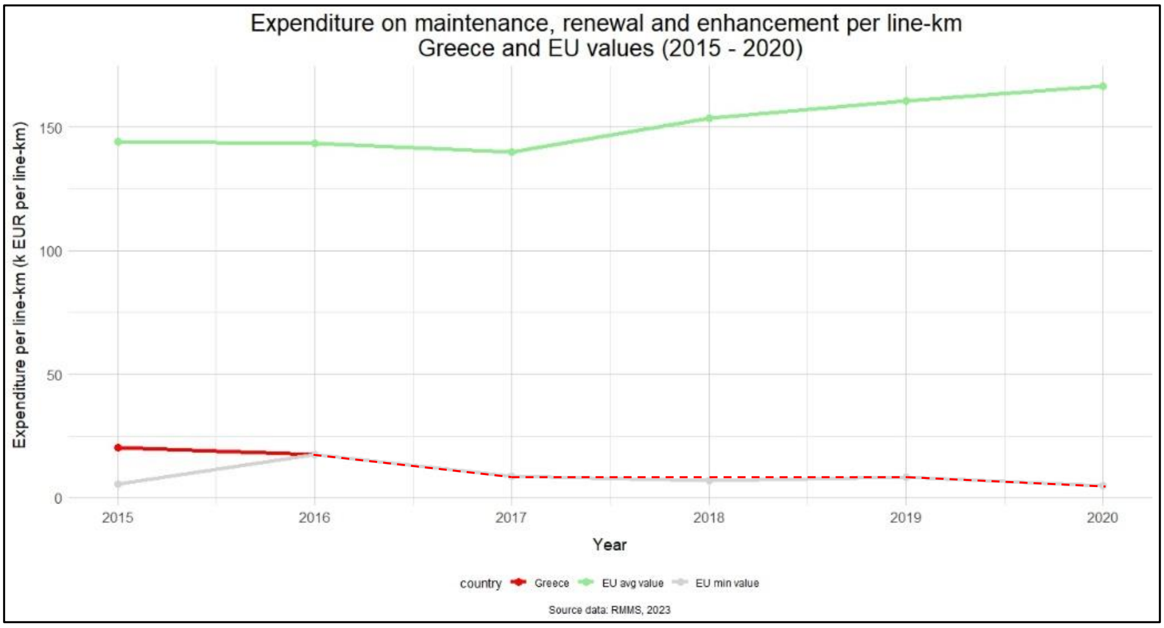


Figure 8. Expenditure on Maintenance in Europe and Greece (source: ERA)

105 When comparing the infrastructure investment for the last 20 years, only in the 2003-2004 period rail spending was higher than road spending. The wider ranges between the two values are in 2013 and 2016-2017 where there was an increase in road investment while decreasing rail investment (aligning with the most severe years of the crisis).

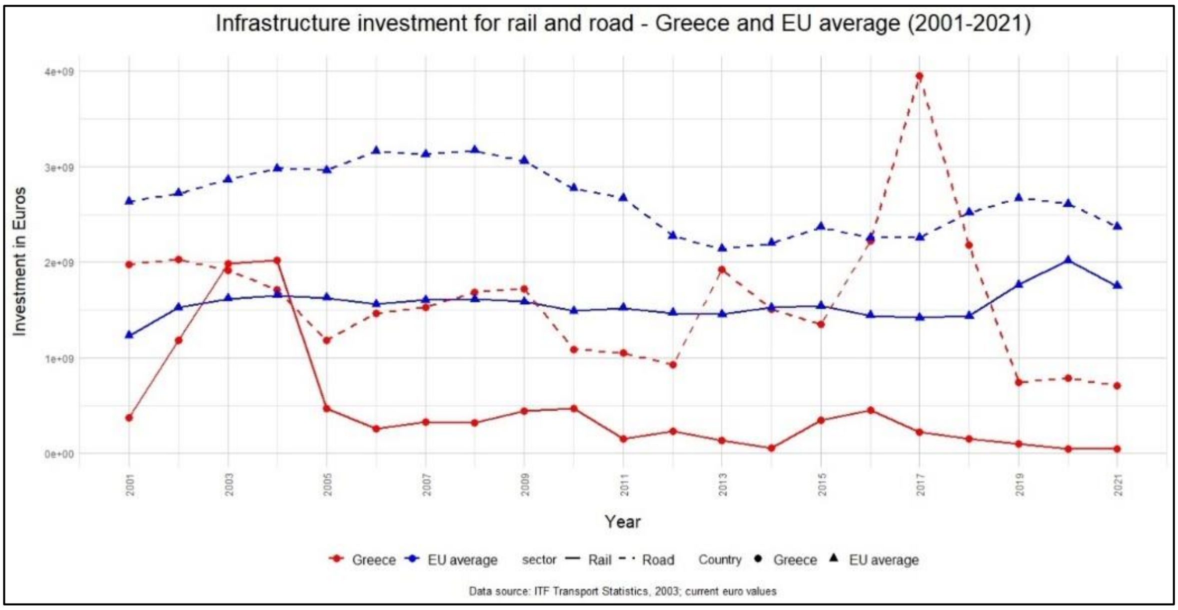


Figure 9. Infrastructure investment for rail and road[4], in Europe and Greece (2001-2021) - (source: ERA)

106 In conclusion, it can be safely stated that the Greek railway sector suffered highly from the economic crises. However, the investigation team was non capable of finding any form of long-term strategical planning to revitalise the Greek railway sector after this period.

[4] The vertical axis on this figure is indicating 2e+09 etc., which is a notation for $2x10^9$ or 2.000.000.000

3.9. Factual description of the events: proximate chain of events leading up to the occurrence

3.9.1. The regulation of train traffic

107 The station master in Neoi Poroi is on a shift from 13:30 to 21:30. In the evening, she is asked by the traffic regulator of OSE to stay longer, to ensure normalisation of traffic and to leave only after the passage of train IC-62.

108 At 18:00, the two train drivers of train IC-63 take on duty in Thessaloniki.

109 A technical problem occurs with locomotive 120-016, which had to be replaced by with locomotive 120-022, resulting in a delay for train IC-63 when leaving Thessaloniki.

110 The train drivers of train 63503 take on duty at 20:00, in Thessaloniki, for a service from 20:00 to 05:00.

111 Due to a technical problem with one of the locomotives, train 63503 does not leave the Thessaloniki Freight Station at 21:15 as scheduled but was delayed until 21:40.

112 According to his declaration, the station master of the night shift arrives in the station of Larissa around 21:20. This is after he was called by a third colleague on his personal mobile around 20:15, at the request of the senior station master of the afternoon shift, with the demand to start his shift earlier so that he could be informed on the abnormal operational conditions that occurred during the afternoon. His first recorded action is replying to a call from the repair facility, starting at 21:45.

113 After a formal transfer of the shift, the two station masters that were on duty during the afternoon shift on 28/02/2023 leave their position around 22:10 and 22:20 respectively, leaving the station master of the night shift to be the sole person responsible for handling the train traffic in Larissa station.

114 Train IC-62 arrives in Paleofarsalo station at 22:06, where a programmed switch between the crews of trains IC-62 and IC-63 takes place. Train IC-62, with the train drivers previously in charge of IC-63, leaves the Paleofarsalo station at 22:38, with a delay of 48 minutes.

115 Meanwhile, at approximately 22:35, the station master of Larissa puts the switches 118 in a bypass position to allow the entry of train 2597, a suburban train from Thessaloniki to Larissa, and coming from Neoi Poroi on the descending track, to park it on the 4th track, being the dead-end track situated between the second and third line in Larissa station.

116 When setting the route for train 2597, the station master of Larissa makes an error with the position of switches 116 and 115B, which is detected by the train driver of train 2597. Correcting this error requires the full attention of the station master between 22:35 and 22:41.

117 At 22:44, the station master of Paleofarsalo informs the station master of Larissa, via GSM-R, of the departure of train IC-62 via the descending track. This information is followed by an exchange on the presence of trespassers on which the station master of Larissa was informed by the police services and ends with station master of Paleofarsalo urging his colleague in Larissa to set the route for the entrance of IC-62 in Larissa.

118 Almost immediately after this exchange, at 22:46 and because it was impossible to operate it remotely, the station master of Larissa orders the switch operator on service to go on the spot of the switch 101 and set it in a bypass position, to allow train IC-62 to enter the Larissa station on track 2, coming from the descending track.

119 Most probably, the station master of Larissa manipulates the keys on the control panel to set the route for train IC-62 to move from Larissa to Neoi Poroi directly after ordering the manipulation of switch 101. When doing this, he leaves switches 118 in the bypass position, herewith directing train IC-62 towards the descending track.

120 At 22:53, the train driver of train IC-62, when in the area of Mezourlo, contacts the station master of Larissa to announce their arrival at Larissa. While the switch operator is not yet ready with the on-site setting of switch 101 at the entry of the Larissa station, the station master of Larissa asks the train driver of train IC-62 to wait.

121 In reaction, at around 22:54, the train driver of train IC-62 slows down the train to a speed below 20 km/h. At 22:57 he re-accelerates, when receiving the authorisation to enter the station from the station master of Larissa with telegram 45 to then slow down again for the entry of the station. Train IC-62 finally comes to a stand still on track 2 in Larissa station at 23:02.

122 At 23:05, with telegram 47, the station master of Larissa gives train IC-62 the authorisation for passing signal LAR11, that is permanently showing a stop aspect, without indication of a track change from the ascending track. This authorisation is referring to a movement that follows track 2, where the train is standing, towards the ascending track. The train driver(s) of IC-62 however do not ensure a clear understanding of the given order and do not repeat the received message. In return, the station master of Larissa does not react on the incomplete communication.

123 In result, at 23:05, train IC-62 starts its movement to leave the Larissa station towards Neoi Poroi.

124 At approximately 23:08, train IC-62 arrives at the switches 118. Confronted with the conflicting information of having received an authorisation without indication of a track change and the switches in a bypass position, directing the train towards the descending track, the train drivers do not show any recognisable reaction and continue their journey towards Neoi Poroi on the opposite, descending track.

125 23:05 – The station master of Neoi Poroi gives train 63503 the authorisation to move to Larissa on the descending track.

126 23:09 – The station masters from Larissa and Neoi Poroi exchange telegrams and inform on the respective hours of departure of trains IC-62 and 63503.

127 Shortly after 23:18 – Head-on collision between IC-62 and 63503.

3.9.2. The collision of the trains

128 By lack of clear footage, a reconstruction of the course of the events and the exact mechanism of the collision can only be based on the known movement of direction of the trains, their speed and mass, and the positioning and the observed damages of the different vehicles after the accident. This reconstruction, in turn, is further hampered by the way the accident site was treated after the rescue operations (4.5.3).

129 Based on the available evidence, the most likely description of the accident mechanism consists of a sequence of three consecutive but distinct phases (1st collision, 2nd collision, slowing down), from the moment of the first head-on collision until the time that every vehicle comes to a standstill at its final resting position.

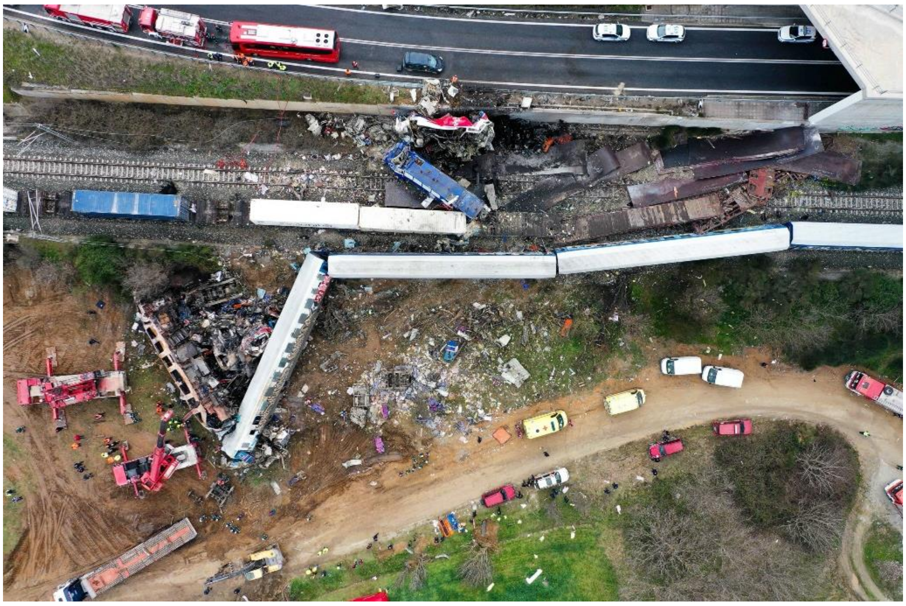


Figure 10. The end position of the 3 locomotives and some of the passengers coaches and freight wagons (http://www.intime.gr/).

130 The 1st phase mainly involved the first 4 vehicles of the two trains: 2 locomotives 120-022 (first) and 120-012 (second) of the freight train and the locomotive 120-023 with its first-class A1 coach. The initial impact is a head-on collision between passenger train locomotive 120-023 and the first freight train locomotive 120-022, that causes the latter, along with the second locomotive 120-012 to be catapulted towards their left over the upward line track and smashed against the motorway wall, with the second locomotive making a U-turn and its rear end sliding over the steel plates carried on the 3rd platform of the freight train to come to a standstill with its front side against the first locomotive and its rear end resting against the first shipping container carried on top of the 4th platform of the freight train (Figure 10, Figure 11, Figure 12).

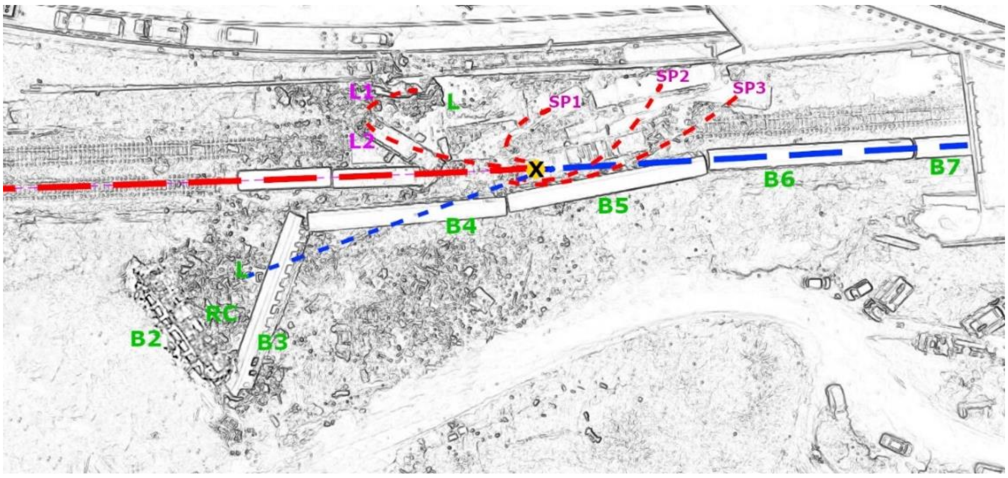


Figure 11. Global movement of the collision, with the initial impact and catapult effects. (SP1,2,3 are Steel Plates, and were also catapulted)

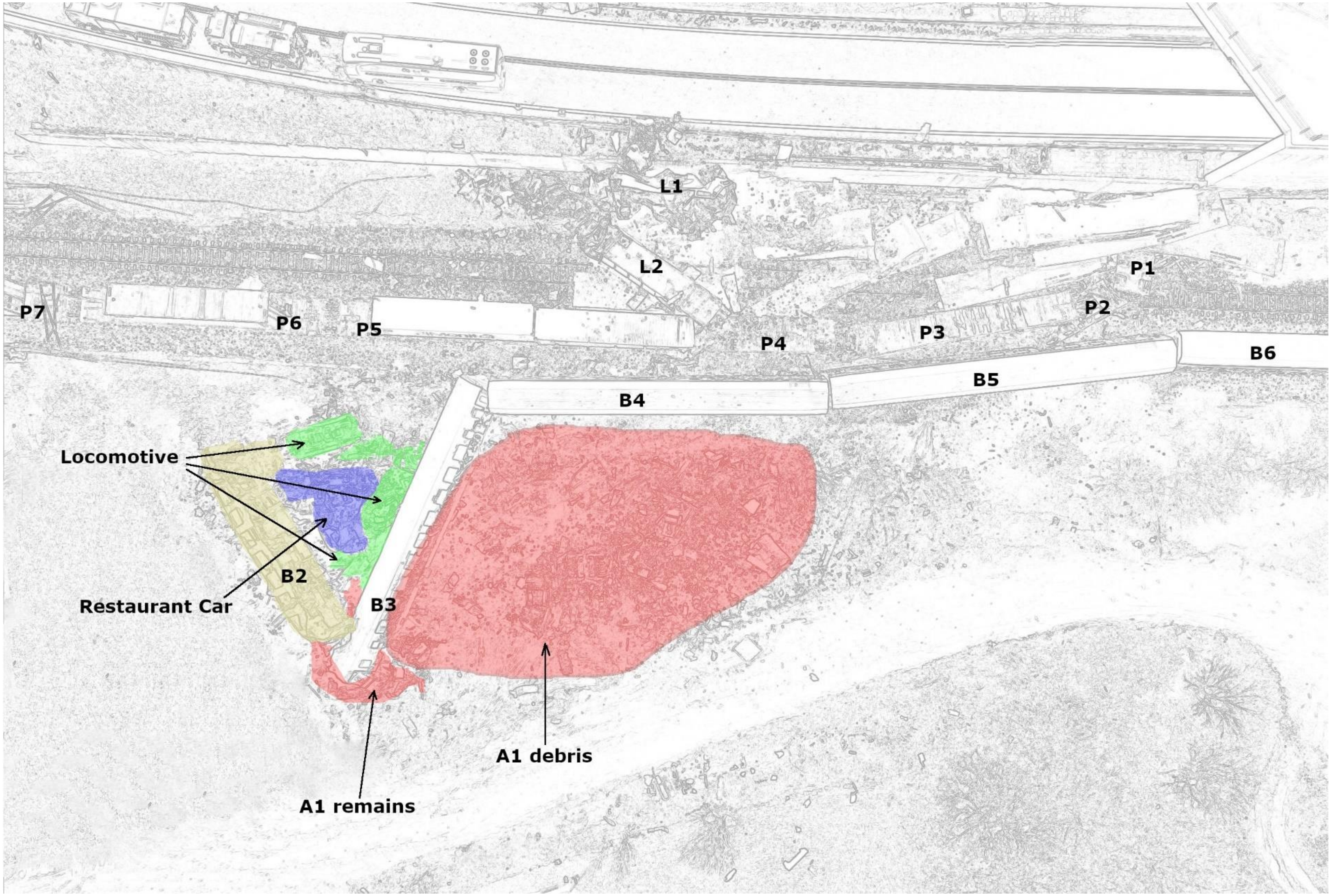


Figure 12. The accident site.

*Best estimated point of the 1st collision: **X**, Freight locomotive 120-022: **L1**, and 120-012: **L2,** Passenger train locomotive 120-023: **Locomotive areas**, First-class A1 coach: **A1 areas**, **Restaurant Car** area, Second-class **B2** on B3 head, then **B3**, **B4**, **B5**, **B6**, (B7 under the tunnel), Freight train platforms **P** 1-2-3-4, and freight wagons 4-7 (and other 6 not on the figure).*

Figure 13. Locomotives 120-022 and 120-012 of the freight train 63503 after the accident. Front view, from the road.

Figure 14. The first locomotive of the freight train (120-022) showing extreme damage from the very heavy head-on collision with the locomotive (120-023) of the passenger train.

131 From the examination of the remains of the first freight train locomotive 120-022, it is clear that the head-on collision bent the front bumper downwards and inwards (Figure 14, Figure 15), severely bending the heavy beams of the lower frame of the locomotive, while at the same time the fact that the roof is missing (Figure 16), is an indication that the passenger train locomotive 120-023 passed over and through the roof of the this 120-022 locomotive.

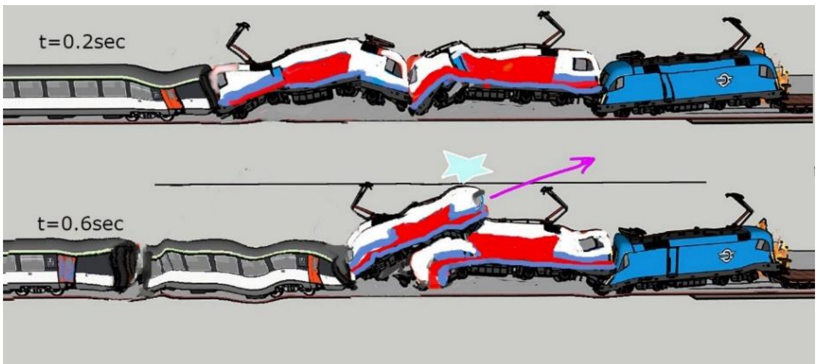


Figure 15. Movement of the passenger train locomotive 120-023 over and through the roof of the freight train locomotive 120-022.

Figure 16. Front view of the locomotive 120-022, roof missing.

132 The passenger train locomotive 120-023 follows a slightly leftward path in its driving direction towards the lower verge, where it hits the ground, followed by the first-class passenger car. Due to the very heavy initial impact, this 120-023 locomotive has been completely destroyed (Figure 17), and its parts were found at an angle of approximately 20 degrees to the left and at a distance of 30 to 45 meters. The A1 coach of the passenger train was completely broken up due to the extreme mechanical loads of the impact and its heavier parts followed a path close to the path of the locomotive parts, at an approximate angle of 25 to 30 degrees to the left. Its lighter parts (seats, internal panels and fittings, luggage, and all casualties) were scattered in a wider area before the end position of the vehicle (see global Figure 12).

Figure 17. Part (chassis) of the completely destroyed locomotive 120-023 of the passenger train IC-62.

133 After the initial collision that heavily damages the first 4 vehicles involved (the two locomotives of the freight train and the locomotive and the first-class coach, A1, of the passenger train), these are no longer mechanically attached to the remaining parts of their respective trains. Regarding the movement of the remaining vehicles of the two trains, it is not possible to accurately calculate the speeds of the two trains at the 2nd phase of the collision. But we know that the trains are now moving slower because some of their kinetic energy was lost due to the 1st impact and also all the brakes have been activated (by manual activation of the emergency brake on the freight train 1 sec before the 1st collision, and by automatic activation of mechanical brakes on the passenger train due to loss of air pressure as a result of the 1st collision).

134 The second collision is another heavy head-on collision that takes place between the Restaurant Car (i.e. the 3rd vehicle) of train IC-62 and an area between the rear end of the locomotive 120-012 and the first of the wagons carrying steel plates (Figure 18). The effort to locate and examine all the remains of the corresponding vehicles of the freight train, shows that it is not possible to locate and identify all these parts.

Figure 18. Estimated area for second collision for the freight train (simulated image behind still of video footage).

135 The rear part of the first platform wagon can be identified among the remains of the vehicles at Koulouri, but the front part is not available for examination, as it was presumably cut in smaller pieces in order to allow easy transport (Figure 19). This action was not documented in any way and there are no photographs of the carriage in its original condition at the crash site before being cut up and moved by an unknown party.

Figure 19. Remains of the first platform that was carrying steel plates.

136 The rear driver's cabin of the 120-012 locomotive appears to be cut off from the rest of the vehicle and it cannot be completely identified anywhere among the debris, apart from a small part of its roof and top headlight (in front of the first container). The rest of the cabin cannot be identified as a whole and also the front panel with the painted number and the two red headlights are also not recognisable among the debris. Presumably, the missing structure is among the crashed and burned remains of the Restaurant Car, as this is the only place in the whole accident site where the fire burned so fiercely that it totally consumed the heavy industrial-grade paint of the blue locomotive, making it unidentifiable.

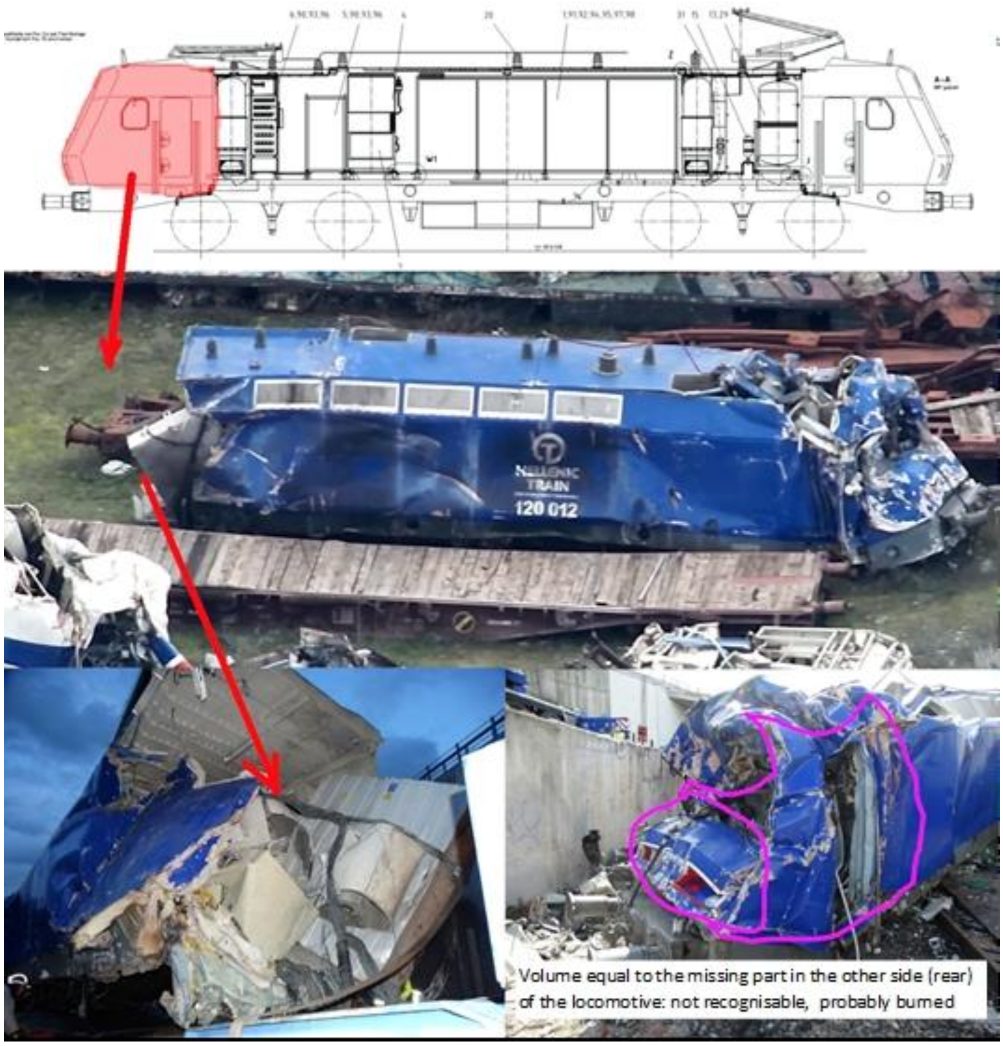


Figure 20. Missing rear-end of the locomotive 120-012.

137 This second collision causes very heavy damage to the Restaurant Car (Figure 21) that is bent into an S-shape mostly due to this initial impact but also sustaining damage while rolling and hitting the ground on its way to the lower verge, to end almost on top of the remains of the locomotive 120-023 and the destroyed A1 first-class coach.

Figure 21. Remains of the Restaurant Car, on the left, S-shaped as found on-site, and on the right, its platform at Koulouri site.

138 By comparing the damage to the steel plates and the Restaurant Car, it can be considered as most likely that the initial impact to the Restaurant Car came not on its front bumper but underneath its "belly", indicating that the Restaurant Car had a slightly "nose-up" attitude at the moment of the impact, which is consistent with the damage observed on the first and presumably topmost steel plate that was found wedged underneath the blue 120-012 locomotive. Meanwhile, the 1st platform of the freight train sustains very heavy damage from the impact with the Restaurant Car that leaves it bent in half and wedged under the remaining steel plates against the wall, and spread few meters after the collision, in the area before the entrance of the tunnel. (Figure 13, Figure 22).

Figure 22. Remains of the top steel plates and final position of the 3 sets of steel plates.

139 During the 3rd phase, there is some kinetic energy remaining in the other vehicles of the two trains and their forward momentum continues with their center of mass following the new vector of velocity that resulted after the 1st and 2nd phase heavy collisions. The kinetic energy is dissipated by the braking action of all wagons and by the derailed wagons scrubbing speed from sliding against gravel and vegetation at the side of the tracks.

140 Derailed by the collision of the Restaurant Car, the B2 vehicle (a passenger coach divided into 11 6-seat compartments) continues straight ahead with a slight angle to the train tracks, nose diving downwards and hitting the ground with its front end, bending and breaking off its front section in the middle of compartment no 2. After the head-on impact, the rear of the wagon is lifted high and to the left and coming down to hit the front of the B3 passenger coach.

Figure 23. Remains of the B2 coach

141 This B3 coach, in the meantime is derailed and veering to the left, its front end moving downhill and cutting down small trees and bushes, while its rear end is pushed straight ahead by the B4 coach (still attached to each other), creating a rotation to the left for the B3 carriage that comes to a stop at an angle when its side hits the debris of the A1 coach and the broken up Locomotive.

142 The impact of the B2 (Figure 23) on the top of the B3 wagon (Figure 24) causes the rear part (11th compartment) of the B2 coach to break off and fall below, while at the same time it causes severe damage to the B3 coach underneath.

Figure 24. Remains of the B3 coach

143 Meanwhile, the remaining 12 vehicles of freight train 63503 and the remaining 4 vehicles of IC-62 continue their last part of their forward movement, where in addition to braking action there is also side impact between the steel plates and the sides of the 2nd and 3rd platform and the sides of the B3, B4 and B5 coaches of the passenger train (Figure 25).

Figure 25. Linear impact of steel plates on the side of the coach B4.

144 Finally, the fourth wagon of the freight train carrying a shipping container, hits the second freight locomotive 120-012 and then comes to a standstill. On the next page (Figure 26), a set of pictures extracted from an animated sequence proposes an overall view of the collisions with their timestamps: image 2 showing the 1st impact, image 4 the 2nd impact and images 5 and 6 the movement till standstill.

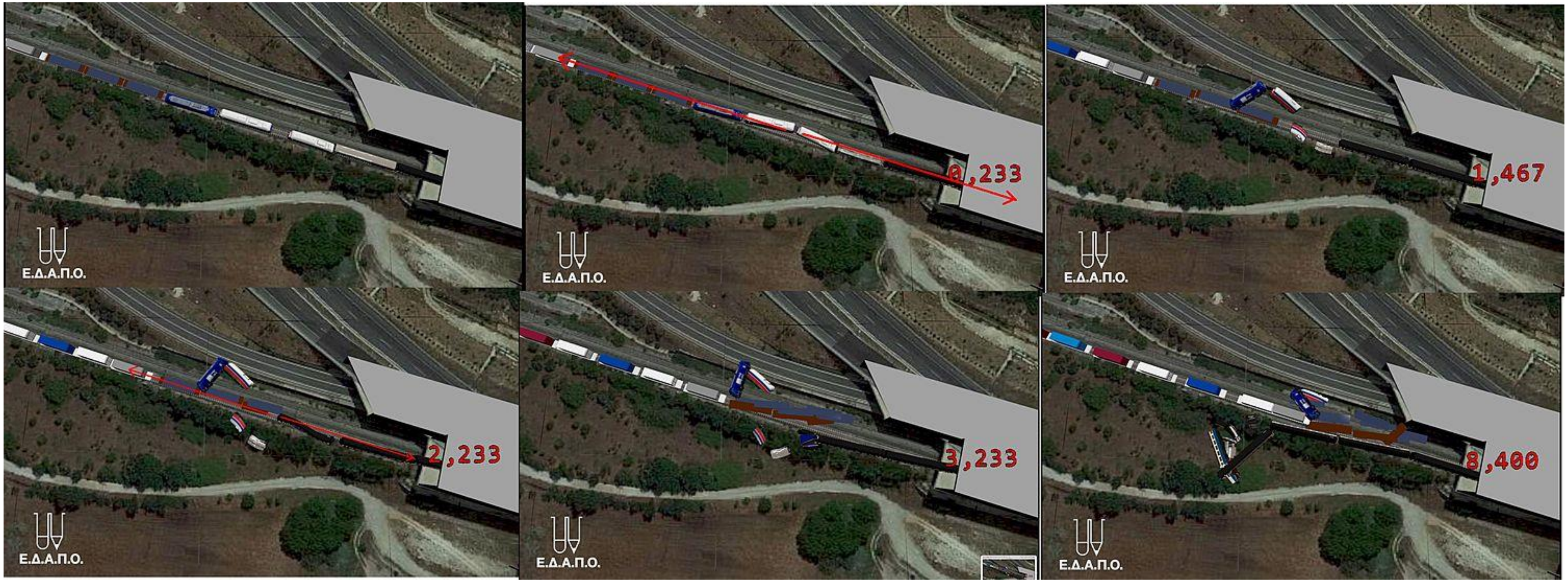


Figure 26. Overall view of the simulated accident mechanism with the timestamps: image 2 showing the 1st impact, image 4 the 2nd impact and images 5 and 6 the movement till standstill.

3.9.3. The arc flashes, the fireball and the propagation of fires

145 The footage of three cameras that have recorded the accident appears to be the only available evidence on which to base an understanding of the fire that almost immediately followed the collision of trains IC-62 and 63503. Careful examination of this footage gives indication that what was initially perceived as a single event can actually be broken down in three distinct stages that need to be considered separately: ignition and creation of a fireball, feeding of the fireball and consecutive pool fires.

146 A first stage that can be observed, the ignition and creation of a fireball, starts at approximately 0.6 seconds after the initial contact between the locomotives of the two trains, when a first electric arc is being recorded on video. A short circuit is created with a bright flash due to the electric arc; and another 2 flashes appear rapidly after, each approximately 0.1 second apart. These 3 bright flashes stop after a total duration of about 0.3 seconds, which is consistent with the expected timing of the tripping of the automatic overload protection that was (manually) recorded at the power control station that remotely monitors all data at Thessaloniki.

Figure 27. First stage, arc flash and ignition. The green circle shows the theoretical expansion radius of the initial deflagration.

147 At the same time, the catenary lines themselves (both lines, one for each direction of travel) have been ripped off due to the collision, but the power was already cut within 0.2-0.3 seconds of the short circuit. Approximately 0.3 seconds after the end of the arc flashes, a fireball starts forming from the ground level and very rapidly expands upwards to a size of approximately 42 meters in diameter, which burns for approximately 2 seconds.

148 At approximately 2 seconds after the initial ignition, a second stage starts, when a new fire plume can be observed, moving northbound, away from the 1st stage fireball. This new fire plume is feeding the original fireball until it grows to almost double the size (80 meters) at approximately 4 seconds after ignition (Figure 28, Figure 29, Figure 30).

Figure 28. First (left) and second stage (right) of the fireball.

149 Thereafter, at approximately 6.5 seconds after the initial ignition, the fireball enters its burnout phase and is finally extinguished at approximately 12 seconds after the initial ignition. As can be observed on the Aegean Motorway video camera that follows the same movement, the fire is not extinguished with the dying out of the fire ball, but rather continues to burn as a pool fire setting fire to the Restaurant Car during a next stage (Figure 33, Figure 34).

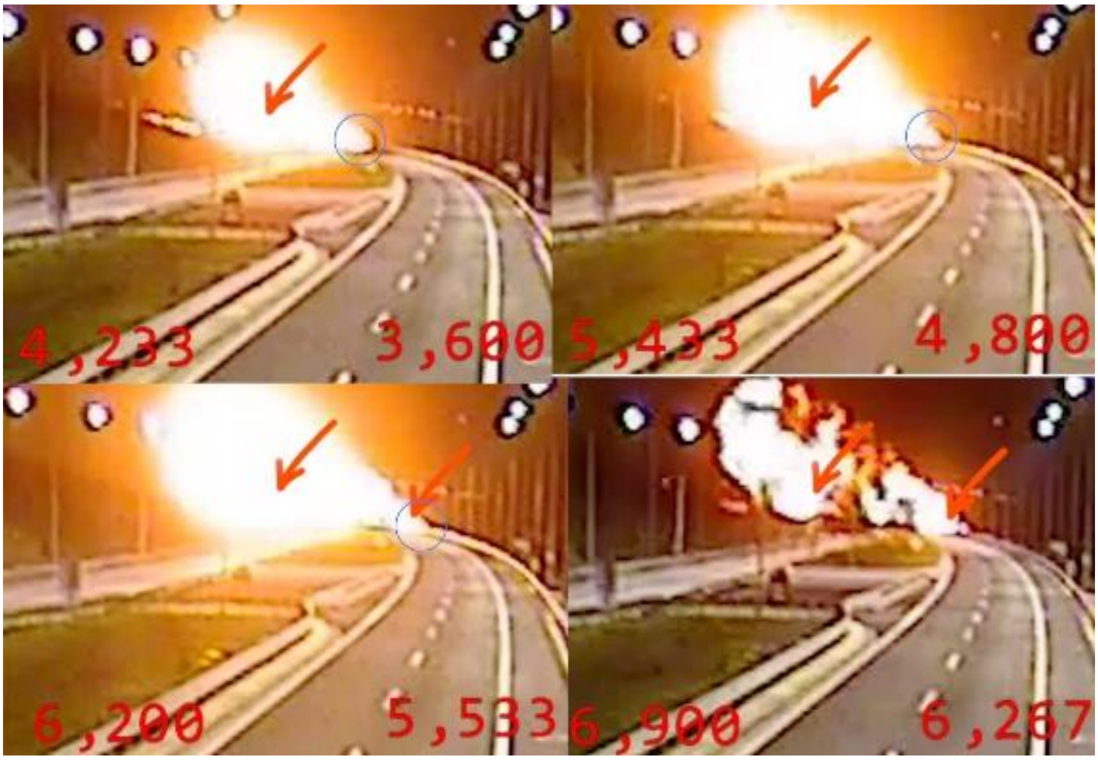


Figure 29. Second stage, fireball (left side of pictures) and fire plume (right side of the pictures)

150 Two separate pool fires continue to burn at ground level after the 1st and 2nd stage fireballs have extinguished themselves, indicating the start of a new, third stage.

151 Pool fire #1 can be seen burning brightly, near the locomotives of the freight train, for approximately 30 seconds. After that, it continues for an unknown period of time burning with smaller flames that can be seen from passenger videos but not large enough to be recorded by the remote cameras overlooking the scene. The video evidence shows stronger flames for 20 seconds and then a decrease in flame size that hides the fire from view, so it is not possible to accurately estimate the duration of this pool fire.

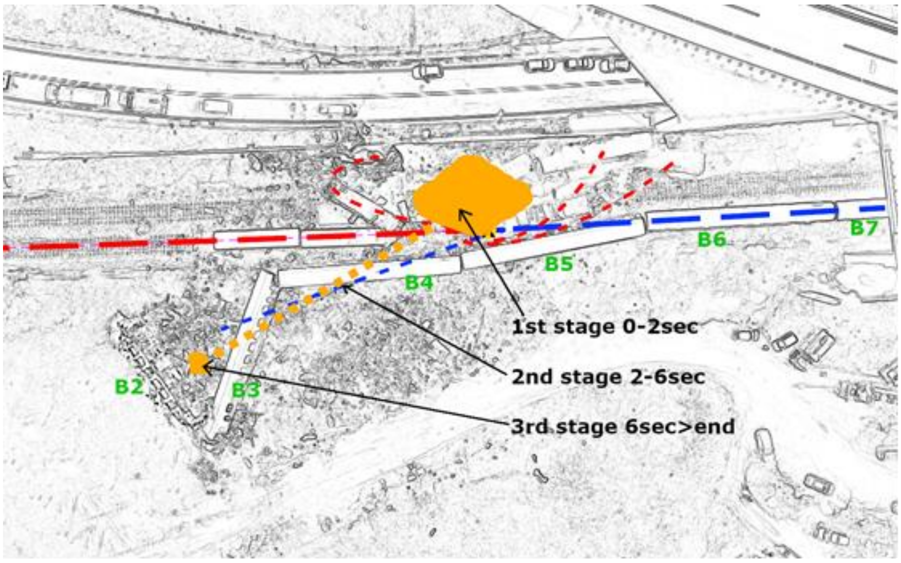


Figure 30. Clarification of the sequence with its timing.

152 It is most likely that this pool fire #1 at some point heats up the silicone oil inside the transformer of the first freight locomotive 120-022 and smaller amounts of silicone oil having already spilled at the area and an additional amount draining from the cracks of the transformer case. This creates a smaller secondary fire of the silicone oil that can be observed in passenger videos 20-30 minutes after the collision and its location and size can be traced by the white residue (SiO_2) that indicates burning of silicone oil as it is observed at the area after the fire.

153 Pool fire #2 is burning with a very strong flame for at least 60 seconds before other combustible materials are added (flame color change), which made fire continue to burn stronger for at least 60 minutes after the collision. This fire has grown so strong in the first 30 minutes that the first firefighting effort at 00:02 (43 minutes after the start of the fire) from a single fire truck pumping water from the railway lines to the fire below, had minimal to negligible effect.

Figure 31. Pool fires #1 and #2

154 There are not enough photos and videos to follow the decay of this fire until at 02:09 it can be seen burning with a smaller flame and then at 03:28 that can be seen almost extinguished (without visible flames from the outside). Infrared drone footage from approximately 05:30 shows a hot area inside the Restaurant Car remains which indicates a small fire simmering unnoticed from the outside (Figure 32). Six hours later, at 11:33 in the morning of 1st March, smoke can be seen coming out of the remains of the Restaurant Car when a crane tries to lift a section at this exact point, indicating that a fire was simmering inside the Restaurant Car for 12 hours.

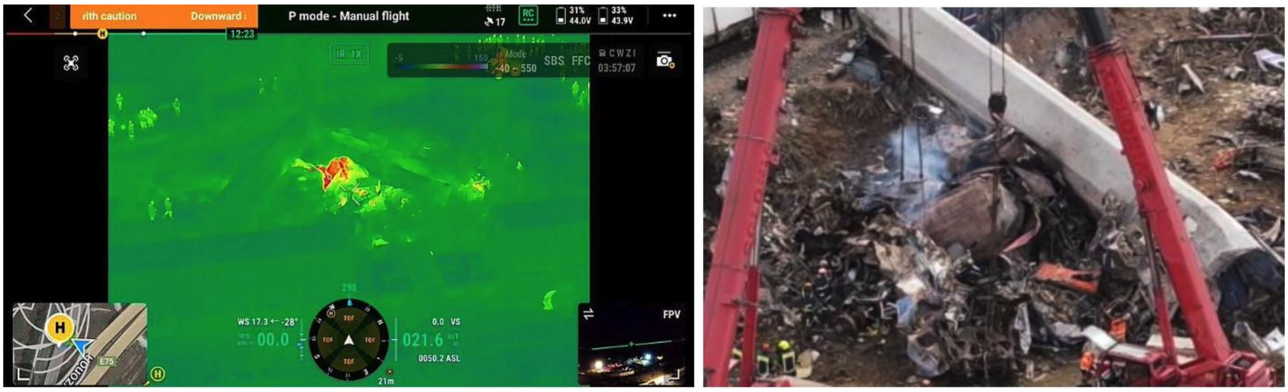


Figure 32. Fire simmering inside the Restaurant Car for 12 hours.

155 Irrelevant to the Pool fire #2, A third fire started from an unidentified small source of ignition at the front of the B2 carriage. This fire, starting at ground level and climbing upwards to start to burn the B2 carriage from one end to the other, was initially very small and considered not threatening by the escaping passengers. According to the timeline precisely recorded by photos and videos, this fire consecutively slowly consumed the total length of the B2 carriage, compartments 3 to 10, for a length of approximately 16 meters, in approximately 40 minutes.

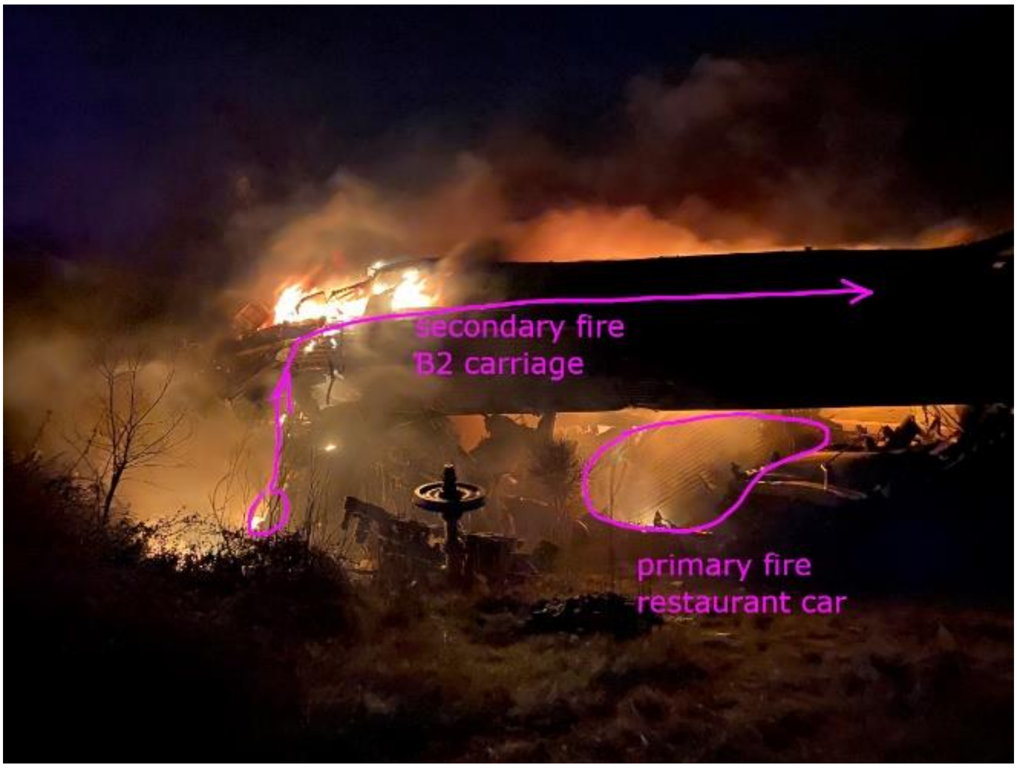


Figure 33. Another fire started at the front of the B2 coach.

156 At 02:12 a photo (Figure 34) of the accident site shows the heavy fire at the Restaurant Car being reduced, with still fire and heavy smoke coming out from the remains of the Restaurant Car and with another two small flames remaining at the front and rear of the B2 coach. A firefighting effort recorded at 02:32 shows foam being pumped towards the carriage, without being clear if it played a role in the actual extinguishing of the fire that had already consumed the total length of the carriage.

Figure 34. Photo showing the heavy fires in the Restaurant Car area (behind), and on the B2 coach (front, above) (Source: EDAPO).

157 From the work of the EDAPO team of investigators, more details and a rebuild of the timeline of the fires are available, with timestamp on photos (Figure 35, next page). This timeline describes the development and decay of the fire (source: EDAPO).

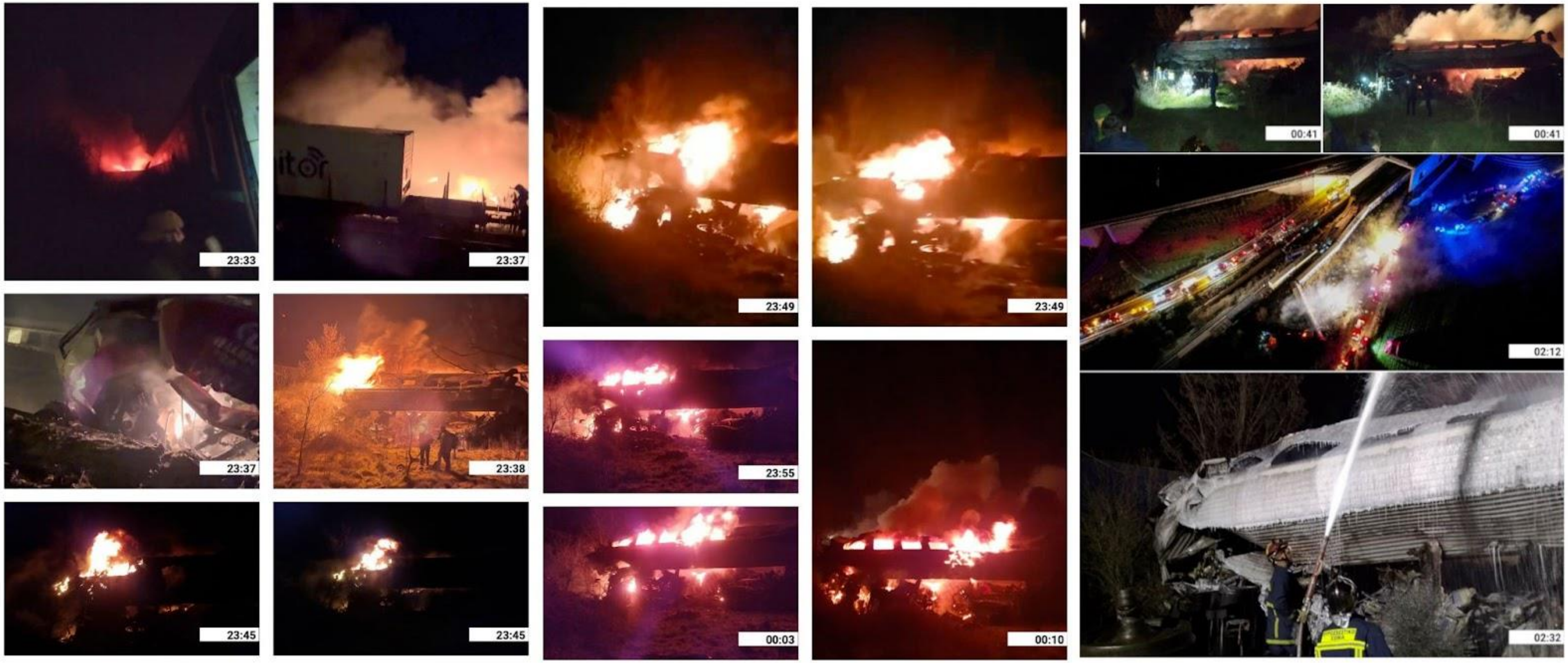


Figure 35. Photos of the fires development and their timestamp (source: EDAPO).

3.10. Factual description of the events: from the occurrence until the end of the rescue services

158 At 23:18, presumably only a few seconds after the collision, the train driver of 2597 train, parked and waiting at Larissa station, calls the station master on the VHF radio and says "Larissa we have no power".

159 At 23:19, two calls are received almost simultaneously at the 112 Emergency Services switchboard, as a result of automatic activation of an emergency call by the iPhone 14 that has this specific feature of recognising a traffic accident and initiating the call. The GPS data recited by the two phones were inaccurate, most probably due to the fact that the phones were inside a speeding train with bad satellite reception. The 112 operators did not realise that this was a rail accident and think at a car accident. They tried to communicate with the caller, without success, so they mobilised the emergency services towards Makrychori, referring to the inaccurate GPS point.

160 At 23:21, a third call is received at the 112 switchboard, this time from a passenger from outside the B2 coach, that gives the information that a train has derailed and there is fire. The 112 operator informs the Fire Service, Police and Ambulance services but the exact location was not clear yet (GPS data was still inaccurate and the caller couldn't pinpoint his position).

161 At 23:22, approximately 3 minutes after the collision, the Electric Traction Controller from Thessaloniki calls the station master at Larissa to tell him that he has an indication of short circuit on the line between Larissa and Rapsani.

162 At about the same time, approximately 23:22, a small van with 2 electricians, working for Aegean Motorway, stops on the asphalt road overlooking the scene of the accident, closely followed by an empty tourist bus who stops also at the same place. The electricians call their Control Center and their Control Center, in turn, calls the authorities to give the exact location of the accident (also recorded on their traffic cameras).

163 At 23:24, the Police starts to summon police cars to proceed to the area.

164 At 23:25, the Fire Service also mobilises its specialist rescue teams and all available fire trucks towards the scene of the collision.

165 At 23:38, (as confirmed by videos recorded by passengers and cross-checked with the footage of the traffic camera's) which is 13 minutes after being alerted and 19 minutes after the collision, the first Police car, coming from the Tempi police station, arrives at the scene and its two officers walk down to assess the situation.

166 At 23:40, 23:42 and 23:44 (as recorded by their ENGAGE system) the first 3 Fire Service vehicles arrive on scene (2 rescue vehicles and 1 water carrying vehicle) from the 3rd station of Larissa, 12 km away.

167 At 23:43, we can see the flashlight of a fireman shining towards the B3 coach (photo from passenger).

168 At approximately 23:46 and 23:47 another 2 Police vehicles arrive from the asphalt road overlooking the accident site.

169 After the first calls to 112, the Ambulance Service was informed about the accident and at first summoned 3 ambulances (time of call 23:31). The first ambulance arrived at the scene of the accident from the asphalt road overlooking the accident site at 23.48 and the other 2 minutes afterwards (time was not recorded exactly by the dispatch center). Presumably the first ambulance crew made an initial assessment of the grave situation and radioed back to the radio dispatcher, because 5 minutes later (at 23.53) the Ambulance Service urgently summoned another 7 ambulances and continued to find and call every other possibly available ambulance from any nearby area.

170 At 23:50, a policeman approaches the B3 coach and can be heard talking to the fireman already there (video recorded by the policeman).

171 During the first 40 minutes (until 23:57) 12 ambulances were summoned and another 12 were summoned during the first hour after midnight. Of them, 4 ambulances arrived before 0:00 and another 17 arrived before 01:00 to collect injured and fatalities.

172 At 00:02, the first firefighting vehicle starts to pump water towards the raging fire from the upper side.

173 At 01:08, firefighting starts from the lower side.

174 By the information provided by the Ambulance Service records and by correlation to other evidence (photos, videos, interviews) it can be deduced that any rescue effort ended around 01:35 with the last of the seriously injured passengers leaving the accident site in an ambulance. From this time onwards, the Ambulance Service started to bring only fatalities to the 2 hospitals at Larissa.

175 During the first 3 hours after the collision, senior Police officers, Civil Protection coordinators and Hellenic Army and Hellenic Air Force officers arrived at the scene along with many more Fire Service vehicles, ambulances and more Police cars. There is no record of the time of arrival of individual officers or from civilian personnel from the Region of Thessaly that coordinates Civil Protection for the area.

176 At 02:30, all representatives of the emergency services have a brief meeting in order to activate the Civil Protection Coordination Body in the context of the implementation of the current institutional framework.

177 During the night, the Fire Service summons its own large crane and a second crane is brought by a civilian contractor working for the Larissa prefecture, along with bulldozers, excavators and gravel trucks.

178 At approximately 05:30, the Fire Service Unmanned Aerial Vehicle Team flies a quadcopter drone over the scene of the accident, remotely sending live video footage to the National Coordination Centre for Operations and Crisis Management (ESKEDIK).

4. Analysis of the occurrence

The following chapter aims at providing a systematic analysis of all the roles (activities) and duties (tasks) of all actors playing a role in the events leading up to the accident and its further handling. This is done by systematically analysing the influencing circumstances for actions and/or decisions, as well as the related feedback and control mechanisms, including risk and safety management as well as monitoring processes.

4.1. Functioning of the technical installations

179 During the investigation, no problems were identified with the functioning of the rolling stock in relation to the cause of the occurrence.

180 On 01/03/2023, around 6:30 to 7:00 in the morning after the accident, the technical experts appointed by the judicial investigation went to the Larissa station, where they inspected the control panel and the infrastructure components to determine the correct operation of the control panel and the response of switches 118 to the operations of the control panel. They concluded that there was no indication of any malfunctioning.

4.2. The regulation of train traffic

181 To be able to better understand the activities and decisions that led to two trains running in opposite directions on the same track, the following critical events were further analysed: setting the route for train IC-62 by the station master of Larissa (4.2.1), the "window" he had for detecting the wrong position of switches 118 (4.2.2), the procedure for authorising the departure of train IC-62 (4.2.3), and the expectation for the train drivers to react on the contradicting information between the received authorisation and the position of switches 118 (4.2.4).

4.2.1. Setting the route for IC-62

182 Probably immediately after having received the information that train IC-62 has left the Paleofarsalo station to move towards Larissa and having instructed the switch operator to position switch 101 to allow train IC-62 to switch from the descending to the ascending track when entering Larissa station, the route for the train IC-62 to move from Larissa station to station Neoi Poroi is manually undertaken, around 22:46. While several switches were to be turned, the last ones in the set, switches 118A/B were left in the diagonal position that had allowed the train 2597 to enter Station Larissa a few minutes earlier. In the following sections, the context in which this action took place is further analysed.

4.2.1.1. Intention

183 There is no indication that the Larissa station master had the intention to leave these switches 118A/B in the diagonal position, and to guide the train IC-62 towards the descending track. This is supported by the recorded communications. Where communications for traffic between the stations of Paleofarsalo and Larissa (e.g. at 22:44 or 23:05) explicitly mention the use of the descending track, as expected, the VHF communications concerning the departure of train IC-62 from Station Larissa only mention on the other hand the route until the entrance of Neoi Poroi, without mention of the descending route (Article 100, point 1006.A of the operational rules). This is an indication that it was not the intention of the station master to send train IC-62 on the descending track.

184 In addition, in the communication through GSM-R with the station master at Neoi Poroi starting at 23:05, there is an exchange of telegrams between the station masters for both the departure of train IC-62 in Larissa towards Neoi Poroi as well as for the departure of train 63503, being sent by the Neoi Poroi station master to the Larissa Station. This however did not help to realise or detect the error. On the contrary, the logic of sending each train on a separate track being strong (each train on its normal route, one on the descending track, the other on the ascending track), this may have reinforced the belief that everything was fine.

185 To forget a step in a sequence of an operation, and particularly with a delay of more than a few minutes between the initial set and its completion, is a common human error, more tied to action support than to the person's

knowledge. By definition, to forget is a non-intentional decision. Its execution and its (non-) recovery before any consequence are mostly influenced: by the workload and pressure, by the level of support given by colleagues, by operating or monitoring tools (technical or organisational). It is therefore absolutely necessary to investigate the context of a (non-)action more in-depth, in order to understand the influences in/of the situation and the organisation.

186 The route for the train IC-62 to move from Larissa station to station Neoi Poroi has been manually undertaken, and not via a more automated procedure. This violation of an existing procedure falls into a category called "routine violation", being a potential source of confusion while experience is growing. To put it in the context of the traffic control room, as analysed in more in-depth through the next points, this more automated procedure - although considered mandatory- was/is not the-single-way-of-doing-the-job. Instead, the manual manipulation of switches was/is still needed and commonly used every day, by every station master, as observed on-site and discussed during several interviews, including with supervisors and management.

Further analysis of the activities has identified a series of other elements that have contributed to this error in the route setting for train IC-62. These are further developed in the points below (4.2.1.2 to 4.2.1.12).

4.2.1.2. The Larissa control panel

187 The main goal of the control panel in operation at the Larissa station on 28/02/2023, in the traffic control room (Figure 36) is the same as for the original control panel that was installed in the '80s: remotely controlling the movement of electrically driven switches and the opening of line-side signals that will allow the passing of trains. Around 2010, the control panels that were functional in the Orfana-Larissa section, gradually stopped working due to technical problems with the control, command and signalling systems and by 2014, except for Larissa, all other control panels were placed out of service. The control panel in Larissa was kept operational and the switches could be operated remotely until around 2017.

Figure 36. The traffic control room with station masters at Larissa Station.

Figure 37. The control panel at Larissa Station

188 The normal operation method of the control panel for the movement of electrically driven switches and the opening of the light signals that will allow for a train to pass, is the simultaneous control of two buttons that automatically set the route (Figure 38).

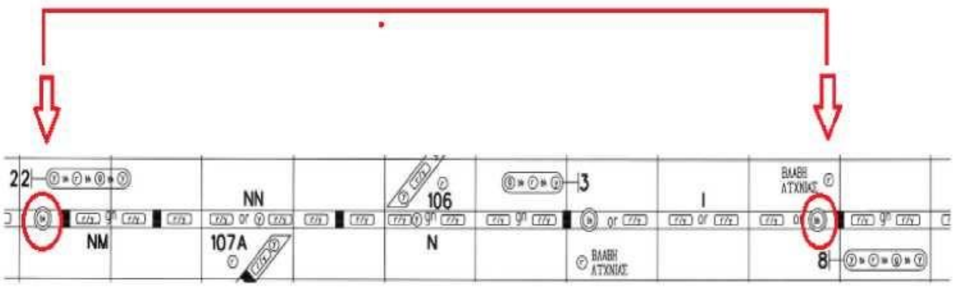


Figure 38. "Automatically setting" the route for a train as explained in the Control Panel manual[5].

189 As it can be observed on the global photo of the control panel (Figure 37), it is a large area with many information and commands that cannot be considered at a glance. To pass from one mode to the other (manual mode to or from automated mode), the station masters must turn a numbered key (the number refers the number of the switch) on the top of the control panel (Figure 46), separately for each switch. The area where to read the switches numbers is small and partially hidden by the plastic and metal key rings (this point is further analysed in the chapter 4.2.2). In the actual practice of using these keys, as it has been explained and shown on site, at least two ways of manipulating them co-exist, one of them being indicative of lack of trust in the system and/or lack of experience (4.2.1.3).

[5] Note that this Figure 33 depicts a generic situation and not the situation specific for Larissa.

190 Considered as a global tool, the control panel remains a complex and partial representation of the station real-world site. In particular, as it can be understood by observing the manipulation of the control panel, distances and time are treated in a different way: while the space is schematised and contracted, time estimation remains implicit, being inferred by the station masters without knowing the actual speed of the trains. The position and movement of trains along the lines are represented by the lights (Figure 39), lighting on (when passing) and off (when passed). While it takes an experienced station master a few seconds to process the passage of a train, it is different for novices (confirmed with several of them). It is clear that this tool generates moments of uncertainty and stress (this point is further analysed in the next paragraphs, and 4.2.6) during both the 'information processing' and 'command execution' stages of their actions.

Figure 39. Position and movement of trains, here in the section ET2 depicted on Katerini Station control panel.

191 The Larissa control panel in the station masters' traffic control room, as well as others in actual operation (Figure 40), is supplemented by pieces of paper "taped" or just "laid" on the inclined panel. Their operational function is to remind the station masters of important local information on operational restrictions or degradations, some for a few hours, others for months (and even longer).

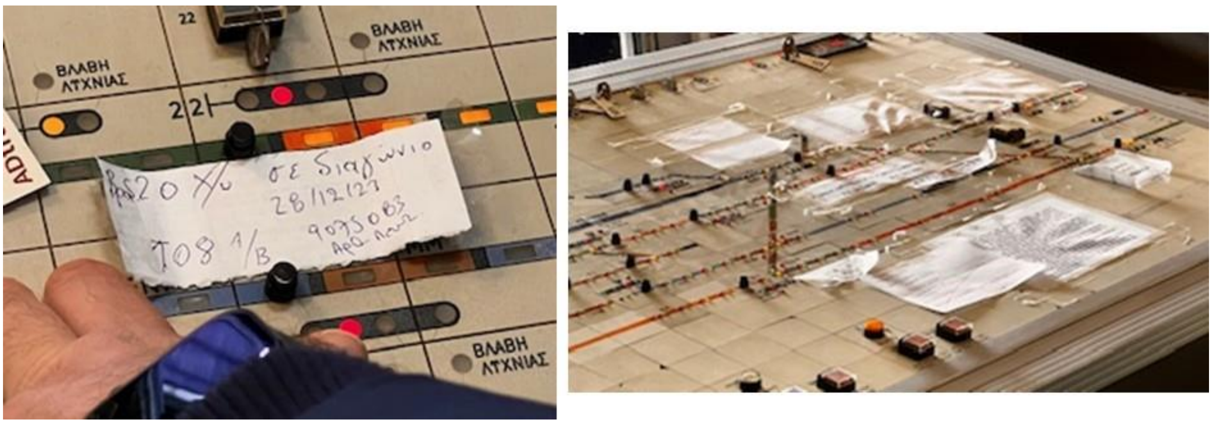


Figure 40. Useful pieces of information.

192 Taken together with another source of influence, namely the numerous communications (as analysed in point 4.2.1.8), in the period of time just before and while the control panel was showing the passage of train IC-62 (240), it should be noted that this panel and the communications area are organised and physically positioned in a way that makes it very difficult to perform both tasks at the same moment. In morning and afternoon shifts these tasks are performed by two station masters in order to avoid excessive workload. When you are concentrating on communications, you are turned sideways in relation to the control panel and the LEDs that are lit in this case are behind you (Figure 41. Positions of station masters when facing the control panel (above) and when

communicating (below) in Larissa station.

193). This directly, logically and naturally explains how Larissa's station master did not 'see' or 'look', and therefore did not 'detect' the train's passage towards the descending track (4.2.2). During the investigation, 2 other situations were identified by the investigation team: one in which the station masters had adapted it and added a desk just in front of the control panel (Figure 42), and the other one, in Athens, when a Station Manager reported this as an issue and their manager made the situation more adapted.

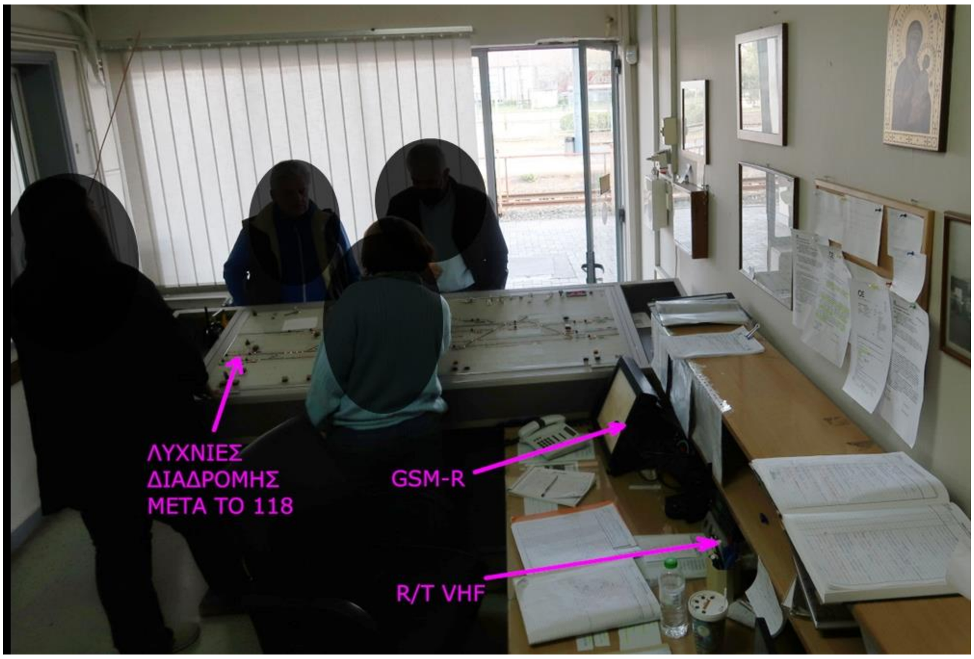


Figure 41. Positions of station masters when facing the control panel (above) and when communicating (below) in Larissa station.

Figure 42. Position of the station masters having adapted their own desk (Station Afidnai).

4.2.1.3. Readiness of station masters for use of the Larissa control panel

194 Following the completion of works to redevelop and test the signalling systems in the Orfana-Larissa section, the control panel in Larissa station was officially handed over by ERGOSE to OSE on 01/11/22 for placing in service.

195 In preparation for this commissioning, the contractor who re-activated the control panel sent on 18/10/2022 a revised manual on how to use it. This manual is a generic explanation on how to operate a control panel and is applicable for the control panels of the same type that are available in several stations. As far as we could identify, no specific work-instructions describing the maneuvers to be carried out for each train (in automatic or manual mode, in normal or degraded mode) were made available. Especially for new station masters, this may have influenced some inconsistent handling of the control panel (see also 4.2.1.4).

196 The contractor also organised one training for station masters in Larissa on 20/10/2022. This training, which included a presentation of the handling of the existing panel and the newly introduced functionalities as well as a practice session, was planned to take place from 9:00 to 13:00.

197 At the time of the training, all station masters working in Larissa were experienced and permanent personnel who had already worked on the Larissa control panel before 2017. Three of them are reported to have taken part in this training. None of the new station masters, enrolled for the 08-2022/01-2023 training, had already been transferred to Larissa and therefore did not benefit from this locally organised training. Based on the provided information, it is unclear whether these newly recruited station masters were trained and assessed in the practical application of operational and local working instructions of the respective control panels they would have to use.

198 At the request of OSE on 16/11/2022, the delivered system of the Larissa Station was modified to allow the station masters to be able to automatically set the departure routes from Larissa to the north. In addition, the signal at the starting point of the route should remain showing a stop aspect and only be passed after an explicit authorisation in accordance with Articles 121 and 122 of Part B of the Operational Regulation (General Movement Regulation, called GKK). To support this request for amendment, it was stated that in the then current situation: "station managers are obliged to operate complex operations (the departure of a local Larissa-Thessaloniki train requires 8 track changes to be checked)" (91).

199 Already on 02/08/2022 OSE issued an "Urgent guideline" making the use of automated mode for route setting mandatory, whenever possible. Although this instruction was mainly aiming at the use of control panels in the area of Thessaloniki, where manual operations had led to mistakes, it was equally intended for future control

panels that were planned to be taken in service and therefore also applied to the use of the control panel in Larissa.

200 Following this technical amendment, OSE issued on 23/12/2022 a new instruction for the use of the Larissa control panel, mandating that: “The station masters of Larissa, necessarily, will form the route using start and target buttons. The exit light signals will remain showing a stop-aspect and will be passed by order of the station master, after making sure that he formed the appropriate route and that the conditions of freedom of the block section are met until the next station in service.”

4.2.1.4. « Normal/accepted » practice to continue to use manual route setting

201 The Larissa station master set the route for IC-62 to move to the north in a manual way, turning the related keys on the control panel for this purpose. This manual operation was recognised as more complex and several instructions were issued (198), so that it was expected for this specific route to be set automatically.

202 As was found when analysing the recordings of manipulations on the control panels for the four previous nights (i.e. 24 to 27 February), the same station master had used the automated way of setting the route for train IC-62 all previous nights. Using the manual way of setting the route for IC-62 on the evening of the 28 was a break in this pattern. These records, however, when looking at the overall picture of how the routes were set for different trains, also clearly indicate that both ways of setting the route, manually and automated, were used interchangeably by this station master.

203 In addition, several of the interviewed station masters, with different levels of experience, declared that in some (degraded) situations or systematically for certain (mostly local) trains, the normal and accepted practice is the manual route setting. This combines with the fact that the automatic setting of the route for trains moving north of Larissa was only technically possible after the introduction of the requested change on 23/12/2022 (198).

204 From the above, it is almost inevitable that the newly recruited station masters will have observed the interchangeable use of the control panel in Larissa. Especially for new station masters, this point of having a partial or conditional set of rules and practices may have influenced some inconsistent handling of the control panel.

4.2.1.5. Competencies

205 The station master performing the night shift on the night of the accident was recruited through a different process than that of the 200+ fixed term new employees (100). As a former employee of OSE, he applied (along with a few others at that time) through a law concerning the “internal movement” into different positions of employees of the wider public sector. His application and re-employment to OSE coincided timewise with the recruitment of the contractual employees, recruited during the summer of 2022, and therefore he made part of the same six-to-seven-months training and education process. But his employment status was permanent.

206 A bit more than one month before the accident, end of January 2023, the Larissa station master succeeded without any doubt at both oral and written exams, after the basic training. From interviews and official declarations we can conclude that he was also perceived by his supervisor at Larissa, by his practical colleagues-trainers and by his co-trainees as very keen to learn and do well, asking questions and looking for answers. In terms of Non-Technical Skills (NTS) or behavioral competencies, he has been described as helpful and eager to work, but also having quite a strong character, and rather over-confident. It should be noted that in this profession it is necessary to acquire a good level of self-confidence, in order to be able to master all the influences weighing on them, as it has been mentioned by several of the lastly recruited station masters, who refer to a period for this of one to one and a half year (301301). This contrasts with the 6-months (renewable) contracts made for most of these newly recruited station masters.

4.2.1.6. Working alone, Job design and Time pressure

207 On the 28th of February 2023, the Larissa station master has been called to start earlier by the station masters of the afternoon shift, because of their exhausting workload of the service, according to the content of the communications and later declarations. Therefore, the nightshift station master took his turn around 21:45 (i.e. involved in his first recorded communication). He was then left alone around 22:15 to 22:20 according to himself and the last communication in which the previous station master was involved (22:04).

208 There is some confusion about the mandatory overlap of hours between the different shifts in Larissa. While on paper the evening shift starts at 22:00 and the afternoon shift ends at 23:00, it can be concluded from official declarations as well as from interviews with various people involved that the current and accepted practice is to end a shift as soon as the next station masters has been informed about the situation of the train traffic and has taken over responsibility for it. On the other hand, there is a recorded conversation in which a colleague seems to be questioning the (imminent) departure of the station master of the afternoon shift, when his call is already answered at 22:00 by the station master of the night shift. This lack of a clear procedure and practice, which should be established for the whole network, contrasts with the potential need for assistance in heavy workload conditions for the newly certified station masters with these risks of the shiftwork organisation being managed at a team-leader level, with the need for a structured performance monitoring through more experienced peers (4.2.7312).

209 Only having one single station master for the night shift in Larissa station was a conscious choice when designing the job. So, at night, the station masters are alone to decide. They take care of all the station master tasks (traffic, communications, documentation, reporting, and self-check). This approach was/is thought to be possible because of less trains (~13) than in the morning (~20) and in the afternoon (~28). Additionally, there are also the traffic regulators (75) who work 24/7, in this case one person, from Athens.

210 However, once correctly considered and understood, the actual workload appears potentially more problematic in terms of dispersion. Indeed, there is a high concentration of trains during the first two hours of the night, from 22h to midnight, and a second peak, less high, at the end of the night, in the early morning. The first effort is all the greater when one or more trains of the previous shift are late and are taken care of by the nightshift station master, not by the ones of the afternoon shift. This was the case the late evening on the 28.02.2023 (Table 5).

Late evening 28/2/2023 Larissa Station Traffic	**Scheduled time**		**Actual time**	**Arrival delay (min), notes**
TRAIN NUMBER (From - To)	ARRIVAL	DEPARTURE	ARRIVAL	
2594 (Larissa - Thessaloniki)	18:54	18:54	28/02/2023 21:15	Mechanical failure, returned to Larisa, on 3rd track
2575 (Volos - Larissa)	22:02	22:02	28/02/2023 22:13	Parked on 6th track cause of 2594
62 (Athens - Thessaloniki)	**22:09**	**22:11**	**28/02/2023 23:02**	+53 min, managed
2597 (Thessaloniki - Larissa)	**22:20**	**22:20**	**28/02/2023 22:48**	+30 min, managed
2576 (Larissa - Volos)	**22:30**	**22:30**	**28/02/2023 23:10**	+40 min, managed
1564 (Καλαμπάκα - Larissa)	**22:32**	**22:32**	**28/02/2023 23:30**	+58 min, managed
2598 (Larissa - Thessaloniki)	**22:54**	**22:54**	**28/2/2023 -**	Managed, late and cancelled due to the accident
63503 (Thessaloniki Freight - Thriasio)	**23:06**	**23:08**	**28/2/2023 -**	Managed (cf. telegram), but didn't arrive to Larissa
2599 (Thessaloniki - Larissa)	23:58	23:58	28/2/2023 -	Not managed, cancelled due to the accident

Table 5. Table with normal service as scheduled, and actual service on the night of 28/02/2023, with the coinciding delays.

211 With the Table 5, the actual workload due to the coinciding delays can be understood. The defective train (56, renamed to 93506) had been occupying the ascending track and complicating traffic before departing from Larissa on 21:50, and operated by the nightshift station master who started earlier. Then, with one defective train (2594) occupying track #3, he had to manage one train running late (63 should have departed from Larisa on 20:46), but also the usual 5 other trains (2575, 62, 2597, 2576, 1564) that were scheduled within a period of one hour (22:00-23:00) plus the announcements and interactions regarding the freight train 63503, all with their own delay, including the management of his own error with train 2597 (4.2.1.9), and the high number of communications (4.2.1.8).

212 This kind of interactions between job design, the workload, the complexity and the time pressure emerging from traffic with delays, can be a critical issue especially for the less experienced workers who need more time to operate or recover.

4.2.1.7. Static/structural additional workload related to the technical deficiencies

213 A series of technical defects and malfunctions, some specific for that day but others already present for several weeks and sometimes even years, created a situation in which station masters operating in Larissa were obliged to perform a series of additional activities compared to the reference situation, without incidents.

214 Due to a problem with the overhead line that occurred earlier that day, traffic between the station of Paleofarsalo and Larissa was operated on a single line (92). This requires additional attention as well as specific communication between both station masters. Furthermore, this also requires an additional action for the trains that enter Larissa from Paleofarsalo from the descending track because the switch-combination 101 had to be turned into the bypass position to allow them onto track 2 in Larissa station (Figure 43).

215 Due to technical problems the switch 101A could not be operated remotely (94, Figure 43), via the control panel. To be able to maneuver the switch in the desired position, the station master has to instruct the local switch operator who in turn has to walk towards the switches and fix them in the requested position with a physical intervention. The station master in Larissa instructed the local switch operator at 22:46 to position switches 101 in a bypass position, directly after being informed by the station master of Paleofarsalo that train IC-62 had left for Larissa. At 22:57, the switch operator informed that the activity was performed.

Figure 43. Switches 101A/B

216 Finally, the absence of signalling in the section(s) north of Larissa, with the exit signal LAR 11 from Larissa station in that direction permanently showing a stop aspect, required from the station masters in Larissa to each time explicitly authorise the train to pass the stop showing signal. In application of Articles 121 and 122 of Part B of the General Traffic Rules, this is done by means of a written order (model 1001), or a telegram message that has to be entered in the Traffic Book of the station. According to this Regulation, this order serves at the same time to attest to the observance of the free line, which in turn demands “the conditions of freedom of a block section to be ensured through communication with the next station on duty”.

217 Common practice was for this specific order to pass signal LAR 11 when leaving Larissa station to the north, to be given by telegram and not with a written order. As will be discussed later (4.2.3.1) this practice, combined with the systematic neglect of structured communication discipline, has led to the weakening of the procedural safety barrier for passing stop-showing signals.

4.2.1.8. High number of communications

218 A significant portion of the workload of the Larissa station master on the evening shift of 28/02/2023, observable and quantifiable, was made up of the received, given, or monitored communications. All recorded communications (VHF radio, GSM-R, 2 fixed telephone lines) from 21:45 onwards, when the station master serving the evening shift has been left in charge of communications, until 23:15, have been listed in one unique file (hence with about 90 min. of different communications). The analysis shows that this period was very intense, with 97 communications of 23 seconds on average, 32 overlapping communications between them and only 17

communications where the station master had to listen only (monitor). For the third half hour, it intensifies even more with 50 communications with a comparable average duration and overlapping. The cumulative duration of communications is 25% longer in this last half hour, leaving less time to understand what was happening, to anticipate and to reason correctly, or even to share some issues with someone.

219 The variability that resides in the error made by the Larissa station master may have parts of its sources of influence in the amount, the duration and the diversity of the communications he had to treat, process or follow-up, especially during the last hour and even more during the last half an hour. Indeed, considering the number of interlocutors (train drivers, switch operator, level crossing guard and residents, policeman, station staff, traffic regulator and other station masters), the topics, and the duration left to "think" or "write", several experimented station masters including one of their managers admitted that the workload at this period of time was more than critical. And with such a combination of workload factors being very rare, it can be considered that this situation has been a huge trap for an insufficiently prepared or unexperienced station master.

220 Analysis of only the communications, not even taking into account other tasks, indicate three peak periods (Figure 44) that appear to correspond with the consecutive mistakes made by the station master: setting the routes for respectively the train 2597 and IC-62 and not detecting the mistake with switch 118. This indicates that periods of too heavy workload, in particular for less experiences operators, can be a direct cause for errors, mistakes and routine violation, because there is "no-time-to-think" or one is "captured-by-the-flow-of-issues-to-contain". This type of workload analysis, with results beyond human capabilities, shows the importance of integration human and organisational factors in risk management practices (4.2.80).

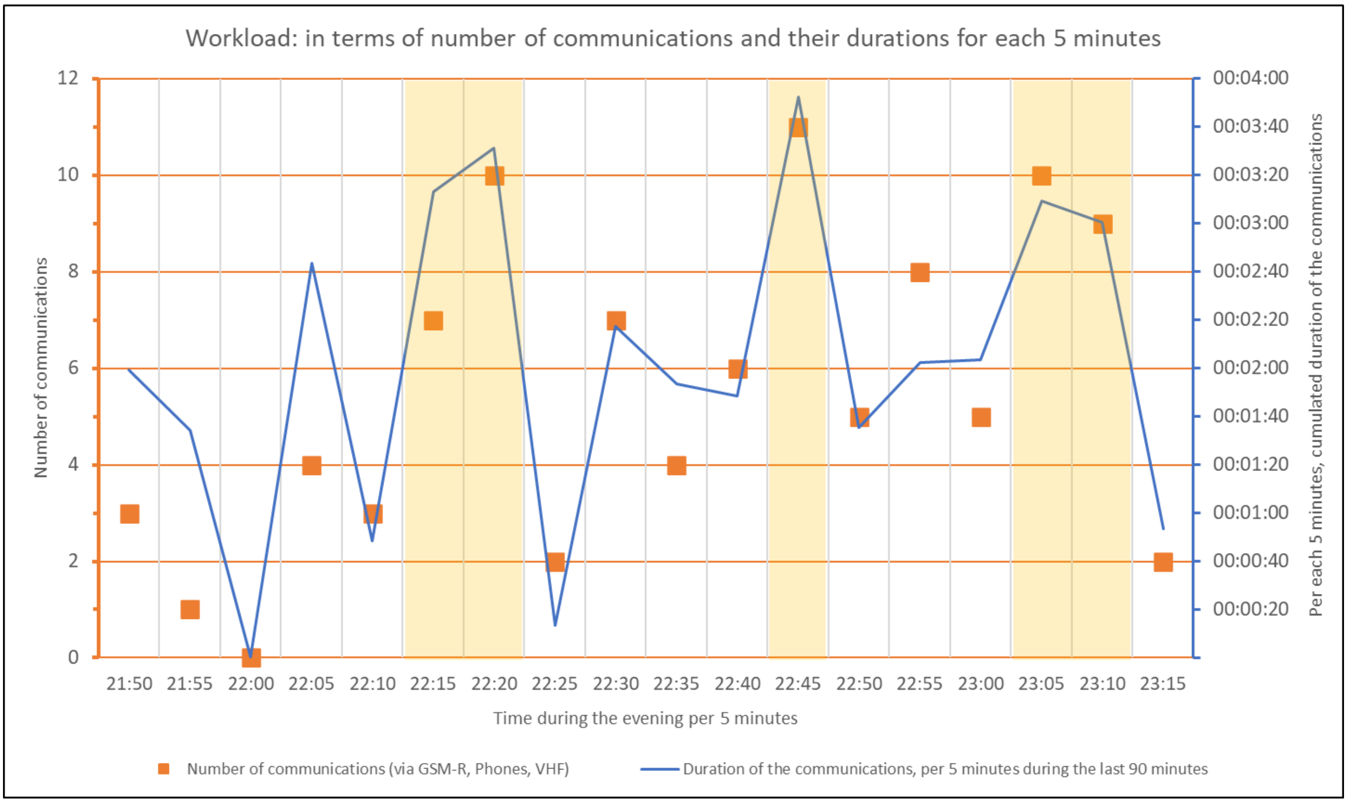


Figure 44. Factual analysis of the communication worload as a risk to be taken into account during HOF integration.

221 While analysing the number and the diversity of the communications, we could also observe that despite the frequent poor quality of the sound, the VHF radio is the most used mean of communication, except between Stations Masters who were using both the GSM-R (with telegram numbers most of the time) or the fix line phone.

4.2.1.9. Dynamic additional workload

222 Approximately around 22:35, after having received a call from the train driver of train 2597 that he was approaching the station, the station master of Larissa manually set the route with the intention for train 2597 to enter Larissa station from the north and be guided to the dead-end track between tracks 2 and 3.

223 This would require the setting of switches 118A/B, 117 A/B, 116, 115B and 111 to be turned in the adequate position (Figure 45). Note that this is also the action that directed switches 118 in the bypass position. Before that, these switches were turned in the straightforward position at 22:12 for the entry of train IC-63. From the recorded actions on the control panel, it can be seen that this was the last time before the departure of train IC-62 that the switches 118 were manipulated through automatic route setting.

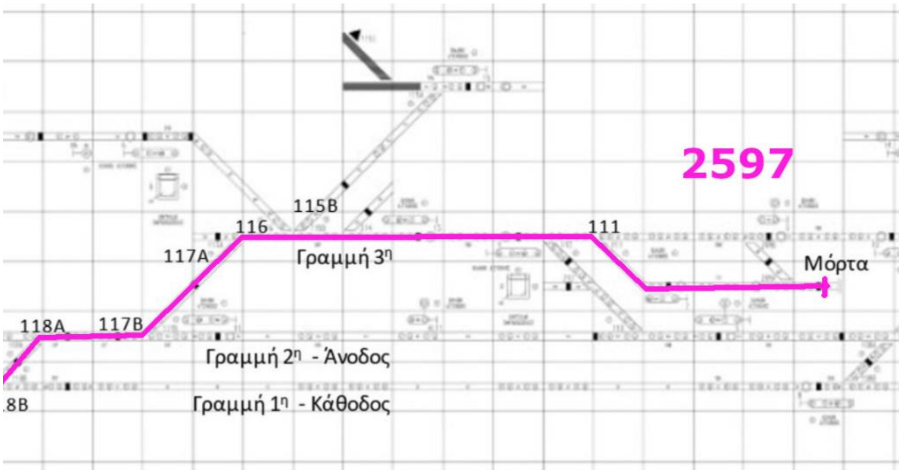


Figure 45. The route for the entry of train 2597.

When manually setting the route for the entry of train 2597, the station master of Larissa forgot to turn the switches 116 and 115B in the correct position. On other occasions these switches would have been in the right position after the entry and acceptance of train 2575 from Volos on track 3. Earlier in the evening, on the 28/02 this train 2575 was positioned on track 6 at 22:10 by the station master of the afternoon shift because track 3 was occupied with train 2594 that had been brought back to the station at 21:30 after traction problems arose on its way to Neoi Poroi (93).

224 This error was detected by the train driver of train 2597, who stopped the train in front of the switches and contacted the station master of Larissa to understand the situation. After having realised his error, the station master instructed the train driver of train 2597 to go back to free the section so that he could put switches 116 and 115B in the correct position. This activity required the full attention of the station master of Larissa between 22:35 and 22:41. Train 2597 finally arrived at a standstill on the dead-end track in the station of Larissa at 22:48.

4.2.1.10. Emotional weight of a previously made error

225 The whole incident with the misrouting of train 2597 is filmed and documented by the train driver of train 2597, with the aim of reporting it in his route journey. He also informed the Traffic Control Center of Hellenic Train on the incident via phone. Furthermore, in the communication on the incident via the open VHF channel, in particular the Train Manager of train 2597 was disrespectful towards the station master.

226 Furthermore, at 23:00, the operator of the Traffic Control Center of OSE calls the station master of Larissa to ask about the incident with train 2597 he was informed about by the Traffic Control Center of Hellenic Train. The station master of Larissa downplays the incident, without giving any specific details. The operator of the Traffic Control Centre anyhow reminds the station master of Larissa to report the incident, hereby mentioning “report it, they have reported it”.

227 At 23:15, the Larissa station master calls his colleague from the afternoon shift, also responsible for reporting findings and incidents for the station area, to talk about the incident of mis-routing train 2597 and, concerned about the reporting of the incident by the train drivers, to ask him what to do. The latter replied that they could report the incident together when in the office the morning after.

228 All this takes place in a context of general tension between train drivers and station staff. Only a few months earlier, following a collision at a level crossing, allegedly documents had been amended by station staff, in an attempt to shift the blame for the incident onto the train driver. This case was even brought to court by the train driver against the Station Manager's Supervisor in charge.

229 It can be expected that this incident and its aftermath created an emotional weight on the station master of Larissa, who as we remember only recently took up service, which may have occupied his mind and created an additional element of worries.

4.2.1.11. Physical "sacralisation" of the room

230 Although there is no evidence that this has actually influenced the attention of the station master when setting the route for train IC-62, it was reported as well as observed during onsite visits, that the operation room for station masters in Larissa is positioned on the platform along track 1 and was without the possibility to provide a separation from the waiting passengers. From this point of view, one can conclude that the commercial role is not fully separated from the safety one, and beyond the advantages, they can interfere.

231 This created a situation in which station masters were frequently disturbed by bypassing colleagues or often even angry passengers requesting information on the arrival of trains that were frequently delayed. Evidence of this was also recorded in communications earlier that day.

4.2.1.12. Fatigue, Age & Time Pressure

232 There is no direct and clear indication that fatigue or lack of sleep, either for the Larissa station master or the train driver(s) of IC-62, contributed to the accident, as far as it could be assessed. However, it seems that the provision or the monitoring of actual shifts can be considered as problematic, in particular for the station masters and at least until March 2023 (4.2.6.2).

233 How the factors of fatigue and age are influencing the performance of operational staff, remains a subject that is worth further analysis, since both profiles - the train driver in charge of the train IC-62 and the Larissa station master that night - were at risk considering their respective individual professional past, health and age. Not only the risk of fatigue should be considered, but also the interaction with the physiological age. This may have been a concern for both the train driver in charge of train IC-62 (59) and the Larissa station master (59). Nowadays, it is recognised that the ability to recover from working irregular hours and nightshifts is lower at their age than for persons in their early fifties for example.

234 This interaction between factors like Fatigue and Age may have played a role, both cognitively (slip, lapse, violation, etc.) and behaviourally (over-confidence, perseveration in error, irritation, etc.). And this, especially in a situation of delays where the time pressure is adding its influence, as was the case in this occurrence: to dispatching the train as quickly as possible with a high risk of precipitation or hurry, and failure to question, review or check for the station master; to recovering a delay on a main passenger train, with additional time added in terms of service hours, at a time that is very tiring for everyone, with the same high risks for the train driver(s).

4.2.2. Identify wrong position of switches 118

235 One possible way to prevent the departure of train IC-62 from the descending (wrong) track was for the station master to recognise his own error in time, and intervene to position the switches 118 correctly and/or instruct the train drivers to stop.

236 On the upper part of the control panel, there are three-position keys that are numbered according to the electrically driven switch they handle. These keys are used for the independent, manual control of any electrically driven switch. Turning the key from the central position by 90 degrees counterclockwise will command the switches to move to the "main" position (indication "K"). Similarly, by turning the key 90 degrees with the clock, the switches are commanded to move to the "bypass" (indicator "Π") position. When there is a correspondence between the physical position of the switches and their control key, the yellow light diode for the indicated position of the switches is lit steadily. Above the key of each switch, there is also a red light diode, in the central position marked "A". This is the position the key should be put in to allows for "automatically setting" the routes. (Figure 46).

Figure 46.Detail of the three-position key for handling switches 118 on the Larissa Control Panel.

237 Switches are indicated on the Control Panel by the intersection of the lines showing the railway lines. Each switch is marked with a number and a letter if two switches have the same number. There are two yellow lights that indicate the position of the switch position in "main" or "bypass"(Figure 47). By setting the route, the lights in the area of the switches light up, as a combination of the light at the entrance of the switch and either the “main” or “bypass” path.

Figure 47. Detail of the switches 118 on the Larissa Control Panel (main-moving-bypass).

238 Lines on which the presence of a train is detected by track circuits or axle counters are displayed on the Control Panel in a sequence of colours delimiting the track circuit or the area controlled by each axle counter. The main lines use a sequence of colours orange/green for the ascending and blue/brown for the descending tracks (Figure 48). Within the coloured lines representing detection circuits photodiodes are placed that light up to give information to the panel operator. Lighting the yellow light on a track circuit means that a train has been "routed" to cross the section of line which is bright. The yellow light remain bright until the train reaches the circuit, when they are switched off and replaced by a group of red lights, which means that there is a train in the specific detection circuit.

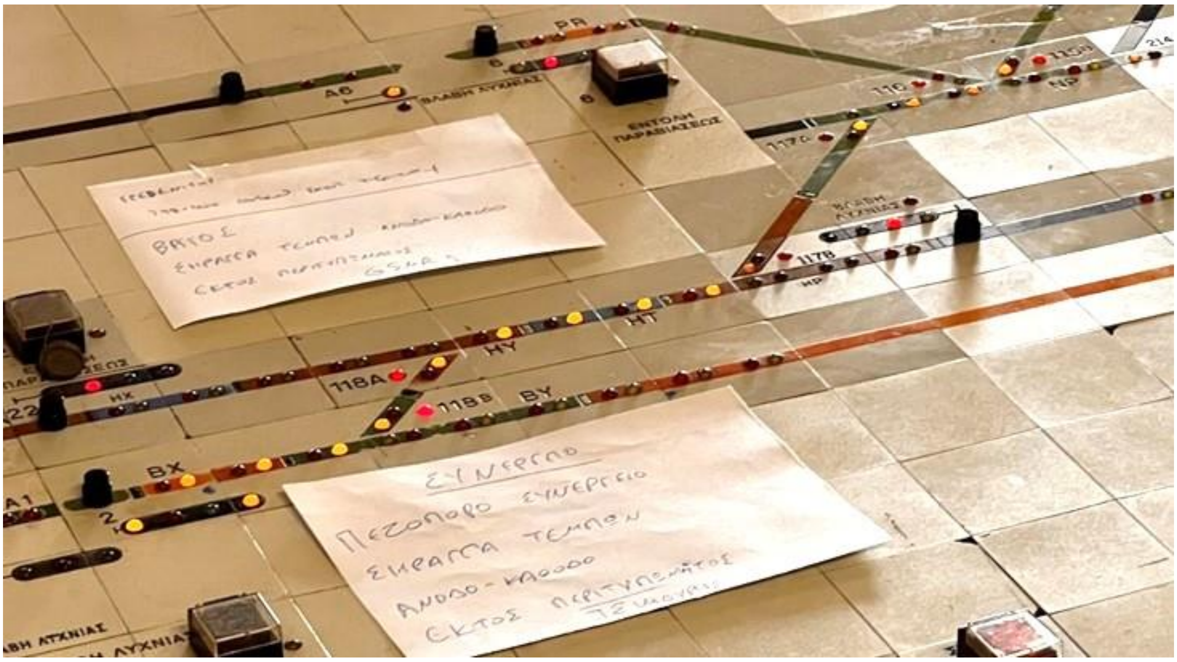


Figure 48. Detail of the Larissa Control Panel with a route set to cross a switch in a bypass position.

239 The Control Panel of the Larissa station was put back in service on 01/11/2022 (194) up to section EA1. The reason for this is that section EA2 partly covers Larissa station but also parts of the Larissa commercial station situated more to the north. This section was planned to be delivered later, as part of the Larissa-Platy works. This however meant that the Control Panel was taken in service without section EA2 of the Control Panel showing any indication. This was also the case on the evening of 28/02/2023, as can be concluded from the “Conclusions of the Commission of experts” who report having observed this during their on-site visit to the Larissa station on 20/03/2023.

240 In the section EA3 (indicated as “EA” on the control panel) there was a permanent indication of occupation as the signalling towards the north of Larissa had not yet been completed. This means that one of the lights in that part of the control panel showing a red aspect, would not be perceived as exceptional or worrying and would probably not immediately attract the attention of the station master.

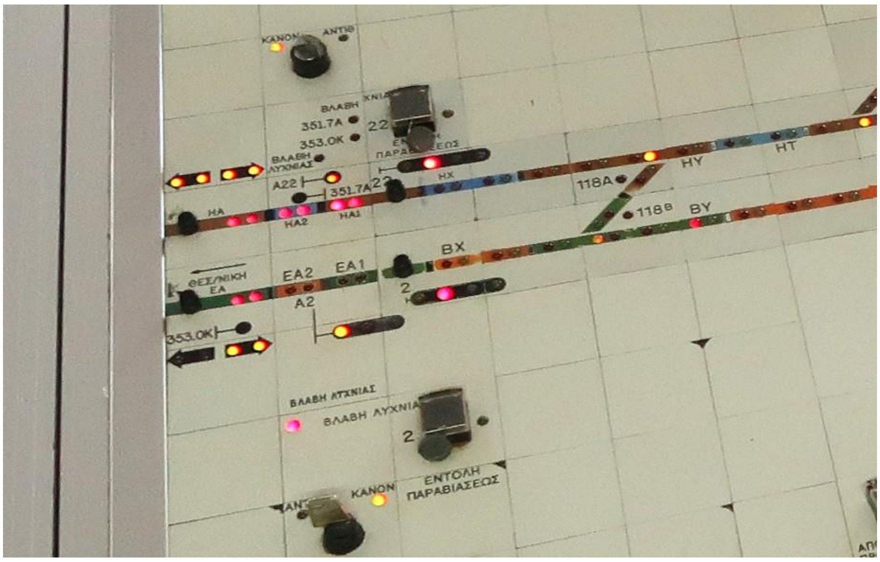


Figure 49. Section EA3 (indicated EA to the left of EA2 on the picture) of the control panel incorrectly indicating an occupation.

241 In practice, this means that the misrouting of train IC-62 was visible for the station master via the following indications:

- On the upper side of the Control Panel, the small light positioned on the right side of the key, above the indication "P", lighting up. Note that as such, the difference between the key turned 90 degrees clockwise or counterclockwise is difficult to distinct, and can therefore not serve as an indication. Also, the key ring that is attached to each key may hinder a clear view on the light. This indication was continuously present on the Control Panel since the estimated moment of setting the route for IC-62, around 22:46.
- On the left bottom side of the Control Panel, the indication of the switch position was visible through 2 lights. Also this indication must have been visible continuously since the estimated moment of setting the route for IC-62, around 22:46.
- When train IC-62 was leaving Larissa station this was also visible through the lighting of the lights representing the sections the train was passing. In particular, the occupation of the descending track by train IC-62 must have been visible on 4 consecutive couples of two lights for a period that represents the time between the passing of switches 118 (estimated at 23:08) and train IC-62 leaving section EA1, about 1,7 km beyond switch 118 B (estimated around 23:09-23:10, or 72 seconds after passing switch 118B). With an additional difficulty that one of these couples was showing a permanent occupation (240).

242 These indications are not easily "readable" for an inexperienced operator, and in any case did not help the station master to identify the wrong positioning of switches 118 in time to prevent the accident, which can be understood by several of the following factors.

243 The indications on the position of switched 118 are small indications, on two distinct positions, on a larger Control Panel (the information of the Figure 47 among the ones from the whole Figure 37).

244 Since around 22:20, the station master was working alone with a considerable workload, that had additional both static (4.2.1.70) and dynamic (4.2.1.9) aggravation components as well as a high number of communications (4.2.1.8).

245 Furthermore, the way the communication means (VHF console, GSM-R and telephone) are positioned on the right of the control panel and at a lower level (Figure 41). This means that, when occupied with whatever communication and logically directed towards the used means of communication, the indications related to the position of switches 118 and the departure of train IC-62 were situated behind the left shoulder of the station master in the left bottom corner of the control panel and so in practice invisible (192).

246 By lack of direct input from the concerned station master (54), the investigation could not identify when exactly he has realised his failure to position switches 118 correctly. Most probably, this happened after 23:18, the moment of the fatal collision, and before 23:40, when a colleague station master arrives in the Larissa control room (after his service at another Station), finding – according to his declarations – the key for commanding switches 118 in the "main" position, guiding traffic towards the ascending line.

4.2.3. Departure procedure of train IC-62

247 Procedural messages are used to send operational instructions associated with appropriate situations to a train driver. They comprise the text of the message itself, corresponding to a situation, and if the message requires the recipient to report back, the text of the report is also given. These messages use predetermined wording, prescribed by the Infrastructure Manager in his 'operating language', and they are presented in the form of pre-prepared forms in paper or digital format.

248 These procedural messages are generally those associated with degraded working conditions. Typical examples would be the authority for a driver to pass a stop-showing signal or an 'end of movement authority', the requirement to run at reduced speed in a particular area, or to examine the line while driving.

249 The normal departure procedure of a train consist of two steps: a first step to "authorise train movement" (4.2.3.1) where the station master gives permission to the train driver to move within the infrastructure and a second step to "ensure authority to proceed" (4.2.3.2) in which the train driver confirms the received authority to proceed.

4.2.3.1. Station master to authorise train movement

250 The authorisation for passing signal LAR 11, permanently showing a stop aspect, is given twice. Firstly, at 23:04, most probably in reaction to a communication of the Train Manager through the VHF channel that "Larissa, 62 is ready" after having closed the doors of the train, the station master authorises the movement of train IC-62 with the message: "62, with 47 go through red exit light and go until the light entry of Neoi Poroi".

251 There is no immediate reaction, in terms of communication, from the train driver(s) on this station master's message, until at 23:05 when the train driver asks: "What's 62 gonna do?". This stays without reaction from the station master who, at that moment is busy with other 2 safety related communications (258). After about 30 seconds, the train driver then asks: "Is Larissa listening?". The station master this time replies immediately with the same message as before: "Listen, with number 47 you pass red exit light, up to entrance, Neoi Poroi entrance signal". The train driver replies with: "Thank you very much".

252 This communication confirms the assumption that the station master had the intention to send train IC-62 on the ascending track to Larissa (4.2.1.1) and was still unaware of his omission to turn switches 118 back in the "main" position. If the intention would have been to send train IC-62 to Neoi Poroi on the descending track, the message to the train drivers would have to contain the explicit information "… on the descending track…". Furthermore, since this is a "case of deviation from the normal course of the journey", it would have been logic -just as for passing the stop-showing signal- to deliver a form "1001" to the train drivers.

253 From the review of documents and declarations from interviewed staff, it can be concluded that it was routine not to use form "1001" systematically. For instance, for a station master working the night shift alone, it was considered unpractical to deliver the form hand-in-hand and the message was passed via an oral telegram. Although the regulation allows for this, it should be noted that both solutions do not provide the same level of clarity: where a written document unambiguously conveys the message, and can be consulted afterwards, a spoken message is more likely to lead to ambiguity. This is even more the case if a strict communication method is not systematically applied (261).

254 Communication between the station masters and the train drivers takes place via a wireless analogue VHF network. This network, however, is not only used for the safety-related communication between station masters and train drivers but is on the contrary an open communication channel that is used for all service communication between on board train staff and between local technical staff in the different stations. As a consequence, without clear identification of the person(s) speaking, there is a significant risk that safety-related messages will be buried under other conversations and/or the risk that the right person to conduct safety-related communications is not correctly identified, as was the case with the initial authorisation for departure of train IC-62 (250).

255 While analysing the communications, we could observe how weak and unprecise the formulation of the exchanges during the communications were, especially between the station masters and the non-station masters, primarily the train drivers, but also others who were calling/called to "discuss" or share some information.

256 During the investigation, we were not able to detect or observe any practical tool to support the quality of safety related communication by the station masters. In particular, the trainees or the newly certified station masters would benefit from such support.

257 Furthermore, the current methodology for safety related communication, as stipulated by the operational rules in GKK, has been unchanged since it was first published in 1972. Meanwhile, specifications for this type of communication have been published at European level, namely in Appendix C of the Technical Specifications for Interoperability relating to the 'operation and traffic management' subsystem of the rail system in the European Union (Commission Decision 2012/757/EU, commonly known as TSI OPE), which was updated respectively in 2019 and 2023. On the Greek side, however, an update of these operational rules, published in 2019, did not take into account this European "standard" that is more detailed and therefore safer, in particular on speech transmission and message receiving procedures (4.2.9, 4.2.20.3).

258 This adds to the already mentioned factors that negatively influenced the performance of the station master on the night of 28/02/2023. In particular, in relation to the high number of communications, it is noted that the during the period between both authorisation for train IC-62 to move towards the north, the station master was involved in two other traffic management related communications with the respective station masters of the neighbouring stations. A first one was related to the upcoming departure of train IC-62 towards Neoi Poroi and a second was related to the departure of train 1564 from Paleofarsolo, via GSM-R and phone respectively.

259 The combination of the impossibility of one-to-one safety related communication between station masters and train drivers and the outdated methodology for this safety related communication, which was still in practice when observing safety-related communications during the investigating, triggered EODASAAM to issue an urgent safety recommendation (6.1.1).

4.2.3.2. Train driver to ensure authority to proceed

260 After having received an authorisation for train movement from a station master, it is expected that the train driver ensures a clear understanding of the given order. In this case, in reply to the authorisation to pass the stop-showing signal LAR 11, the train driver only replies with: "Thank you very much" (251), so without any repetition of the message and without communication of a telegram number.

261 After listening to several safety-related communications between station masters and train drivers, both recorded on the day of the accident and during observations during the investigation, we must conclude that it was routine and accepted practice not to follow the prescribed, more or less strict communication patterns.

262 Furthermore, the lack of direct reaction by the train driver(s) of train IC-62 could be explained partly by a conversation that took place between at least one of them and the driver of the previously arrived train 2597. As can be seen on recorded video footage from inside the station, the latter, when on platform 2 on his way to his driver's cab, changes the direction of his movement at 23:02 and stops near the locomotive of train IC-62 to have a 3-minute exchange, until the actual departure of train IC-62 (250).

263 Train IC-62 finally leaves the station of Larissa with a delay of 48 minutes, which may have urged the train drivers to speed up the departure procedure. As can be heard in the recordings listened to, some sense of haste and nervousness is at least present in the conversations of the main train driver.

264 The train driver of the IC-62 in charge at the time of the collision was a very experienced train driver, described as having good knowledge. In terms of non-technical skills, he is described as having a strong independent mindset and character, and rather over-confident. Note that, as for the station masters, a good level of self-confidence is also needed to carry out the train drivers' tasks. The second train driver who is in the cab to assist and altern in driving, was a recently certified train driver (November 2022).

265 The most experienced of the train drivers driving IC-62 has been the mentor of the younger train driver, possibly creating an un-balanced hierarchical relationship and a reluctance of the younger train driver to react "against" his older colleague. Further assumptions, related to the fitness of the main train driver, and a possible disagreement between both drivers that could have influenced their behaviour, were investigated but could not be confirmed.

4.2.3.3. Station master to react on incomplete communication procedure

266 In respect to safety related communication and in particular for procedural messages, it is expected as good practice that whoever is giving the message shall check that the message is received and repeated back as required and, if necessary, correct an error that has been made in the message. Furthermore, the station master is expected to take the lead in safety related communications.

267 Despite the fact that the communication for departure of train IC-62 was without any repetition of the message and without communication of a telegram number from the side of the train driver(s), the station master does not react on this incomplete communication.

268 From recorded communication throughout the day of the accident and involving different actors, it can be concluded that it was routine not to follow a strict communication pattern (e.g. no repetition of messages, no communication of a telegram number, etc.).

269 This finding would have been equally applicable to the station master who was working the evening shift, as is evident from the testimony of colleagues. In separate declarations, they state that they had spoken to him earlier that evening about, respectively, not providing a telegram number when requested and allowing a train driver to use a mobile phone to communicate about train traffic.

270 It can also not be excluded that the station master, only recently appointed in his role and still with the incident of earlier that evening in mind (4.2.1.10), found it difficult to correct an experienced and rather assertive train driver.

4.2.4. Train driver(s) to react on contradicting information

271 Although they would be expected to stop in front of the switch and contact the station master to get clear instructions, as did the train driver of train 2597 earlier that evening (224), there is no clear indication that the train driver(s) of train IC-62 reacted on the position of the switches not being compatible with the received authorisation (251).

272 Not only is there no trace of any communication between the train drivers of train IC-62 and the station master after their departure from Larissa station[6]; the provided GPS-speed profile only shows a slight deceleration after departure (and no stop) in the area of switches 118[7], and the guard at the Agias level crossing, located some 400m after switches 118, also declared to the investigation team that train IC-62 did not stop.

273 On the other hand, it can be excluded that the train driver(s), with all their experience would not have realised they were driving towards Neoi Poroi on the descending track and not the ascending track. This findings leads to the conclusion that they somehow accepted this as normal. Some of the following elements could partly explain this.

274 Travelling on the opposite track and single-track operation was not an exception. Due to problems with the overhead line (92), train IC-62 had just completed the section between Paleofarsalo and Larissa on the opposite (descending) track. And, earlier that day, between 19:21 to 21:38, the section between Larissa and Neoi Poroi was temporarily exploited on the descending track only (93). More in general, train drivers were (and still are) used to be confronted with daily changes due to ongoing works and/or failing assets, requiring continuous alertness and resilience on their side.

275 The hypothesis that the train drivers assumed that the ascending track between Larissa and Neoi Poroi was (still) blocked, contradicts the recorded communication from the station master of Neoi Poroi, who explicitly mentioned "traffic on double line" when authorising IC-63 (at that moment, with the train drivers who later run the IC-62) to move from Neoi Poroi to Larissa on the descending track. It remains however possible that both train driver switched roles between driving IC-63 and IC-62, and that this communication was not perceived equally good by both.

276 The crew of train IC-63 have also passed train 93506 (formerly IC-56), which left Larissa Station for Thessaloniki at 21:50, at 22:02 in the section between Zachari and Evangelismos, on the opposite track. This may have created the good situational awareness with a double line traffic. It is however not possible to be sure that this train 93506 has been perceived. The train driver of the 93506 couldn't confirm any received sign when passing each other.

[6] An expert report of the voice recordings before and during the accident was ordered in the context of the judicial investigation. The National Technical University of Athens concluded on 14/01/2025 that: "*it is established that there has been no change after 00:07:00 hours of 1 March 2023, nor in the contents … nor in the audio content of the audio files in question, relating to the recordings of 28/02/2023 and the time interval from 22:30' to 23:55'*".

[7] It is recognised that recordings by GPS are not always accurate and that stops, if only of a short duration, are not reflected. However, it is considered that a stop to sort out the issue with the conflicting information would take time and would lead to a recorded communication.

277 The delay of 48 minutes on the planned itinerary has also to be considered: it may have impacted the train drivers' understanding of the situation of other trains, so they didn't expect another train to travel in the opposite direction on the descending track.

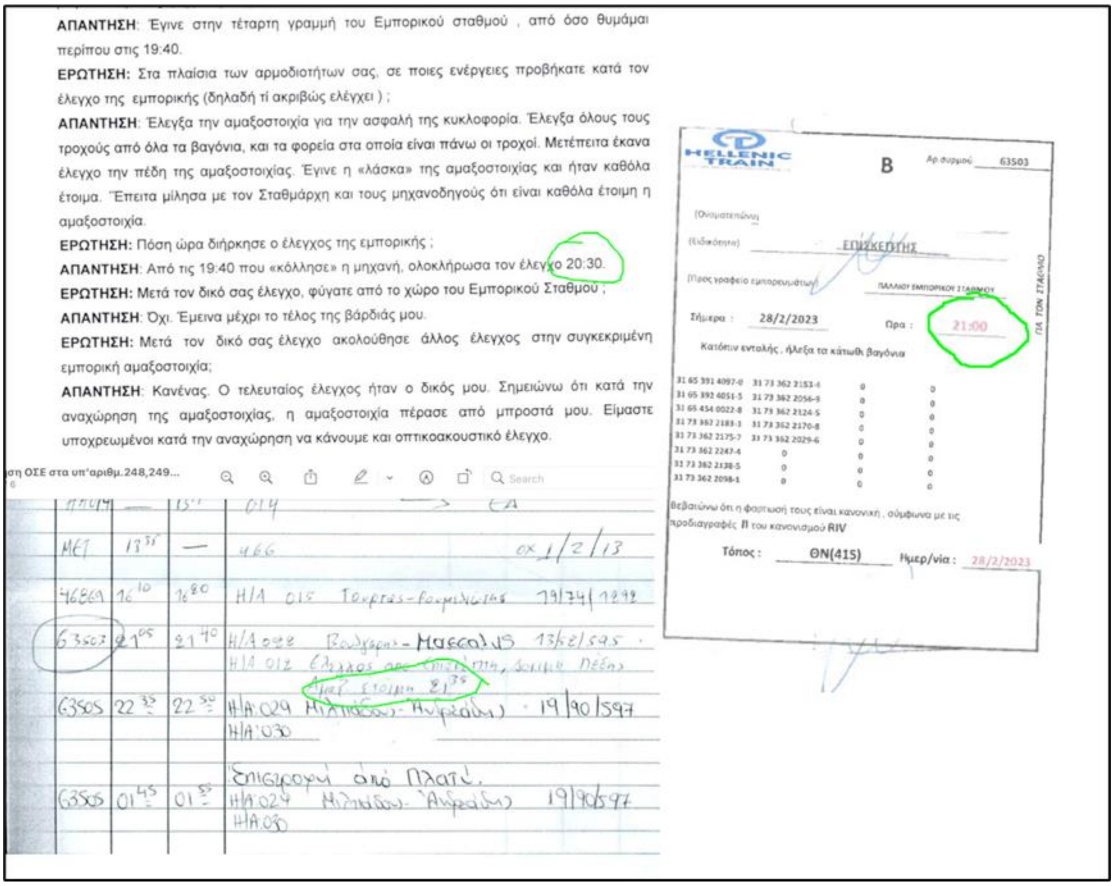
278 Around 23:07, at a moment that train IC-62 is most probably still approaching the switches 118, the guard at the Agias level crossing communicates the message "62, clear also from Agia" ("62, ελευθερο και από αγιά") via the open VHF channel, indicating that it is safe to pass the level crossing. It remains unclear whether the drivers of train IC-62 may have mistakenly understood this as confirmation that they could continue their route on the opposite track.

4.2.5. Management of the train 63503

279 The 63503 was due to depart from the Thessaloniki Freight Station at 21:15.

280 The freight train was reportedly checked before departure by an OSE employee who stated to the Investigating Judge that he finished his pre-departure safety checks, which was the last one performed for this train before departure, at 20:40 and then watched the train leave the station, confirming that there was nothing on the train besides the declared load.

281 The same employee signed the train composition sheet at 21:00. A comparison of the relevant available data (Figure 50) when plotted on the same timeline of events (Figure 51), shows that the statement of the OSE employee and the signed and stamped report slip are not consistent with the most probable (cross-referenced by 3 sources) timeline of events.



ΑΠΑΝΤΗΣΗ: Έγινε στην τέταρτη γραμμή του Εμπορικού σταθμού , από όσο θυμάμαι περίπου στις 19:40.

ΕΡΩΤΗΣΗ: Στα πλαίσια των αρμοδιοτήτων σας, σε ποιες ενέργειες προβήκατε κατά τον έλεγχο της εμπορικής (δηλαδή τί ακριβώς ελέγχει) ;

ΑΠΑΝΤΗΣΗ: Έλεγξα την αμαξοστοιχία για την ασφαλή της κυκλοφορία. Έλεγξα όλους τους τροχούς από όλα τα βαγόνια, και τα φορεία στα οποία είναι πάνω οι τροχοί. Μετέπειτα έκανα έλεγχο την πέδη της αμαξοστοιχίας. Έγινε η «λάσκα» της αμαξοστοιχίας και ήταν καθόλα έτοιμα. Έπειτα μίλησα με τον Σταθμάρχη και τους μηχανοδηγούς ότι είναι καθόλα έτοιμη η αμαξοστοιχία.

ΕΡΩΤΗΣΗ: Πόση ώρα διήρκησε ο έλεγχος της εμπορικής ;

ΑΠΑΝΤΗΣΗ: Από τις 19:40 που «κόλλησε» η μηχανή, ολοκλήρωσα τον έλεγχο 20:30.

ΕΡΩΤΗΣΗ: Μετά τον δικό σας έλεγχο, φύγατε από το χώρο του Εμπορικού Σταθμού ;

ΑΠΑΝΤΗΣΗ: Όχι. Έμεινα μέχρι το τέλος της βάρδιάς μου.

ΕΡΩΤΗΣΗ: Μετά τον δικό σας έλεγχο ακολούθησε άλλος έλεγχος στην συγκεκριμένη εμπορική αμαξοστοιχία;

ΑΠΑΝΤΗΣΗ: Κανένας. Ο τελευταίος έλεγχος ήταν ο δικός μου. Σημειώνω ότι κατά την αναχώρηση της αμαξοστοιχίας, η αμαξοστοιχία πέρασε από μπροστά μου. Είμαστε υποχρεωμένοι κατά την αναχώρηση να κάνουμε και οπτικοακουστικό έλεγχο.

ση ΟΣΕ στα υπ'αριθμ.248,249...

MET	13:35	—	466 ox 1/2/13
46869	16:10	16:80	H/A 015 Τουρτας-Φαρμακ... 19/74/1292
63503	21:05	21:40	H/A 022 Βουλγαρης-Μαccalis 13/52/595 H/A 012 Έλεγχος ... δοκιμή Πέδης Αμαξ. έτοιμη 21:35
63505	22:35	22:50	H/A 029 Μιλτιάδου-Ανδρεάδης 19/90/597 H/A 030
			Επιστροφή από Πλατύ.
63505	01:45	01:55	H/A 029 Μιλτιάδου-Ανδρεάδης 19/90/597 H/A 030

HELLENIC TRAIN

B Αρ συρμού 63503

(Ονοματεπώνυμο)

(Ειδικότητα) ΕΠΙΣΚΕΠΤΗΣ

(Προς γραφείο εμπορευμάτων) ΠΑΛΑΙΟΥ ΕΜΠΟΡΙΚΟΥ ΣΤΑΘΜΟΥ

Σήμερα : 28/2/2023 Ωρα : 21:00

Κατόπιν εντολής , ήλεγξα τα κάτωθι βαγόνια

31 65 391 4097-0	31 73 362 2153-4	0	0
31 65 392 4051-5	31 73 362 2056-9	0	0
31 65 454 0022-8	31 73 362 2124-5	0	0
31 73 362 2183-1	31 73 362 2170-8	0	0
31 73 362 2175-7	31 73 362 2029-6	0	0
31 73 362 2247-4	0	0	0
31 73 362 2138-5	0	0	0
31 73 362 2098-1	0	0	0

Βεβαιώνω ότι η φορτωσή τους είναι κανονική , σύμφωνα με τις προδιαγραφές II του κανονισμού RIV

Τόπος : ΘΝ(415) Ημερ/νία : 28/2/2023

ΓΙΑ ΤΟΝ ΣΤΑΘΜΟ

Figure 50. Inconsistencies of the timeline of the checks during the shunting operations of the freight train 63503.

282 The freight train 63503 did not leave at 21:15 as scheduled but was delayed until 21:40. The reason for the delay, as reported by Hellenic Train, was that the pantograph of the 120-017 locomotive failed to deploy correctly so it had to be replaced by the 120-022 locomotive.

283 The TELOC data logger shows both locomotives 120-012 and 120-022 leaving the Thessaloniki Passenger Station

and arriving at Thessaloniki Freight Station and then remaining stationary for approximately 25 minutes (from 21:15 until 21:40).

284 The same timeline of events is supported by GPS data of the movement of the locomotives as provided by Hellenic Train. A similar timeline is supported also by the logbook of the station master at Thessaloniki Freight Station (locomotives arrive at 21:05, test finished by 21:35 and train leaving at 21:40).

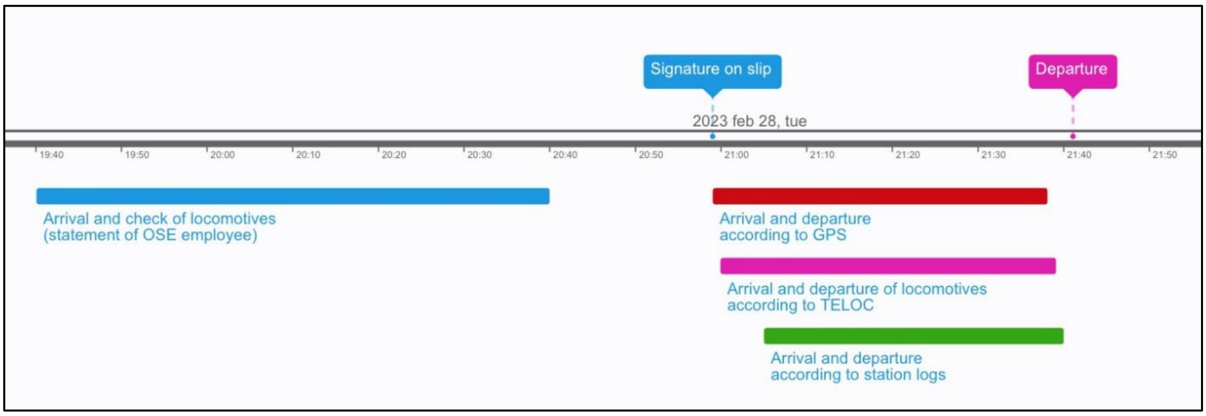


Figure 51. Timeline of the movement of the freight train 63503

Thessaloniki	21:40
TX1	21:50
Sindos	21:57
Platy	22:13
Aiginio	22:25
Katerini	22:40
Litochoro	22:51
Leptokarya	22:59
Neoi Poroi	23:05

Table 6. Table of the time at each intermediate station before leaving Neoi Poroi as recorded by OSE.

285 Video footage from the loading of the freight train 63503 is missing, like most of the video footage of its itinerary until the site of the accident.

Further analysis of the safety management systems

The European legislative framework clearly states that the operators, infrastructure manager and railway operators, are responsible for controlling the risks inherent to their activities. To control these operational risks, they must implement a safety management system. Therefore, to better understand which underlying elements can explain the contributing factors found above, the relevant processes of these safety management systems were further analysed as reported in the points below (4.2.6 to 4.2.16).

The safety management system of OSE

4.2.6. Manage competence of station masters

286 A competence management system shall ensure that staff having a role that affects safety are competent in the safety-related tasks for which they are responsible. And this means to include at least: the identification of the competencies (including knowledge, skills, non-technical behaviors and attitudes) required for safety-related tasks, the selection principles (basic educational level, psychological and physical fitness required); the details of the initial training, experience and qualification; the ongoing training and periodic update of existing competencies; the periodic assessment of competence and the checks of psychological and physical fitness to ensure that qualifications and skills are maintained over time; and any specific training in relevant parts of the operational rules, as embedded in the safety management system, to deliver their safety-related tasks. Also, the organisation shall provide a training program which is demonstrated to reach its purpose and ensure that the right program is delivered to the right person, in due time, with traceable evidence, and submitted to control, review and continuous improvement.

287 From a general point of view, it has been difficult to obtain more than the list of the points to be covered during the theoretical training, the names of the trainers, the periods of time dedicated to these training activities, the content of the examinations and the final results of the group of trainees ending the training in January 2023.

288 To be able to perform a full analysis, we would have needed more information and at least the following points: the full integration path included the practical points to be covered, the training of the trainers with their training abilities (teaching needs dedicated competencies), the role and preparation of trainers included the practical co-workers-trainers, the links made with the risk assessment of degraded situations (and emergencies) and/or previous occurrences, the formal lists of the participants for each training, and some reports showing how controls or audits were put in practice to improve the competence management.

289 The fact that these elements could not be transmitted at least creates the presumption that they do not exist and were therefore never put in practice for managing the competence of station masters, whether experienced or newly recruited.

4.2.6.1. Integrating new station masters

290 The current content of the theoretical part of the training is built with a knowledge mindset. It is not clear how previous occurrences, and classical or less classical degraded situations, are valorised through a risk assessment or a simulation (tabletop or in-situ). The identification of the competencies seems to be an approximative matching between important theoretical chapters, and the timeline of the training program.

291 There is no specific centralised direction given to the development of the critical Non-Technical Skills needed to perform the activities of a station master, or to their assessment or follow-up.

292 Once the newly recruited trainees have finished the theoretical courses given in classrooms, they are regionally dispatched and integrated in the shift services of different stations. There is no (or poor) follow-up and traceable control of who is doing what, where, when, with whom, and learning what. This is especially true for the practical part of the training (but not only).

293 There is no specific centralised direction given to this integration, and no dedicated assessment of the practicality and quality of it.

294 There is no particular assessment or no exchange of information, between the theoretical part and the practical

part of the training. So, it remains possible that a trainee comes rather unprepared or insufficiently prepared to the practical part, hence in the middle of the traffic operations that have to be processed by the experienced ones (the co-workers-trainers) in real-time.

295 Specific to the practical part of the training is the way the trainees are placed and rotate through different stations, with different experienced station masters, and with different ways of managing the traffic (there are different kind of control panels, and there are stations without control panel). As such, this approach can be seen as good or valid, however there is no assurance nor traceability of what trainees are actually doing as individual, and if their rotation is sufficient or not to acquire the necessary competences to be able to work safely under all conditions.

296 Although presumed by OSE as known and standard practice, the roles of the co-workers-trainers, who are dedicated to pursuit the practical training of the new station masters (not yet certified), are not defined. It is not known or explained how they are chosen or prepared in order to fulfill their training mission. There is no follow-up of their specific training tasks, which are by the way possibly interfering with the ones of ensuring the traffic.

297 The feedback that is distributed via the co-workers-trainers to the trainees is not explained, shared, consolidated, validated, standardised nor traceable.

298 These co-workers-trainers, who ensure the practical part of the integration, are not involved in the final examination, nor in intermediary evaluations, whether summative (by giving feedback) or normative (by giving points). It seems that they are not recognised at all as trainers, or at least this is how they feel and comment their situation.

299 There is no or poor assurance that all the safety critical points for traffic operation are integrated in the practical training, and assessed via observation of practice or via a relevant practical assessment. A relevant example is the one already described (195) that explained that as far as we could identify, no specific work-instructions describing the maneuvers to be carried out for each train (in automatic or manual mode, in normal or degraded mode) were made available, hence this may have influenced some inconsistent handling of the control panel.

300 The global assessment of the cohort of August 2022 shows a strong consistency to success, showing that all the participants got notes between 7 and 10 both for the oral and the written parts. This puts in question whether the approach can define the real operational capability of the new station masters.

301 Once certified it is assumed by the management, and maybe even by some newly certified station masters, that they are ready to perform at the level expected, whatever the situations or the resources made available to master them. However, it has been repeated several times by different station masters, new and experienced ones, that it takes at least between one year and 1.5 year of operational practice to be more at ease, less stressed, and more confident in performing the work of station master. This shared vision does not seem to be taken into account at any point, neither in the direction given to practice, nor in the theoretical lesson plan, nor in the Non-Technical Skills as currently (un)supported, and nor in the final feedback given after integration in order to eventually improve the whole training content and approach.

302 Even if the integration of such a high number of newly recruited station masters should be considered, from a safety perspective, as a significant change, there is no indication that this change has ever been the subject of any specific risk assessment (4.2.12). On the contrary, the presented approach appears to be a copy of the way the training of station masters was performed 20 years before.

4.2.6.2. Rostering of station masters

303 In this investigation, on several occasion during several months, when a reporting on the actual performed shifts was asked, the investigators were given the rostering as it was planned. However, informally and even in an official declaration, some experienced workers have shared their agenda with extended period of time being worked, even at night. For example, 29 nightshifts in a row. Of course, this is to be linked with some managerial challenges like both the brutal and the progressive staff reductions without any risk assessment. Or to be linked with a mechanism to compensate the reduction in salaries after the 50% cut due to the socio-economical crisis of 2010 onwards. Nevertheless, serious doubts remain as to the regularity (even in relation to current Greek legislation in this area) of the organisation of shifts and its ongoing monitoring.

304 Indeed, it has appeared to be impossible to obtain from OSE's operational and central Departments the actual performed shifts, with a starting and ending time recorded, for each individual and for longer periods of time. This

problem of traceability on the actual performed work was not only detected for questions raised by EODASAAM, but was also confirmed to be an obstacle for RAS in performing its supervision activities and this until recently.

305 Given the exchanges we have had on this subject both with OSE and with Hellenic Train representatives, it seems that the belief or the assumption, that "the legality of the shifts as planned (we should add "as actually worked") gives a complete protection against work-related fatigue", may be problematic, at least in terms of setting up a proper fatigue management system for safety-critical 24/7 professionals. On the contrary, no centralised direction or strategy is given and no control is organized of this key Human and Organisational Factor. Such an important topic for safety (and health) is left to the individual discretion of the planners or supervisors, with all the bad usage, abuses or excesses that one can imagine.

306 It's important to remind and emphasize that even if we would have excellent station masters (or train drivers) who are very well trained - once impacted by repeated lack of sleep - their physical fitness and many other important personal factors will deteriorate until they become an issue for them first, and then a problem, sooner or later, for their colleagues or interlocutors, and ultimately even for safety.

4.2.6.3. Continuous training of station masters

307 No structured initiative to ensure the continuous training of station masters could be identified. Once they have obtained their initial "certificate", station masters are considered competent for the rest of their career, regardless of any changes that may appear in their working environment. The main argumentation for this appears to be the lack of available resources: when following training, the concerned station masters cannot be rostered for operational shifts.

308 Moreover, the only initiative related to the transmission of knowledge on operational changes that could be detected, is related to the re-activation of local control panels and is outsourced to the subcontractors who are in charge of the installation (196). Participation to these training sessions is specified by contractual quotas and involves only some of the station masters, available at the time of the training. With the control of participation to these sessions not properly carried out, there cannot be any assurance that all the concerned professionals were involved and have acquired the necessary competences before the actual change takes place.

4.2.7. Monitor performance of station masters

309 It is the role of the infrastructure manager to plan and operate the monitoring process set out in the EU Regulation on a common safety method for monitoring (EU 1078/2012), and to ensure that the relevant risk control measures (even the ones implemented by their contractors) are monitored in compliance with this Regulation. The monitoring process shall contain the following activities: (a) the definition of a strategy, priorities and plan(s) for monitoring; (b) the collection and analysis of information; (c) the drawing up of an action plan for instances of unacceptable non-compliance with requirements laid down in the management system; (d) the implementation of the action plan, if such a plan is drawn up; (e) the evaluation of the effectiveness of action plan measures, if such a plan is drawn up.

310 Although a station masters performance monitoring used to exist in the past, currently no monitoring of their operational performance and their capabilities take place for the permanent station masters (enrolled as Public Servant). The Larissa station master, unlike his co-trainees, was already part of the permanent staff and his performance was therefore considered not to be subject any structured monitoring.

311 For contractual staff that are hired with 6-months renewable contract, and only since Tempi accident (not before), a dedicated form to be filled has been introduced for supporting the assessment of their performance.

312 On the evening of the accident, as was observed through the recording of communications and declarations of the concerned persons, three of his more experienced colleagues from stations and from the traffic regulation, intervened and requested more clarification, indicated an error, or pointed out a risk of misunderstanding to the station master performing the night shift at Larissa station. This type of peer-review can be potentially useful when well framed and embedded in an open culture and in the training of non-technical skills, and eventually contributing to the performance monitoring and improvement. However, none of his colleagues intervened and we could not identify any structured approach and/or guiding directions that would support such an intervention by peers.

313 On the other hand, the Internal Regulation of OSE, published by Ministerial decree in versions of 2016 and 2022,

specifies that OSE's Traffic Control Division is responsible for the central coordination and traffic control in real-time (in communication with the RUs), in accordance with the traffic and safety regulations, and the instructions for personnel relocation whenever needed under real-time conditions. In the afternoon and evening of the 28th February, 2023, the traffic situation cannot be considered as "normal": four trains had broken down, there were delays, congested traffic and a lot of problems to be solved. This was clearly an irregular situation and, according to this Internal Regulation, it would be up to the Traffic Control Division to take actions in order to regulate traffic in such a way as to resolve conflicting demands and prioritise actions, including taking actions to employ reserve or additional personnel until the traffic is normalised again. This, however, did not happen.

314 Furthermore, the possibility of monitoring station master performance, in particular for compliance with the requirement to set routes automatically, was introduced in the "Urgent guideline" that was published by OSE on 22/08/2022 (199): "The reception or departure of a train without route formation but with individual operation shall be disciplinary controlled by examination of the recording equipment of the signalling systems." Lack of resources and the technical difficulties to retrieve the information on the applied method for route setting, made however that this monitoring activity was never put in practice.

315 Another level of performance monitoring is also possible through the digitalised traffic control rooms (note that such a control room was not in place at the Tempi accident occurred), and this concerns the supervision of traffic in tunnels, and also, as in the example below, traffic management itself. As was observed during on-site visits (Figure 52), on several occasions during the investigation, it is clear that decision made via the control panel in Larissa station a few dozen meters further on (just as it could also be fifty or hundred kilometers) can easily be observed and supervised. However, it is currently not used in that way, and it is not clear if there is any intention to do so in the future. It was observed that there has been an effort to put into operation these traffic control rooms wherever infrastructure (signalling) is available. Their use, however, is still limited by lack of the maintenance of the switches. As a result, still large parts of the Athens-Thessaloniki route are not monitored remotely.

Figure 52. Digitalised traffic control room in Larissa station, with experienced staff, in 2025.

316 Last but not least, there is the "natural" role of the supervisor of the station masters. Alike any other direct supervisor, the regional or local leader can or could assume this continuous or occasional monitoring. However, no indication or centrally organized initiative could be found that would guide this monitoring initiative. The perception reigns that monitoring performance would lead to detecting non-compliances and consecutive punishment of staff. Considering the lack of operational staff, monitoring the performance of station masters was thought to be impracticable and therefore abandoned.

4.2.8. Management of HOF Integration

317 Understanding and managing the interactions between humans and other elements of a socio-technical system, requires taking care of the integration Human and the Organisational Factors, not on paper but in the real life practice. This integration will ensure to reduce the number and the seriousness of the errors, to reduce also the cost of many corrections in projects, to anticipate the occurrences with human-oriented risk control measures, etc. Classically it is recognised that this approach shall address risks associated with the design and use of equipment, with the tasks themselves, with the working conditions and the organisational arrangements. In this approach, both human capabilities and limitations are taken into account. And generally speaking with the double goal of improving the well-being at work and the influences on human performance.

318 Through several examples and evidence gathered during the investigation, we deduce that the integration of the human and organisational factors in a risk management approach is not yet in place. For example:

- the design and implementation of the control panel,
- the design and follow-up of the rostering,
- the design and decision-making about the workload in particular for the nightshift,
- the design and decision-making about the sacralisation of the traffic control center,
- the continuous application and the reinforcement of the not suitable procedure of using exclusively the automated mode,
- the poor support and the ambiguity of the roles of the co-workers-trainers involved in the basic training,
- the absence or poor attention paid to the actual working conditions when investigating incidents, being prompt to blame and re-train as the only learning outcome.

319 It is important that risk management (4.2.12) and competence management systems (4.2.6, 4.2.13), as well as their monitoring and supervision (4.2.7, 4.2.14, 4.2.19), and the capabilities to learn from previous events (4.2.16 to 4.2.18), are considered in a consistent way to support the integration of HOF, both for operational and managerial staff.

4.2.9. Manage operating rules

320 The regulatory framework for managing traffic on the Greek railway network is described in the General Movement Regulation (GKK). This Regulation contains two main parts (Part A, on the meaning of the signalling installation, and Part B, on the regulation to organise traffic operations). This regulatory framework, which is published as national legislation, is complemented by written instructions, internal working documents and the circulars issued by the Directorate for Traffic of the infrastructure management, OSE, providing specific instructions, useful information and details for specific actions at specific time periods and for specific sections of lines and/or stations.

321 The latest version of this regulatory framework results from the analysis, performed between February 2018 and August 2018, by a working group, established by a Ministerial Decision in February 2018, and composed of representatives of the Directorate for Rail Transport of the Ministry of Infrastructure and Transport, the infrastructure Manager OSE, RAS, and trade unions POS, PEPE and PEP TRAINOSE. This framework was approved by the Management Board of OSE in September 2018 and then it was subsequently published in the Government Gazette as a Decision of the Minister for Infrastructure and Transport in March 2019, with effect from 01/08/2019. Finally, with another relevant Ministerial Decision, the modified GKK entered into force on 01/01/2020.

322 Following the amendment of the GKK and the publication of the relevant Ministerial Decision, a working group composed of representatives of the Directorate for Rail Transport of the Ministry of Infrastructure & Transport, the Infrastructure Manager OSE and RAS took over in July 2019, including the review of existing national safety rules and the establishment of new ones, mainly considering the Appendix I to the Annex of Implementing Regulation (EU) 2019/773 (OPE TSI), which had been already published in May 2019. This working party identified and proposed specific articles of various pieces of Greek legislation and circulars of the infrstructure manager OSE, as potential national rules in the field of railway safety, including specific articles of the already modified GKK. As part of the process, the above-mentioned resulting regulatory framework was submitted to an electronic consultation with the national railway sector in the middle of June 2019, whose representatives were invited to participate in it, submitting any comments and observations as well as proposals for the recognition of any other

legislation as national safety rules. Following the above consultation, on 1 July 2020 the Ministry of Infrastructure and Transport submitted the proposed national rules in the field of railway safety, to the ERA and the European Commission for assessment in accordance with Articles 25 and 26 of Implementing Regulation (EU) 2016/796.

323 While the main aim of this work was to align the national framework with changed requirements in Regulation (EU) 2019/773 (OPE TSI), there are no specific references in the main text of the GKK to the safety-related communication methodology established by Appendix C of the EU Regulation (257). Requirements of EU Regulation, in this case Appendix C to Decision 2012/757/EU (TSI OPE 2012), are considered to be directly applicable in the Member States. This means that a strict application of the methodology by station masters and train drivers is expected, without the need for further specification in the national legislation. Moreover, elements of safety-related communication would not be accepted and get a negative opinion during the assessment of National Safety Rules by ERA (4.2.20.3).

324 In this reasoning, integration of the methodology into various documents relating to communications, such as the operational rules and the communication procedures being part of the Safety Management Systems of respectively the infrastructure manager and the railway undertakings, is required, as well as the re-training and faithful application of the methodology by the train drivers and the station managers. Following the publication of the amended GKK, RAS, in two letters addressed to the railway sector, explicitly pointed out that "procedures and processes required by the TSI OPE should be part of the operational rules and procedures and should be integrated into the Safety Management System (SMS) of the IM and RUs". While these letters contain a list of items to be covered, corresponding to Appendix I, however, no explicit mention is made of the need to integrate appendix C or any other elements related to the communication methodology. Consequently, the operational organisations were not explicitly alerted and probably not aware of the need to also update the communication methodology.

4.2.10. Provide train drivers with real time information

325 Train drivers, before departure, are provided with information on infrastructure related restrictions via on the one hand the timetable, provided to the train drivers by Hellenic Train and on the other hand regarding temporary speed restriction, provided by OSE.

326 Further restrictions and real-time changes need to be communicated to train drivers by the station masters, either via specific forms (e.g. 1001) or via verbal messages over the VHF channel.

327 Furthermore, in accordance with the Hellenic train driver's Rule Book (SMS 052), drivers must contact the company's Traffic Monitoring Centre to report problems identified in railway infrastructure, rolling stock and significant delays on routes. The communication of the train drivers with the Traffic Monitoring Centre is made by telephone. The role of the Traffic Monitoring Centre is also to alert train drivers, via the same channel, of imminent risks on the network, of which it was informed via the traffic regulator of OSE or via its own sources.

328 From the recorded communications of the station master of Neoi Poroi, its is confirmed that the train drivers of train IC-63 (who would later switch to become in charge of train IC-62) were informed that the service with double track operation between the stations of Neoi Poroi and Larissa was restored, when leaving the Neoi Poroi station from the 1st track.

329 It is important to remind that technical communication means need to be available to be able to contact the train drivers in real-time with urgent safety information.

330 In the OSE reply to the Investigating Judge dated 02-08-2024, it is explained that a network of radio links through the existing TETRA network was put in place in 2013, so that local simplex VHF communications from different analogue receivers coupled with digital relay stations along the way, would be picked up from the air and relayed digitally to a remote repeater that would rebroadcast the remote signals through an analogue VHF transmitter.

331 This system is described with a schematic diagram that shows the different stations, repeaters and links and it is mentioned that the system was working properly without any complaints from its users.

332 The recordings from the various stations from the day of the accident (as provided by OSE in the reply to the Investigating Judge) show that the relay system was not performing as expected at the day of the accident. As one of the many examples, CH1_00000459_90.wav recording from Rapsani shows that there is no repeater and no digital relay of signal along the line, as the Neoi Poroi station master talking to a train passing through the area is very clearly heard, but the reply of the train driver is not heard at all, because it is a lower power transmission

that is not so strong to be picked up directly by the Rapsani receiver. If a repeater or radio link was operating properly, this transmission of the train driver should have been picked up by all receiving stations in the area and along the route of the train. However, it is highly doubtful that this could have influenced the course of the accident.

4.2.11. Manage technical installations (assets)

333 It is the role of an infrastructure manager to manage the safety risks associated with physical assets throughout their life cycle, from design to disposal, and fulfil the human factors requirements in all phases of the life cycle. To ensure this, the organisation shall ensure that the assets are used for the purpose intended while maintaining their safe operational state and their expected level of performance. The infrastructure manager shall manage the assets in normal and degraded operations, and detect as soon as reasonably practicable instances of non-compliance with operating requirements before or during the operation of the asset, including the application of restrictions of use as appropriate to ensure a safe operational state of the asset. In addition, to control risks where relevant for the supply of maintenance, at least the need for maintenance to keep the asset in a safe operational state shall be identified, based on the planned and real use of the asset and its design characteristics.

334 In particular the degradation of elements related to the control, command and signalling installations appeared to have influenced the workload and performance of the station master in Larissa station on the night of 28/02/2023 (3.8.10).

335 In interviews, the concerned engineers declared that there is no monitoring of the performance and no preventive maintenance planned for these assets. By lack of competent staff, an intervention is only possible when a (critical) asset fails.

336 While incrementally completed, OSE puts into service parts of bigger renewal project. However, for contracts that are concluded for major renewal projects (like contract 717), there is no provision for (preventive) maintenance because contractually the ownership by OSE can only begin when the whole project is completed. In the event of damage for such infrastructure, a formal and cumbersome procedure must be followed as specified by the Greek law the governs public works resulting in serious delays for the repair (the Law 3669/08 Article 58, effective at the contract 717 time, is now replaced by the Law 4412/2016 Article 157).

337 Internal documents of OSE show that the funding for long term preventive maintenance, along with the need for upgrading of the network and the recruitment of additional staff, was identified as a primary concern by OSE's management and discussed with the Government, at least in the period 2021-2022. At that time, the total requirement for upgrade works along the main network was estimated to be € 670 million, while a 10-year maintenance scheme was estimated to be of the order of € 550 million.

338 Beginning of February 2023, this resulted in the approval of the participation of the Greek State in the financing, up to a maximum of € 80 million, for a project for the "Rehabilitation, Upgrading and Maintenance of the Rail Axis of Northern Greece through a PPP". No information is available to the investigation team on how this decision was further implemented.

4.2.12. Risk management

339 Dynamic risk management is the core of a well-functioning safety management system. The main risks arising from an organisation's operational activity are mapped, risk management measures are identified, the effectiveness of which is continuously monitored and the residual risk is assessed. The impact of changes to the organisation, which may have an impact on safety, is also systematically evaluated.

340 Procedure D-07 of the infrastructure manager's Safety Management System concerns the identification of threats and opportunities from a possible operational or organisational change. This procedure demonstrates compliance with the requirements of points 2.1.1 (h), (i), 3.1.1.1 (a), (b) and 5.3.3 (a), (b) of Annex II to Commission Delegated Regulation (EU) 2018/762. Technical risk analysis and assessment is covered by procedure D-19 of the SMS. The former procedure stipulates that the "process is mainly used … when significant changes are implemented such as: new human resources, new information and communication systems, …".

341 As far as could be identified, procedure D-07 was not applied in the cases of the integration of new station masters, neither for the introduction of the control panel in Larissa station (4.2.1.3). The continuous compliance and implementation of OSE's SMS procedures is supervised by the RAS on a sample basis. The application of the above

procedure in respect of the integration of new station masters as well as for the re-activation of the control panel in Larisa station was not subject to supervision by RAS (4.2.19.3).

342 Furthermore, the risk register of OSE does not seem to be adapted to the main missions of the IM (i.e. construction and infrastructure maintenance as well as traffic management). The list of risks does not seem exhaustive, and the descriptions of identified mitigation measures -mainly focusing on compliance with rules- as well as proposed monitoring activities are not detailed enough to find a clear link with operational activities and the related procedures.

343 As reported systematically by RAS in their annual safety reports, the related Common Safety Method on Risk Assessment (Regulation (EU) 402/2013, known CSM RA) is not applied by the Greek railway sector, except in a few cases. The ERA audit of RAS in 2019 (4.2.20.2), on the other hand, identified that: “RAS has not developed a plan for close supervision on the use of the CSM on risk assessment and does not question the assessment methodology used by their stakeholders for determining the significance of a change”.

344 In accordance with the relevant action plan after this ERA audit, RAS has included in its Supervision Strategy and its annual Supervision Plans the supervision of the implementation of the CSM RA and has intensified its effort to promote and support the national railway sector to understand the requirements of the CSM RA, in particular as a topic for discussion in supervision meetings. Although timid, first applications become visible on the side of OSE, the overall results of these efforts, as reported by RAS, are still poor.

The safety management system of Hellenic Train

4.2.13. Manage competence of train drivers

345 A competence management system shall ensure that staff having a role that affects safety are competent in the safety-related tasks for which they are responsible. And this means to include at least: the identification of the competencies (including knowledge, skills, non-technical behaviors and attitudes) required for safety-related tasks, the selection principles (basic educational level, psychological and physical fitness required); the details of the initial training, experience and qualification; the ongoing training and periodic update of existing competencies; the periodic assessment of competence and the checks of psychological and physical fitness to ensure that qualifications and skills are maintained over time; and any specific training in relevant parts of the operational rules, as embedded in the safety management system, to deliver their safety-related tasks. Also, the organisation shall provide a training program which is demonstrated to reach its purpose and ensure that the right program is delivered to the right person, in due time, with traceable evidence, and submitted to control, review and continuous improvement.

346 Hellenic Train explained the steps of the training for their train drivers. Once the European Driving License is issued by RAS (according Law 3911/2011), and the supplementary type B certificate is obtained (cf. their SMS dedicated procedure), the train drivers are trained and certificated according to the particularities of each route. Hellenic Train added that the train drivers are evaluated on the basis of reports produced by the tutor supervising them.

347 In response to the apparent contradiction between on the one hand the problems in safety-critical communication, not only for the train driver of the IC-62 in charge when the collision occurred (260) but also more widespread (261), and on the other hand the description given of this train driver as being very experienced and having a good knowledge (264), the investigation team questioned the continuous training provided to train drivers.

348 In the reply, the team was directed towards the tutoring/mentoring of train drivers, in place before and extended since the accident. Tutors or mentors are both assessing and acting as on-the-job trainers. This point is then also considered when analysing the monitoring of train drivers performance (4.2.14). So far, we couldn’t however identify any structured approach that would support a program for a continuous or on-going training of train drivers and its execution before the accident. Moreover, for the train driver in charge of train IC-62, no detailed evidence was provided of such a relevant continuous training nor assessment, in line with mentioned weaknesses: the tutoring form is poorly filled-in by a tutor (not on the official list of tutors) without any specific or useful information. Hellenic Train reported that the train driver was very experienced and was listed on the official RAS register as a certified trainer and examiner. It is therefore worrying that such training and assessment contrast

with recorded behaviours (4.2.3.2) or behaviours deduced from the context (4.2.4).

349 Another important part of the competence management system is related to non-technical skills, behaviours and attitudes. As previously reported (264, 265), in a context where two train drivers (and sometimes even more) are sharing the driving responsibilities in an alternate way (Figure 53), it is expected they benefit from a crew resources management training, developing their non-technical key competencies (ex. management of stress, of time, of anger, error detection and recovery, etc.). This would also include the capabilities, the willingness, and openness to solve and report any issue related to safety in a context of diverse interpersonal relationships (especially with issues related to obedience, power, and respect issues). This type of peer-review and/or crew resources management is useful when well framed and embedded in an open culture, and in the training of non-technical skills, and eventually contributing to the overall performance and continuous improvement. We could however not identify any structured approach and or guiding directions that would support this.

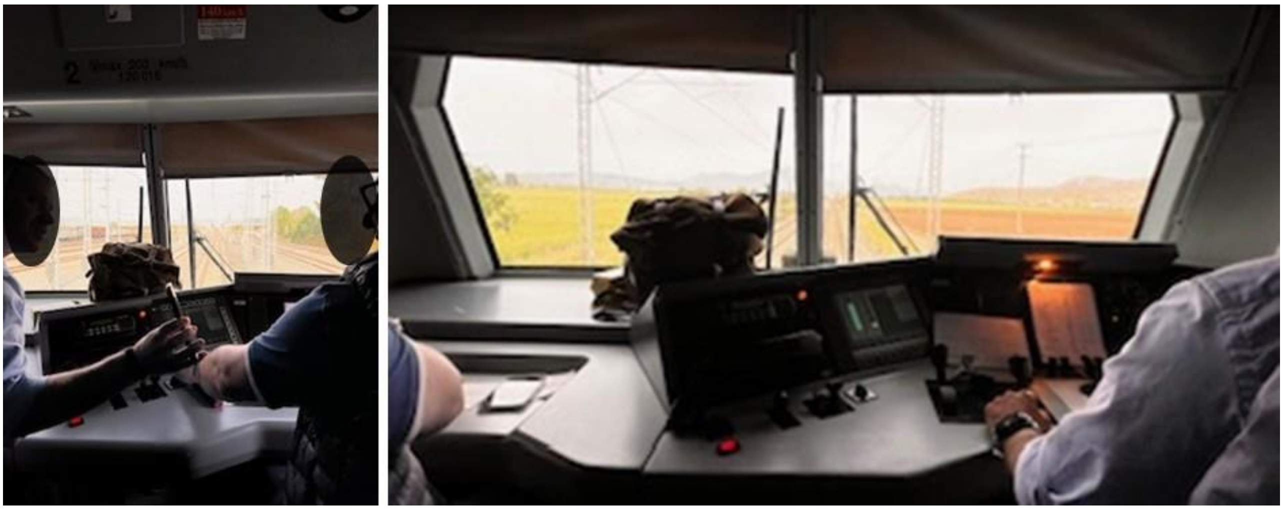


Figure 53. Photos of the train drivers crew, positions and alternance.

4.2.14. Monitor performance of train drivers

350 It is the role of each railway undertaking to plan and operate the monitoring process set out in the EU Regulation on a common safety method for monitoring (EU 1078/2012), and to ensure that the relevant risk control measures (even the ones implemented by their contractors) are monitored in compliance with this Regulation. The monitoring process shall contain the following activities: (a) the definition of a strategy, priorities and plan(s) for monitoring; (b) the collection and analysis of information; (c) the drawing up of an action plan for instances of unacceptable non-compliance with requirements laid down in the management system; (d) the implementation of the action plan, if such a plan is drawn up; (e) the evaluation of the effectiveness of action plan measures, if such a plan is drawn up.

351 The general poor practice of train drivers in relation to the application of a structured methodology for safety-related communication (255), was not detected by the monitoring system of Hellenic Train.

352 Since the accident, Hellenic Train has been unable so far to have access to the recordings of the communications between the OSE Station Managers and their train drivers. The request of Hellenic Train for obtaining these recordings for monitoring purposes has been made on several occasions, and a series of initiatives have been taken, although no common analysis platform has been launched to date. This leaves the monitoring of communications only to be checked by Mentors/Instructors accompanying the train drivers and, in result, Hellenic Train is gathering only an incomplete picture of the real performance of train drivers.

353 The main source for monitoring train driver performance is constituted by the activities of a team of Mentors. Their role is to make a direct, real-time monitoring, accompanying the train drivers in the cab; reminding good attitudes or procedures, sharing advice, supervising communications, etc. Their reports are also used in a training context. However, Hellenic Train could not provide the investigation team with evidence of mentoring activities, performed during the last 3 years, specifically related to the train driver in charge of the train IC-62.

354 Furthermore, the performance and activities of train drivers are partly monitored via the on-board data recording

system (TELOC). Since Tempi, this resource has been used in an improved approach, in order to detect anomalies in the diving performance of train drivers, with a particular focus on over-speeding. Not only the team dedicated to this monitoring has been extended but also the frequency of the checks and the delivery of detailed feedback to the concerned train drivers has been improved.

355 The train drivers' communications with the Traffic Monitoring Centre of Hellenic Train, which is in direct contact with the traffic regulators of OSE, is not being used to reinforce the performance monitoring in operational situations.

356 On some occasions, OSE is monitoring the speed of the trains especially in the case where temporary speed restrictions are an important constraint but also absolutely necessary, because of the need of maintenance of the infrastructure. This is used by OSE to inform Hellenic Train of over-speeding incidents.

4.2.15. Ensure the safety and security of loading

357 Hellenic Train is not involved in the loading and securing of the freight wagons they are transporting. This is done by the customer/consignor, who is liable to the carrier for all the consequences of a defective loading or securing. Nevertheless, Hellenic Train, as railway undertaking, remains fully responsible for the safe running of its trains.

358 To ensure this, a series of pre-departure checks are scheduled that contain: control of the correct loading of open wagons, checking the seal of closed wagons, check of the train composition and a final additional check by a personnel (called visitor) before the departure of the train.

359 In particular, the composition sheet, which contains information on wagons and goods and is an additional element to the route sheet for freight trains, and thus communicated to several employees of different organisations, is considered by Hellenic Train to be a solid measure to control the risk of transport of undeclared cargo. In addition, procedures to check compliance with these prescriptions are reported to have been established, in order to ensure strict observance of the above loading/unloading procedures.

360 This appears to contradict the findings of this investigation, that identified inconsistencies in the reported checks for train 63503 (4.2.5). Based on the provided information, it is therefore unclear to what extent Hellenic Train effectively has control over the safety and security of the goods being transported.

Learning from previous events

361 Reporting and analysing incidents and accidents is an essential part of safety management. Past safety events can provide valuable insights into potential hazards and the effectiveness of existing safety measures. By identifying what went wrong, organisations can identify underlying causes and implement corrective measures to prevent future occurrences. This proactive approach not only enhances safety but also builds a culture of continuous improvement.

4.2.16. Reporting and analysis of events by the infrastructure manager

362 The infrastructure manager, OSE, follows the specifications of Circular DET 99 for the reporting and analysis of incidents occurring on its network. This procedure, dating from 1998, stipulates that "for each serious railway incident that caused major damage, endangered traffic safety or caused fatal injury", a report must be drawn up by a specially appointed committee. It should be noted that this committee is supposed to be composed of personnel of OSE with a hierarchical position and without any specific training in incident or accident investigation. The procedure further indicates which factual data should be collected and specifies the structure of the reports to be drawn up.

363 The structure to follow for incident reporting within OSE includes a "Description" section, with the details of the incident, a "Documentation" section, with the analysis of the incident, a "Causes" section with the key elements that led to the incident, a "Damages" section describing the damage and operational consequences, a listing of the responsible persons together with "the regulations they have violated and on the basis of which they are held liable" in the Responsibilities section and finally the suggestions of the investigation Committee to avoid similar incidents in the future in the "Comments" section.

364 This structure was followed in the incident reports that were analysed. In particular, reports of station master errors when remotely operating switches that occurred prior to the accident described in this report were

reviewed, with the aim of determining what lessons were learned from them. Such incidents occurred on November 11 and 22, 2022, and both reports conclude that the cause of the incident is the irregular action of the respective station master. No attempt is made to analyse and understand the context in which these errors were made. Moreover, neither report takes the opportunity to make proposals to avoid such mistakes in the future.

365 There are other indications that the risks associated with remote switch operation could be identified and were even partially recognised. Already on 02/08/2022 OSE issued an "Urgent guideline" making the use of automatic route setting mandatory, which, we were told, was in response to mistakes with manual operation of switches (199). Also, the request of OSE on 16/11/2022 to change the setting for departure routes from Larissa to the north was partly driven by a recognition of the complexity of operating switches manually (198).

366 While this latter intervention at least attempts to make the working conditions for the station masters more error-free, the emphasis of the introduced risk control measures is still mainly on the individual effort of station masters to apply rules correctly. This is even reinforced in the "Urgent guideline" from 02/08/2022 that states that "The reception or departure of a train without automatic route setting but with manual operation of the switches shall be disciplinary controlled by examination of the recording equipment of the signalling systems.". However, this monitoring of route setting by station masters was never put in practice (4.2.7).

367 There is no indication that any risk assessment related to the activity of route setting was performed. There was (and probably still is), on the other hand, a strong belief that -without any limitations- the strict application of operational rules by station masters (and train drivers) is enough to ensure the safe operation of the railway system. This is not only reflected in the choice of risk control measures but also in the scope and depth of reported incidents. Furthermore, given the vague description of incidents to be reported and analysed (362) and indications that not all incidents are systematically reported (e.g. 226), it is doubtful that all events with learning potential are systematically reported and analysed. As a result, the potential of OSE to learn lessons from incidents and thus implement structural improvement measures that can create a work environment that supports the work of operational staff is limited (if not non-existent).

368 This is confirmed by the internal investigation of the Tempi accident by OSE, that was finalised only in August 2024. Not only is the timing of events in the descriptive part incorrect and creating confusion about whether the second authorisation by the station master (251) was given before or after the departure of train IC-62 from the Larissa station. Moreover, the final conclusion of the report is "Failure to apply and/or incorrect application of the General Traffic Regulation" by the station master of Larissa and the train drivers of IC-62.

369 Not only the late date of starting an official internal investigation is indicative for OSE's lack of capacity to learn from adverse events, but also the fact that -to our knowledge- no internal dissemination of the results took place so far.

370 The proposals of OSE's internal investigation committee to avoid similar incidents in the future are: 1) "Strict application of the procedures provided for in the General Traffic Regulation for preventing human error", 2) "The setting of stricter experience criteria for the placement of station masters in key stations", and 3) "Targeted recruitment of staff, especially in sectors related to traffic operations and infrastructure maintenance". It should be noted that for the two last recommendations, no indication nor justification can be found in the report.

371 The fact, as reported by OSE, that similar reports were requested by Prosecutors of penal or civil courts, and are used as evidence, is (and will always be) a clear obstacle to developing a context in which open reporting and learning from mistakes become a natural part of safety management.

4.2.17. Independent investigation of accidents

372 The European railway safety legislation attributes a core role to National Investigating Bodies (NIB) in creating the necessary learning capability within the railway sector in an independent and objective manner. Not only do they have the obligation to investigate all serious accidents from a safety perspective, determining the causes of an accident or incident to avoid recurrence and with the results of the investigations being made publicly available. Other accidents and incidents should also be subject to safety investigations by the NIB when they involve significant precursors to a serious accident.

373 It falls within the competence of individual Member States, as part of the transposition of the Railway Safety Directive ((EU) 2016/798), to establish a NIB, fully independent of the actors of the rail system in their organisation and capable of carrying out their tasks in an open and non-discriminatory way. In order to fulfil their tasks, the

NIB should have the necessary internal and external organisational capacity in terms of human and material resources as well as timely and direct access to evidence and witnesses.

374 Despite being legally established (e.g Law 4632/2019, transposing the Railway Safety Directive and Law 5014/2023, published in the Government Gazette 14/A/21-1-2023 and setting up EODASAAM as a multimodel NIB), at the moment of the Tempi accident, as in the decade before, Greece had no functioning NIB that could independently investigate railway accidents and incidents. As a result, by lack of independent investigations, no sector wide lessons were learned from previous accidents and incidents.

375 The absence of an active and functioning NIB, as a breach of European law, was identified during ERA's monitoring of NSA activities in 2019 and 2022 respectively and reported as such (4.2.20.2), clearly stating in the latter report that "No independent investigation of serious accident/incident is performed" and labeling this as "an important safety risk". In addition, ERA also alerted the European Commission in a letter of 16/04/2021 that there was no functioning NIB in Greece.

4.2.18. Follow-up of safety occurrences by the NSA

376 In principle, safety recommendations issued by the NIB shall be addressed to the National Safety Authority (NSA), which shall, within the limits of their competence, take the necessary measures to ensure that the safety recommendations are duly taken into consideration, and, where appropriate, acted upon by the different railway operators. In addition, the findings of NIB investigations should form an essential input for the NSA's supervision strategy and plan (4.2.19.3).

377 Another possible source of information to fulfill the requirement for a NSA to establish a risk-based supervision strategy and plan is the operational incidents that are reported by railway undertakings and the infrastructure manager. Before the Tempi accident, RAS, within its responsibilities as NSA, used to receive from Hellenic Train the 'daily safety and incidents sheets' on a daily basis, 'telegrams' from the infrastructure manager recording incidents and accidents occurring on the national network, as well as relevant internal investigation reports of these two companies. The choice of incidents that are reported seems to be rather unstructured, and not based on a concrete description of what is expected (e.g. type of incidents/events to report, thresholds, information to be shared, deadline for reporting etc.). In the event of significant or repeated incidents, RAS requests the concerned railway operators to provide additional information. Other RUs operating on the Greek rail network did not send accident and incident reports to the RAS.

378 In the context of this investigation, it is worthwhile to note that RAS addressed three consecutive requests (dated 26/10/2022, 20/01/2023 and 24/02/2023 respectively) to receive information on two derailment incidents related to remote switch operation by station masters (364). In the second letter, they mention that "traffic management and operation of the telecommand system will be an area of the Authority's supervisory activity in 2023.". In the third letter, in turn, RAS questions "…whether the factors that led OSE staff to the incorrect arrangement of the change of route by a station master (incomplete training, staff fatigue, another factor) have been further analysed and whether measures have been taken or will be taken to address them.".

379 Immediately after the serious accident at Tempi, by Decision No 18/2023 of 01.03.2023, RAS decided to conduct an ex officio investigation into the accident. This investigation concluded that the accident was caused by infringement of and/or non-compliance with a long list of European, national, organisational (i.e. SMS) and pure operational rules. Without, however, providing any analysis of the (underlying) reasons of these non-compliances. These ex-officio investigations carried out by RAS aim to establish infringements of the legislation, in accordance with Article 70 of Law 4632/2019. In this context, the report of this investigation resulted in the recommendation and decision of RAS Plenary to activate the procedure for the hearing of the IM OSE and RU HELLENIC TRAIN by RAS with a view to validating the findings of the above-mentioned infringements and taking measures to address these infringements. This hearing procedure is currently ongoing by the competent RAS Hearing Committee.

380 Another source of information on adverse events, available within the entire Greek railway sector, was provided in the numerous alarming letters sent by Trade Unions in the years preceding the accident. Although significant safety problems were reported in these letters, they were perceived as not-objective and mainly inspired by political motives, therefore not triggering any noticeable change or improvement. A similar line of reasoning probably applies to the resignation letter from the then CEO of Hellenic Train in 2022, which - in retrospect - predicted the situation that led to the Tempi accident with frightening precision.

381 In conclusion, by lack of a NIB to perform the independent analysis of accidents and events, the capability of the Greek railway sector to learn from adverse events relied entirely on the investigations performed by the operators as part of their SMS. These internal investigations, however, by focusing on the errors made by individual front line staff, systematically lacked the necessary depth to introduce sustainable changes, herewith limiting the learning potential to an extreme minimum. A situation that was further reinforced by the way RAS focused on non-compliance in its investigations, analyses and recommendations.

Further analysis of the control layers

In addition to the obligation for operators to implement a safety management system, European legislation provides for various levels of control to verify the correct implementation and functioning of the safety management principles. The analysis of the functioning of these control layers that are relevant for this investigation is reported in the points below (4.2.19 to 4.2.21).

4.2.19. Control activities performed by the National Safety Authority

382 A national safety authority (NSA) should oversee continued compliance with the legal obligation imposed on a railway undertaking or infrastructure manager to establish a safety management system (SMS). Establishing evidence of such compliance is mainly document based at the moment of granting a safety certificate or a safety authorisation but will require on-site inspections and other supervision tasks in order to assess that the operators continue to duly apply their SMS in a continuous way.

4.2.19.1. Approval of train drivers

383 According to the technical specification for interoperability relating to the ‘operation and traffic management’ subsystem of the rail system in the European Union, the staff performing safety-critical tasks must have appropriate fitness to ensure that overall operational and safety standards are met. Both the railway undertakings and the infrastructure manager must put systems in place to ensure that such additional examinations and assessments are undertaken as appropriate for their respective concerned staff.

384 Both procedures to become or to be maintained in the role of train driver, and the license/certification a train driver must own, can be checked and monitored by the National Safety Authority.

385 In the context of this accident, and because of the profile of one of the train drivers of the IC-62 (who had to overcome different kind of health issues during several years), the investigation team tried to retrieve all the possible information and files concerning the case. The file made available was particularly vague only mentioning a final positive advice. In order for this train driver’s license to remain valid, health certificates were sent to the RAS for 2021, 2022 and 2023 by doctors, in which the train driver is deemed fit for work. In their reply RAS points out that in their view recognised doctors are fully responsible for issuing train drivers’ health certificates, based on the medical examinations carried out. However, despite the seemingly seriousness of the health concerns, none of the medical examinations and psychological assessments related to the function of the train driver could be found.

386 The lack of information in such a serious case led the investigation team to question the medical and psychological criteria to be used, their communication to the relevant assessment places and specialists, their assessment frequency and occasions, and the nature and extent of the useful feedback shared with the managers concerned so that they could take appropriate risk management measures. The capability of railway operators to manage these issues as part of their safety management system should be part of the supervision activities performed by RAS.

4.2.19.2. Safety Authorisation for the Infrastructure Manager OSE

387 With its Decision No 1940/20-10-2021, RAS approved the renewal of the Safety Authorisation of the infrastructure manager OSE (EL 21 2021 0001), initially issued in 2015 (EL 21 2015 0001), with effect from 4 October 2021 and until 3 October 2026. This Safety Authorisation was updated again (EL 21 2022 0001), maintainting the same expiry date, with Decision No 1647/21-06-2022, in order to satisfy the requirement for the infrastructure manager OSE

to demonstrate compliance with Annex II of the Commission Implementing Regulation (EU) 2019/779, in relation to the maintenance of vehicles used exclusively for its own operations.

388 Both authorisations make mention of a limited number of "problematic points", mainly in relation to observations made during previous supervision activities, which however "do not prevent the renewal of a Safety Authorisation and (for which) the completion of the required actions will be checked by the RAS during supervision, following the issuance of the renewed Safety Authorisation.". The serious weaknesses in OSE's SMS regarding essential processes like performance monitoring (4.2.7), learning capacity (4.2.16), competence (4.2.6), risk and change management (4.2.12) that have become apparent through this investigation were not identified when these safety authorisations were issued.

389 A partial explanation is that during the assessment phase of OSE's applications for a safety authorisation, the assessment went only as far as the availability of the documentation and the verification of compliance of these documents, mainly the SMS procedures, against the requirements of Annex II of Regulation (EU) 2018/762, without requiring the submission of objective evidence for the implementation of these procedures.

390 The above objective evidence was supposedly sought during the supervision phase and several weaknesses in the implementation of OSE's SMS were identified (e.g. 378, 341). However, as also identified by ERA through consecutive monitoring of NSA activities in 2019 and 2022 respectively (4.2.20.2), the supervision activities by RAS are underdeveloped, leading to the finding that "RAS has not developed a view on the level of safety performance of the Greek railway system" (4.2.19.3).

391 Additionally, although the non-application of Regulations (EU) 1078/2012 (common safety method on monitoring of the SMS) and (EU) 402/2013 (common safety method on risk evaluation and assessment) was observed and reported, RAS implemented a strategy to support and assist the infrastructure manager and the railway sector in general, providing advice on understanding the requirements for the SMS. This strategy generated, at the best, only a very slow change.

4.2.19.3. Supervision of Safety Management Systems

392 Regulation (EU) 2018/761, provides a common purpose for supervision to make sure National Safety Authorities give appropriate effect to overseeing that the railway undertaking, or infrastructure manager has and implements effectively its safety management system so that the railway system operates safely. Following the outcomes of their supervision, the NSAs may take proportionate enforcement actions (e.g. temporary safety measures) to ensure legal compliance and inform the stakeholders about the changes made to the safety regulatory framework as well as any emerging risks or increase of risks in their Member States.

393 When assessed against the criteria of this regulation, as earlier also identified by the consecutive monitoring of NSA activities by ERA in 2019 and 2022 respectively (4.2.20.2), the supervision activities of RAS showed clear deficiencies. Although a supervision strategy, that takes into account relevant elements in relation to the observed safety performance of the Greek railway system, was developed in between the two monitoring activities, RAS is still missing a structured and risk-based planning for its supervision activities. Moreover, there is no integrated and systematic analysis of the safety performance of each railway undertaking and infrastructure manager, resulting in the impossibility for RAS to establish a view on the level of performance of the Greek railway system. Finally, non-compliance by railway operators, even when persisting, is only addressed with exchange of letters and limited communication, without making use of the existing sanctioning mechanisms.

394 Several elements explain this lack of effective supervision by RAS. First of all, there is an evolving knowledge among the personnel carrying out supervision, of the requirements set by European legislation. Secondly, there is an imbalance between the tasks required for safety supervision and the available human resources. Of the 20 employees employed by RAS (on an allowed number of 35), only 6 are available for supervision activities, from which only 4 are working in the Safety Department. Finally, there is a limited recognition of the authority that RAS can and may exercise as NSA, mainly on the side of the infrastructure manager. A typical example of this is that when, after the Tempi accident, OSE - under threat of financial sanctions - was ordered by RAS to no longer use the poorly trained station masters that were recruited in 2022, until agreed remediate actions were taken, this order was completely ignored by OSE, so far without any consequences. Since the Tempi accident, RAS has started to use more effectively its legal powers, by imposing, in several cases, fines for breaching provisions of the law.

4.2.20. Control activities performed by the European Union Agency for Railways

395 With the introduction of the 4th Railway Package, the European Union Agency for Railways (ERA) acquired a series of additional supervisory or authority tasks. These include, among other activities, the issuing of single safety certificates for railway undertakings and the monitoring the activities of NSAs. Regulation (EU) 2016/796 provides the legal framework that sets out the guidelines for these activities.

4.2.20.1. Single Safety Certification for Hellenic Train

396 Because the area of operation covered more than one Member State, a Single Safety Certificate (EU1020220295) was issued by ERA on 21/12/2022 for the railway undertaking TRAINOSE, with a validity period of 5 years. Upon request, ERA issued an update of this Single Safety Certificate (EU1020230029) on 06/02/2023, to reflect a change in the railway undertaking's legal denomination (from TRAINOSE to Hellenic Train). This renewal confirmed the expiry date of 20/12/2027 from the initial certificate.

397 Regulation (EU) 2018/763, establishes the practical arrangements for issuing single safety certificates to railway undertakings. To ensure a common understanding of the severity of concerns raised during the assessment process of an SMS by ERA or by a NSA, this regulation provides in a harmonised categorisation of "issues". "Type 1" (request for clarification for the understanding of the application) and "Type 4" (amendment of the application file or specific, immediate action to be taken by the applicant) are blocking for the issuing of a Single Safety Certificate. "Type 2" and "Type 3" issues are related to 'residual concerns', not preventing the issuing of the certificate but for which the follow-up of agreed actions by the applicant is deferred for later supervision, which is a task that belongs exclusively to the National Safety Authorities concerned with the area of operation.

398 The Single Safety Certificate for TRAINOSE/Hellenic Train was delivered with 12 "Type 2" and 12 "Type 3" issues. This list of outstanding issues was communicated to the railway undertaking in the decision letter for issuing the Single Safety Certificate and the final assessment report on 21/12/2022. Both documents also contained information about the imminent supervision of the remaining Type 3 issues by the Greek and Bulgarian National Safety Authorities.

399 As part of the certification process, Hellenic Train developed and submitted an action plan for all "Type 3" and "Type 2" issues. The follow-up of the adequate implementation of this action plan is done by RAS based on a more or less monthly reporting by Hellenic Train, that had been agreed between RAS and Hellenic Train during a supervision meeting in May 2023. In the context of this investigation, in particular regarding the identified issues with the monitoring of train driver performance (4.2.14), the "Type 3" issue S-20220819-001-009 is relevant, requiring Hellenic Train to improve its SMS monitoring activities. The initially agreed deadline of 30/06/2023 to solve this residual concern has, through successive request agreed by RAS, been postponed by more than a year and at the time of analysis -18 months after the conditional issue of the safety certificate- the action had still not been completed.

400 The main reason of this delayed action appears to be, on the side of the railway operator, a lack of understanding of the requirements imposed by the legal framework (i.e. Regulation (EU) 1078/2012) and how to translate them into concrete and operational application. Furthermore, the fact that the safety certificate has been granted for a period of 5 years, although completely legitimate and in line with the legislation provided for, seems to lead both the National Safety Authority and the railway operator to underestimate the importance of the action and to a lack of sense of urgency. Combined with the lack of adequate supervision by the concerned NSA(s), this leads to a situation where critical safety management processes, that were assessed as residual concerns for supervision, can stay unchanged for years and potentially evolve into major non-compliances, which may affect safety performance or create serious safety risks, without being noticed.

4.2.20.2. Monitoring of NSA performance

401 The process for monitoring the performance and decision-making of National Safety Authorities is governed, on the one hand, by Art. 33 of Regulation (EU) 2016/796, defining scope and limitations of the mandate, and making explicitly mention of the effectiveness of the monitoring by national safety authorities of safety management systems of railway actors. On the other hand, there is ERA's Management Board decisions no.161 and no. 274, as required by Art.33 (2) of the Regulation (EU) 2016/796, adopting the policy, working methods, procedures and practical arrangements for this monitoring of NSA performance. Pursuant to this audit procedure, findings are

classified either as observations or as a deficiency, with the latter preventing the NSA from effectively performing some or all its tasks. Although providing criteria for identifying findings that are affecting NSAs' ability to deliver safety/interoperability tasks, the method and the current legal framework do not fully provide for the possibility to identify those findings with potential bigger impact on railway safety.

402 RAS, in its capacity as National Safety Authority for Greece, was the subject of two audits by ERA under this regime of NSA monitoring. The first of these audits, conducted between 25/09/2019 and 20/11/2019, resulted in 4 observations and 4 deficiencies concerning the topic of supervision and on the topic competences, 2 deficiencies and 2 observations. Following ERA management Board decisions, the scope of the audits in the first audit cycle only covered the topics of competences and supervision. Despite an agreed action plan on which regular documentary evidence of implementation was provided, the second audit, that took place between 19/02/2022 and 04/11/2022, concluded that: the 4 deficiencies were not fully addressed and remained deficiencies, and of the 4 observations, 1 could be closed, 2 were addressed only partially and were kept as observations and 1 was not addressed adequately and became a deficiency (393).

403 Apparently, the little progress between both audits regarding the adequate supervision of the railway sector by RAS, was not identified as critical during the intermediate follow-up that is based on the evaluation of documents and explanations provided during feedback meetings, and no further measures were triggered as the Greek NSA accepted the findings and committed to work to deliver the required improvements, by implementing the agreed action plans.

404 Audit reports resulting from the NSA monitoring activities are systematically sent to the concerned NSA, to the Member State (via the relevant Permanent Representation to the EU) and to the European Commission, on whose behalf the NSA monitoring activities are performed. The findings of the NSA monitoring audit of 2019 regarding the lack of adequate supervision by RAS apparently did not trigger any reaction from the Greek ministry and or the European Commission, which can be explained by the fact that the exercise was part of the first audit cycle that was run and an action plan formed part of the report. Furthermore, it is impossible to determine what the response would have been following the finding that little or no progress had been made between the two audits, as the Tempi accident occurred less than two months after this report was sent.

405 A follow up documentary check was performed of the evidence provided by RAS at the request of the ERA team performing a check of the state of implementation and application of Union legislation on railway safety in Greece, under Article 35.5 of Regulation (EU) 2016/786. The follow up of the NSA monitoring audit in this case was combined with the ERA advice.

4.2.20.3. Screening of national safety rules

406 Because the current system, in which numerous national rules continue to exist, may lead to possible conflicts with EU rules and give rise to insufficient transparency and possible discrimination against operators, The European Commission decided that a gradual reduction of national rules, including operating rules, needs to be reinforced. To support this, ERA is tasked with the examination of draft and existing national (safety) rules.

407 The main scope of ERA's assessment is to check whether the notified national rules enable the essential requirements for railway interoperability to be fulfilled, the CSMs and TSIs in force to be respected and the CSTs to be achieved, and that they would not result in arbitrary discrimination or a disguised restriction on rail transport operations between Member States.

408 In the specific case of the Greek operating rules, the reviewed national rules in the field of safety were submitted to ERA on 01/07/2020. By email of 05/04/2022, ERA sent its comments on the assessment of the submitted national rules in the field of safety, which were discussed in a videoconference on 01/06/2022 with the participation of representatives of the Ministry of Infrastructure and Transport, OSE and RAS. 15/07/2022, the Ministry of Infrastructure and Transport submitted the comments from Greece on the ERA's assessment of its national rules.

409 Furthermore, on 23/02/2024 ERA provided Greece with an updated assessment, taking into account recent changes in the European legislative framework and, in particular, Implementing Regulation 2023/1693, which amends Implementing Regulation (EU) 2019/773. Mainly by lack of resources on the side of ERA and because of the complexity and operational nature of the rules to be analysed, the process is still on-going.

410 Furthermore, there is no transparency on what happens with notified national rules that receive a negative

assessment of ERA, which would be the case with operating rules specifying the methodology for safety-related communication. Questioned on the follow up on the practical application of EU railway law, including immediately applicable legislation, such as Regulations and Decisions, the European Commission replied to rely essentially on information from the Agency's monitoring of national safety authorities and notified bodies and complaints. In this context, the European Commission also stated that: "Member States bear the primary responsibility to correctly apply and implement Union law. National safety authorities were established to supervise the application of the EU acquis among stakeholders, given their technical expertise and the high complexity of Regulations and Decisions in the field of rail, such the TSI OPE.".

411 In the specific case of Greece, where the need for integration of the required communication methodology into operational instructions was not recognised by the entire railway sector (incl. Ministry and National Safety Authority (4.2.9)), the lack of control can result in the inadequate implementation of EU specified operational rules that can have a direct impact on safety.

4.2.21. Enforcement of EU legislation

412 The EU legal framework applicable for the railway system includes Directives, which require transposition by Member States, as well as Regulations and Decisions, which are directly applicable and as such do not need to be transposed into national law. So far, the Commission's efforts concerning enforcement of the EU legal framework have focused primarily on transposition checks of Directives, which are carried out on an ex officio basis. However, to follow up on the practical application of EU railway law, including immediately applicable legislation, such as Regulations and Decisions, the Commission relies essentially on information from the Agency's monitoring of national safety authorities and notified bodies and complaints.

413 Where the findings of NSA monitoring audits reveal non-compliance with EU law and the answers provided by the by Member State are insufficient, the Commission can open an infringement procedure under Article 258 of the Treaty on the Functioning of the European Union. The procedure is addressed to the Member State and not against individual bodies or authorities. Formal infringement cases can be preceded by informal dialogue with the Member State through the so-called EU Pilot mechanism in order to gather additional information and evidence and endeavour to solve the matter outside formal infringement proceedings. As regards Greece, an EU Pilot was opened in connection with the transposition of Directive (EU) 2016/798.

414 The findings of the NSA monitoring audit of 2019 (for which the report was delivered in January 2020) concerning the lack of an operational NIB were duly taken into account and fed into the process of conformity check of the Greek transposition of the Rail Safety Directive which was running in parallel at the time. In April 2021, in the framework of an EU Pilot case, the Commission contacted the Greek authorities to obtain explanations on transposition and application of some of the provisions of Rail Safety Directive, including Article 20(1) laying down the obligation to investigate serious accidents. In their reply, the Greek authorities shared their intention to prepare a legal amendment merging the accident investigation bodies for rail and air transport. To this end, Law 5014/2023 was published on 21 January 2023 which established the National Organisation for the Investigation of Air and Railway Accidents and Transport Safety (EODASAAM). It would take another 14 months before the railway part of this investigating body became operational, with the transfer of a first investigator in charge (44).

415 With the (cumbersome and time taking) infringement procedure being the only formal instrument for enforcement at the Commission's disposal whenever informal contacts prove insufficient to solve a matter of compliance with EU law, precious time is lost whenever the identified non-compliances are related to elements of legislation that concern railway safety.

4.3. The collision of the trains

416 At the moment of the first impact, as registered by the on board TELOC data recorded that was retrieved from the accident site, the speed of train 63503 was 89.91 km/h. This is within the speed limit of 100 km/h for freight trains at this location (4.2.4). Since the train drivers of train 63503 could not possibly have identified the impending danger of the passenger train coming out of the tunnel earlier, emergency braking was activated only one second before the actual impact.

Figure 54. On board TELOC data recorder, train 63503, locomotive 120-022, retrieved by judicial experts on the 05.03.2023.

417 With the TELOC data recorder for the train IC-62 damaged and having its electronic data storage components destroyed by the fire that followed the collision, there is no direct recording of the speed of train IC-62 at the moment of the first impact. However, subsequent elements suggest that the speed of the passenger train was also within the predetermined limits of 160 km/h (4.2.4). There is the last data point recorded from the onboard GPS module showing a speed of 154 km/h 12 seconds before the first impact. Moreover, EDAPO, using the available recordings of highway traffic control camera's, also calculated the speed of this train as being approximately 150 km/h at the moment of the impact.

4.3.1. Injury causation mechanisms

418 The 4 train drivers that were sitting in the drivers' cabins were killed instantly due to the extreme forces of the impact. The extreme mechanical forces extend backwards to include the rear cabin of the IC-62 locomotive (1 casualty, reserve driver as passenger) and the first class coach (12 passengers and 1 railway employee travelling as passenger). From the state of the totally destroyed vehicles and the autopsy reports of the casualties, it is clear that no one of these 18 casualties had any chance of survival due to the brutal deceleration and mechanical forces of the initial collision.

419 Another 9 casualties were due to mechanical trauma caused by secondary crashes of vehicles that followed the initial impact. Two of them were train employees who happened to be at the front of the Restaurant wagon and another 7 were passengers travelling in the front two and in the last compartment of the B2 coach. All 7 were found outside the wagon: 3 at the front, subsequently burned outside any closed structure, another 2 at the front with heavy injuries, and 2 at the back, ejected from a broken off compartment. From the findings of the autopsy reports and other available information, we can conclude that these 9 casualties survived the initial impact but then were very severely injured in the following 3-4 seconds during the secondary crashes of the vehicles, without any chance of survival.

420 According to the best possible estimate, 20 (+/- 2) casualties were further caused by the structures closing in on them and crashing them without leaving them enough survival space. The actual cause of death would be mechanical trauma in conjunction with suffocation due to compression of the chest.

421 In the course of its movement towards its final resting position, 2 of the 31 occupants of the Restaurant wagon were ejected with survivable injuries and were helped along from other passengers to the ambulances that arrived later.

422 Of the remaining 29 occupants of the Restaurant wagon, another 4 managed to escape under their own powers from the burning and twisted steel structures during the first minute after the collision. All 4 survived with various injuries that were subsequently treated in the hospitals.

423 The B3 coach of the passenger train was not subjected to heavy deceleration forces and was totally survivable, if not for secondary impacts from the B2 coach hitting its roof and a section of the locomotive hitting against the side of the B3 coach. There were 2 casualties that both suffered severe head and spinal trauma due to impact by heavy debris entering through the side windows. Both casualties were killed instantly without any chance of survival, given the unlucky position they happened to be at (other passengers sitting next to them were practically unharmed). And 5 injured victims were ejected during the crash or jumped from a height to exit the carriage.

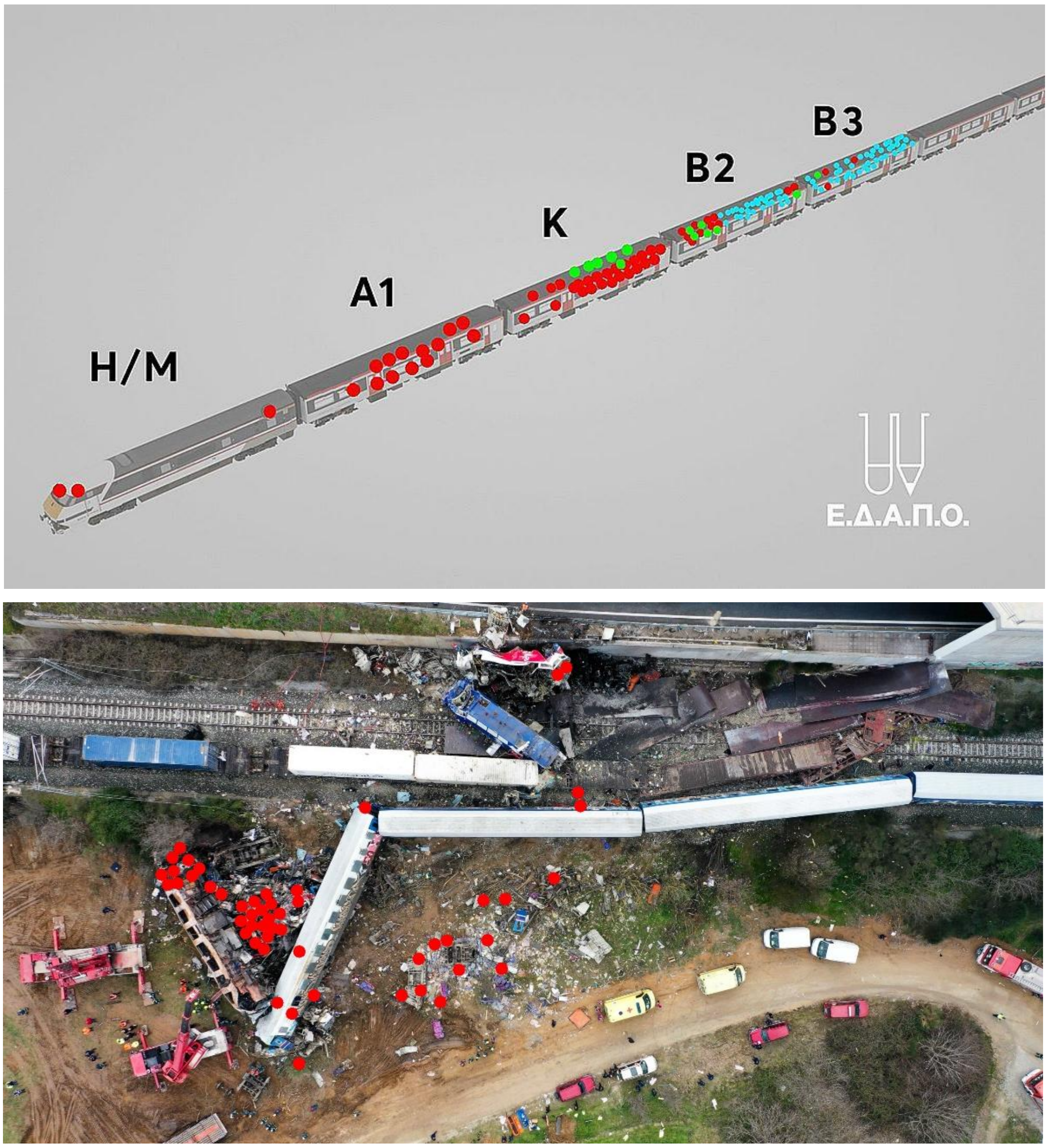


Figure 55. Initial and final estimated positions of fatalities, visualised on the scheme of the impacted part of the IC-62, and on-site.

4.3.2. Self-evacuation of passengers

424 The following table provides a further detail of the passengers for each of the coaches of IC-62.

B4, B5, B6 and B7	*All passengers self-evacuated safely without further injuries*
B3 2nd class coach	*3 dead, 3 trapped, approx. 55 climbed out and left safely (no fire)*
B2 2nd class coach	*11 dead, 35 survivors: 5 injured ejected during the collision, 30 jumped out in 19 minutes*
Restaurant Car	*25 dead, 6 survivors: 2 were ejected during the collision, 4 crawled away in the first 1 minute*
A1 1st class coach	*13 casualties due to extremely heavy mechanical loads, absolutely no chance of survival*

Table 7. Passengers for each of the coaches of IC-62.

425 By the time the emergency services arrived at the scene, except for three trapped passenger in coach B3, every one of the survivors had already evacuated themselves from actual danger. The emergency services (Fire Service) used power tools to cut away seats and metal structures to release three lightly injured passengers and two of the dead, approximately 90 minutes after the accident.

426 Emergency lighting of passenger coaches B4, B5, B6 and B7 worked properly and all passengers self-evacuated safely without further injuries. Emergency lighting on coach B3 was operational after the initial impacts, but only for a few seconds. When the B3 coach came to rest at its final position, the rear end of the B2 coach crashed on the roof of the front section of the B3 coach and the electrical panel handling the power distribution of the wagon was destroyed, shutting down the emergency lighting. The passengers broke a window and self-evacuated successfully.

427 Passengers from coaches B4 to B7 managed to operate the emergency handles of the doors and open the doors to self-evacuate successfully. On the B3 coach, access to the front doors was limited due to parts of the roof collapsing and blocking the narrow passage to the door. Passengers chose to break a window on the left side and climb down from there in order to self-evacuate. The Fire Service used the same window in order to enter and evacuate 3 casualties and 3 injured passengers who were trapped and needed mechanical tools to release them.

428 At least two passengers sustained serious injuries (bone fractures and dislocations) during evacuation: 1 female passenger jumped from the top row of windows of the B2 coach and was injured by falling on debris below (subsequent passengers jumping from the same window avoided this by throwing their luggage to land on top of softer surface) and 1 male passenger who was the first to jump from the B3 coach front left window, sustained serious injuries by falling on debris below (subsequent passengers evacuating from the same window took care to climb down carefully in order to avoid injury). An unknown number of passengers were reportedly lightly injured during evacuation, mostly in a similar way.

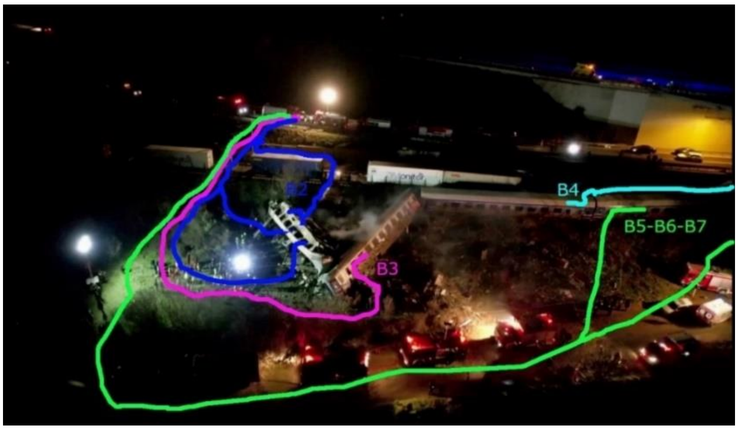


Figure 56. Self-evacuation paths of passengers before emergency services arrived at the scene.

429 After all uninjured passengers had self-evacuated by walking across the railway lines and climbing to the road overlooking the accident site, large tourist buses (summoned by Hellenic Train, being of the same company that is regularly used to transfer train passengers to the end station when a train breaks down) were used to transfer them to Thessaloniki train station. Evacuation of the first 50 passengers was very quick because an empty tourist bus happened to pass from this road and its driver stopped at 23:21 (two minutes after the accident) and called the authorities to summon help and waited to pick up the first evacuees, leaving for Thessaloniki at 00:46 (1hr and 20 mins after the accident).

4.3.3. Crashworthiness

430 Regulation (EU) 2023/1694 relating to the "rolling stock – locomotives and passenger rolling stock" (TSI LOC&PAS) defines the concept of "passive safety" as aiming at complementing active safety when all other measures have failed. For this purpose, the mechanical structure of vehicles shall provide protection of the occupants in the event of a collision by providing means of: limiting deceleration, maintaining survival space and structural integrity of the occupied areas, reducing the risks of overriding and derailment and limiting the consequences of hitting a track obstruction.

431 To meet these functional requirements on passive safety and reduce the consequences of collision accidents, railway units shall comply with the detailed requirements that can be found in standard EN 15227:2020. This standard provides a framework for determining the crash conditions that rail vehicle bodies can be designed to withstand. The objective is to provide a level of protection that is consistent with the most common collisions and associated risk through the application of the design collision scenarios specified in the standard. It is however clearly stated that: "It is not practical to design vehicle structures to protect the occupants against all possible accidents or to consider all possible vehicle combinations".

432 In application of this standard, vehicles designed to operate on international, national and regional networks, which is the case for the locomotives and coaches involved in this accident, shall be assessed for 4 design scenarios (i.e. a leading end impact between two identical trains, with a different type of rail vehicle, with a road vehicle and with a low obstacle). The design collision scenario that is most relevant for the accident under investigation, provides in a leading end impact between two identical trains, where the moving train is impacting an identical stationary train at a collision speed of 36 km/h.

433 Based on the above, it is obvious that the vehicles were not designed for the collision that took place, and that active safety measures should have been in place to reduce the severity of consequences.

4.3.4. Defining speed limits

434 A possible way of actively managing the risk of collision at high speed is to reduce the speed of trains. Based on international practice, one would expect a speed restriction (e.g. to maximum 40 km/h) whenever a section is entered with an authorisation to pass a stop-showing signal or any other End of Authority, which was the case with signal LAR11 in Larissa (91).

435 A similar speed restriction can be expected on lines with lateral signals, in the event of a general failure of the lateral signalling system (e.g. due to a power failure) as was the case between Larissa and Thessaloniki. This expectation is also mentioned in the textbook on "Railway Signalling Systems and Traffic Control Technologies", which had a first edition published in 2017, and that is used within OSE to disseminate the signalling basics to operational staff. In this textbook one can read that "A network without electric signalling is not necessarily unsafe … (but) it is problematic for a railway to carry out its traffic with density and speeds corresponding to lines equipped with electrical signalling systems, but without them existing or functioning.".

436 Furthermore, Article 76 (point 801) of the Traffic Regulation (Part B), identifies "the layout and condition of the signal equipment" as one of the essential element to take into account when determining the maximum speed of trains on a specific line (next to: the design, the composition and condition of the line, the set-up and condition of equipment for electrification, the existence, layout and operational status of the ETCS protection system, and the characteristics of the rolling stock making up the train).

437 Also point 803 of the same regulation refers to "the state of the track or electrification or signalling" as possible justifications to impose temporary speed restrictions. Specific instructions exist to put this in practice for specific ad-hoc cases of a deactivated interlocking and in the context of track works.

438 For the section north of Larissa, with a design speed of 200 km/h, the permissible speed was set to 160 km/h in order to compensate for the fact that no train protection was available. It is however unclear what criteria were used to define this new speed limit and what risks were considered when doing so. Moreover, this does not compensate for the fact that this section was not equipped with signalling. No criteria nor arrangements appear to exist to support such a decision in daily practice. This would be expected to be part of OSE's Safety Management System, and would not be accepted as a Notified National Rule according to Art.8, §3c of 2016/798.

4.4. Fireball, fire plume and fire pools

439 As described before (3.9.3), observing the course of the fire gives rise to making a distinction between 3 different stages (Figure 30, page 47):

a. Stage 1, with the release of fuel, its ignition, and the creation of an initial fireball that lasts for about 2 seconds and grows to a size of 40 meters.

b. Stage 2, with a second release of fuel, generating a fire plume that is adding to the initial fire ball and making it grow for 4 more seconds to a size of 80 meters. This combined fireball enters its burnout phase about 6 seconds after the ignition and dies down at approximately 10,5 seconds after the ignition.

c. Stage 3 is characterised by a main pool fire, underneath the Restaurant Car, for a total time of around 2 hours, initially consuming the fuel remaining after the fire ball and in a later stage feeding with other fuels.

440 During all this time, passengers report a moderate wind blowing from the north to the south, which is confirmed by available videos. The Mean Wind speed from 2023-02-28 23:00 to 2023-03-01 01:00 as measured at the weather station in Gonoi, close to Tempi, shows 7 m/s or about 4 Bf, which is low or like “a light breeze that can be felt on face” (extract from the Beaufort Wind Scale specifications).

4.4.1. Injury causation mechanism

441 The fireball that can be seen in the videos of the accident only lasted for approximately 10 seconds, but it created a very large thermal load for structures and passengers within its radiation range. The primary fireball extended upwards and burned at a height of 30-40 meters above the coaches. A secondary fire plume that can be seen feeding off a fuel source low on the tracks and feeding the main fireball, was within closer range to passengers travelling inside the Restaurant Car and the B2 coach.

442 Some of the passengers with severe burns show an irregular shape and pattern of burns that are more consistent with contact with burning liquid rather than heat radiation from a distance. It is not possible to identify the exact cause and mechanism of these burns, since no tissue samples were taken for laboratory testing and no special examination of the burns was performed.

443 The fact that out of the 31 persons (passengers and staff) inside the Restaurant Car at the time of the collision there are 6 survivors (and notably, 1 of the 6 did not sustain any burns at all) is an indication that the fireball itself was not enough to cause fatalities during its duration. It is more likely that the fatalities at this stage were caused by the secondary effect of the fire that continued to burn.

444 Among the injured passengers who escaped the accident and were treated for severe burns, there are no reports of sustained exposure to fire (i.e. trapped near a flame for a considerable amount of time). Most passengers sustaining severe burns state that they “did not realise what exactly burned them” and most of them agree that they were exposed to severe heat for only a few seconds at the time of the collision or contact with hot surfaces.

445 Of the total length of the passenger train IC-62, the only parts that were totally consumed by the fire were the rear part of the Restaurant Car (letter K on the drawing, Figure 55, page 91) and the B2 passenger coach.

446 29 of the 57 casualties are listed as “burned” in the official post-mortem reports. Of these 29 (+1 for a total of 30 if we include the 57th missing person) casualties, there is enough evidence to support the finding that 5 persons had survived the initial impacts but were unable to escape while the fire was spreading towards their trapped position. Further to this, there is indication to support the hypothesis that another 2 (to possibly 4) casualties could have been alive at the same time and subsequently lost their lives in the fire.

4.4.2. Fire protection of vehicles

447 There was no active (automatic) firefighting system installed in any of the carriages involved. The passenger train was equipped with portable fire extinguishers at either end of each carriage. There is however no indication that any firefighting took place using these portable fire extinguishers, either by train personnel or by any of the passengers.

448 One fire extinguisher is reported to have been used to break a window at the front of B3 wagon. Two passengers (acting officers of the Hellenic Navy) used a portable fire extinguisher outside the carriages in order to pull another injured passenger from the edge of a fire burning at ground level below the front of the B2 carriage.

449 This secondary fire of the B2 coach started from the bottom part and in due course (around 23:35) went up to the front part of the B2 coach and consumed the entire length of it, without any active firefighting until the fire reached the end of the wagon and started to threaten the B3 wagon (Figure 57). By 23:38 or after about 16-20 min, the front of the B2 wagon had started to burn with very strong flames. After that stage, this fire did not show any abnormal or unexpected speed and flame strength (Figure 57). The slow speed of this fire is consistent with a fire that feeds on the upholstery, the fittings and the construction materials of the carriage itself, without the obvious presence of any accelerant. Without any firefighting (either active or automatic), the fire took its course and burned every flammable material available. After about 35-40 min, the fire had advanced further along the coach and by 00:00 it had passed midway through the available length. By 00:40, the fire had consumed the entire length of the B2 and had started to self-extinguish, likely having nothing else to burn.

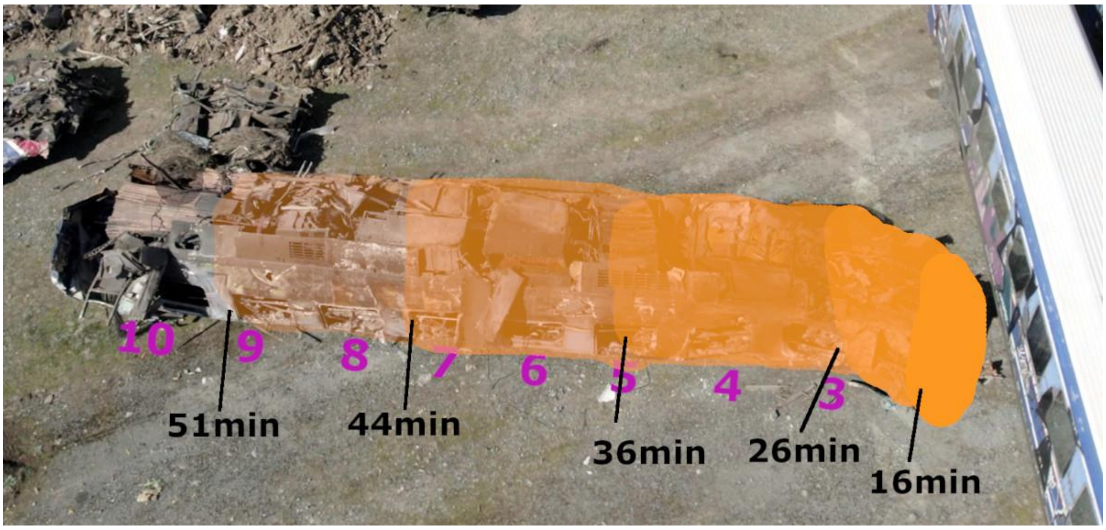


Figure 57. Progression of the fire in the B2 coach (from right to left, in minutes). (Source: EDAPO)

450 In relation to fire protection, the Locomotives and Passengers Technical Specifications for Interoperability (i.e. Commission Regulation (EU) No 1302/2014 as amended) refers to the standards EN 45545-2:2013 and EN 1363-1:2012. Standard EN 45545-2 was considered an important development in this domain, as it allowed to harmonise the pre-existing fire safety national rules from several EU Member States (e.g. DE, ES, FR, IT, UK and PL). This TSI, however, does not require any mandatory upgrade on fire safety for existing rolling stock (except for renewal, upgrade or situations specifically mentioned in the TSI).

451 When asked about the material used in the passenger coaches of train IC-62, Hellenic Train referred to the verification of compliance with existing regulations that is checked and ensured by a Notified Body, whenever there is an application for authorisation. A situation may however exist where vehicles were authorised or used without such a decision before the actual legal framework came into force. In such a case, there is no guarantee that compliance was verified, and so even with existing fire safety regulations, it remains possible to find old coaches that do not comply with any of these requirements.

452 Samples from three different seats from two different coaches were sent by EODASAAM to RST Labs in Germany to be tested according to ISO 5660-1. The results of these tests are, at the moment of writing this report, not yet known. It remains to be evaluated whether better fire-retardant materials could have played a role in the survival chance of casualties that had survived the initial collision and subsequently lost their lives from the fire.

4.4.3. Possible causes of the fireball and fires

4.4.3.1. Observations

453 From examination of all available video footage (2 cameras from Aegean Motorway, 1 camera from "Maliakos-Kleidi", 4 short videos shot by passengers) the following observations can be made in relation to the event.

454 The term "explosion" has a dual meaning of deflagration (subsonic rapid burning of some kind of fuel with external oxidiser), and of detonation (supersonic explosion of highly explosive material). In this accident, the explosion observed was most likely a deflagration - and not a detonation - as it can be observed in the frame-by-frame breakdown of its ignition. Also, there are no reports of any supersonic sound or blast heard or felt by any of the survivors, further pointing to a deflagration and not a detonation.

455 The first electric arc that is being recorded on video can be observed at a height corresponding to the height of the catenary line above the train tracks. This arc is presumably caused by the passenger train locomotive that is lifted upwards and contacts the catenary line.

456 The deflagration is ignited approximately 0.3 seconds after observing the electric arc, and it starts at ground level (note the hemispherical shape) with the huge amount of sparks from the emergency brakes locking the wheels of both trains (consistent with victims' testimonies) being the most probable source of ignition.

457 A comparison between the viewing angles of the three available cameras with an effort (via triangulation coupled with kinematic analysis of the crash sequence) to locate the exact point of initial ignition shows a probable point of ignition in the area between the 2nd locomotive of the 63603 freight train and the first flatbed carriage of the same train (Figure 58).

Figure 58. Estimated point of initial ignition.

458 The following sequence of images (frames from the Aegean Motorway video) starts at 2 seconds after the initial deflagration that started at the place indicated by the red arrow. As can be observed by these video frames, a dark irregular shape is moving in a northbound direction for a duration of approximately 4 seconds, during which time strong flames can be observed coming out. The distance covered was approximately 40 meters so this gives a mean speed of 10m/sec or 36kph for the carriage until it comes to a stop.

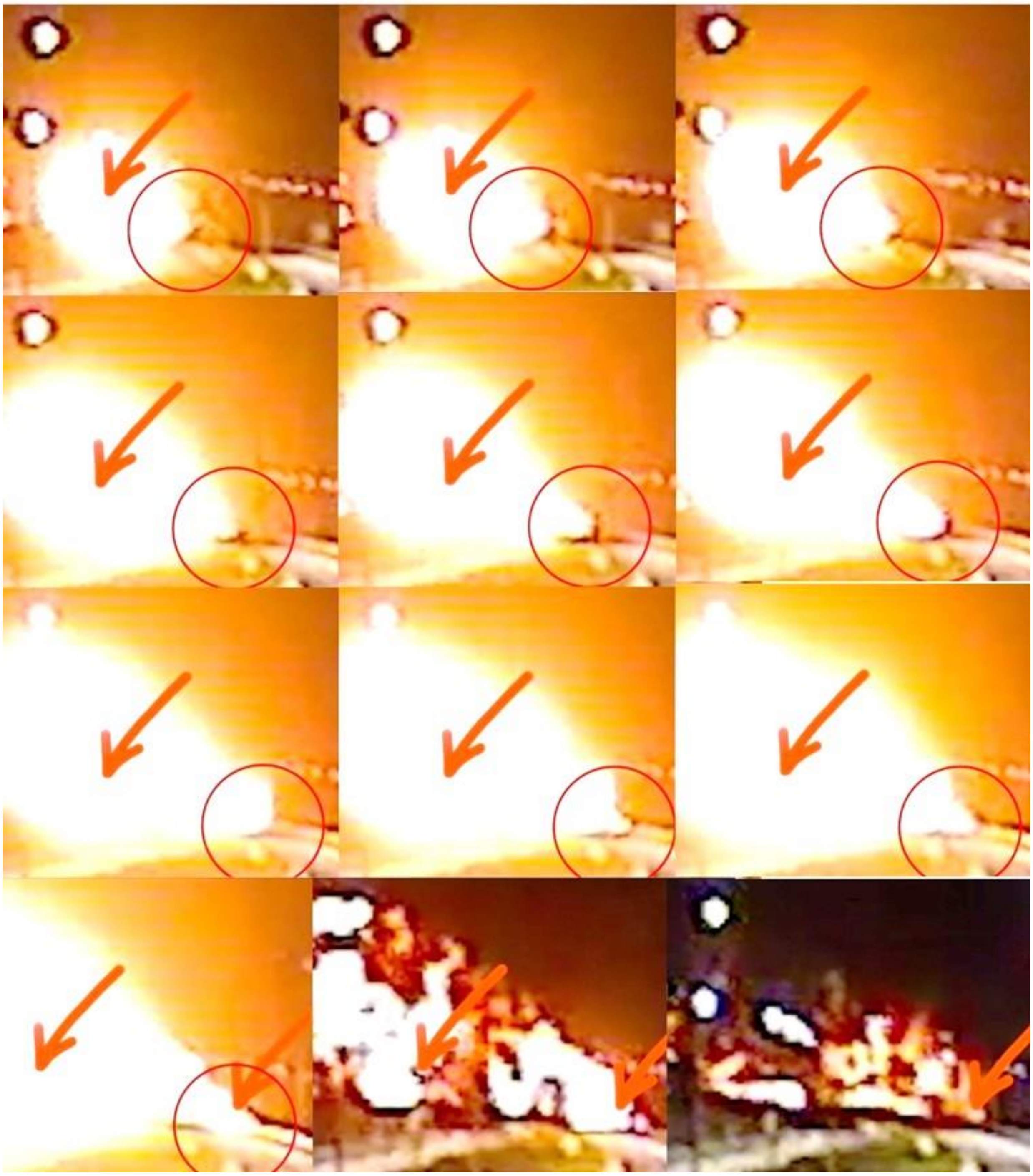


Figure 59. The sequence of the fire from the point of collision to the final stage.

459 The shape of the initial deflagration and ensuing fireball is consistent with liquid volatile fuel and not with liquified gas, which would create a jet fire and not a fire plume. A jet fire is “a high temperature flame of burning fuel released under pressure in a particular orientation" meaning that a jet fire would have a different shape and random orientation (not only upwards). Further indication of this, is the existence of the secondary pool fires that continued to burn, and which could not be created by a gas. The very quick initial deflagration and the shape and lift of the “mushroom” form also point towards a volatile, liquid fuel (an oil fire would fall quickly to the ground).

460 The second stage of the deflagration appears to involve a separate point of ignition, starting from inside the initial fire ball. The duration of this 2nd stage, the actual height of fire plumes, and the feeding of the fireball, indicate that a considerable amount (mass) of fuel is involved in this stage, creating this kind of plume form, and feeding the original fireball during approximately 4 seconds until the movement stops and the fireball enters its burnout

phase. Given the similar flame color and similar burning characteristics, it can be safely assumed that the type of fuel that is burning is the same as in Stage 1. This is an indication that either: 1) a second volume of the same fuel is burning while moving northbound, or 2) that the original volume, after having spilled a part of its contents during Stage 1 of the deflagration (0-2 seconds from ignition), is now moving northbound, following the movement of the Passenger train.

461 The above frames from the Aegean Motorway video (Figure 59) do not allow to identify the dark irregular shape. To be able to identify this part of the passenger train that was making the fireball move to the north, evidence from the video that has recorded the event from the southern side ("Maliakos-Kleidi" camera), and other available videos collected by passengers a few minutes after the crash was correlated.

462 The passenger videos show a very strong but very concentrated fire burning fiercely from the bottom of the Restaurant Car (color yellow added) while the remains of the passenger train locomotive (including the transformer filled with silicone oil) can be observed at a very close distance but clearly not on fire. This observation can be verified by the examination of the remains of the trains on the next day (Figure 60, Figure 61), where it is clear that the locomotive (color green added) is mechanically destroyed and, like the transformer (color red added), only has burn marks on one side, while the Restaurant Car (color blue added) is totally consumed by the fire.

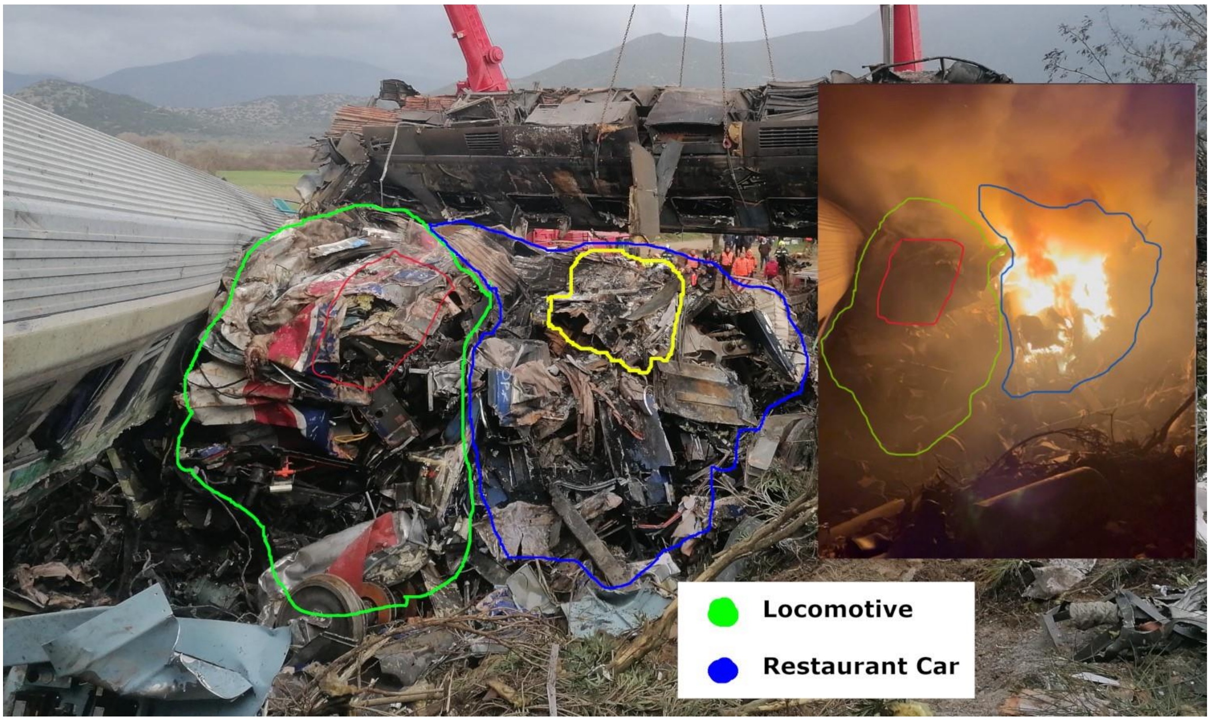


Figure 60. Restaurant burning next to the passenger train locomotive, with the position of the transformer in red.

Figure 61.Further images of the location of the Restaurant Car, Passenger Locomotive and its transformer.

463 By following this fire backwards in time, it is most likely that the fire that consumed the Restaurant Car is the same fire that has been recorded 4 minutes after the crash, burning from the bottom of the (crashed and bent in an S-shape) Restaurant Car (color yellow added). This is also the same fire that is observed from the "Maliakos-Kleidi" camera (Fig. Y), as an uninterrupted continuous movement from the fire plume (stage 2) to pool fire #2 (stage 3).

Figure 62. Fire plume moving into pool fire #2, as observed by the "Maliakos-Kleidi" camera.

464 The two pool fires can be observed burning up any remaining fuel that was not consumed in the fireball. By comparing the geometry of the nighttime frames of video to the daylight images, it is confirmed that the two pool fires are located where fire evidence were found in the morning.

Figure 63. Location and approximate size of pool fires #1 and #2.

465 When following the logic of these observations, it is highly unlikely that the locomotive and its transformer filled with silicone oil played a primary role in the stage 2 fire plume and stage 3 pool fire #2.

466 This fire that is consuming the Restaurant Car is not easy to evaluate as it is not an open pool fire on clear ground but a fire starting among the debris of the carriages and subsequently feeds on the materials of the carriage and most probably on the silicone oils leaking from the locomotive transformer (which is feeding the fire from an elevated position nearby). The gradual change of flame color (from purple-white to deep yellow) is also consistent with the assumption that the original fuel is only active during the first minutes and then other fuels are involved.

467 A video shot by a passenger 2 minutes after the collision shows this fire burning the remains of the Restaurant Car with a strong flame for at least 60 seconds before other combustible materials are added (flame color change). Another video, shot from a distance, at 14 minutes after the collision, shows the flames to have grown to a larger size and this fire continues to grow for the next 30 minutes as recorded by various other videos from passengers and emergency responders.

468 By lack of definite record of the total consumption of the initial source of fuel, it is difficult to quantify pool fire #2 with absolute accuracy. Nevertheless, there are valid observations that can be made from the events recorded and also calculations using the tools provided by the USNRC (www.nrc.gov):

a. Considering the first minutes of pool fire #2, the small footprint of the initial fire as recorded by the videos shot by passengers, gives an approximate size of not more than 10 square meters. With a generic hydrocarbon fuel of 300, liters, feeding a pool fire of 10 square meters. an estimated duration of 290 seconds (4.8minutes) and 12 meters flame height is calculated.
b. To estimate the duration of a secondary pool fire feeding on silicone oils, a quantity of 1500 liters of silicone oil feeding a pool fire of 30 square meters (a larger area consistent with the footprint of the twisted and deformed remains of the restaurant car) gives an estimated duration of 160 min, which is consistent with the time that the restaurant fire had self-extinguished, presumably due to lack of flammable material.

469 It is not clear at which point the fire started to burn the building materials of the Restaurant Car, but from the later examination of the layout of the debris, there is strong evidence of silicone oil slowly draining from the passenger train transformer and feeding this fire that continued to burn for at least 90 minutes with strong flames.

470 As can be observed from the remote "Maliakos-Kleidi" camera until approximately 18 seconds after the crash, pool fire #1 on the other hand, burned strongly for a very short period on the tracks near the locomotives of the freight train. After that, the larger flames are extinguished and smaller flames continue to burn at ground level, as observed by video footage shot by passenger 4 minutes after the crash (Figure 64).

Figure 64. Fire inside the transformer of freight train as a secondary result of pool fire #1.

471 Using the tools provided by the USNRC (www.nrc.gov) to estimate the approximate quantity of fuel consumed during this pool fire #1, and assuming an area of 40 square meters and a spill of 100 liters of generic hydrocarbon fuel, a pool fire duration of 25 seconds can be calculated. A secondary fire that continued to burn locally fed briefly on silicone oil coming out of the small cracks of the two transformers, as can be concluded from white powder residue SiO_2 (silicon dioxide, silica) that can be seen on pictures (e.g. Figure 66).

472 The amount cannot be quantified as we do not have a record of the start and finish of this event, but it can only be relatively small, given the small amount of white residue found on the scene. Also, the large amount of unburned oil that soaked the ground below the two locomotives and in the surrounding area gives indication that pool fire #1 extinguishes itself before burning the total amount of oil in the transformer and in the area. This fire did not cause any injury to passengers and did not destroy any carriage or part of the trains.

473 Furthermore, freight train 63503 did not show any further interaction with the fire, other than a very small local fire inside the broken transformer of the 120-022 first locomotive and a small pool fire outside the two locomotives burning on the ground (Figure *65*) and creating residue on the side of both locomotives without actually burning any parts of the locomotives. The white residue above indicating again the burning of silicone oil.

Figure 65. A local fire inside and outside the broken transformer of the first locomotive of the freight train, 40 minutes after the accident.

474 The fact that pool fire #1 has left two different residues is a direct indication that two different fuels appear to be involved in the event: 1) white residue, being SiO_2, characteristic for the burning of silicone oil, and 2) black residue with xylene traces, consistent with hydrocarbon fuels. The small amount of SiO_2 that was observed at the crash is consistent with the localised pool fire following the initial deflagration, but not the amount that can be expected if a large amount of fuel was burned.

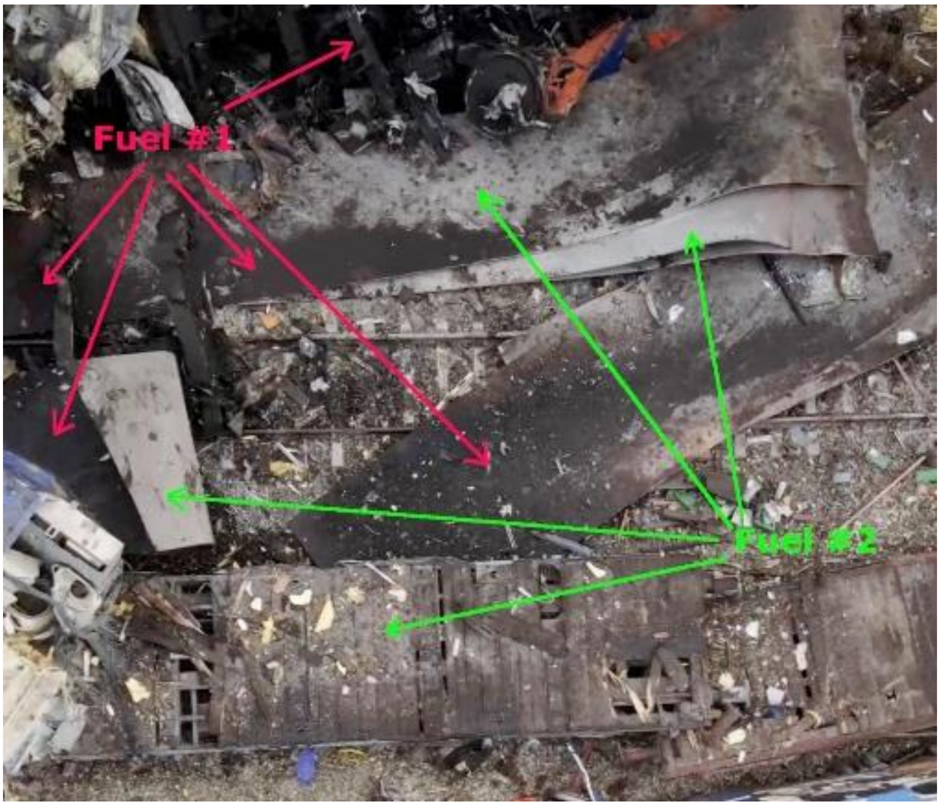


Figure 66. Evidence of two different fuels burning in the pool fire #1, one leaving black, the other leaving white residue.

475 According to the expert report of Prof. Konstandopoulos, "the 2400 kg of transformer silicon oil would result in approximately 1.94 metric tons of silicon dioxide (SiO_2) as combustion residue, which would be dispersed over all surfaces and give a characteristic white, dusty texture everywhere. This was not observed at scale, except for a few very localized areas where transformer oil was burned." (Figure 66, 485).

476 No soil and material samples or swabs from surfaces were taken from the scene of the accident before the remains of the trains had already been carried away to the Koulouri field. At the request of families of the victims, the judge ordered for samples to be taken from the soil at the scene of the accident and from the remains of the trains at Koulouri, on 28th March 2023, 29 days after the accident. The results of the chemical analysis (undertaken by the official State Chemistry Lab) were deemed inconclusive, due to the delay of 28 days and the contamination of the scene.

477 Even so, an observation that can be noted is the fact that traces of various hydrocarbons were found, among them most notably traces of xylene found in sample number EMP12-21 in a soil sample at the side of the tracks. When a second sampling and analysis was carried out in October 2023, two soil samples taken from exactly the same area (samples no EMP51-5 and EMP51-6) did not contain any xylene, indicating that xylene is not normally present as a result of pollution or other natural reasons. This reinforces the abnormal presence of xylene in the first sample.

478 If a proper sampling and analysis was done at the scene of the accident on 1st March, 2023 (10-12 hours after the accident), there would be enough information to identify the type and the location of the source for the unknown fuel (ref to site autopsy).

479 Comparing the relatively small amount of fuel that is seen feeding the #1 pool fire in comparison with the quantities involved during the initial fireball, the stage 2 fire plume and the two pool fires #1 and #2, leads to the assumption that the remaining fuel that was not consumed during the initial release and fireball, did not spill on the ground, but that its source got trapped and carried along with the twisted and bent remains of the Restaurant Car. This assumption is a possible explanation for a total amount of fuel shared between different stages, namely a first release to feed the initial fireball, a second release to feed the moving fire plume and the remaining quantity feeding the pool fire starting the fire that consumed the restaurant car.

480 Given their technical characteristics and the quantities of the materials in the trains that theoretically could have contributed (e.g. liquid batteries in entangled powertrains and passenger wagons, electronic fluid in the traction converter, cooling medium for air conditioners per passenger wagon, compressed air tanks in each locomotive), these do not provide enough fuel to explain the creation and development of the observed fireball (80m and sustained for 10 seconds). Furthermore, the technical description of the Restaurant Car (WRMZ coach) does not list any installation of any type of liquified gas and the information provided is that no actual cooking takes place on board; only electric sandwich toasters and microwave ovens are used to heat up pre-cooked food. Therefore, ruling out any other flammable material from the Restaurant Car itself and by elimination of all other possibilities, the most probable explanation for the above findings appears to be an unidentified volume of liquid fuel that is caught inside the S-bend of the chassis of the Restaurant Car during the 2nd collision between the Restaurant Car and the first platform of the 63503 freight train, and which is carried along to its final place among the other debris of the carriages.

4.4.3.2. Expert opinions and simulations

481 With the information available through the video footage from 3 different cameras that have recorded the event being the only evidence available, also efforts to calculate and/or simulate the possible causes of the deflagration, fireball and fires, through reverse engineering were attempted.

482 For this, EODASAAM reached out to institutions with specific expertise on the matters of accidents, explosions and fire. Five of them, from diverse countries, declined in supporting the investigation because of specific and legitime reasons. Nevertheless, it was possible for EODASAAM to organise the needed support as described below.

483 Firstly, RI.SE, a state-owned research institute collaborating with academia, industry and society as a central part of the Swedish innovation system, was contracted for a 2-week evaluation project on the possibility of ignition of known materials and substances on the train.

484 RI.SE provided a report that offers an opinion on the possibility of liquid silicone oil breaking up in droplets of sizes ranging from 0.5 to 4mm in diameter and these droplets dispersing in an area that would be consistent with the observations of the size of the fireball and the findings at the accident site. According to this hypothesis, it is possible to have the silicon oil breaking up in such a way that droplets of the mentioned sizes would be created and dispersed in the area. Thus, the mechanism of the silicone oil igniting and creating a fireball is deemed theoretically possible according to references in the literature.

485 In addition, EODASAAM reached out to Mr. Konstandopoulos, Professor of Chemical Engineering at the Aerosol & Particle Technology Laboratory of the Aristotle University, Thessaloniki, Greece, with questions related to the possibility of the formation of a combustible aerosol mix of silicone oil as a direct cause of the crash. Prof. Konstandopoulos offered a short technical report on the issues in question, stating that, given the approximate time of 0.4 sec for the initial ignition and development of the fireball, there is no realistic way to suggest that such an energy transfer and silicone oil ignition and combustion could possibly happen in the given timeframe and rate of development of the fireball combustion. Furthermore, Prof. Konstandopoulos has calculated the amount of white dust (silicone dioxide, SiO_2) that would have been formed after the combustion of 2.4 metric tons of PDMS oil, to the amount of 1.94 metric tons that were clearly not present at the accident site.

486 In parallel, under the supervision of EDAPO, computational fluid dynamics (CFD) simulations were run in an attempt to recreate the event as recorded by the cameras using only mathematical computer models and their visualisation tools[8]:

- Fire Dynamics Simulator (FDS) is a CFD model of fire-driven fluid flow. The software solves numerically a form of the Navier-Stokes equations appropriate for low-speed, thermally-driven flow, with an emphasis on smoke and heat transport from fires.
- Smokeview (SMV) is a visualization program that is used to display the output of FDS and CFAST simulations.

487 The advanced features of CFD models (such as handling complex three-dimensional geometries and environments, analysing reactive or non-reactive flow of compressible or non-compressible fluids) are accepted and valid scientific tools to support dynamic consequence assessment in the perspective of implementation in advanced safety studies dealing with fires, explosions and toxic dispersions. This was confirmed by experts from the universities of Pisa and Ghent, which were contacted on the recommendation of TU Delft as known international experts in the field of CFD.

488 Both the University of Pisa and the University of Ghent offered an opinion on the scientific validity of CFD analysis to modelise deflagrations. Furthermore, EODASAAM contracted the University of Ghent to review the work on CFD analysis of the Tempi accident, as was already done by EDAPO. This review resulted in a report that offered a technical opinion on the validity of the variables and parameters for modelling that had so far been used in the CFD simulations, in order to recreate the event as recorded by the cameras with the most realistic scenarios. The adjustment of some of the variables and parameters led to an improved and more reliable set of CFD simulations and analysis, that resulted in the following findings:

a. Among different types of hydrocarbon fuels that were tested, it was found that the results were very similar for many different types of fuels with similar physical quantities, with the most important parameter being mass of fuel. LPG, gasoline fuel, naphtha mixture, etc. of the same total mass provide almost the same result (similar fireball size and duration) with only very small differences in the shape of the fireball.
b. Calculations, with the mathematical CFD models, indicate that approximately 2500 kg of generic hydrocarbon fuel is needed to recreate the 3 distinct stages (1000, 1200 and 300 kg respectively) of the explosion, the fireball and the secondary pool fires that were recorded in the 3 videos that show the event from 3 different angles.
c. The duration of the release of fuel during stage 2 (approximately 4 seconds) and the observed result (fireball size growing from 40 to 80 meters in diameter) point out to a quantity of fuel which is estimated at around 1200 kg by the CFD simulations. If true, this rules out the possibility of liquid fuel (silicone oil from the transformer or any other liquid fuel from an unknown source) "splashing all over" the Restaurant Car, because such an action could not hold and release 1000 kg of fuel for 4 seconds. The only such possibility would be for the liquid fuel to enter the Restaurant Car through its broken windows, but the 6 Restaurant Car survivors do not support such an occurrence, nor do they have any burn injuries consistent with 1000 kg of fuel burning from inside their carriage.
d. It is further estimated that a quantity of 300 kg of Hydrocarbon fuel may have been involved in the pool fire #2, consuming the Restaurant Car, that continued to burn for more than 2 hours feeding also on silicone oil

8 FDS and Smokeview are free and open-source software tools provided by the National Institute of Standards and Technology (NIST) of the United States Department of Commerce.

and the materials of the internal fittings of the carriage. It is not possible, however, to accurately calculate this quantity due to the unknown time of secondary ignition of additional fuels involved, which is also the case for the amount of fuel that was burned in the other pool fire.

e. The examination of video footage and corresponding CFD analysis for the 2nd stage of the deflagration point towards a single source for the 2nd stage of the deflagration. Although it is not possible to confirm that the fuel for the 1st stage of deflagration has the same origin as the fuel for the 2nd stage, it is most probable that all 3 stages of the phenomenon are burning the same source of fuel.

489 Using the assumptions of RI.SE (484), an extra CFD simulation was run using the smallest droplet diameter mentioned (0.5mm) and complete atomization of the whole mass of fuel, which resulted in the following findings:

- Silicone oil of the type used in the power transformers of the locomotives could not be made to explode and create a large fireball in any way at all. Even if large sources of heat and open flames were added as a possible ignition source and even if the silicone oil was sprayed in various ways against a wall in order to create dispersion and smaller droplets, the only possible result was a very short ignition of 0.3-0.4 seconds that did not propagate to the rest of the quantity of the oil.

490 This is further confirmed by examination of the outside casting of the three transformers, showing that the quantity of silicone oil that could possibly escape during the first 0.3-0.4 seconds would not be enough for the large fire ball that was observed (Figure *67*).

Figure 67. Large cracks of the transformer still attached under the 120-022 locomotive (Left). Bumps, folds, rips and large cracks of remaining locomotive transformer 120-023 (right), see also Figure 61.

491 The above simulation also corresponds with the finding that there is no mechanism to create a fine mist of droplets at this stage, since the original point of impact is now 5-6 seconds in the past, 30 meters to the south and with the wind blowing in the opposite direction. This fact alone should rule out any fuel with similar characteristics to silicone oils.

492 Even if the hypothesis of ignition and creation of the initial fireball could be accepted, the 2nd stage of the fireball is more difficult to explain with silicone oil as fuel: the fire plume is observed as coming out of a fuel source already burning fiercely, obviously without any additional heat source and under ambient temperature. Survivors from the restaurant car did not report any significant temperature change during this stage and do not show any burns due to radiation. These elements point to the fact that the unknown fuel is volatile and very flammable.

493 The detailed information on CFD initial conditions, technical parameters and test results can be found in Appendix to this report.

4.4.3.3. Conclusion

494 The presence of a flammable substance with the characteristics as determined in the previous analyses is not mentioned on the transport documents of freight train 63503. Also, the recently released videos of train 63503, although not yet made available to EODASAAM by the judicial investigation, do not make any transport of a representative amount of flammable material visible in a location consistent with the above findings. EODASAAM recognises this fact, but this does not dismiss the above observations (4.4.3.1) that are clearly documented.

495 These observations, together with the performed simulations, confirm the conclusion that was also made by Prof. Konstandopoulos: "The large fireball at the Tempi railroad accident that occurred within 0.5 sec from the collision of the trains cannot be attributed to the transformers oil (PDMS) which although combustible at high enough temperatures (> 400) it could not - due to reaction kinetics reasons - ignite in the prevailing environment. Furthermore, the absence of white dust (Silicone dioxide, SiO_2) at the scene of the accident, in quantities that would justify the combustion of a large quantity of silicone oil, is another clear indication that such an occurrence did not take place. Hence the origin of the fireball consistent with a few tons of a flammable volatile fuel needs to be searched elsewhere."

496 The mass of this flammable volatile liquid has been estimated, via the CFD modelisation, in the order of magnitude of 2,5 tons. So far, the investigation has not identified any substance, with the properties and total mass known to have been in the rolling stock, which could have had this role. Similar to the previous steps (488), EODASAAM will contract a renown institute to review the validity of the variables and parameters that were used in the revised CFD analysis.

497 Despite this uncertainty about the source of the observed phenomenon, EODASAAM has explicitly chosen not to postpone the publication of this report. First of all, the fireball and the subsequent fire "only" had an impact on the consequences of the accident, without contributing to its causes. More importantly, the Greek railway system needs to know and accept the results of this accident investigation as soon as possible, in order to be able to start the necessary improvement process.

4.5. The functioning of the emergency services

4.5.1. Immediate response to the emergency situation

4.5.1.1. Firefighting

498 The Fire Service arrived at the scene from the top side (the paved road overlooking the crash site) at 23:42. At 23:57 the firemen are seen preparing their hoses and pulling them downhill to reach the uppermost part of the fire of the Restaurant Car.

499 Firefighting by means of water spray started at 00:02 from the first firefighting truck that set up a water supply to the uppermost (closest to the railway line) part of the Restaurant Car fire and at 01.08 a second firefighting effort started from the other side of the fire (lower, closer to the gravel road below).

500 As can be seen by video footage available, this initial firefighting effort had minimal effect against a very strong fire that continued burning for at least another 2 hours before dying down at around 02:00 having no fuel left to burn. The firefighting efforts continued for about 30 minutes and the fire was almost extinguished by 02:30.

501 At 02:32 the firemen can be seen spraying firefighting foam on the burned remains of the B2 wagon in preparation for their entry to search for fatalities.

502 Smoke continued to come out from the enclosed parts of the wreck of the Restaurant Car and a Fire Service thermal camera shows a source of heat (presumably a simmering fire inside the Restaurant Car) at around 04:30, when the firefighting effort has already been concluded.

503 Failure to effectively cool down every part of the wreckage and extinguish every source of fire, let a small fire to continue to burn inside the folds of the wreckage for about 12 hours, as can be observed by video footage taken at 11:33 on 1st March, where smoke is seen coming out of the same part of the wreckage as was seen with the infrared camera during the night.

4.5.1.2. Rescue of victims

504 The Fire Service Commanding Officer led the efforts of the various units of the Fire Service responding to the incident, coordinating units from various Fire Stations and from various branches, including “EMAK” which is a specialist team of rescuers that use mechanical means in order to gain entry in tight places.

505 At the time of the Fire Service arrival at the scene, it was unknown if there were trapped passengers inside the wagons, so the various units started to search the wagons and the area around the wreckage. According to the timeline of events as reconstructed after the accident, by the time the Fire Service arrived, almost every survivor had already left the wagons, either by self-evacuation or with the help of other passengers (4.3.2).

506 There were 3 passengers with injuries (bruises and fractures, not life-threatening) trapped inside the B3 wagon that required the help of EMAK to cut and lift seats and overhead electrical equipment and free them, an operation that was successfully concluded by 00:15-00:20. From this time onwards, the Fire Service continued with recovery of fatalities, that continued for the next 3 days.

507 After the first stage of rescue by any means that lasted about 2 hours, the Fire Service Commanding Officer asked the local Civil Protection officers to summon large cranes and earth moving equipment in order to clear the surrounding area for the large cranes to set up. Large floodlights were set up during the night and by 04:00 to help with the body recovery process.

508 During the first 6 hours after the accident, other Civil Protection officers and volunteer units arrived at the scene, along with a strong representation of Police, Ambulance and Rail Company personnel. The efforts of rescue, firefighting and body recovery were however organised by the Fire Service.

4.5.1.3. Medical assistance

509 There was no triage and no record of any injured passengers, as the ambulances just came on the scene and picked up whoever was presented to them. The passengers that were heavily injured and required emergency evacuation were 7 in total and were evacuated by the lower side away from the railway tracks, from 00:49 until 01:35. Another 5 passengers with serious injuries had managed to walk and climb by themselves or were carried by other passengers on the road to be admitted in the first ambulances that had arrived and left the scene from 00:00

until 00:35. Many more were slightly injured and were transported to hospitals by ambulance or other means.

510 There was no (need for) first aid at the scene of the accident since all injured passengers were transferred as quickly as possible to the local hospitals where they were admitted and treated for their injuries. At this stage, there was no provision for psychological aid for survivors of the accident. Those who were admitted and treated at the hospitals, received a visit from the duty psychologists many days after the accident. Survivors that were not admitted at a hospital were encouraged to call a hotline offering psychological support over the telephone.

511 The two hospitals at Larissa (Larissa General Hospital and University Hospital of Larissa) were immediately put on high alert and started receiving the seriously injured passengers and the fatalities during the night. On the next day, a list of all injured passengers was made available to the public, listing 20 passengers at the Larissa General Hospital, 36 passengers at the University Hospital of Larissa, 14 passengers at the University Hospital of Thessaloniki, 4 passengers at Gennimata Hospital in Thessaloniki and another 2 at Katerini General Hospital. Among them, there were 6 seriously injured passengers in the Intensive Care Units at Larissa.

512 Although the list of injured passengers was compiled quickly and precisely (during the morning hours of March 1), the telephone hotline number that was given to the relatives of the train passengers was not handled in a satisfactory way (recordings of 112 telephone calls show that a lot of the relatives had to call back at the 112 switchboard to complain that their calls to the information hotline were not answered). A local newspaper published the list on their website on March 1 and that was probably the way that all relatives were informed.

4.5.2. Management of perimeter and physical access

513 International standards require for the organisation of an emergency situation and to enable coordination to be as effective as possible, that a dedicated intervention zone should be delimited. The intervention zone is the area within which the necessary actions are taken in order to control the emergency situation. Depending on the specific emergency situation, generally the entire territory affected by the emergency situation is divided into a “Red”, “Orange” and “Yellow” zone, related to the risks they pose and the services and people authorised to access them. These zones are set up from the heart of the emergency situation to its periphery, taking into account element like: the nature of the emergency situation (e.g. fire with release of potentially toxic fumes, the weather conditions, the general topography and structure of the emergency situation terrain).

514 The “Red” zone is the area in which the intervention of the emergency services takes place. This zone, which is exclusively reserved for emergency services, experts and technicians, should be delimited by an exclusion perimeter, established by the police.

515 The “Orange” zone, is the area in which the logistical support of the intervention services is organised. It is only accessible to the intervention services and is delimited by the isolation perimeter. It is normally up to the police to set up this isolation perimeter and install the filtering controls located at the intersection between the isolation perimeter and the access/evacuation routes.

516 The “Yellow” zone is the area in which the necessary actions are taken to guarantee access to the intervention services and the smooth running of the intervention itself. Transit traffic is diverted and the curious and those interested in disaster tourism are kept away. The zone is delimited by the deterrent perimeter, established by the police, in principle only occupying the main access routes. Within the “Yellow” zone, a service car park can be provided for the intervention services as well as a First Destination Point (PPD) and a car park for ambulances and vehicles intended for the transport of evacuees and/or non-injured victims.

517 In the case of the Tempi accident, a very loose perimeter was set up by the Police during the first hours after the accident, mainly to keep journalists outside the main operations area. This perimeter was not guarded carefully and, to our knowledge, no record was kept on who had access and who actually entered and left the area. As can be clearly seen in the photographs of the first hours after the accident, anyone wearing any type of coloured jacket, any fluorescent vest or any volunteer insignia at all, would be admitted without any challenge. Furthermore, relatives living nearby had unrestricted access to pick up slightly injured or unharmed passengers without any recording.

4.5.3. Mapping of the accident site

518 A first phase of immediate response to an emergency, which aims at rescuing all survivors, is normally followed by a more administrative and judicial phase. This phase contains the forensic analysis of the site with the

detection, localisation, visualisation, collection, photographic recording and/or video recording, numbering, packaging, sealing and storage of all material evidence, with a view to analysis and subsequent use thereof. This includes a precise recording of the location of bodies, the marking and numbering with appropriate labels and with a unique number of each body or part thereof - and taking photographs before any movement.

519 To support this new phase, the police service responsible for the initial intervention shall close off and protect the place where the facts occurred, as well as, where appropriate, the places where objects related to the facts are discovered, by establishing one or more judicial exclusion perimeters, with the aim of: 1) protecting the evidence, traces and evidence, 2) preventing contamination of these places by exogenous traces, 3) allowing the tasks of technical and scientific investigation to be carried out by the competent services. Note that these perimeters could be different from the intervention zone that was necessary for the immediate intervention.

520 In the case of the Tempi accident, there was no recording of traces, evidence or any identification cues from the site of the accident. The fatalities were brought to the morgue without any numbering or identification; they were numbered sequentially as they arrived there. Any identification documents found on the bodies, were initially used for informal identification, pending DNA identification.

521 The accident was initially investigated only in the scope of understanding the cause of the collision. In the first hours after the accident, the focus of the investigation was at Larissa train station, where appointed judicial experts checked the functions of the control panel and the correct function of all motorised switches and all indicator lights. A few specific items that were considered as evidence during the first few days after the accident (TELOC recorders, speedometer, USB stick with recordings of signalling systems etc), were confiscated by the Police and handed over to the judicial investigators. Consequently, the site of the accident was not handled as holding any valuable evidence, no samples were collected and no careful recording of the debris was kept before the heavy machinery lifted and trampled on everything, before gravel was removed and the area was swept clean.

522 In a similar manner, the cause of the fireball and the fire was not investigated until 29th March, when a team of chemists appointed by the investigating judge went to the accident site and at the place where the remains of the wagons were kept, in order to collect soil samples and swabs for chemical analysis.

523 Nevertheless, both the police and the Fire Brigade drew up a photo document and a summary report, assuming that this was sufficient as mapping of the accident site, which is indicative for a lack of understanding of the importance of this step to safeguard an in-depth analysis of the accident and possible safety learnings.

524 Furthermore, according to one of the interviewed persons who did the identification of the deceased victims, the task of performing an adequate mapping of an accident site requires a specific knowledge and expertise that currently is also not available withing the DVI team.

4.5.4. Handling of the fatalities

4.5.4.1. Body recovery

525 Recovery of fatalities started at about 2 hours after the accident and continued throughout the night and in the next days (the last body part was recovered on 4th March). According to the official records, a total of 109 body parts were recovered: 55 on 1st March, 50 on 2nd, 3 on 3rd and 1 on 4th March.

526 From declarations, it was noted that the concerned emergency services felt a high pressure to recover the bodies and body parts as soon as possible, to avoid any negative images to appear in the media the next morning after the accident.

527 During the first hours after the accident, fatalities and body parts were recovered by the Fire Service and immediately handed over to the ambulances to be taken to the morgue at Larissa General Hospital. The location of the fatalities and body parts was not documented in situ and all records that could be consulted are from the admission of the bodies and body parts in the morgue, where an identification number was assigned to each one.

528 The delicate task of searching for any traces of the casualties was performed by the firemen and various untrained volunteers (members of various private volunteer teams can be seen in photos and videos helping in the actual task of human remains recovery without any official record of this). The special Hellenic Police team, OATHYK (DVI), established for the task of recovering and identifying casualties of mass disasters, was appointed to perform the identification of recovered bodies (535) and did not visit the accident site, even on the next two days while the firemen continued to sift through burned debris searching for any human remains.

529 Protection officers based at Larisa were asked by the Fire Service commanding officer to provide large cranes and earth moving equipment in order to start with body recovery as quickly as possible. The Civil Protection officers called local subcontractors that had worked in the past for the Larisa Prefecture. Additional help was asked from the Aegean Motorway Operations Command who also had their own subcontractors that were called to help.

530 By 04:00 the first bulldozer and 2 large cranes had started arriving at the scene and the Fire Service commanding officer asked for the area beside the B2 wagon to be flattened so that the cranes could set up safely. The work started during the night and by first light the cranes were into position and started to work, lifting wreckage and whole wagons.

531 In the next 3 days, additional equipment was summoned (bulldozers, excavators, flatbed trucks, gravel trucks etc.) to help with lifting wreckage in order to recover fatalities. By the end of March 3, the search for human remains officially ended and the Fire Service left the accident site, leaving the railway personnel and the local Civil Protection teams to work from March 4 until March 7 to clear the area and transfer everything to a local field that was used as a holding ground.

532 On 3rd March, when the decision was made to end the search for human remains, it was known that the casualties were 57 and 36 of them were already identified (as per the official announcement of the Fire Department). The fact that 1 of the 57 casualties would not be identified and still be missing after the end of the DNA identification procedure, was not known at this time. Consequently, the decision to use heavy machinery to tear apart the Restaurant Car and to trample and dig over its burned remains and then scoop all burned debris on gravel trucks to be carried away, prevented from identifying the last casualty.

533 Furthermore, it should be noted that a small body part belonging to an already identified casualty was found among the burned debris of the rearmost 6m of the Restaurant Car on 30th May, 2023 (536). Another 160 bone fragments were retrieved after careful sifting of the burned debris and ashes on 15th and 16th November, 2023, by the Larissa Medical Examiners Office (538).

4.5.4.2. Storage of fatalities

534 All bodies and body parts were immediately transferred to the central morgue of the local coroner service at the Larissa General Hospital. There is no record of any issues with the storage and processing of the fatalities.

4.5.4.3. Identification of fatalities

535 It was quickly decided and announced to the public that all fatalities would be identified only via DNA match, presumably to spare the families of the casualties of the burden of visual identification. The identification procedure was handled by the Hellenic Police Mass Disaster Victim Identification team (DVI, OATHYK in Greece) that collected information from relatives and filled Ante-Mortem forms and then collected DNA samples from relatives and arranged for the testing at the DNA labs in Athens. The process was handled in the shortest possible time so that the families would be informed as quickly as possible.

536 At the end of the DNA matching procedure, on March 8, 56 casualties were identified but no human remains could be identified to the 57th casualty. Even though it was known that the remains of 1 casualty are missing, there were no further actions on this. Three months later, on 31st May, a private accident investigator appointed by some families of victims to investigate the case, accidentally found another small part of human remains among the burned debris of the Restaurant Car and the authorities immediately retrieved it (it was later matched through DNA to one of the 56 casualties) but still no other actions were taken by the authorities for a more thorough search of the remains of the trains.

537 After continuous pressure from families of the casualties, there was eventually a new search of the burned remains of the Restaurant Car in November 2023, where more than 150 broken and burned pieces of human bones were found, unfortunately too late to provide valid DNA samples for positive identification of the 57th casualty that was riding in the Restaurant Car at the time of the collision.

538 At the same time (November 2023), a thorough search of the burned debris inside the B2 coach exactly at the place where burned remains of casualties had been recovered during the first hours after the accident, provided a lot of DNA material and human remains that were subsequently matched to the casualties that investigators knew that had lost their lives there.

539 Also, on request of the investigating judge, a team of specially trained cadaver dogs cleared the rest of the wagons,

debris and gravel, only to make sure that even after 9 months, nothing else was left behind.

4.5.4.4. Post-mortem examination and determination of cause of death

540 The Post-mortem examination on all casualties was concluded as quickly as possible, so that the fatalities would be released to the families for the funerals.

541 On 27 of the 57 casualties, the cause of death is attributed to very heavy trauma as a result of the mechanical forces of the impact. On the 29 casualties that were extensively burned by the fire, the post-mortem report lists "burning" as the cause of death.

542 In the latter case, as explained by the coroner in an official statement in the context of the judicial investigation, the reasoning that was held was that the burned victims would not have survived the fire anyhow. Unfortunately, this leaves the actual mechanism of death (severe trauma or burning) as unknown, which in turn makes it difficult to identify the appropriate counter measures from a safety point of view. One post-mortem report in particular shows findings that prove that the person had survived the collision and lost his life due to the fire.

543 Laboratory testing for the detection of carboxyhaemoglobin could help to make this distinction. This particular test, a standard test for any accident where fire is involved, would have provided crucial information about the actual cause of death, even for very extensively burned bodies (2cc of blood would be enough for this test).

544 However, the test was only carried out for the 5 train drivers (4 active and 1 travelling as a passenger). For the 52 passengers that lost their lives in the accident, these tests were omitted in the initial post-mortem examinations. Later examination was impossible, as all blood and tissue samples were destroyed on 10th April, only 40 days after the accident.

545 From the autopsy reports, and to the surprise of interviewed specialists, it was found that the medical examiners failed to obtain an alcohol blood test for the train driver of the IC-62. The reason for this, as officially declared in witness statements, was that the remains did not contain enough blood for this test.

4.5.4.5. Information management about fatalities

546 One hospital (Larissa General Hospital) was used as a centre of information for all families of fatalities, and on 1st March all families were directed to the hospital amphitheater. Early in the day, lists of injured passengers were collected from all hospitals initially involved and one master list was compiled and read to the families waiting for information.

547 In the morning of 1st March, there were 3 lists: a list of (informally identified) fatalities, a list of injured survivors from all hospitals and a third list of missing persons, compiled on the spot by adding new names during the day by families that could not find their relatives in either of the other two lists.

548 It was decided by the authorities that no visual identification of fatalities would take place, in order to protect the families from the additional psychological burden of having to identify heavily deformed, mutilated or burned fatalities.

549 At around 13:00 it was announced to the families that DNA samples would be collected and a special team arrived from Athens and started collecting samples at around 15:00, a procedure that lasted until 19:00 (a few additional samples were collected on the next day).

550 The DNA samples were rushed to the police labs in Athens along with blood and tissue samples from the fatalities in order for the procedure to be concluded as fast as possible. The results started to come to Larissa on 2nd March and continued until 3rd March when the latest DNA identifications concluded a list of 55 identified casualties (536).

551 The families were handed over the remains of their relatives inside sealed caskets with the explicit instruction not to open them. There was no specific information concerning individual families and victims, all families received the same instructions

4.5.5. Operational coordination

552 In principle, each emergency situation is handled by emergency services. Their missions are divided into five disciplines: 1) rescue services, 2) medical, health and psychosocial assistance, 3) the police at the location of the emergency, 4) logistic support, and 5) information. Although each of them is considered to have established and

to follow their single-disciplinary intervention plan, there is need for interdisciplinary collaboration and coordination to ensure the adequate organisation of the different interventions on the ground and, if necessary, to set up and raise the intervention zone (4.5.2). In most cases, this coordination is ensured by appointing an Operations Director at the scene of the emergency, who is responsible for the operational coordination and for leading the operational command structure that is composed of at least the directors of the disciplines concerned in the field.

553 In the case of the Tempi accident, it appears that there was no actual operational coordination of different services at the scene of the collision. First responders declared that "we did what we usually do and what our radio dispatcher told us, there was no active command post or coordination during the first hours after the accident". From these declarations it can be concluded that there was no overall command structure in place, no overall Operations Director was explicitly appointed and each different service (Police, Fire Service, Army, Civil Protection) continued to be coordinated by its respective senior officer.

554 Communication between the various services and forces involved did not follow any identified protocols or procedures and there is no written record of such interdisciplinary communications. Based on interviews with various people involved in the rescue and recovery operations, it is clear that there was no form of communication between the various telephone switchboards and radio operators issuing directions to each service member, but rather each service or force operated on its own initiative, following its own command structure, protocols and culture. This lack of coordination can also be found in the impossibility on drafting a joined site investigation report between the Police and the Fire Brigade.

555 As a direct result of this lack of coordination and communication, no records were kept on the situation and condition of the severely injured passengers that were taken to local hospitals, nor from any of the intervening persons. More importantly, a systematic record of the location of the fatalities, the parts of mutilated bodies, the place, position and condition of severely burned fatalities or the location of important findings, which would have been useful later in this investigation, is missing (4.5.3).

556 Although no intervention zone nor any consecutive judicial perimeter was properly designated and guarded, it is clear that the search for human remains officially ended at the end of 3rd March, 2023 (Fire Service Press Statement on this date). From 4th March to 7th March, access to the accident site was only loosely guarded, with Hellenic Train, OSE and private contractor employees working to clear the area and repair the railway lines. After 7th March, the accident site was not guarded any more, de facto lifting the intervention zone without any formal notice or decision.

4.5.6. Strategic coordination

557 A Strategic Coordination Committee plays a crucial role during emergencies by ensuring a cohesive response among various stakeholders. It facilitates communication and collaboration between government agencies and authorities, enabling a unified approach to problem-solving. The Committee assesses the situation, prioritises resources, and develops strategic action plans to address the crisis effectively. It also monitors the evolving situation, makes timely decisions, provides guidance to operational teams, organises information for the population and neighboring municipalities.

558 A Coordination Committee, with representatives of the emergency services, was formed at 02:30 of 1st March, 3 hours after the collision, after a specific request of the senior Fire Service officer. During this first meeting of the Committee, it was decided that more resources would be mobilised and more hospital and morgue space would be needed.

559 There was a second meeting 2 hours later (04:30, March 1st) without any further actions recorded, only with updated membership to include new arrivals and confirmation of the requests of the 1st meeting. There is no written record and no other information from interviews to indicate that the Coordination Committee actually operated as a committee and reached joint decisions or action plans. Despite having organised two Coordination meetings, it seems that each service continued to operate under its own orders, initiatives, and personnel without any interaction at the organisational level.

560 In the hours and days after the accident, information to the public was handled by the Fire Service and the Hellenic Police Press Officers who issued written statements and also carried out short live broadcasts on national

television, updating information on number of casualties and injured passengers and with contact information for the relatives of the passengers. They issued 13 public statements in the first 3 days (9 in the first 24 hours, 2 on 2nd March and 2 on 3rd March). By the end of 3rd March, when the Fire Service ended its Search and Recovery phase, there were no more bulletins or live broadcasts by the authorities.

561 Furthermore, the decision to end the search by the end of the third day (3rd March) is not documented in any way in the various documents and relevant correspondence between the investigating judge and the various services as included in the judicial investigation files. The only information on the decision to end the search can be found in the public announcement of the Fire Department by their official spokesman on 2nd March where he states "we expect the search to continue until midday tomorrow" and then on the morning of 3rd March when he states "we expect the search to be concluded by midday today". There is no further information or announcement on the matter and it seems that the search was concluded by the end of 3rd March (even though another body part was found on the next day, 4th March). The decision to end the search for human remains in such a short time seems to be connected with the decision to quickly clear the accident site and move all crashed vehicles and all debris from the accident site to another place nearby.

4.5.7. The Human Loss Management Plan

562 The "4th ed. of Special Plan for Human Loss Management" sets out a system for the proper organisation and coordination of the bodies and services involved, for the effective management of incidents involving numerous deceased persons as a consequence of physical, technological (including biological, chemical, radiological and nuclear incidents) and other disasters as well as criminal and terrorist acts, always respecting the religious and cultural perceptions of the deceased. In this context, coordination concerns the interconnection of individual actions between the authorities/bodies involved in consequence management and the competent pre-trial investigation authority as well as the finding and allocation of additional resources. It states in its introduction that: "A prerequisite for achieving this goal is the synergy, cooperation and interoperability of stakeholders at all levels of administration." The plan is published by, the General Secretariat for Civil Protection, and drafted in particular by the Directorate for Emergency Planning and Response.

563 In summary, this plan provides in a specification of roles and responsibilities of possible bodies involved, including for activation of the Plan, a 9-step operational process and instructions for coordination, information to the public and the media, forensic support, and psychosocial support. The 9 consecutive steps of the operational process, specified in the Plan are: 1) Area security/Perimeter control, 2) Site inspection, 3) Search/Evacuation/Recovery of victims, 4) Sorting, registration and initial identification of deceased persons, 5) Designation of areas for temporary preservation and identification of bodies, 6) Operation of a temporary preservation area, 7) Necropsy of bodies, 8) Management of bodies and their attributes to relatives, 9) De-escalation.

564 The plan describes the concept of the Preliminary Investigation Authority, whose role is particularly important for the activation of the Plan, the further management of the incident, and the carrying out of a pre-liminary investigation. The Preliminary Investigation Authorities, depending on the type and location of the incident, may in principle be the following: 1) The Hellenic Police, which is a General Investigative Authority of the country in accordance with Article 31 of the Code of Criminal Procedure, 2) The Hellenic Coast Guard, which undertakes the preliminary investigation in its maritime area of responsibility, ships and all kinds of floating structures, public and private ports and their port areas, 3) The Fire Brigade, which undertakes the preliminary investigation of arson crimes, 4) Civil Aviation Authority (CAA) carries out the preliminary investigation duties for aviation accidents. In any case, by order of the competent Public Prosecutor's Office, the preliminary investigation may be assigned to any investigating officer.

565 If activated, this Special Plan would transfer the responsibilities for the coordination of individual actions between the bodies involved in consequence management and the competent Preliminary Investigation Authority, related exclusively to the management of the bodies and their delivery to their relatives, to the Civil Protection General Secretary as the head of the Civil Protection in Greece. Activation of this Plan was proposed 3 hours after the accident, at 02:30 AM of 1st March, by the Fire Service senior officer at the scene who called a meeting among senior officers of all services present. Despite this request, there is no paperwork to support the actual activation of the plan, which would be the case if the formal specifications of the Special Plan for Human Loss Management would have been strictly followed.

566 It is however clear from the activities described above (in particular 4.5.4) that following this first meeting (and

the second one 2 hours later) everybody involved at the scene of the accident assumed that the Special Plan for Human Loss Management had been activated. The evening of 1st March, there was even a joint announcement of the Fire and Police Services in which the activation of the Human Loss Management Plan was mentioned.

567 In their interviews and official statements, all Civil Protection members (including the General Secretary himself) state that the Human Loss Management Plan was never officially activated, so the actual command and control of the situation belongs to the investigating agency which in this case would be the Police. This however contradicts the official media release of the Ministry of Climate Crisis and Civil Protection, published on 1st March, that states that "…since the first moment the Human Loss Management Plan was activated by the General Secretary of Civil protection".

568 The Police accepts responsibility for the investigative part away from the accident site, but they do not accept total operational command of the situation at the scene of the accident. Also, they point out that the Investigating Judge was overseeing the investigation and any major decisions such as ending the search for human remains and moving everything to Koulouri was done under the Investigating Judge's oral approval.

569 The Fire Service accepts responsibility only for operational decisions during the first hours in the firefighting, search and rescue and human remains recovery stages.

570 The Investigating Judge was overseeing the police procedures and investigations since the first hours after the accident but did not play an active role in the handling of the accident site. He is not listed as being present at the first meeting of the coordination committee and there is no report of anyone seeing him at the scene of the accident during the first 24 hours.

571 The government was present at the scene since the first hours after the accident with acting Ministers and General Secretaries of different ministries, but all operating under an "observer" role, without someone acting in an official way issuing orders.

572 The Police Department of Tempi had the duty to investigate the accident, due to its local jurisdiction. By the time of 05:30-06:00 in the morning of 1st March when most of the casualties were found, the Larissa Traffic Police department was officially appointed as Preliminary Investigating Authority (PIA).

573 The PIA and another officer of the Traffic Police department, with some previous knowledge of investigating railway accidents, had at 03:00 1st March proceeded to interview the personnel of OSE in Larissa Station and ordered the appropriate alcohol and drug tests to be carried out in a Larissa Hospital. The Traffic Police department, due to its duty as PIA, did not take part in the guarding of the accident scene and relevant sites.

574 The job of Traffic Police as PIA was completed on 2nd March, when the case file was turned over to the prosecutor's office and then eventually to the investigator of the Larissa Court office.

575 A psychosocial objective is clearly set out in the Plan, in terms of 'psychosocial support for the relatives of the deceased'. However, the description of the responsibilities and activities in "stage 9. Psychological Support" are not clear and/or not complete: responsibilities, needed resources and coordination for all these operations are missing, the psychological needs phases are not covered, etc. Furthermore, the target audiences of this discipline and the prevention of PTSD-related disorders should go beyond only the families of deceased victims. It is also unclear how the Plan will ensure that "psychologists and social workers" themselves are prepared and trained for the breadth and depth of the diagnostic activities and initial monitoring of PTSD-related impacts. Lastly, there is no provision for evaluating and improving this part of the plan.

4.5.8. Disaster preparedness

576 The "Special Plan for Human Loss Management" is distributed to all agencies and services involved, but there appears to be little or no provision for training and supervision of its correct implementation. In case of a large-scale accident or a natural disaster, it is not clear that the respective emergency services are properly informed and knowledgeable in order to implement it. Also, the mechanism of activation of the Human Loss Management Plan is unclear for railway accidents, administratively complex in its implementation and leading to confusion: in the Tempi case, it is not clear if the plan was actually activated or not (different opinions stated from Civil Protection officials and Police and Fire Service officers) and who had to take on the role of Preliminary Investigation Authority.

577 In the context of emergency planning and crisis management, the organisation of exercises is an important aspect.

In order for the cooperation between the parties involved to go as well as possible, the participants must have developed a kind of routine regarding the work to be done, so as not to be overwhelmed by the emergency situation. This ‘routine’ can only be acquired through the force of repetition of the exercises.

578 Two types of exercises can therefore be organised: 1) Table-top exercises, where the different services are gathered around the table and must react as they would in reality, and 2) Field exercises: in which case the exercise is staged where the emergency situation would take place and in principle a real deployment of staff and resources on site is organized.

579 The General Secretariat for Civil Protection informed that trainings were provided to PIA throughout the country and that they systematically take part in exercises that are organised on the initiative of facility operators like airports and ports. It is unclear, however, if any of the services and/or their specific staff involved in the Tempi accident had ever participated in a specific table-top or actual field exercise, but from what they reported we can conclude that no training exercise took place that trained all different services together. The Fire Service organises large scale exercises for accidents inside tunnels. There is however no information made available to the investigation on any exercise ever having taken place for a railway accident with catastrophic consequences.

580 The Directorate for Emergency Response Planning of the Secretariat-General for Civil Protection is responsible for updating/revising the “Special Plan for Human Loss Management” on the basis of lessons learned from facts and exercises, but also on the basis of administrative or institutional changes, in an effort to continuously improve and update this plan. This plan, which originally dates from 2011, is now in its 4th version. However, it appears that no debriefing of the experience with the Tempi accident took place, in order to improve the coordination of services and the requirements from the plan.

4.6. Post-emergency activities

581 Right after such a chaotic disaster and for weeks and beyond, one should be prepared to deal both with the duties of the investigations, and the requirements in terms of medical and psychological follow-up. Especially for the psychosocial part, Infrastructure Managers and Railways Undertakings know they have by definition exported risks and impacts towards their passengers and staffs. Moreover, and especially for the ones who are involved with safety critical tasks, the prevention of the Post-Trauma Stress Disorder (PTSD) is key in terms of being fit for those tasks and maintaining the full capability of their competencies.

4.6.1. Management of evidence & start of the investigations

582 Direct evidence collection immediately after a serious railway accident is crucial for several reasons. First, it ensures the preservation of physical evidence, such as wreckage, data recorders, and information on the position of fatalities which can provide valuable insights in the crash mechanism and potential causes of the accident. Early evidence collection helps prevent contamination or loss due to environmental factors or time-sensitive deterioration. Additionally, gathering witness testimonies shortly after the event increases the reliability of accounts, as memories can fade or change. This immediate action supports thorough investigations and enhances safety measures, ultimately contributing to improved railway safety and accident prevention in the future.

583 In the case of the Tempi accident, there was no recordings of traces, evidence or any identification cues from the site of the accident. In the first hours after the accident, the focus of the police/judicial investigation was at Larissa Station, in an attempt to understand the direct cause of the collision. The appointed investigators checked the functions of the control panel, the correct function of all motorised switches, and all indicator lights. The site of the accident was not handled as holding any valuable evidence, no samples were collected and no careful recording of the debris was kept before the heavy machinery lifted and trampled on everything, before gravel was removed and the area swept clean (4.5.3).

584 The cause of the fireball and the fire was not investigated until 29th March, when a team of chemists appointed by the investigating judge went to the accident site and at the place where the remains of the wagons were kept, in order to collect soil samples and swabs for chemical analysis.

585 The local police station (Tempi Police Station) was used as a place of safe storage of items collected from the accident site, mostly consisting of personal belongings of passengers, including luggage left behind, mobile phones and clothes. These items were not considered initially as “evidence” but rather as “lost and found” and some passengers retrieved their belongings during the first days after the accident. The families of the casualties also had a chance to search for the belongings of their relatives and retrieve anything belonging to them. Six months later, on 9th August, 2023, a judicial order was issued ordering the police to photograph, list and confiscate the remaining items as evidence.

586 A few specific items that were considered as evidence during the first few days after the accident (TELOC recorders, speedometer, USB stick with recordings of signalling systems, etc.), were confiscated and handed over to the judicial investigators.

587 Video footage showing the 63503 freight train, a very important piece of evidence, was initially missing from the available materials for the investigation. The videos in question were recorded by approximately 50 different cameras, recorded at separate digital recorders at the Thessaloniki Freight Station and at a further 18 different stations or control points along the route. The 24 different hard disks that held the footage that possibly showed the 63503 along the way, were not confiscated by the investigators, but rather asked for with a considerable delay from the investigating judge. The additional delay of the replies from OSE (who is the owner and operator of the surveillance camera system) meant that the footage in question was overwritten and could not be retrieved by technical means. A report by a British independent expert, requested by the judicial authorities, explains the impact of the delay on the possibility of retrieval of video material recorded at an earlier date.

588 Another important fact that came up at a later date, was that the 6 hard disks that had been delivered to the investigating judge's office by OSE supposedly from the Thessaloniki Freight Station and supposedly showing the loading of the freight train, were found to contain footage from the Thessaloniki Passenger Station which is located at an entirely different area. All these delays, mistakes and claimed misunderstandings, result in the fact that not one frame of video footage of the 63503 is available from the official surveillance video system operated – via a contractor – by OSE.

589 Causal to all this is the overall lack of knowledge on how to conduct the investigation of such a serious railway accident. In particular the absence of a functioning national investigating body (4.2.17), as required by the Railway Safety Directive (i.e. 2004/49/EC, later replaced by (EU) 2016/798) since 2004, is herein a crucial factor.

4.6.2. Medical follow-up

590 All injured victims were admitted at hospitals in Larissa and Thessaloniki and, according to the received declarations, most of them received satisfactory medical support.

591 One very seriously injured victim was transferred to a specialist hospital in the USA, and is now (Jan. 2025) still continuously under treatment at another specialist hospital in Italy, with all costs covered by the state Health Ministry.

592 After their release from the hospitals, all injured victims were promised by the National Organisation for Providing Health Services (EOPYY) that their medical costs would be covered. In practice, this proved difficult for many, when they had to pay their own bills and then collect receipts and submit them for reimbursement.

4.6.3. Psychological impact and support

593 An accident impact has to be considered as a psychosocial risk - being low or high, being silent or visible, being immediate or delayed, and being more or less experienced by the people involved. Nowadays, it is scientifically recognised and resumed by the terms post-traumatic stress disorder (PTSD). The absence of effort to consider or treat it, must be seen as an additional risk of aggravation and in some cases it will impair the restoration of a normal life.

594 Since decades we all know that industrial activities, being private or public, are exporting some of their risks towards their customers, their neighborhoods, and obviously also towards their own employees. Generally speaking, there is enough goodwill to consider a humanistic approach of these specific risks, since they are better understood, recognized, assessed and cured when the risks become a reality. However, beyond goodwill, there are several structured legal references to refer to when it is about identifying what to do, when or with whom. The aim of risk management applies here too: to anticipate and organise the risk control measures to be taken to avoid any extra aggravation of the emotional or psychological impact.

595 Specifically in EU Railways, there are a lot of remarkable initiatives to structure and organise these risk control measures. Some of them were started about 25 years ago, so even before any structured safety management systems. As far as employees are concerned, these initiatives can be first seen in the context of occupational safety or health & safety, already initiated with Directive 89/391/EEC and its transpositions. At the same time, it must be remembered that for these employees, being affected by such a risk means seeing their competencies, and the ability to use them, reduced or even impeded. This leads to a serious risk of further impact on the processes in which they are involved, i.e. in terms of operational safety. This is also why several requirements in the Common Safety Methods on Safety Management Systems, (EU) 2018/762, are directly and indirectly linked with such a challenge of anticipating any risk arising from human and organisational factors, logically including those activities that can impair employees, and in turn impacting operational safety with the additional risk of other consecutive accidents, in the following hours, days and weeks.

596 Just as importantly as what precedes, and in line with the (EU) 2018/762, it is necessary to consider that all the railway organisation responsible for the risk of their activities shall identify the emergency situations and associated timely measures to be taken to manage them. Infrastructure Managers with their Safety Authorisation, and the Railways Undertakings with their Single Safety Certificat have to do this. Moreover, these organisations shall identify and document the roles and responsibilities of all parties, and shall have plans for action, alerts and information in case of emergency, and shall describe how resources and means for emergency management have been allocated, and how training requirements have been identified.

597 The general principles of managing this risk that emerge from professional consensus would include the

following[9]:

- The psycho-social response in situations of mass emergency should be pro-active, instead of waiting to react to a problem or demand that may arise.
- A more continuous appraisal of the global situation is needed for the long term, and this includes more than the follow-up of each individual affected.
- Continuous evaluation is required, not only of the methodology and approaches used for support of individuals, but especially regarding the mass emergency specific approach, with the objective of integrating lessons learned in the event of new situations of mass emergency.
- It is important to be clear about who is leading the organisation of psycho-social support, and equally important is that the psycho-social support is clearly linked to the medical emergency management function.

598 Nowadays, it is also considered that the Emotional or Psychological Support, in case of a major accident, should even be directly included in the Discipline 2 (D2, Medical). Any intervention plan after such major accident should anticipate the risk of PTSD for the victims, the victims' relatives, the employees, the ones who are involved on-site, and all the ones who feel involved and have symptoms in line with a potential PTSD. In most cases, several phases are planned with their own activities: an acute phase, a transition phase and a long-term phase. This requires well-defined roles for coordination, hand in hand with other interveners like the DVI team, the Hospitals Psy-teams, the Police or Fire-Brigade Psy-teams, etc. Moreover, there are two kind of activities: one dedicated to organise a collective answer, and one dedicated to organise and monitor the individual answer given to the impacted persons.

4.6.3.1. Psychological impact of the Tempi accident

599 There was a provision for psychological support to the affected people in the form of a telephone hotline that was operational for a few weeks after the accident. However, the hotline was experienced as a very initial and light support. For example, when you called a second time and by lack of recording any earlier interventions, you needed to tell again all the details from the start.

600 The injured victims received generic psychological support in the form of 1 or 2 routine visits by the hospital psychologists, with no follow-up after their discharge from the hospital.

601 For the families of the casualties, there was a psychological support during the first 2-3 days after the accident by police psychologists being present during all interactions with the authorities. Many of the relatives of casualties received follow-up telephone calls during several months after the accident, by the General Secretary of Social Solidarity himself, but there was no organised and proactive support in order to prevent Post Traumatic Stress Disorder to any non-professional involved.

602 One Thessaloniki hospital organised two support groups for the psychological support of 25 survivors that lasted for 6 months, this being the result of an initiative by the specific team of psychiatrists and psychologists working for this particular hospital.

603 On the side of OSE, no specific action was initiated, neither for the ones directly involved (in the accident process or on service that evening/night), nor for the ones who intervened on the accident site. In the following months, an informal and oral support message was spread within the organisation, with no defined traceability and no dedicated target.

604 On the side of Hellenic Train, several debriefing sessions were organised in the following days and weeks, mostly targeting the train drivers.

605 Most of the teams who had been involved from the emergency services, had an open access to their own internal psychosocial support team (Fire Brigade, Police, OATHYK). At the Fire Brigade, a special ad-hoc debriefing was organised, also because of the intensity of the event and the numerous new or nearly new enrolled fire staff.

[9] There is a field of publications on this topic, and it is referred here to SEYNAEVE (G.J.R.) (Edit.). Psycho-Social Support in situations of mass emergency. A European Policy Paper concerning different aspects of psychological support and social accompaniment for people involved in major accidents and disasters. Ministry of Public Health, Brussels, Belgium, 2001, 42 pag. plus annexes. ISBN: D/2001/9387/1

4.6.3.2. Survey's goals

606 Far beyond the social and public reactions mentioned in §71, for the victims concerned and those more directly involved, there possibly remains a risk of PTSD - established, reduced or even exceeded, given the time taken to launch and complete this investigation. EODASAAM decided therefore to develop, coordinate and launch an emotional and psychological survey in order to understand the nature and extent of this specific risk.

607 The first aim of this dedicated and limited survey is to estimate less subjectively the residual, but maybe significant, level of emotional and psychological impact directly and indirectly caused by the Tempi accident. As such, any emotional and psychological issue related to a PTSD may be considered as a consequence of the accident. This consequence may also be amplified, and/or may have long delays before reducing or disappearing, as a function of the effort taken to consider and treat it in due time, with the adequate resources.

608 The risk of PTSD materialises and is recognised by unusual and often amplified reactions of our body, our thoughts, our emotions, as well as in our relationships with others and our environment. Some emotional pain such as the loss of our beloved ones can remain acute for a long time, and this is unfortunately quite normal. However, this syndrome – or set of symptoms – sometimes described as normal reactions to exceptional situations, can set in, diminish, amplify, disappear and even reactivate. This can be even with persons who have not been deprived of a beloved one, but who have risked their own lives, or witnessed the death or accident, or who were involved at the on-site scene after the accident, and even at a distance from the accident with a direct or supposed role.

609 The second aim is to estimate if this potential psychological impact may have been amplified by a lack of support provided in the following period. At the same time, there is also an amplified risk due to the persistent images of the accident, the contradictory or even unfounded information, which has circulated and is still circulating in all the private contexts and public media.

610 The questionnaire and the detailed results are described in the appendices B and C.

611 The sample, the findings and outcomes of this survey are described hereafter.

4.6.3.3. Survey sample

612 After having interviewed several persons and groups from the stakeholders and having discussed with two representatives of the victims and families, we decided to disseminate several identical versions of the survey via key contacts persons who could even add or relay some extra information.

613 The survey groups are:

1) Passengers injured in the accident (13) and passengers not injured in the accident (2). This group is then referred to as "Victims".
2) Relatives of a deceased passenger (10). This group is then referred to as "Victims' Relatives".
3) Officers from Police, DVI or Fire Brigade (14). This group is referred to as "Emergency Professionals".
4) Members of the railway organisations (45), of whom
    a. (9) had some involvement on the accident scene that night and/or the following days, and this group is then referred to as "Involved Railways Professionals".
    b. (36) had no such involvement. This group is then referred to as "Not Involved Railways Professionals".

614 Of the 84 people who completed the survey, 30 chose to do so non-anonymously. We interpret this result as an indicator of their understanding of the approach and confidence in the data processing. After a scrupulous analysis of the information collected, none of the contributions seemed internally contradictory or fanciful.

615 About 15 plain text explanations, clarifications and/or personal elements have been also shared by the survey participants along with their more quantitative questions/answers. These additional elements make possible to better interpret and understand both their quantitative answers and their personal views or life difficulties.

4.6.3.4. Survey results

The main results about the current severity of the trauma (as assessed with the previously described tool)

616 A full overview of the survey figures is reported in the annexes. We insist on treating the quantitative data obtained with caution, even though the groups may appear to be representative, sufficiently numerous, in confidence (non-anonymous) or full of important qualitative information. It is still possible to argue that other people in an even more critical situation did not want to contribute to the survey. Just as, conversely, it is possible to argue that other people feeling very well did not want to contribute to the survey. Finally, it would also have been possible to improve the way the survey was distributed, but the limited resources and the desire for discretion and quality were just as important.

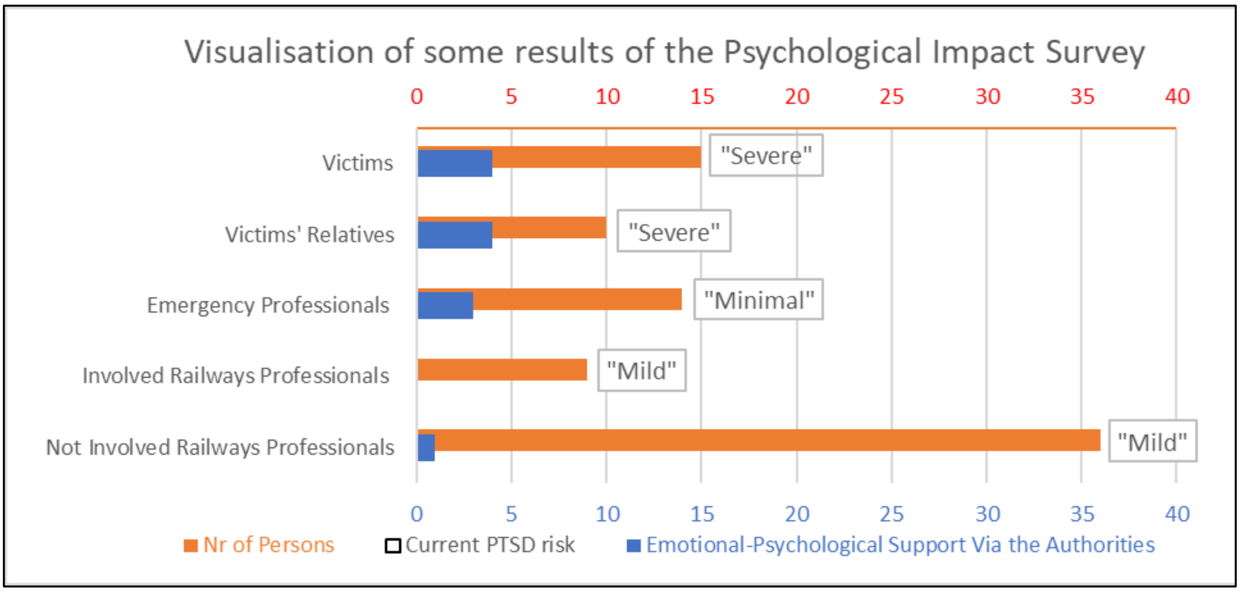


Figure 68. Visualisation of some results of the Psychological Impact Survey.

617 Among the groups “Victims” and “Victims’ Relatives” taken together (25 persons), there are still 17 persons who are still experiencing the trauma at a ‘severe’ level of the measuring scale or above (median of 19 and 20 for the two respective groups).

618 The group “Victims” can also be described as facing more remaining symptoms (and no one without any symptoms), with a median of 7 per person (13 being the maximum number of symptoms).

619 The group “Victims’ Relatives” has a median number of symptoms equal to 4.5, which is the double of the two “Railways Professionals” groups (median of 2) and, 4 times the “Emergency Professionals” group (1).

620 Within the groups “Railways Professionals” (45 persons in total), there is still a severe trauma for 5 persons, and a moderate level for 9, while the global group remains with an assessed current level of trauma being ‘mild’ (superior to the one of the “Emergency Professionals” group).

621 Involved and Not Involved Railways Professionals are similar together on all the indicators of current symptoms and trauma. Only 3 out of 45 persons report not currently experiencing any symptoms.

622 Among the “Emergency Professionals” group (14 persons), there is no one left with severe or moderate trauma. 3 persons report to remain with no symptom at all. One person, with a ‘mild’ level of trauma, has still to face several symptoms and not enough improvement despite the support.

The main results about the Emotional / Psychological support

623 The group of “Victims” is also similar to the “Victims’ Relatives” one in terms of the Emotional or Psychological support received. About 2/3rd of the groups received this support ‘early enough’ or ‘in the first days’. And about 1/4th of the group was left without this support, it was ‘never proposed’ or defined as coming ‘too late’.

624 In terms of the way that this support 'arrives' to the dedicated persons, we must report that the most important way is by their own, via their families or friends or acquaintances. If there is a little difference for the group "Victims", it is a strong tendency with the group "Victims' Relatives" who reports two times more 'via their own, their families, etc.' then via the 'authorities'. More importantly from a risk of PTSD point of view, 6 persons of the 25 – identified with a current 'severe' level of trauma – are still receiving no professional support.

625 Within the groups of "Railways Professionals" and the group of "Emergency Professionals", we expected they could declare receiving the Emotional or Psychological support via their employer or hierarchical line, or another internal or external service. It was explicitly mentioned in the "Emergency Professionals" (converging with most of our interviews with their different subgroups). It was never mentioned for the "Railways Professionals". And on the contrary they were 40 professionals out of 45 declaring to be never proposed such professional support (or not remembering such proposal). Nevertheless, for the ones (12) who reported to benefit from such a support, they declared feeling much or very much better. From a risk of PTSD point of view, still 3 of these "Railways Professionals" – identified with a current 'severe' level of trauma – are not receiving professional support.

4.6.3.5. Survey outcomes

626 An important finding, based on the survey results, is the fact that there are persons who are left without any professional – emotional or psychological – support. Also important, is to consider the high risk of trauma, here being reported with the help of a recognised scale. Indeed, looking at the groups "Victims", "Victims' Relatives" and "Railways Professionals", there are still 22 persons at a 'severe' level or above (more than 1/4th of the whole sample). By contrast, in the group "Emergency Professionals", no such 'severe' or even 'moderate' risk have been reported.

627 Another finding is related to the risk control measures that are not taken (or not enough taken) to prevent any aggravation of the stress syndrome PTSD, being not enough proactive while considering the emotional or psychological needs, and this, for the "Victims", the "Victims' Relatives" and even for the "Railways Professionals". Given the humanistic point of view, given the structured risk management that is required both for Operational and Occupational Safety, and given the management of emergencies that have to be organised and coordinated, we could expect a higher involvement of the authorities and the railways employers.

628 Finally, EODASAAM also decided to let this survey open during the coming months. Indeed, we can then monitor the entries from time to time and reevaluate if necessary these specific 'potentially evolving' results.

https://ec.europa.eu/eusurvey/runner/QuestionsToTempi-Victims-And-Involved-746388

4.6.4. Other support

629 Hellenic Train decided to provide all families of the casualties with a monetary compensation (42,000 euros per casualty) as a first installment against future compensation that will be awarded to them in due course.

630 The law 5039/2023 (FEK A 83 - 03.04.2023) was voted that cleared any debts that the casualties and their close relatives had against the government (taxes, fines etc.), and provided in a monthly pension to be paid to the families of the relatives and to the injured victims with a disability of more than 67% caused by the accident. Additionally, the law provided to injured victims and close relatives the right to be appointed to the wider public sector, to the injured the right to be compensated for hospitalisation and rehabilitation expenses and provided free individualised psychological support to the family members of the deceased and to those on board during the accident.

5. Conclusions

5.1. Summary and conclusions of the analysis

631 The most likely scenario considered to explain the head-on collision between passenger train IC-62 and freight train 63503 is the forgotten placement of switches 118 A/B by the inexperienced station master, working alone in Larissa station that night, which guided the passenger train on the opposite, descending track. The potential barrier, where the train drivers react to the conflicting information between the position of the switches and the granted movement authority, was missed by the train drivers.

5.1.1. Immediate cause

632 The collision between passenger train IC-62 and freight train 63503 could happen because both trains were travelling in opposite directions on the same descending track between the stations of Larissa and Neoi Poroi.

5.1.2. Causal factors

633 The station master did not use the automated method to set the route for train IC-62 to leave Larissa station to the north, towards Neoi Poroi, which would have positioned all switches correctly. Instead, he commands the individual switches manually and, when doing so, forgets to place the switches 118 A/B in the “main” position; herewith guiding train IC-62 towards the descending line. This mistake goes further unnoticed by the station master.

634 The investigation identified a number of factors that may have influenced the station master’s actions when setting the route for train IC-62:

a. The information needed to control train traffic that can be "read" from a control panel is complex, spread out in different places and supplemented by handwritten notes regarding temporary points of interest. As was confirmed by several of them, deciphering all information is not obvious for novice station masters (4.2.1.2). Because not all sections were already included in the control panel and some of them were temporarily out of use, it was not straightforward to identify the route of train IC-62 past switches 118 A/B on the evening of the accident (4.2.2).

b. Based on the provided information, it is unclear whether newly recruited station masters were trained and assessed in the practical application of local, operational working instructions for the respective control panels they would have to use (4.2.1.3).

c. While several of his colleagues that were recruited with him, refer to a period of one to one and a half year before getting confident with the required tasks, the station master that was on duty in Larissa station on the night of the accident had less then one month of experience (4.2.1.5).

d. Although the manual operation of switches was considered more complex and several instructions were issued to systematically set routes automatically, using the target buttons on the control panel, it was still common practice among station masters to use both methods (4.2.1.4).

e. The night shift in Larissa station is designed to be performed by one single station master. This is based on a static interpretation of the tasks and does not take into account the dynamic character of the activities to be performed (4.2.1.6).

f. A series of technical defects and malfunctions, some specific for that day but others already present for several weeks and sometimes even years, created a situation in which station masters operating in Larissa were obliged to perform a series of additional activities compared to the reference situation, without incidents (3.8.1).

g. A significant portion of the workload of the Larissa station Master on the evening shift of 28/02/2023 was made up of an exceptional high number of communications, using different means of communication and communication with very diverse interlocutors. The fact that a significant proportion of the conversations held do not or only indirectly relate to the management of train traffic also contributes to an increased workload (4.2.1.8).

h. The control panel in Larissa station and the area with the technical installations to be used for different types of communication are organised and physically positioned in a way that makes it impossible to perform both tasks at the same time (245).

i. In the last half hour before setting the route for train IC-62, the station master of Larissa made an error in setting the route for the entry of train 2597. Correcting this error required the full attention of the station master during a period of at least 6 minutes, adding to the normal workload (224).

j. It can be expected that this incident (with the train 2597) and its aftermath created an emotional weight on the inexperienced station master of Larissa, which have occupied his mind and created an additional element of worries (4.2.1.10).

635 The authorisation for train IC-62 to pass stop-showing signal LAR11 was given verbally by the station master of LarIssa and was not confirmed through read-back by the train drivers of IC-62. This stayed without reaction of the station master, leaving it uncertain how the authorisation, (implicitly) indicating a departure to Larissa via the ascending track, was understood by the train drivers (4.2.3).

636 In addition to the above factors that continued to influence the performance of the station master, the investigation identified a number of factors that may have influenced this communication practice:

a. It was routine not to use a written instruction (via form “1001”) for authorising trains to leave Larissa to the north. Although the regulation allows for this message to be passed via oral communication and while the two solutions are both valid, one is simpler but prone to errors, while the other is more reliable but requires greater effort (and is thus avoided) (253).

b. The quality of safety-related communications is in general unstructured, often without read-back and/or exchange of telegram number (261).

c. The current methodology for safety-related communications, as stipulated by the Greek operational rules GKK, does not follow more recent European regulations on the methodology for such communications (257)

d. The wireless analogue VHF network is an open communication channel, used for all service communications between on-board train staff and local technical staff in the different stations, does not allow for a direct one-to-one contact between station masters and train drivers for safety-related communications (254).

e. No tool (e.g. checklist or detailed work instruction) is available for station masters to support the structure and quality of safety-related communications for station masters (256).

f. At least one of the train drivers of IC-62 was in conversation with a colleague who was standing on the platform, when the station master first authorised train IC-62 to departure (262).

g. The long-lasting experience and reported assertiveness of the train driver of IC-62 may have influenced the willingness of both his younger colleague (265) and the station master (270) to speak up when detecting some anomalies.

637 The combination of the impossibility of one-to-one safety related communication between station masters and train drivers and the outdated methodology for this safety related communication, which was still in practice when observing safety-related communications during the investigation, triggered EODASAAM to issue an urgent safety recommendation (6.1.1) in June 2024, not waiting the end of the investigation.

638 Although they would be expected to stop in front of the switch and contact the station master to get clear instructions, there is no indication that the train drivers of train IC-62 reacted on the position of the switches not being compatible with the received authorisation (4.2.4).

639 The investigation identified a number of factors that may have influences the train drivers’ actions when passing switches 118:

a. Travelling on the opposite track and single-track operation was not an exception, and in the section just before, from Paleofarsalo to Larissa, train IC-62 was driving on the opposite, descending line (274).

b. The delay of 48 minutes, when leaving Larissa station, may have impacted the train drivers’ understanding of the position of other trains (277).

c. Although several events contained information of the contrary, there is still a slight chance that the train drivers of IC-62 assumed that the section between Larissa and Neoi Poroi was still operated on a single line, via the descending track, as was the case earlier that day (275, 276).

5.1.3. Underlying factors

640 The Greek railway sector suffered highly from the economic crises that started in late 2009 and reached a peak in 2010. This resulted in poorly maintained and increasingly degrading infrastructure and a structural shortage of staff to continue to provide the usual service. A situation from which the railway system was not recovered by the beginning of 2023 (3.8.2).

641 OSE does not provide in any preventive maintenance of its main assets for control, command and signalling.

Interventions only take place when (critical) assets fail, even for renewal projects that are partly taken in service (4.2.11).

642 For train drivers, who are confronted with changes due to ongoing works and/or failing assets on a daily basis, this requires a continuous alertness and high level of resilience.

643 The way OSE is managing the competence of station masters does not guarantee that they are competent in the safety-related tasks for which they are responsible:

a. The initial training is theoretically oriented (290).
b. No evidence is provided for the development of necessary non-technical skills (291).
c. There is no assurance that the practical training is sufficient to acquire the necessary competences to work safely under all conditions (295).
d. No structured initiative exists to ensure the continuous training of station masters, in order for them to maintain and/or improve their competences (4.2.6.3).

644 No structured monitoring of the performance of any of the station masters was performed in the beginning of 2023, leaving OSE unaware of any deterioration in the performance of safety-related tasks (4.2.7).

645 OSE does not take into account the need for integrating Human and Organisational factors. This results in the used equipment, demanded tasks, made available work environment and overall organisational arrangements stretching the limits of their operational staff beyond what is humanly acceptable in a sustainable way (4.2.8).

646 The integration of a high number of station masters mid-2022 was never considered, from a safety perspective, as a significant change (4.2.6.1). A similar finding was made for the re-integration of control panels. In general, the risk and change management of OSE is not adapted to the main missions of an infrastructure manager, and the link with operational activities is underdeveloped and poorly understood (4.2.12). A strong belief reigned that all operational risks can be controlled by strictly applying rules, under all conditions, and only recently a first attempt of risk management can be noticed.

647 The potential of OSE, and by extension the entire Greek railway sector, to learn lessons from incidents and accidents, and thus implement structural improvement measures that can create an environment that supports the work of operational staff, is limited if not- non-existent (4.2.16).

648 Hellenic Train could not demonstrate that they had put in place an on-going training in particular for safety-related communications and relevant non-technical competencies (skills, behaviours or attitudes) (4.2.13).

649 Hellenic Train has no process to systematically monitor the performance of their train drivers regarding the quality of safety-related communications (4.2.14).

5.1.4. Factors affecting the severity of consequences

650 Railway vehicles are not designed for a collision with a speed above 36 km/h, so active safety measures should be in place to reduce the severity of consequences. Unlike for example, the condition of track elements, for which temporary speed restrictions are imposed, no criteria nor arrangement exist within OSE to adapt the maximum allowed line speed to the condition of the signalling system (438).

651 Based on the observations that could be made, there is no indication that the technical equipment of the rolling stock used gave rise to the formation and expansion of the enormous fireball that arose after the impact, and subsequently resulted in the secondary fires. With the existing evidence it is impossible to determine what exactly caused it, but simulations indicate the possible presence of a hitherto unknown fuel.

652 It remains to be evaluated whether better fire-retardant materials could have played a role in the survival chance of casualties that had survived the initial collision and subsequently lost their lives from the fire.

653 Considering on the one hand the outcomes of the Psychological Impact Survey (4.6.3.5), and on the other hand the level of preparedness of the Plan on this topic (575), we conclude that there was/is a high risk of aggravation of the initial consequences related to the PTSD, especially for all the ones who did not have the possibility to access to this support in time. We note that there are still 22 persons at a 'severe' level or above (more than 1/4th of the survey sample).

5.1.5. Safety observations

654 Although not linked to causes of the accident or the severity of the consequences, the investigation has identified

the following, additional elements that are relevant for a safe management of incidents on the Greek railways.

655 There was no actual operational coordination of different services at the scene of the collision: there was no overall command structure in place, no overall Operations Director was explicitly appointed and each of the different services (Police, Fire Service, Civil Protection) continued to be coordinated by its respective senior officer.

656 This resulted in particular in the fact that no proper mapping of the accident investigation site was performed. This is partly due to a limited understanding of what such a mapping requires in order to be able to use its results for further investigation that can contribute to railway safety. Confusion over who is ultimately responsible for such a mapping in the case of a railway accident with consecutive fire has also contributed to an incomplete investigation.

657 Also at a strategic level, and despite having organised two Coordination meetings, it seems that each service continued to operate under its own orders, initiatives, and personnel without any interaction at the organisational level.

658 Knowledge for the correct application of “Human Loss Management Plan” was missing with several of the emergency services. No exercises to prepare for its coordinated implementation in a railway context have ever been organised, neither was any initiative taken to learn from the experience from the Tempi accident.

659 The initial collection of evidence for a further safety investigation shows several flaws, resulting in the loss of potentially vital information for understanding the causal and underlying factors of the accident and ultimately improving the safety of the railway system.

5.1.6. The role of the controlling authorities

660 In the beginning of 2023, as in the decade before, Greece had no functioning National Investigating Body that could independently investigate railway accidents and incidents. As a result, by lack of independent investigations, no sector wide lessons were learned from previous accidents and incidents (375). This is reinforced by the general accepted belief that a safe functioning of the railway system, under all circumstances, can be obtained by strict rule compliance, without any supporting equipment or protection systems.

661 The National Safety Authority, RAS, when issuing the safety authorisation for OSE, did not identify the above critical weaknesses in the Safety Management System (4.2.19.2). Several of these weaknesses in the implementation of OSE’s SMS were later identified during the supervision phase and notified to OSE for corrective measures, without leading to any noticeable change.

662 This can partly be explained by the finding that the supervision capacity of RAS is underdeveloped, leading to a situation where RAS has not developed a complete enough documented view on the level of safety performance of the Greek railway system (4.2.19.3).

663 When delivering the single safety certification for Hellenic Train, the European Union Agency for Railways, communicated (non-blocking) residual concerns that had to be resolved to improve the safety management system. This included an issue related to the strategy for monitoring performance. With this issue still not being resolved, 18 months after certification, any sense of urgency seems to be lost on the side of the operator and on the side of RAS, who is charged with supervising the implementation of corrective actions. One of the main factors that can explain this, next to a poor understanding of what is required, is the validity period of 5 years when issuing the certificate (4.2.20.1). Adding to this, is the already identified lack of adequate supervision by RAS, leaving it therefore unable to identify major non-compliances, which may affect safety performance or create serious safety risks (393).

664 Issues with the supervision capacity of RAS were identified during consecutive audits performed by the European Union Agency for Railways in 2019 and 2022. The joint follow-up of corrective actions, by ERA (4.2.20.2) and the European Commission (4.2.21) did not lead to any quick improvements in the supervision practices of RAS. Furthermore, it has taken almost 5 years since the identification of a non-compliance, before efforts to have the related EU requirements implemented, effectively led to an operational railway investigating body (414).

665 While NSA monitoring and/or the execution of authority tasks could occasionally identify some of the issues, there is no active follow-up at European level of the adequate implementation of operational rules that are specified in EU legislation, and thus not to be reported as national rules.

5.2. Measures taken since the accident and related to our conclusions and recommendations

666 In the final phase of the investigation, the main stakeholders were asked to provide an overview of measures already taken since the accident in Tempi regarding their own contribution to improving the railway system in Greece. A more or less comprehensive list of measures taken was provided to us, by the Ministry of Transport and Infrastructure, RAS, OSE and Hellenic Train. The most important elements of these lists, directly related to improving the management of the underlying factors identified in this report, are described below.

667 The Ministry of Transport and Infrastructure has launched an extensive campaign to upgrade, renew, and in some places expand the existing railway infrastructure, which include the retrofitting of signalling and telecommanding and the installation of the automatic train protection system ETCS. Although it will take several years for these projects to be fully realised, this effort -when continued- will help to put the Greek railway infrastructure back in a state that allows normal operation.

668 In addition, replying to the findings of an audit on the state of implementation and application of Union legislation on railway safety in Greece[10], and following consultations and in agreement with the European Commission, an Action Plan was started, by the Ministry of Transport and Infrastructure. The European Commission, to which Greece is reporting bi-monthly, acknowledges in its press statement of 16/12/2024, accompanying a letter of formal notice to Greece, that "there is good progress in the implementation of this Action Plan", while "nevertheless shortcomings in the implementation of the (Safety) Directive continue to persist". The same Action Plan also partly addresses some of the underlying factors also identified in this report:

a. The creation of a new, unified public body, incorporating OSE, ERGOSE and partly GAIAOSE, in order to address the gaps and/or overlaps of responsibilities between the currently operating bodies, as well as the lack of direct and effective coordination.
b. Signing of a contract between OSE and the Greek State, increasing the annual funding from 45 to 75 million euros and defining the obligations and rights of both parties.
c. Reinforcement of the staffing of the reformed OSE, RAS, EODASAAM and the Ministry of Infrastructure and Transport, as approved in Law 5167, which was adopted in December 2024.
d. The elaboration of a Strategic and Operational Plan and Investment Plan for the development of rail transport in Greece, in collaboration with the European Investment Bank (EIB).
e. The organisation of a sector wide risk management intiative, with the aim of mapping safety processes and highlight critical problems.
f. The creation of a national investigating body (EODASAAM) with sufficient human and financial resources to investigate serious railway accidents in a completely independent manner.
g. Clarification of the complementing roles and responsibility for safety between RAS and the Ministry of Infrastructure and Transport.

669 All stakeholders reported to actively participate to the above Action Plan of the Ministry of Transport and Infrastructure. In addition to reiterating the above actions, some individual initiatives were also mentioned by all stakeholders that contribute to improving identified underlying factors for the Tempi accident in this reports.

a. OSE is in the process of preparing new procedures for the oral and written communication between station masters as well as the organisational and technical arrangements for monitoring its correct application.
b. In addition, OSE reported on the installation of 300 cameras, for continuous monitoring of trains, in the tunnels of Platamonas, Tempi, Opthrys, Kallidromos and Agioi Anargyroi. Recording and monitoring are carried out in real time at the Tunnel Control Centers (TCCs) of Larissa and SKA.

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[10] Pursuant to Article 35 (5) of Regulation (EU) 2016/796, the audit was requested by the European Commission and performed by the European Union Agency for Railway between April and October 2023.

c. Hellenic Train provided specialised psychological support for the reintegration of its personnel after the accident and concluded a contract with a specialised psychologist for future support of employees.

d. Furthermore, Hellenic Train invested in the intensive retraining of train drivers and attendants, aiming to strengthen their skills and created the position of Tutor, selection procedures through interviews, guidance with manuals as well as continuous monitoring.

e. Together with the Democritus University of Thrace, Hellenic Train also designed a training program for executives on the topic: "Railway Safety: Principles, Procedures, Systems and Investigation – Incident Management" (647).

f. Finally, Hellenic Train reported on an important effort that was made for the redeployment of the roling stock fleet to the ETCS and GSM-R systems.

g. With letters in April and September 2023, RAS instructed all railway actors to report all incidents and accidents in which they are involved, including the minimum specific information to report (date of incident/accident, category of event, location, mileage, property damage, number of dead, number of seriously injured, number of slightly injured, etc.), together with the related internal accident and incident investigation reports. As reported by RAS, this request stayed without effective response by the sector.

5.3. Additional observations

670 While judicial investigations are obviously absolutely necessary, their excessive focus on individuals over organisational and systemic factors can inhibit the openness needed for rail safety improvements. The investigation team insists on going beyond human error, and on adopting an organisational and system focus.

- The use of internal investigation reports (of railways stakeholders) to prosecute workers will repeatedly inhibit the development of a necessary, well-informed and fair safety culture, making the personnel reluctant to report near misses, minor incidents, errors or difficulties, resources issues, etc. Indeed, the harmful impact of this kind of over-focus of the judicial investigations has been demonstrated for several decades[11].
- Furthermore, through their single scope of legal compliance, the current judicial investigations can miss the organisational and systemic target, and do not assist in the direction of strengthening of the system ensuring against industrial risks. Yet, these organisational insurance systems are the only ones capable of assuming the rare but damaging industrial risks, and being capable to compensate the victims without waiting the lengthy outcome of all the also needed legal proceedings.

[11] The specific directive (EU) 2019/1937 is also tackling this issue (whereas, 9): "*The importance of whistleblower protection in terms of preventing and deterring breaches of Union rules on transport safety, which can endanger human lives, has already been acknowledged in sectorial Union acts on aviation safety, namely in Regulation (EU) No 376/2014 of the European Parliament and of the Council (8), and maritime transport safety, namely in Directives 2013/54/EU (9) and 2009/16/EC (10) of the European Parliament and of the Council, which provide for tailored measures of protection for whistleblowers as well as specific reporting channels. Those acts also provide for the protection of workers who report their own honest mistakes against retaliation, so-called 'just culture'. It is necessary to complement the existing elements of whistleblower protection in those two sectors, as well as to provide protection in other transport modes, namely inland water way, road and railway transport, to enhance the enforcement of safety standards as regards those transport modes.*"

6. Recommendations and learning points

6.1. Safety Recommendations

671 Several of the recommendations identified as a result of EODASAAM's investigation in the Tempi accident go beyond the remit and powers of individual organisations and can therefore not be implemented without the support of the Greek Government.

672 Recommendations for which the implementation lies with the railway operators OSE and Hellenic train are, as requested by Article 26.2 of the Railway Safety Directive, (EU) 2016/798, are equally addressed to the National Safety Authority, RAS, who has the task to supervise and take all necessary measures to ensure their adequate and timely implementation.

673 The recommendations must be considered as means to improve the safety and the safety management. As requested by the Regulation (EU) 2018/762, on the Common Safety Methods on Safety Management System, OSE and Hellenic Train shall evaluate the effectiveness of the corrective measures once implemented. Furthermore, OSE and Hellenic Train shall use information relating to the investigation to review their risk assessment, to learn with the aim of improving safety and, where applicable, to adopt corrective and/or improvement measures.

674 During the course of the investigation, it also gradually became apparent that there is a need to **create the sense of urgency required to improve the socio-technical rail system**. This is true for OSE and Hellenic Train, but also for RAS which have to consider all the necessary means, including the restriction or revocation of the safety certificates and/or authorisations, the fines to apply, and the conditions to be placed on the granting and maintain of the safety management certificate. During the investigation process, in addition to the serious safety incidents that occurred, there were unacceptable delays both in the planning and execution of actions related to the urgent safety recommendation produced in June 2024, as well as in the submission of the requested evidence. There are also several European regulations that are still not applied in practice, and more generally, many requirements in the safety management system that are poorly or not respected in reality.

6.1.1. The Urgent Safety Recommendation emitted in June 2024

675 ***Recommendation 2024-RL01-001.*** *During the investigation, already an* ***urgent safety recommendation*** *was made, with the intent to address the combined risk of safety-related messages lacking structure and methodology as well as the use of an open communication system where safety-related communications cannot be prioritised over all other communications.*

The recommendation urged all stakeholders to work together without delay to implement in the Greek rail system:

1. A safety-related communication methodology that respects the requirements of Commission Implementing Regulation (EU) 2023/1693 amending Implementing Regulation (EU) 2019/773 on the technical specifications for interoperability relating to the operation and traffic management subsystem of the rail system within the European Union, and in particular Appendix C thereof.

2. A means of communication enabling direct one-to-one contact between station managers and drivers for all safety-related communications.

6.1.2. Recommendations under the initiative of OSE

676 The following recommendations are under the initiative of OSE. However, it appears that other stakeholders may have to consider and contribute to their implementation.

677 ***Recommendation 2025-RL01-001.*** *The intent of this recommendation is to better understand the risks related to the operational reality of the current railway system in Greece and to improve the way OSE is controlling these risks. Particular attention will be required for the risks related to renewal and/or maintenance works that are executed while the railway system remains operational.*

OSE should conduct a systemic review of all operational, organisational and technical risks relevant to the type, extent and area of operations currently carried out by the organisation. The review should include as a minimum those risks arising from:

a. The degraded state of assets and their gradual renewal.
b. The available human resources.
c. The technical, operational and organisational changes that impact the safety of railway operations.
d. The Human and Organisational Factors such as workloads, job and human-machine interfaces design, usability and suitability of the working environment, rostering and fatigue, an aging work force and the usability of procedures and work instructions.
e. The consequences of incidents and accidents in terms of PTSD, and their aggravation when not taken into account during the psychological needs phases, both for the external and internal concerned people, and especially the employees who are responsible of the safety related tasks and their organisation.
f. When deciding on the safety measures, OSE should ensure that it aims at creating a working environment that supports operational staff to succeed in their safety related tasks.

678 ***Recommendation 2025-RL01-002.*** *The intent of this recommendation is to optimise the performance and reliability and manage the safety risks associated with physical assets, throughout their life cycle.*

OSE should develop an asset management programme for all railway assets (tracks, bridges, tunnels, catenary, signalling systems, telecom systems, …) that contains at least the following elements:

a. Inventory: A comprehensive database of all assets with the categorisation and classification of all different railway assets.
b. Condition monitoring: Real-time data collection on asset conditions, whenever possible; combined with scheduled inspections and assessments for preventive maintenance.
c. Maintenance management: Development of maintenance schedules (predictive, preventive, corrective), work order generation and tracking for maintenance tasks, and resource allocation and planning for maintenance activities.
d. Lifecycle management: Tracking the entire lifecycle of railway assets from acquisition to decommissioning.
e. Operational performance monitoring: Analytics for performance metrics (reliability, availability, maintainability) and benchmarking against industry standards and KPI.
f. Risk management: Identification and assessment of risks associated with asset performance, and implementation of strategies to mitigate risks (safety protocols, emergency response plans).
g. Financial management:
   1) Cost tracking for asset acquisition and maintenance.
   2) A multiannual investment plan that covers all the needs (asset renewal and maintenance costs) to assure that the railway network can be maintained and operated safely.

679 ***Recommendation 2025-RL01-003.*** *The intent of this recommendation is to ensure that staff performing safety*

related tasks is prepared for this, that their competence is regularly assessed and maintained and that tasks are carried out accordingly, including the set of competencies related to the non-technical skills and arrangements regarding physical and psychological fitness when recruited but also during the career.

OSE should strengthen its competence management system, to cover at least the following elements:

a. The identification of the competencies (including knowledge, skills, non-technical behaviours and attitudes) required for safety-related tasks, with a particular attention to crew resource management.
b. The selection principles (basic educational level, psychological and physical fitness required).
c. The details of the initial training, experience and qualification, including for trainers.
d. The ongoing training and periodic update of existing competencies.
e. The periodic assessment of competence and the checks of psychological and physical fitness to ensure that qualifications and skills are maintained over time.
f. Any specific training in relevant parts of the operational rules, as embedded in the safety management system, to deliver their safety-related tasks, in particular in relation to safety-related communications.

680 ***Recommendation 2025-RL01-004.*** *The intent of this recommendation is to enable OSE to become aware of any deterioration in the performance of safety-related tasks, for the activities station masters as well as for other safety critical tasks.*

OSE should develop a system for monitoring the performance of safety-critical tasks that contains at least the following elements:

a. Define safety-critical tasks: Identify and categorise tasks deemed safety-critical based on risk assessments and establish clear standard and expectation for these tasks.
b. Develop performance metrics: Create specific, measurable indicators, related to safety performance and aligned with operational safety goals.
c. Implement monitoring tools: Utilise technology (e.g. logged route setting, recorded communications) to track performance and incorporate checklists and reporting tools to monitor the adherence to and applicability of safety protocols.
d. Perform Routine audits and inspections: Schedule regular audits to evaluate performance (incl. compliance with safety standards and incorporate unannounced inspections and observations to ensure adherence and applicability in real-world conditions.
e. Establish reporting mechanisms: Create a straightforward system for reporting issues, near misses and safety incidents, and encourage a culture of open communication regarding safety concerns.
f. Engage in continuous improvement: Solicit feedback from personnel involved in safety-critical tasks to identify areas for improvement. Regularly review and refine protocols, trainings and monitoring processes.

681 ***Recommendation 2025-RL01-005.*** *The intent of this recommendation is to create the potential for OSE to learn lessons from incident and make use of them for implementing structural improvement measures that can create an environment that supports the work of operational staff.*

OSE should develop a system to report, log, investigate and analyse accident and incident related to the organisation's railway operations, that contains at least the following elements:

a. Initial reporting: All events that are plausible candidates for in-depth investigation should be reported – in sufficient detail to decide whether an investigation should take place.
b. Selection: The events selected for in-depth investigation should be those from which as much information as possible can be extracted that is useful for preventive work.
c. Investigation: The procedures and methodologies for investigation are constructed to provide information that is as useful as possible for prevention of future accidents.
d. Dissemination of results: The investigation results are distributed to all those who can use them to prevent

future accidents.

e. Preventive measures: The information from event investigations is used to prevent future accidents, with a focus on supporting operational staff in safety-critical activities.

f. Evaluation: The safety information sharing process is regularly evaluated, and it is itself improved through experience feedback.

682 ***Recommendation 2025-RL01-017.*** *The intent of this recommendation is to maximise the availability of recorded data which could assist accident and incident analysis. It considers both technical reliability and processes used to recover images before they are over-written.*

OSE should review and where necessary improve its processes for recording, storing safety performance related data (CCTV footage in stations, recorded communications, logged actions from control panels, etc.). This recorded data should be easily made available for both internal and external investigation of incident and accident. This includes acquiring and maintaining the competencies to easily access the data and transfer it in useful information. For new systems that will be acquired in the future, this recording/storing accessibility should be part of the design and tender process. Particular attention should go to the synchronisation and correct time registration.

In relation to ***Recommendation 2025-RL01-004***, OSE should reflect on the possibility to use these technologies for continuous monitoring for safety performance in a non-blaming context.

6.1.3. Recommendations under the initiative of Hellenic Train

683 The following recommendations are under the initiative of Hellenic Train. However, it appears that other stakeholders may have to consider and contribute to their implementation.

684 ***Recommendation 2025-RL01-006.*** *The intent of this recommendation is to ensure that train drivers (and other staff whenever relevant) performing safety related tasks are prepared for this, that their competence is regularly assessed and maintained and that tasks are carried out accordingly, including the set of competencies related to the non-technical skills and arrangements regarding physical and psychological fitness when recruited but also during the career.*

Hellenic Train should strengthen its competence management system, to cover at least the following elements.

a. The identification of the competencies (including knowledge, skills, non-technical behaviours and attitudes) required for safety-related tasks, with a particular attention to crew resource management.
b. The selection principles (basic educational level, psychological and physical fitness required).
c. The details of the initial training, experience and qualification.
d. The ongoing training and periodic update of existing competencies.
e. The periodic assessment of competence and the checks of psychological and physical fitness to ensure that qualifications and skills are maintained over time.
f. Any specific training in relevant parts of the operational rules, as embedded in the safety management system, to deliver their safety-related tasks, in particular in relation to safety-related communications and crew resource management.

685 ***Recommendation 2025-RL01-007.*** *The intent of this recommendation is to enable Hellenic Train to become aware of any deterioration in the performance of safety-related tasks for the activities of train drivers.*

Hellenic Train should develop a system for monitoring the performance of safety-critical tasks performed by train drivers that contains at least the following elements.

a. Define safety-critical tasks: identify and categorise tasks deemed safety-critical based on risk assessments and establish clear standard and expectation for these tasks.
b. Develop performance metrics: Create specific, measurable indicators, related to safety performance and aligned with operational safety goals.
c. Implement monitoring tools: Utilise technology (e.g. recorded communications, on train data recordings) to track performance and incorporate checklists and reporting tools to monitor the adherence to and applicability of safety protocols.
d. Perform routine audits and inspections: Schedule regular audits to evaluate performance (incl. compliance with safety standards) and incorporate unannounced inspections and observations to ensure adherence and applicability in real-world conditions.
e. Establish reporting mechanisms: Create a straightforward system for reporting issues, near misses and safety incidents, and encourage a culture of open communication regarding safety concerns.
f. Engage in continuous improvement: Solicit feedback from personnel involved in safety-critical tasks to identify areas for improvement. Regularly review and refine protocols, trainings and monitoring processes.

6.1.4. Recommendations under the initiative of RAS

686 The following recommendations are made for implementation by RAS:

687 ***Recommendation 2025-RL01-008.*** *The intent of this recommendation is to strengthen the potential of the Greek railway sector to learn from adverse event. This reporting, as well as internal incident and accident investigations, should in no case be used in judicial investigations.*

RAS should develop an occurrence reporting system that contains at least the following elements:

a. A list of events to be reported, with identification of the deadline for reporting and the details to be reported.
b. Criteria for deciding on the depth of further analysis, with a focus on those occurrences from which as much information as possible can be extracted that is useful for prevention of future accidents.
c. Taxonomies on contributing and systemic factors that can help explaining the context in which the occurrence took place, away from blame and pure rule compliance.
d. The distribution of investigation results to all those who can use them to prevent future accidents.
e. Information on the measures taken to prevent future accidents.

The use of this reporting system should be imposed on the infrastructure manager and all railway undertaking operating on the Greek network.

688 ***Recommendation 2025-RL01-009.*** *The intent of this recommendation is for RAS to strengthen its capacity for supervision with the aim of establishing a view on the level of safety performance of the Greek railway system, as required by (refer to CSM SU).*

RAS should develop and implement the necessary supervision activities, in line with the requirements of Regulation (EU) 2018/761, to allow assessing whether the railway undertaking's or infrastructure manager's safety management system is effectively working. For developing this approach effectively, RAS should make use of the experience and methods already establish by more mature National Safety Authorities in other European Member States.

6.1.5. Recommendations under the initiative of the Greek Ministry of Transport and Infrastructure

689 The following recommendation is made for implementation by The Greek Ministry of Transport and Infrastructure:

690 ***Recommendation 2025-RL01-010.*** *The intent of this recommendation is to create a context in which the different responsible railway actors have the means at their disposal to meet the demands placed on them to develop and maintain a sustainable and safe railway system.*

The Ministry of Transport and Infrastructure should, within the limits of its competences, ensure that railway safety is generally maintained and, where reasonably practicable, continuously improved. To achieve this, at least the following elements must be completed in the short term:

a. In cooperation with the railway stakeholders, the development and implementation of a multi-annual strategy for the safe operation of the Greek railway system, providing for the timely renewal and maintenance of the network, the determination of the evolution of necessary financial and human resources and the setting of priorities for safe operation in terms of the resources effectively available.

b. To ensure that the National Safety Authority (RAS) and the National Investigating Body (EODASAAM) have at their disposal, on an ongoing basis, the necessary organisational set-up, financial and human resources to effectively carry out the tasks assigned to them in the Railway Safety Directive, as well as to create a framework that allows them to be periodically accountable for this.

c. To create an institutional context that allows the railway sector to recruit the right profiles in a targeted manner and within a limited and competitive time frame, which will allow the above objectives to be achieved quickly.

6.1.6. Recommendations under the initiative of ERA

691 The following recommendations are made for implementation by The European Union Agency for Railways:

692 ***Recommendation 2025-RL01-011.*** *The intent of this recommendation is to generate a quicker implementation of SSC action plans.*

The European Union Agency for Railways should develop and implement additional criteria for deciding when limiting the period of validity of a Single Safety Certificate is necessary to ensure the effective control of risks affecting the safety of railway operations within an adequate time frame. This should be combined with a more explicit cooperation with the NSAs concerned on the follow-up of the most critical elements of the action plan that is presented at the issuance of the respective Single Safety Certificates.

693 ***Recommendation 2025-RL01-012.*** *The intent of this recommendation is to generate a quicker implementation of NSA action plans in relation to identified deficiencies that prevent the NSA from effectively performing the monitoring of Safety Management Systems of railway actors.*

The European Union Agency for Railways should develop and implement in its audit method a system that allows to prioritise those deficiencies that prevent a National Safety Authority from effectively performing its task of monitoring the Safety Management System of railway actors and creating an overview of their safety performance. The follow up of the adequate implementation of the action plans related to these deficiencies should go beyond documentary review and make use of the possibility to conduct additional visits, audits and/or (pre-announced) inspections in a timely manner.

6.1.7. Recommendations under the initiative of The European Commission

694 The following recommendations are made for implementation by The European Commission:

695 ***Recommendation 2025-RL01-013.*** *The intent of this recommendation is to generate the necessary leverage to enforce Member States to adequately and timely satisfy the EU requirements on safety policy setting, the functioning of National Safety Authorities and National Investigating Bodies, and the system of national rules.*

The European Commission should develop and implement a framework where, based on continuous monitoring of the respect and effectiveness of Members State responsibilities under the Safety Directive, necessary corrective actions can be agreed, and their timely implementation followed up and enforced.

696 ***Recommendation 2025-RL01-014.*** *The intent of this recommendation is to generate a view on the adequateness of implementing EU specified operational safety rules within the national framework of Member States, at all levels.*

The European Commission should define and implement an extended assessment framework for operational safety rules in Member States. This framework should be applicable to all operational safety rules, including the adequate implementation of operational safety rules that are specified in EU legislation, and not be limited to only notified national safety rules.

6.1.8. Recommendations under the initiative of the Greek Ministry of Climate Crisis and Civil Protection

697 The following recommendations are made for implementation by The Greek Ministry for Climate Crisis and Civil Protection:

698 ***Recommendation 2025-RL01-015.*** *The intent of this recommendation is to enable rapid and coordinated assistance during an emergency situation.*

The Ministry of Climate Crisis and Civil Protection should develop, in collaboration with the different emergency services (Fire Brigade, Medical and Psychosocial Support, Police, Civil Protection) and based on international recognised good practice, detailed instructions for an Emergency Response and Crisis Management Plan that describes in detail at least how:

a. In addition to the coordination that is established within each discipline, interdisciplinary collaboration takes place at two levels: at the operational level and at the strategic management level.
b. How to set up the perimeters, physically delimit them, signal them, monitor them and ensure access control to the areas of the intervention site.
c. How to perform the mapping of the accident site, to preserve a maximum of evidence for further safety investigations.
d. How to prepare the dedicated competent resources, to organise the activities in function of the psychological needs phases, and to perform and assess these activities, both at the collective and individual levels, in order to prevent and reduce the PTSD risks.

Once established, the Ministry of Climate Crisis and Civil Protection should take ownership for the adequate implementation of this Emergency Response and Crisis Management Plan, in order for the cooperation between the parties involved to go as well as possible. This should be achieved through the systematic organisation of both Table-top and Field exercises. The experience of these exercises, as well as the lessons learnt from real interventions should be used to continuously improved the coordination at both levels.

699 ***Recommendation 2025-RL01-016.*** *The intent of this recommendation is to ensure proper investigation of railway accidents.*

The Ministry of Climate Crisis and Civil Protection should take the necessary steps to include the role of EODASAAM, in support of the Preliminary Investigating Authority, for all railway related accidents in an updated version of the Human Loss Management Plan and eventual other Emergency Response and Crisis Management Plans that are to be developed in response to ***Recommendation 2025-RL01-014***.

6.2. Other recommendations

700 No other recommendations result from this investigation.

6.3. Learning points

701 The investigation team observed a strong press & media impact on the investigation, victims and families.

- On the 28.02.2023, after the search for survivors ended, preventing media intrusion and protecting the worst and saddest images from being public, became a major challenge on the accident site. Pressure from coordinators to restore the accident site led to loss of evidence. The investigation team stresses the need to learn from this lack of respect and order.
- While media interest in Tempi accident was and still is intense, the focus on rail safety is minimal, often even distorting key findings. An example is the unbalanced focus on the cause of the fireball, which, while worsening consequences, was not a causal factor to the accident. Moreover, in general, leaked information is turned into very low quality articles, as sensational coverage overshadows important investigation elements. Also, the media often prioritise legal blame over safety improvements, even publicly condemning individuals before judicial conclusions. The leaks and the blaming approach of the media is having a major impact on the effort needed by the investigation team to maintain a good working relationship with all stakeholders, while at the same time having to pursue an entirely different, forward thinking investigation objective.

702 Despite the described long-term organisational drifts or deviations, many railway staff remain dedicated, like heroes working under extreme conditions. However, they are deeply affected by the media’s negative and oversimplified portrayal of railway issues, and by the daily risks of being prosecuted while doing their normal job in abnormal conditions.

Appendix A. Description of the Rolling Stock of both Trains

Rolling Stock of freight train 63503

Figure 69. First locomotive, Siemens Hellas Sprinter 120-022. NVR Engine: 91 73 212 0 022-7. Last maintenance "I1" 23/02/2023, Thessaloniki.

Figure 70. Second locomotive, Siemens Hellas Sprinter 120-012- NVR Engine: 91 73 212 0 012-8. Last maintenance "I1" 15/02/2023, Thessaloniki. (https://www.railpictures.net/photo/832753/)

3	Wagon 31 65 391 4097-0	Maintenance by the owning company "MZ" (status GCU_1/1/2023)
4	Wagon 31 65 392 4051-5	Maintenance by the owning company "MZ" (status GCU_1/1/2023
5	Wagon 31 65 454 0022-8	Maintenance by the owning company "MZ" (status GCU_1/1/2023)

Figure 71. Type of platform supporting the steel plates (For the steel plates: WAGON 31 65 xxx MZ , https://hellas-express.eu/viewtopic.php?f=15&t=43&p=1162&hilit=454#p1162).

CONTAINERS

Figure 72. Type of platform supporting the containers (p. vgenopoulos, https://hellas-express.eu/viewtopic.php?f=13&t=69#p361) .

6	Wagon 31 73 362 2183-1	Last maintenance 29/04/2022, overhaul (Work. Volos) maintenance every 6 years
7	Wagon 31 73 362 2175-7	Last maintenance 10/11/2022, overhaul (Work. Volos) maintenance every 6 years

8	Wagon 31 73 362 2247-4	Last maintenance 10/11/2022, overhaul (Work. Volos) maintenance every 6 years
9	Wagon 31 73 362 2138-5	Last maintenance 24/08/2022, overhaul (Work. Volos) maintenance every 6 years
10	Wagon 31 73 362 2098-1	Last maintenance 14/12/2022, overhaul (Lab. Volos) maintenance every 6 years
11	Wagon 31 73 362 2153-4	Last maintenance 31/01/2023- overhaul (Work. Thessaloniki) maintenance every 6 years
12	Wagon 31 73 362 2056-9	Last maintenance 13/12/2022, overhaul (Lab. Volos) maintenance every 6 years
13	. Wagon 31 73 362 2124-5	Last maintenance 12/10/2021, overhaul (Lab. Thessaloniki) maintenance every 6 years
14	. Wagon 31 73 362 2170-8	Last maintenance 24/11/2022, overhaul (Work. Volos) maintenance every 6 years
15	Wagon 31 73 362 2029-6	Last maintenance 24/11/2022, overhaul (Work. Volos) maintenance every 6 years

2. Rolling stock of passenger train IC 62

Figure 73. Passenger locomotive 120-023.

www.youtube.com/@Tzifari_Productions

Siemens Hellas Sprinter 120-023 engine latest maintenance 'I1' 20/02/2023, Thessaloniki plant

NVR: 91 73 212 0 023-5

Figure 74. Passenger Coach A1 first class.

https://upload.wikimedia.org/wikipedia/commons/0/0e/J26_432_Bf_Kalamb%C3%A1ka%2C_ADm_%28%C2%BBViaggio%C2%AB%29.jpg
https://hellas-express.eu/viewtopic.php?f=12&t=270#p2047

Admz Coach 8496019, NVR: 73 73 849 6 019-8, Class A car last maintenance “F1” 14/09/2022, Mech. Renti

Figure 75. Restaurant Car.

https://el.m.wikipedia.org/wiki/%CE%91%CF%81%CF%87%CE%B5%CE%AF%CE%BF:J26_767_Bw_Thessalon%C3%ADki,_WRmz.jpg

https://hellas-express.eu/download/file.php?id=2321&sid=08c0a888800faa581b77a1ef168b99eb

Wrmz Coach 8896734, , NVR: 73 73 889 6 734-8, unnumbered canteen wagon last maintenance “F1” 19/01/2023, Mech. Renti

Figure 76. Passengers Coach second class, model Pullman.

Photo showing Pullman model B3-B7
(https://hellas-express.eu/download/file.php?id=2314&sid=08c0a888800faa581b77a1ef168b99eb)

4	B2: Bmz Coach 2196003, ,NVR: 73 73 219 6 003-8, ‘**Coupe’** class B wagon	last maintenance “R1” 20/02/2023, Mech. Renti
5	B3: Bmpz Coach 2096503, , NVR: 73 73 209 6 503-8, ‘**Pullman’** class B wagon	last maintenance “F1” 14/02/2023, Mech. Renti
6	B4: Bmpz Coach 2096569, NVR: 73 73 209 6 569-9, ‘Pullman’ class B wagon No4	last maintenance “F2” 11/01/2023, Mech. Renti
7	B5: Bmpz Coach 2096567, NVR: 73 73 209 6 567-3, ‘Pullman’ class B wagon	last maintenance “F2” 22/01/2023, Mech. Rendi,
8	B6: Bmpz Coach 2096563, NVR: 73 73 209 6 563-2, ‘Pullman’ class B wagon	last maintenance “R1” 11/12/2022, Mech. Rendi,
9	B7: Bmpz Coach 2096507, NVR: 73 73 209 6 507-9, ‘Pullman’ class B wagon	last maintenance “F1” 03/01/2023, Mech. Renti

Damages on the rolling stock of the freight Train 63503

All photographic materials of this section are based on or extracted from the Judicial Experts report, (19.06.2023), and the Freight wagon investigation, Judicial experts report (04.03.2024).

Figure 77. Position 1) Siemens Hellas Sprinter 120-022- NVR Engine: 91 73 212 0 022-7 Extreme damage on the front, roof missing, and rear heavily damaged form the rear collision with the attached locomotive 120-012. Rear view in Figure 14.

Figure 78. Position 2) 120 012 locomotive, heavy damage in the front (with locomotive 120-022) and rear, signs of crash against 1st container on P4, without the missing rear cab.

Figure 79. Position 3) nr 1 platform carrying steel plates, front half totally destroyed by heavy impact with Restaurant Car.

Figure 80. Position 4) nr 2 platform carrying steel plates, lost bogies from derailment but very slightly damaged, no signs of heavy crash.

Figure 81. Position 5) nr 3 platform carrying steel plates, lost bogies from derailment, slight damage (twist) due to crash from the rear.

Figure 82. Plaforms as found on the accident site.

Figure 83. Positions 6) and 7) – on the left, the platform nr 4 (damaged, lost front bogie, not derailed) carrying the first container. On the right, the first container (OOCL) is shifted in rear direction, hurting the next container (ZIMonitor).

Figure 84. Positions 8)-15) The remaining plaforms carrying 8 containers, undamaged and still sealed (or remained empty, ofr the 2 last ones), not derailed, stopped along the line and were driven away normally.

Damages on the rolling stock of the passenger train IC 62

Figure 85. Position 1) 120 023 locomotive, totally destroyed, broken into large pieces. Remaining piece of the basement platform. Part with transformer still visible. Other side in Figure 17. At the position 2) the A1 1st class coach, totally destroyed, has broken into small pieces, and was not recognisable as a whole vehicle.

Figure 86. Position 3) Restaurant Car, very heavily damaged from initial crash (folded, bent into S-shape) and burned down. Here, suspended from the crane cables.

Figure 87. Position 4) B2 2nd class coach, heavy impact damage in the front and rear, fire slowly consumed it.

Figure 88. Position 5) B3 2nd class coach, derailed and went down a slope, lost bogies, no other damage from derailment or crash, specific impact damage from B2 coming down from above.

Figure 89. Positions 6-9) B4-B7 coaches, B4 and B5 derailed and were hit on the side by steel plates, B6 and B7 did not derail, no damage, B7 remained nearly all in the tunnel.

Appendix B. Variables and parameters for the CFD testing

Fire Dynamics Simulator (FDS) (https://pages.nist.gov/fds-smv/) is a Computational Fluid Dynamics (CFD) code developed by the National Institute of Standards and Technology (NIST) in the USA. FDS has been developed to simulate fire-related scenarios involving low-speed flows (Mach < 0.3), with an emphasis on smoke and heat transport from fires and is currently the state-of-the-art CFD code when it comes to fire modelling and research in the context of fire safety engineering.

Since the observed event during the Tempi accident is clearly a subsonic deflagration and not a detonation (no blast, no sound, speed of development of fireball size observed through video analysis), FDS is deemed suitable for the simulation of such an event.

The investigation into the possible cause of the fireball and ensuing fires during the Tempi accident tried to answer two different questions that led to two separate tasks:

Task #1: evaluation of the possibility of PDMS oils to ignite and create a fireball similar to the one observed through video footage of the accident

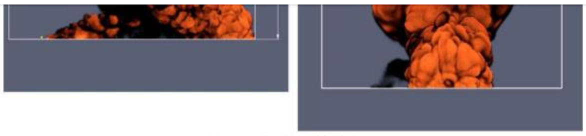
For this task, silicone oil was modelled as a new species in FDS using the following properties:

	SiliconOil
Chemical Formula	C3H10O1.5
Specific Heat kJ/(kg·K)	1,46
Density (kg/m³)	963
Vaporization Temp (C)	150
Melting Temp (C)	-50
Heat Of Evaporation (kJ/kg)	300
Critical Flame Temp (C)	1.500
Autoignition Temp (C)	450
Heat of Combustion (MJ/Kg)	17
CO Yield	0,003
Soot Yield	0,2

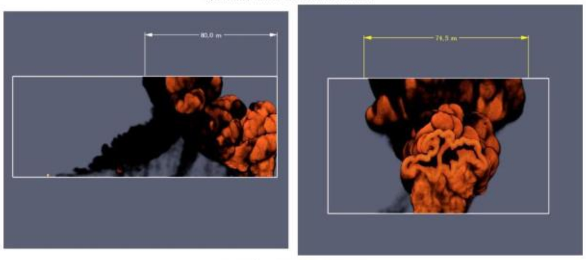
It is noted that PDMS silicone oil actually is more resistant to thermal decomposition and combustion, due to the silicone creating a protective layer around each droplet, offering a barrier to oxygen diffusion and assisting in the overall thermal resilience of PDMS.

Various tests were run in order to simulate the possibility of silicone oil actually igniting in the presence of a heat source, in the form of an open flame (a pool fire inside a large bucket) or a heated vertical plate. Silicone oil was considered already atomized in small droplets of 500nm (much smaller than the 1000-4000nm as estimated by the RI.SE. report) and the total quantity of fuel was blown in particle form against a heated wall or an open flame. Several simulations were run using different geometries of release and dispersion and different values of AIT (auto-ignition temperature), starting from the realistic value of 450C and going down to 350C as suggested by UGent in order to simulate the possibility of piloted ignition, and even down to 250C which is an unrealistically low value that would be representative of less safe mineral oils.

The results of these tests rule out the possibility of PDMS silicone oils creating such a big fireball and pool fire, as the only possible result is a small localized ignition that will not propagate through the rest of the material, even if the total quantity of silicone oil is unrealistically atomized and dispersed all over the area.



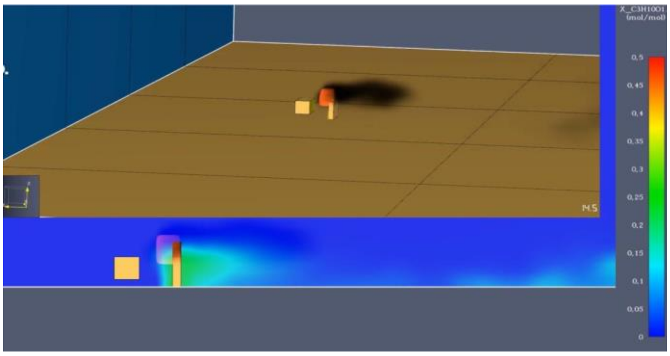
4,5 seconds after initialization



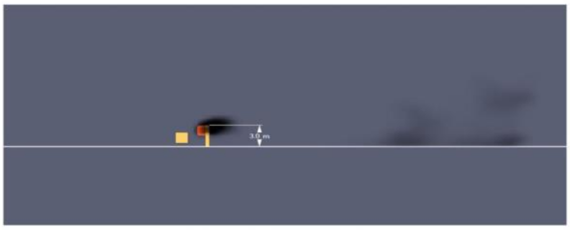
6 seconds after initialization

Case02_05

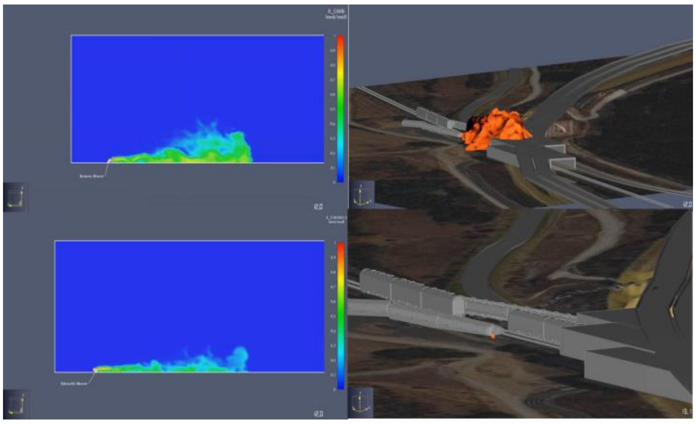
Δεν παρουσιάστηκα ανάφλεξη του υγρού καυσίμου (Video Case02_05.mp4).



CASE ID	Fuel	Are a (m2)	Fuel Initial velocity (m/s)	Mass Flux (Kg/m2s)	Flow Duration (sec)	Air Flow (m/s)	Fireball max Diameter -average (m)	fireball duration (sec)**
Case04_05	Silicon Oil Liquid	3	10	600	2	10	n/a	n/a



4,5 seconds after initialization



Task #2: estimation of quantity of generic hydrocarbon fuel that would create a similar fireball as the one observed

For this task, N- PENTANE (C_5H_{12}) was chosen as a generic hydrocarbon fuel, representing a typical mix of fuels such as naphtha, in order to only estimate the quantity of fuel involved without actually trying to identify the exact type of fuel (a task that is not considered realistically possible through reverse engineering).

The theoretical part of the simulation is the setting of the appropriate settings and initial conditions in accordance with the suggestions from UGent for this specific task:

Size of computational domain (length x width x height): 160 m x 100 m x 80 m

Grid size 0.25m (cubic cell) 15m (approx.) around the event and 0.5 (cubic cell) for the rest of the domain

Boundary conditions:

Wind model based on Monin-Obukhov Similarity:

thermal stability = STABLE (L=350m)

Landscape = open (Zo=0.03m)

Z velocity = 0

reference height = 2m

Ambient temperature: 12C

Relative Humidity: 94%

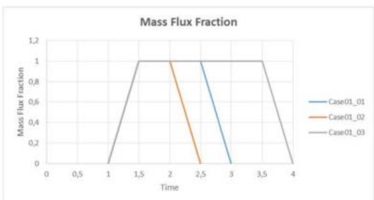
For this particular task, AIT=0 was deemed a reasonable choice as it was no longer needed to confirm the initial mechanism of ignition but rather to estimate the amount of fuel required in order to create the result (size, shape and duration) of the fireball as observed from the video footage of the accident.

The reason for the use of CFD simulation for this task was the fact that this was not a straightforward BLEVE event with a single release of known fuel from a single, stationary source, but rather a very complex event with a cascade release of at least two distinct stages, leading to two different pool fires of not clearly documented duration and size.

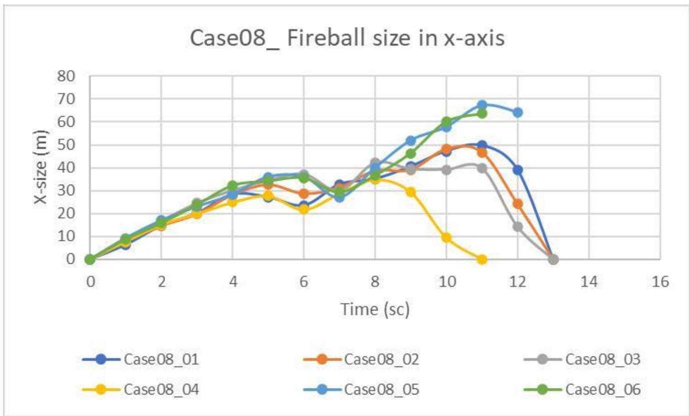
In comparison with theoretical models that estimate the maximum diameter and duration of a fireball from a single release of known fuel, the CFD simulation was expected to provide an estimate that would probably be longer in duration for the same maximum size. This can be attributed to the fact that a given amount of fuel would create a corresponding maximum fireball diameter, but probably with a slightly longer fireball duration due to the time added due to the delay of the cascade release.

Also, in the course of the development of the final model, various sensitivity studies were carried out, using various small scale models in order to evaluate specific parameters and their effect to the result of the simulation:

Case01_05	Silicon Oil	3	10	0 (-Y)				10	0 (-Y)	
Case01_06	LPG (Butane)	3	10	0 (-Y)	600	2	2700	10	0 (-Y)	39



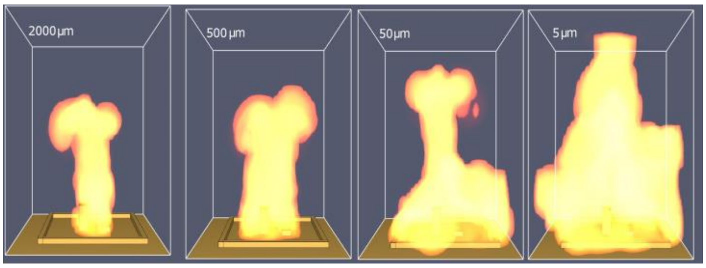
Εικόνα 1 Ρυθμός ροής εύφλεκτου υλικού



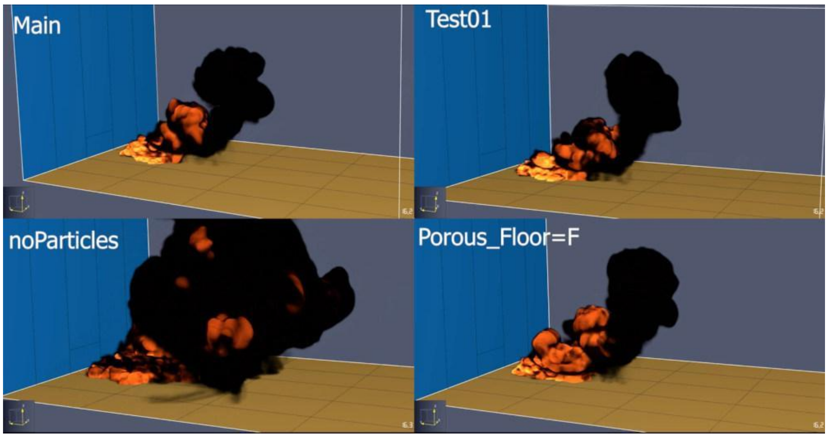
Case ID	Flow Velocity (m/s)	Flow mass (kg/m²s)	Particles mass flux (kg/m²s)	Mean diameter (μm)	Porous floor	MLR (Kg)	Burned mass(Kg)	Comments
Case00_SD_01	0	0	1000	500	default	3,8	3,3	No pool fire
Case00_SD_02	0	0	1000	500	FALSE	4,5*	4,0*	Pool fire, last HRR=1600KW
Case00_SD_03	0	0	1000	50	default	44,7	16,5	No pool fire, Πολύ ψηλά η φλόγα εκτός domain, last HRR=2800KW
Case00_SD_04	0	0	1000	50	FALSE	39,9 *	16,25*	Pool fire, last HRR=1600KW, Πολύ ψηλά η φλόγα εκτός domain
Case00_SD_05	0	0	1000	10	FALSE	533*	57,0*	Numerical instability, last HRR=172000KW
Case00_SD_06	0	1000	n/a	n/a	FALSE	1200	39,7	Πολύ ψηλά η φλόγα εκτός domain
Case00_SD_07	0		n/a	n/a	FALSE	120	12,0	
Case00_SD_08	0		n/a	n/a	FALSE	120	25,4	**Grid 10cm**
Case00_SD_09	0		n/a	n/a	FALSE	120	12,0	

* *Keep burning after 30sec of simulation*

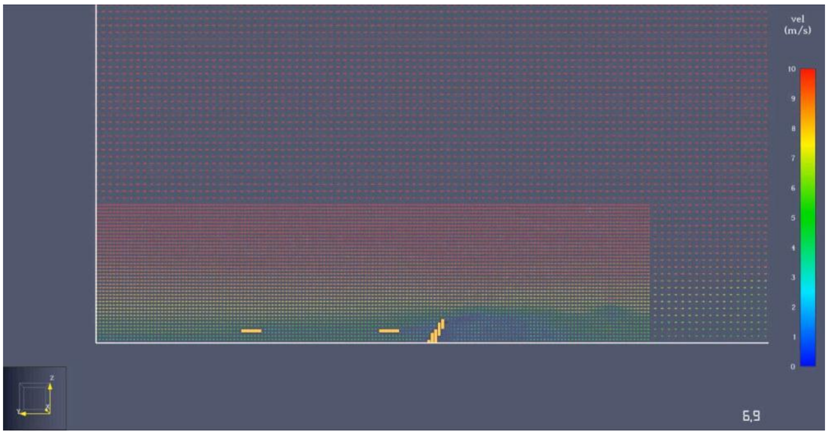
Droplet size (particle diameter) was evaluated and a comparison was run between particle diameter of 5, 50, 500, 2000μm in a particle release of similar characteristics to the one used in the final model. It was observed that there was a considerable difference when droplet size was very small (5 and 50nm) in comparison with the chosen value of 500nm, but for the larger diameter of 2000nm the effect was much smaller, indicating that in order to study an event with millimeter-sized droplets, 500nm particle diameter is deemed reasonable.



Also, a comparison was run between different amounts of liquid, gas and combined liquid and gas state of the same fuel, in order to validate the sensitivity of the FDS software to changes of state of fuel. Due to lack of any information relevant to volumes of fuel and their headspace, it was decided that no assumption would be made on this issue and the total amount of fuel would be considered as liquid particles.



Boundary conditions were also compared in various small scale tests that gave an indication of the effects of the wind profile to the shape of the fireball. It was understood that small changes in the wind profile could affect the shape but not the maximum diameter, the rate of development of the phenomenon or the total duration of the fireball, so a realistic wind profile as close as the meteorological conditions of that day was used with the understanding of the small effect in the end result.



Grid sizes were compared with a quick sensitivity study that compared grid sizes of 0.1 to 0.5m and a square shape in comparison to the oblong shape. In this particular geometry and type of release, it was understood that grid size only played a very small part in the accuracy and repeatability of the simulation, so a reasonable square grid size was chosen for the final model.

Having arrived at an accepted set of settings and initial conditions, the development of the actual model for the simulation of the Tempi accident was a very long and complex procedure involving various assumptions that were chosen as the most fitting to the event that needs to be reverse engineered without solid information.

After a detailed analysis of the observations from the three videos that have recorded the accident, it is clear that the event can be considered as a sequence of three distinct stages:

Stage 1 is the first release for 2 seconds that creates a fireball of approximately 40m in diameter.

Stage 2 is the second release for 4 seconds from an unidentified volume of fuel moving northbound that feeds the original fireball that grows to a maximum diameter of approximately 80m.

Stage 3 is the pool fire that continues to burn with very strong flames as an uninterrupted sequence of the same source of fire that created the fire plumes that appeared during Stage 2.

In order to model the above sequence of events, a 2-stage release was chosen with the blower (Vent) size arbitrarily chosen with the dimensions of 2.0m x .25m with the assumption that any vent size should be smaller than the maximum width of a train carriage (2.7m). A small sensitivity study showed that a vent of 1.5m x 0.20m gave very similar results (very slightly wider fireball development for the wider opening), and even an increase in size to 3.0m x 3.0m did not play such an important part in the shape and duration of the fireball. The important parameter is Particle_mass_flux that controls the amount of fuel that passes through the vent, as long as the vent area comfortably exceeds the minimum required for a given mass flux and initial release speed. Also, several tests were run with different angles and initial velocities of the two releases, in an effort to choose the option that most closely represents a realistic interpretation of the train geometry, but also the option that can turn out a simulation result as close as possible to the actual video of the accident.

It is noted that it is not possible to simulate a moving source of release in FDS, so the Stage 2 release was modelled with a static blower of the same vent size as the first stage release, but this being situated 10m away and blowing fuel at an angle and initial velocity that would feed the original fireball in as a similar way as possible to the target video.

As for the Stage 1 initial release, a comparison of different possible geometries and initial speeds of fuel release showed that the most realistic results were obtained when the fuel particles were blown towards an obstruction with an inclination that would deflect part of the fuel spray upwards and another part to the side. After testing 12 different combinations of fuel quantities and fuel speeds for the two releases, the one most closely resembling the recorded video was Case08_07 with respective quantities of 800 kg for stage 1, 1200 kg for Stage 2 and 300-500kg for stage 3 pool fire. Obviously, this is only to provide an order of magnitude and not an exact number, as there are other combinations of fuel, velocities and geometries that could possibly replicate the target video. It is clear, though, that the order of magnitude is correct, as it is not possible to create a comparable sized fireball without at least 2000kg of fuel. Furthermore, absence of a large pool fire #1 as recorded by video evidence, rules out the possibility of a larger quantity of fuel (e.g. 10-15tn) that would have created and sustained a large pool fire as an aftermath to the crash.


9,933
9,300
9,867
9,233

Appendix C. Psychological Impact Survey: the questionnaire

The survey tool was composed of different parts.

a. Identify oneself by the role experienced during or since the accident by choosing between several options, including an open one to complete. And, if desired, mention own name.
b. Identify – if any – the "*most important*" symptoms that appeared "*During the weeks and months after the accident*", among 13 frequently used to characterise PTSD risk and presence.
c. Explore if they had been "*offered professional emotional or psychological support*", and the kind of support received.
d. In case of reported symptoms and support, it explores if "*the above symptoms improved since Tempi accident*" and if an improvement had been felt since the start of the supportive treatment.
e. After having asked the agreement of assessing "*the possible personal impact of Tempi accident still today*", a set of standardised short-listed questions (8) with a 5 Likert-scale is proposed. This part is a published Short Post-Traumatic Stress Disorder PTSD Rating Interview SPRINT[12], and recognised as a brief and global assessment for PTSD. The authors clearly indicate how to scale the severity of the trauma, from 'no or minimal symptoms', 'mild symptoms', 'moderate symptoms' and 'marked or severe symptoms'.
f. To close the questionnaire, the participants are offered the possibility to add or to explain additional elements in terms of opinion and experience.
g. In order to spare the response time of the participants, there were introduced several logical conditionals between questions.

Once built, the questionnaire was spread in the investigation team, improved, translated, then shared with one of the direct victims of the accident and one representative of the victims' relatives, then improved again, and finalised.

[12] Connor, K.M. and Davidson, J.R.T. (2001). *SPRINT: a brief global assessment of post-traumatic stress disorder*. International Clinical Psychopharmacology 2001, 16:279-284.

Appendix D. Psychological Impact Survey: the tables of the results

	The groups of persons		
Survey Sub-Groups	Groups Name	Number of Persons	Not anonymous
Passengers injured in the accident (13) and passengers not injured in the accident (2)	Victims	15	11
Relatives of a deceased passenger (10)	Victims' Relatives	10	5
Officers from Police, DVI or Fire Brigade (14)	Emergency Professionals	14	2
Members of the railway organisations with some involvement on the accident scene that night and/or the following days	Involved Railways Professionals	9	5
Members of the railway organisations with no such involvement	Not Involved Railways Professionals	36	7

The groups of persons			Number of symptoms remaining		
Groups Name	Number of Persons		Counted Symptoms for the whole group	Median Nr of symptoms per person (max 13)	Nr of persons with 'no symptom'
Victims	15		106	7	0
Victims' Relatives	10		40	4.5	0
Emergency Professionals	14		22	1	3
Involved Railways Professionals	9		18	2	1
Not Involved Railways Professionals	36		99	2	2

The groups of persons			PTSD risk		
Groups Name	Number of Persons		SPRINT result (MEDIAN)	Better since the start of treatment, from 0 to 10 as an improvement scale, average (nr of persons answering)	Nr of "Worse/ no change / minimally"
Victims	15		19	4 (15 persons)	6
Victims' Relatives	10		20	5 (10 persons)	3
Emergency Professionals	14		3.5	6 (4 persons)	1
Involved Railways Professionals	9		8	9 (4 persons)	0
Not Involved Railways Professionals	36		7	8 (8 persons)	4

The groups of persons			Emotional / Psychological Support						
Groups Name	Number of Persons		Was never proposed / Don't remember	Yes but too late	Yes, and From first days / Early enough	via authorities	on your own, via family, etc.	Still severe (still with prof. support)	Still severe or Serious (no prof., or no support)
Victims	15		3	1	10	4	5	6	4
Victims' Relatives	10		3	1	6	3	9	5	2
Emergency Professionals	14		0	3	11	3	4	0	0
Involved Railways Professionals	9		8	0	1	0	5	1	0
Not Involved Railways Professionals	36		32	0	4	1	8	1	3

The Greek version of the Psychological Impact questionnaire

☑ Αποθηκεύστε ένα εφεδρικό αντίγραφο στον υπολογιστή σας (προχωρήστε σε απενεργοποίηση αν χρησιμοποιείτε δημόσιο/κοινό υπολογιστή)

Ερωτηματολόγιο σχετικά με το ατύχημα των Τεμπών, για τους επιβάτες, τους συγγενείς αυτών και για το προσωπικό των εμπλεκόμενων υπηρεσιών/φορέων.

Τα πεδία με αστερίσκο (*) είναι υποχρεωτικά.

Σελίδες Έναρξη ...

Ο Εθνικός Οργανισμός Διερεύνησης Αεροπορικών και Σιδηροδρομικών Ατυχημάτων (ΕΟΔΑΣΑΑΜ / HARSIA - https://www.harsia.gr/) είναι μέλος του Ευρωπαϊκού Δικτύου Εθνικών Αρχών Διερεύνησης (NIB Network https://www.era.europa.eu/agency/stakeholder-relations/national-investigation-bodies/nib-network-european-network-rail-accidents-national-investigation-bodies_en) και υπάγεται στην εποπτεία του European Union Agency for Railways (ERA - https://www.era.europa.eu/).

Το συμβούλιο του ΕΟΔΑΣΑΑΜ ανέλαβε καθήκοντα την 18/09/2023. Με την ανάληψη των καθηκόντων του συμβουλίου του, ο Σιδηροδρομικός Τομέας του ΕΟΔΑΣΑΑΜ έκανε επίσημο αίτημα προς τον ERA για την συνδρομή του στο έργο της διερεύνησης του ατυχήματος των Τεμπών. Ο ΕΟΔΑΣΑΑΜ ανέλαβε επίσημα την διερεύνηση του τραγικού δυστυχήματος των Τεμπών την 15/03/2024, με την τοποθέτηση του πρώτου σιδηροδρομικού διερευνητή και τη συγκρότηση της επιτροπής διερεύνησης του σιδηροδρομικού δυστυχήματος των Τεμπών, η οποία απαρτίζεται από στελέχη του ΕΟΔΑΣΑΑΜ και του ERA.

Η διερεύνηση που διεξάγει ο ΕΟΔΑΣΑΑΜ είναι ανεξάρτητη από την αστυνομική και δικαστική έρευνα αλλά και από την έρευνα άλλων σιδηροδρομικών φορέων. Η έρευνα του ΕΟΔΑΣΑΑΜ δεν αφορά την απόδοση υπαιτιότητας ή ευθύνης αλλά την έκδοση συστάσεων ασφαλείας με σκοπό την βελτίωση της ασφάλειας του σιδηροδρομικού συστήματος.

Σε αυτό το πλαίσιο ο ΕΟΔΑΣΑΑΜ επιθυμεί να εξετάσει την διαχείριση της ιατρικής και άλλης υποστήριξης στους τραυματίες, στους λοιπούς επιβάτες και στις οικογένειες αυτών, λαμβάνοντας άμεση πληροφόρηση από τους ίδιους. Για τον σκοπό αυτό έχει ετοιμαστεί ένα (διαδραστικό) ερωτηματολόγιο, οι απαντήσεις στο οποίο (εφόσον είναι αρκετές σε αριθμό) θα αναλυθούν ανώνυμα και με πλήρη εμπιστευτικότητα.

Η άμεση πληροφόρηση από την μεριά των θυμάτων του ατυχήματος μπορεί να συνεισφέρει με μοναδικό τρόπο, σε αντίθεση με τις πληροφορίες που λαμβάνονται από τρίτα άτομα ή φορείς.

Η έρευνα αυτή έχει σχεδιαστεί αποκλειστικά για τους εμπλεκόμενους στο ατύχημα των Τεμπών. Παρακαλούμε να μην κοινοποιήσετε τον σύνδεσμο ή τις λεπτομέρειες της έρευνας σε τρίτους, καθώς αυτό μπορεί να επηρεάσει αρνητικά την εγκυρότητα των αποτελεσμάτων. Σας ευχαριστούμε για τη συνεργασία σας και τη συμβολή σας στη διασφάλιση αξιόπιστων και χρήσιμων δεδομένων.

Σημειώνεται ότι δεν είναι υποχρεωτική η απάντηση σε όλες τις ερωτήσεις.

Στην περίπτωση που περισσότερες από μία απαντήσεις είναι κατάλληλες, υπάρχει η δυνατότητα για την επιλογή πολλαπλών απαντήσεων.

HARSIA

Απεικονίσεις

Σύνηθες Μορφή προσβασιμότητας

Γλώσσες

ελληνικά

Επικοινωνία

Δελτίο επικοινωνίας

Να αποθηκευτεί ως σχέδιο

Αποθηκεύτηκε για τελευταία φορά στις 21/02/2025 18:59:58

Καταγγελία για κατάχρηση

*

Είστε...

- ☐ ένας από τους επιβάτες που τραυματίστηκαν στο ατύχημα
- ☐ ένας από τους επιβάτες που δεν τραυματίστηκαν στο ατύχημα
- ☐ συγγενής αποθανόντος επιβάτη
- ☐ συγγενής επιβάτη που επέζησε
- ☐ πυροσβέστης ή αστυνομικός
- ☐ εργαζόμενος νοσοκομειακών υπηρεσιών ή πλήρωμα ασθενοφόρου
- ☐ μέλος του ΟΣΕ ή άλλης σιδηροδρομικής εταιρείας και είχατε κάποια εμπλοκή στον χώρο του ατυχήματος εκείνη τη νύχτα ή/και τις επόμενες ημέρες
- ☐ μέλος του ΟΣΕ ή άλλης σιδηροδρομικής εταιρείας και ΔΕΝ είχατε κάποια εμπλοκή στον χώρο του ατυχήματος εκείνη τη νύχτα ή/και τις επόμενες ημέρες
- ☐ άλλο (εάν επιθυμείτε μπορείτε να διευκρινίσετε)

Εάν επιθυμείτε να μας βοηθήσετε να αυξήσουμε την αξιοπιστία αυτής της έρευνας και δεδομένης της αυστηρής ανωνυμοποίησης των αποτελεσμάτων, μη διστάσετε να δώσετε το όνομά σας παρακάτω.

Κατά τις εβδομάδες και τους μήνες μετά το ατύχημα, ποια από τα παρακάτω ήταν τα σημαντικότερα συναισθηματικά συμπτώματα σας ;

- ☐ Καθόλου συναισθηματικά συμπτώματα
- ☐ Ανεπιθύμητες αναμνήσεις και/ή επαναλαμβανόμενοι συλλογισμοί σχετικά με το ατύχημα
- ☐ Επαναλαμβανόμενοι εφιάλτες από την εμπειρία του ατυχήματος
- ☐ Αισθήματα αναστάτωσης, εκνευρισμού
- ☐ Σωματικές αντιδράσεις όπως ταχυπαλμία, αναπνευστικά προβλήματα, υπερβολική εφίδρωση
- ☐ Αποφυγή υπενθυμίσεων του ατυχήματος (αποφυγή της συναναστροφής με συγκεκριμένους ανθρώπους, αποφυγή χώρων, συζητήσεων κ.λπ.)
- ☐ Προβλήματα να θυμηθείτε κάποια κομμάτια από το περιστατικό
- ☐ Έντονα αρνητικά συναισθήματα ή σκέψεις
- ☐ Αδιαφορία για δραστηριότητες που απολαμβάνατε παλιότερα
- ☐ Αδυναμία να βιώσετε θετικά συναισθήματα
- ☐ Ριψοκίνδυνη συμπεριφορά και εκτέλεση πράξεων που θα μπορούσαν να σας βλάψουν
- ☐ Δυσκολία να συγκεντρωθείτε
- ☐ Δυσκολία να αποκοιμηθείτε ή να κοιμηθείτε για πολλές ώρες
- ☐ Αίσθημα αποστασιοποίησης ή απομόνωσης από άλλους ανθρώπους

*

Σας προσφέρθηκε επαγγελματική συναισθηματική ή ψυχολογική υποστήριξη ;

- ○ Δεν θυμάμαι
- ○ Ποτέ και νομίζω ότι δεν τη χρειαζόμουν
- ○ Ποτέ και νομίζω ότι τη χρειαζόμουν
- ○ Ναι, από τις πρώτες ημέρες
- ○ Ναι, σχετικά νωρίς
- ○ Ναι, αλλά πολύ αργά

Σχετικά με αυτή τη θεραπεία...

- ☐ Δεν σας έχει προταθεί τίποτα
- ☐ Ναι, από τις αρχές
- ☐ Σας προτάθηκε υποστήριξη, αλλά ήταν από μέλη της οικογένειας, φίλους ή γνωστούς
- ☐ Δόθηκε προτεραιότητα στα σωματικά σας τραύματα, κάτι το οποίο νομίζετε ότι ήταν λογικό για την περίπτωσή σας
- ☐ Δόθηκε προτεραιότητα στα σωματικά σας τραύματα, αλλά αυτό νομίζετε ότι ήταν ανεπαρκές για την περίπτωσή σας
- ☐ Λάβατε μόνο φαρμακευτική αγωγή
- ☐ Λάβατε φαρμακευτική αγωγή αλλά κάνατε και θεραπευτικές συνεδρίες
- ☐ Κάνατε μόνο θεραπευτικές συνεδρίες
- ☐ Αρνηθήκατε κάθε τέτοια θεραπεία
- ☐ Αποφασίσατε να βρείτε αυτή την υποστήριξη μόνοι/ες σας

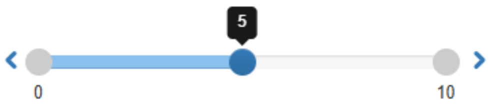
Έχουν βελτιωθεί/μειωθεί τα παραπάνω συμπτώματα μετά το ατύχημα;

- ○ Είναι χειρότερα
- ○ Καμία αλλαγή
- ○ Βελτιώθηκαν ελάχιστα
- ○ Βελτιώθηκαν πολύ
- ○ Βελτιώθηκαν πάρα πολύ
- ○ Υπήρχαν σκαμπανεβάσματα και η κατάσταση δεν είναι καλή ακόμα
- ○ Υπήρχαν σκαμπανεβάσματα αλλά η κατάσταση τώρα είναι εντάξει

Πόσο καλύτερα αισθάνεστε από την έναρξη της θεραπείας; (ως ποσοστό)

Μετακινήστε τον συρόμενο δείκτη ή αποδεχθείτε την αρχική θέση του..

0% Καθόλου καλύτερα 100% καλύτερα



* Συμφωνείτε να μας βοηθήσετε να αξιολογήσουμε τον πιθανό προσωπικό αντίκτυπο της Tempi ακόμη σήμερα;

Ναι | Όχι

Κατά τη διάρκεια της περασμένης εβδομάδας...

(Πρόκειται για ένα τυποποιημένο σύνολο ερωτήσεων.)	καθόλου	λίγο	μέτρια	αρκετά	πολύ
Πόσο σας έχουν ενοχλήσει ανεπιθύμητες αναμνήσεις, εφιάλτες ή άλλα ερεθίσματα που σας θυμίζουν το ατύχημα;	○	○	○	○	○
Πόση προσπάθεια έχετε καταβάλει για να αποφύγετε να σκέφτεστε ή να μιλάτε για το γεγονός ή να κάνετε πράγματα που σας θυμίζουν αυτό που συνέβη;	○	○	○	○	○
Σε ποιο βαθμό έχετε χάσει την ευχαρίστηση για πράγματα τα οποία απολαμβάνατε παλιότερα, έχετε κρατήσει αποστάσεις από τους ανθρώπους ή δυσκολεύεστε να βιώσετε συναισθήματα;	○	○	○	○	○
Πόσο σας έχει ενοχλήσει ο κακός ύπνος, η κακή συγκέντρωση, η νευρικότητα, ο εκνευρισμός ή το αίσθημα εγρήγορσης για το τι γίνεται γύρω σας;	○	○	○	○	○
Πόσο σας έχουν ενοχλήσει πόνοι, ενοχλήσεις ή η αίσθηση κόπωσης;	○	○	○	○	○
Σε ποιο βαθμό σας έχουν αναστατώσει υπερβολικά / ασυνήθιστα κάποια στρεσογόνα γεγονότα ή δυσκολίες που συνέβησαν;	○	○	○	○	○
Πόσο έχουν επηρεάσει τα παραπάνω συναισθηματικά συμπτώματα την ικανότητά σας να εργάζεστε ή να εκτελείτε καθημερινές δραστηριότητες;	○	○	○	○	○
Πόσο έχουν επηρεάσει τα παραπάνω συναισθηματικά συμπτώματα τις σχέσεις σας με την οικογένεια ή τους φίλους σας;	○	○	○	○	○

Θέλετε να προσθέσετε κάτι ή να εξηγήσετε την άποψη ή την εμπειρία σας;

Σας ευχαριστούμε για την πολύτιμη συνεισφορά σας.

The English version

(not distributed, but useful in the context of the report)

☑ Save a backup on your local computer (disable if you are using a public/shared computer)

Questions to the Tempi victims and involved

Fields marked with * are mandatory.

Pages: Start ...

HARSIA

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Report abuse

The National Air and Rail Accident Investigation Agency (EODASAAM / HARSIA - https://www.harsia.gr/) is a member of the European Network of National Investigation Authorities (NIB Network https://www.era.europa.eu/agency/stakeholder-relations/national-investigation-bodies/nib-network-european-network-rail-accidents-national-investigation-bodies_en) and is under the supervision of the European Union Agency for Railways (ERA - https://www.era.europa.eu/).

The EODASAAM board took office on 18/09/2023. With the support of its board, the Railway Sector of the EODASAAM made a formal request to the ERA for its assistance in the investigation of the Tempe accident. EODASAAM formally undertook the investigation of the tragic accident at Tempe on 15/03/2024, with the appointment of the first railway investigator and the establishment of the Tempe Railway Accident Investigation Committee, which is composed of EODASAAM and ERA members.

The investigation carried out by EODASAAM is independent of the police and judicial investigation and the investigation of other railway bodies. The EODASAAM investigation is not about attributing blame or liability but about issuing safety recommendations with a view to improving the safety of the railway system.

In this context, EODASAAM wishes to examine the management of medical and other support to injured persons, other passengers and their families, taking direct feedback from them. To this end, an (interactive) questionnaire has been prepared, the answers to which (if sufficient in number) will be analysed anonymously and in complete confidentiality.

Direct information from the side of the accident victims can make a unique contribution, unlike information obtained from third parties or institutions.

This investigation is designed exclusively for those involved in the Tempi accident. Please do not disclose the link or the details of the survey to third parties, as this may negatively affect the validity of the results. Thank you for your cooperation and your contribution to ensuring reliable and useful data.

Please note that it is not mandatory to answer all questions.
It should be noted that not all questions need to be answered. In case more than one answer is appropriate, there is the possibility to choose multiple answers.

* You are...

- ☐ one of the passengers injured in the accident
- ☐ one of the passengers not injured in the accident
- ☐ a relative of a deceased passenger
- ☐ a relative of a passenger who survived
- ☐ a firefighter or a police officer
- ☐ a member of hospital or ambulance services
- ☐ a member of OSE or another railway company, who had some involvement on the accident scene that night and/or the following days
- ☐ a member of OSE or another railway company, who had NO involvement on the accident scene that night and/or the following days
- ☐ Other, or if you wish to specify:

If you wish to help us increase the reliability of this survey, and given the strict anonymisation of the results, please feel free to provide your first and last name below.

During the weeks and months after the accident, which of the following emotional symptoms were your most important ones?

- ☐ You had no emotional symptoms
- ☐ Unwanted memories and/or repeated reasoning
- ☐ Repeated nightmares of the stressful experience(s)
- ☐ Feeling upset, irritable
- ☐ Physical reactions like heart pounding, trouble breathing, sweating
- ☐ Avoiding external reminders of it (people, places, conversations, etc.)
- ☐ Trouble about remembering some parts of what happened
- ☐ Having strong negative beliefs, or feelings
- ☐ Lost of interest in activities you used to enjoy
- ☐ Trouble to experience positive feelings
- ☐ Taking too many risks or doing things that could harm you
- ☐ Having difficulty concentrating
- ☐ Trouble falling or staying asleep
- ☐ Feeling distant or cut off from other people

* Have you been offered professional emotional or psychological support?

- ◯ I don't remember
- ◯ Never, and I think I didn't need it
- ◯ Never, and I think I needed it
- ◯ Yes, from the first days
- ◯ Yes, and early enough
- ◯ Yes, but too late

About this treatment...

- ☐ You have not been proposed anything
- ☐ Yes, from the authorities
- ☐ You were offered this support, but it was by family members, friends or acquaintances of these persons.
- ☐ Priority has been given to your physical injuries, and it was normal to you
- ☐ Priority has been given to your physical injuries, and it was insufficient for you
- ☐ You have had medication only
- ☐ You have had both medication and therapeutic sessions
- ☐ You have had therapeutic sessions only
- ☐ You refused all such treatment
- ☐ You decided to find this support on your own

How much have the above symptoms improved since Tempi?

- ◯ Worse
- ◯ No change
- ◯ Minimally
- ◯ Much
- ◯ Very much
- ◯ It's been up and down, and it's still not going well enough
- ◯ It's had its ups and downs, but now it's fine

How much better do you feel since beginning treatment? (as a percentage)

Reset to initial position

No better at all — 100% better

5

‹ 0 ———— 10 ›

* Would you agree to help us assess the possible personal impact of Tempi still today?

Yes No

During the past week...

(This is a standardised set of questions.)	not at all	a little bit	moderately	quite a lot	very much
How much have you been bothered by unwanted memories, nightmares, or reminders of the event?	○	○	○	○	○
How much effort have you made to avoid thinking or talking about the event, or doing things which remind you of what happened?	○	○	○	○	○
To what extent have you lost enjoyment for things, kept your distance from people, or found it difficult to experience feelings?	○	○	○	○	○
How much have you been bothered by poor sleep, poor concentration, jumpiness, irritability, or feeling watchful around you?	○	○	○	○	○
How much have you been bothered by pain, aches, or tiredness?	○	○	○	○	○
To what extent have you been abnormally upset by stressful events or difficulties?	○	○	○	○	○
How much have the above symptoms interfered with your ability to work or carry out daily activities?	○	○	○	○	○
How much have the above symptoms interfered with your relationships with family or friends?	○	○	○	○	○

Do you want to add something or explain your opinion or experience?

We thank you for your precious contribution.

Appendix E. Evidence and their Source

1. Documents, video, photo from the Judicial Investigation, via the Special Court of Appeal of Larissa
2. Photos, notes, and documentation shared and stabilised after the interviews (EODASAAM)
3. Photos, notes, and documentation shared and stabilised after the work-sites observations (EODASAAM)
4. Photos, notes, stabilised after the accident site and the Koulouri site observations (EODASAAM)
5. Documents, photos, requested by EODASAAM, received from the investigating team EDAPO
6. Documents, photos, requested by EODASAAM, received and not received from the Stakeholders
7. Complementary evidences and specific analysis, solicited by ERA experts, from one expert of EDAPO
8. Complementary specific analysis, requested by EODASAAM or received, from different experts or labs
9. Data produced by the target audience of the Psychological Impact Questionnaire (EODASAAM)
10. Greek and EU regulatory references

Appendix F. Figures and Tables

Appendix G. Glossary & Acronyms

TERM	DEFINITION
ascending track	The line with traffic direction from Athens to Thessaloniki
automatic route setting	In this report the term is used for a type of route control system of interlocking whereby the signaller operates one pushbutton at the commencement (entrance) of the required route and a second at the finish (exit) of the route. This action initiates the setting of all points required by the route.
block (section)	A portion of line with defined limits between which only one rail traffic movement is permitted at any one time
bogie	A structure incorporating suspension elements and fitted with wheels and axles, used to support rail vehicles at or near the ends and capable of rotation in the horizontal plane.
catenary (wire)	In overhead electrification, the two overhead wires mounted above the track and supporting the contact wire.
centralised traffic control (CTC)	A system of remotely controlling the points and signals at a number of interlocked stations, junctions and crossing loops in automatic signalling areas, from a centralised conrol room or signal box.
coach / carriage	A coach is designed for carrying passengers.
Common Safety Methods	Common Safety Methods (CSMs) describe how the safety levels, the achievement of safety targets and compliance with other safety requirements should be fulfilled
continuous welded rail	Track where the rail is joined by welding (and other non-moveable joints such as glued insulated joints) in lengths greater than 300 metres.
(sub)contractor	Contracting companies, sub-contractors and rail safety workers working for either of these.
control panel	A panel which incorporates a layout of tracks for the area controlled from the signal box and which contains levers for the control of signals, routes, points, releases, etc. In certain cases, the control panel is combined into the track indicator diagram.
degraded mode conditions	The state of the part of the railway system when it continues to operate in a restricted manner due to the failure of one or more components.
descending track	The line with traffic direction from Thessaloniki to Athens
line	The entire railway route/network (includes tracks, stations, signals).
electric control centre	A building containing apparatus for ther control of the feeder stations, track sectioning cabins and equipment associated with the overhead line equipment
power controller	The worker in charge of the electrical control room, who controls the power supply to the overhead traction wiring equipment, and is responsible for all switching operations and isolations of electrical equipment.
electric locomotive	As distinguished from a diesel locomotive, the traction motors obtain power from a wire suspended above the track. Contact is made to this wire by a pantograph mounted on the roof of the locomotive.

european rail traffic management system (ERTMS)	A system for managing rail traffic, enabling it to operate on compatible signalling systems across European borders
european train control system (ETCS)	A three level, unified, modular automatic train protection specification to enhance interoperability across Europe.
gauge (track)	The distance between the inside running (or gauge) faces of the two rails, measured between points 16 mm below the top of the rail heads.
Infrastructure Manager	The Infrastructure Manager is responsible for the ownership, control or management, for the construction and maintenance of track, civil and electric traction infrastructure, or the construction, operation or maintenance of train control and communication systems, or a combination of these
interoperability	A term used to mean the possibility of uninterrupted movement of trains from differing countries (states) across international (state) borders.
level crossing	A location where the railway line and a road or pedestrian walkway cross paths on the same level
local control panel	An interlocking machine that may be switched to and from local control, but is capable of being switched to remote control.
locomotive	Self-propelled, non-passenger-carrying railway vehicles used for hauling or propelling other (typically freight or passenger) rolling stock.
movement authority	Permission for a train to run to a specific location as a signalled move.
proceed / off (aspect)	A proceed aspect in a colour light signal, or the arm of a semaphore signal or disc signal inclined at 45 degrees or more, or distant signal other than at its most restrictive aspect.
stop / red / on (aspect)	A red aspect in a colour light signal, or the arm of a semaphore signal in the horizontal position, denoting 'stop' or 'caution', or distant signal at most restrictive aspect.
pantograph	An apparatus fixed to the roof of electric traction vehicles to draw current from the overhead supply.
platform (wagon)	A wagon with a full width substantially flat deck, without side walls and with or without stanchions, bulkheads and other load support and restraint systems.
railway infrastructure	Facilities other than rolling stock necessary for a railway to operate safely including railway track, associated track structures, over- or under-track structures, supports (including supports for railway equipment or items associated with the use of a railway), tunnels, bridges, stations, platforms, train control systems, signalling systems, communication systems, electric traction infrastructure, buildings, workshops and associated equipment.
rolling stock	Any vehicle that operates on, or intends to operate on, or uses a railway track, including any loading on such a vehicle, but excluding a vehicle designed for both on- and off-track use when not operating on the track. Rolling stock is a collective term for a large range of rail vehicles of various types, including locomotives, freight wagons, passenger cars, track machines and road-rail vehicles.
route	The path along a section of track between one signal and the next, along which an authorised movement is to be made.

route control system interlocking	A system whereby a route is set and the signal leading over it is cleared by the signaller operating a route setting button or buttons. Two types are in use, one being the "Entrance-Exit" or "Push-Push" type whereby the signaller operates one push- button at the commencement and a second at the finish of the route. The other is the "one control switch" (OCS) type whereby a separate switch or push-button is provided for each route on a signal and the signaller operates the switch or push- button for the route required. The interlocking between routes may be relay interlocking or computer based interlocking.
route setting	A system in which all points in a route are set to the required positions, and the signal at the entrance to the route cleared by the operation of one or two control functions.
safety critical	Directly influencing safety (when applied to equipment or systems).
safety related	Having the potential to influence safety (when applied to equipment or systems).
signal (light)	A visual display device which conveys instructions or provides prior warning of instructions regarding the driver's authority to proceed.
signalling (system)	A series of electrical, electronic, electro-mechanical units brought together to form a system which controls the safe movement of trains.
single line operation	The operation of a main line upon which trains are operated in either direction on a single track.
single track	A line that consists mostly of only one track where only one train is able to travel/pass at one time.
sleeper	Sleepers are bearers used to hold the rail in place at the correct gauge and to transmit loads through the ballast to the formation. They have traditionally been made of wood but are gradually being replaced by concrete or steel sleepers.
stakeholders	Those people and organizations who may affect, be affected by, or perceive themselves to be affected by, a decision or activity.
standard	An authorised document, including specification, procedure, instruction, directive, rule or regulation, which may set mandatory requirements.
standard gauge	The name given to the gauge of track of 1435mm
station master	The employee responsible for the management and control of traffic movements and occupancy authorities.
switch	A combination of a set of points, V crossing and guard rails which permits traffic to turnout from one track to another.
switch Operator	Personnel to manually set turnouts
telegram	A telegram is a concise and formal communication used for transmitting operational or safety-critical messages, delivered either orally via voice communication systems or in written form through delivery of notes
track	The combination of rails, rail connectors, sleepers, ballast, points, and crossings, and substitute devices where used.
train	A single unit of rollingstock or two or more units coupled together, at least one of which is a locomotive or other self propelled unit.
train manager	The train manager is a railway employee who is responsible for rail passengers comfort, safety, and commercial tasks.

train protection system	A system that supervises train speed and target speed, alerts driver of the braking equipment, and enforces braking when necessary.
vehicle	Used to denote rail vehicles where reference to a specific type or class is not required or not intended.
wagon	A wagon is generic term used for carrying passengers, goods or cargo.

Acronym	English (EN)	Greek (EL)
CAA	Civil Aviation Authority	Αρχή Πολιτικής Αεροπορίας
CCTV	Closed-Circuit Television	Τηλεόραση κλειστού κυκλώματος
CFD	Computational Fluid Dynamics	Υπολογιστική Ρευστοδυναμική
CSM	Common Safety Method	Κοινή Μέθοδος Ασφαλείας
CSM ASLP	Common Safety Methods on Assessment of Safety Level and safety Performance	ΚΜΑ για την Αξιολόγηση του Επιπέδου Ασφάλειας και την Απόδοση Ασφαλείας
CTC	Centralised traffic control	Κέντρο ελέγχου κυκλοφορίας (ΚΕΚ)
DNA	Deoxyribonucleic acid	Δεοξυριβονουκλεϊκό οξύ
DVI	Disaster Victim Identification	Αναγνώριση θυμάτων καταστροφής
EDAPO	Committee for the Investigation of Independent Family Experts (see EL)	Επιτροπή Διερεύνησης Ανεξάρτητων Πραγματογνωμόνων Οικογενειών
EMAK	Catastrophe Response Special Unit (see EL)	Ειδική Μονάδα Αντιμετώπισης Καταστροφών
EN	European Standard (Europäischer Norm)	Ευρωνόρμα
EODASAAM	National Organisation for the Investigation of Air Transport and Rail Accidents and Transport Safety (see EL)	Εθνικός Οργανισμός Διερεύνησης Αεροπορικών & Σιδηροδρομικών Ατυχημάτων & Ασφάλειας Μεταφορών
EOPYY	National Organisation for Providing Health Services (see EL)	Ε.Ο.Π.Υ.Υ. - Εθνικός Οργανισμός Παροχής Υπηρεσιών Υγείας.
ERA	European Union Agency for Railways	Οργανισμός της Ευρωπαϊκής Ένωσης για τους Σιδηροδρόμους
ERTMS	European Rail Traffic Management System	Ευρωπαϊκό Σύστημα Διαχείρισης Σιδηροδρομικής Κυκλοφορίας
ETCS	European Train Control System	Ευρωπαϊκό Σύστημα Ελέγχου Τρένων
HOF	Human and Organisational Factors	Ανθρώπινοι και Οργανωτικοί Παράγοντες
GKK	General Movement Regulation (see EL)	Γενικός Κανονισμός Κυκλοφορίας
GSM-R	Global System for Mobile Communications – Railway	Παγκόσμιο Σύστημα Κινητών Επικοινωνιών – Σιδηροδρόμου
IC	Inter-City	Υπεραστικό
IM	Infrastructure Manager	Διαχειριστής υποδομής (ΔΥ)
ISO	International Organization for Standardization	Διεθνής Οργανισμός Τυποποίησης
NIB	National Investigation Body	Φορέας Διερεύνησης (Σιδηροδρομικών) Ατυχημάτων
NSA	National Safety Authority	Εθνική Αρχή Ασφάλειας
OATHYK	Hellenic Police Mass Disaster Victim Identification team (see DVI) (see EL)	Ομάδας Αναγνώρισης Θυμάτων Καταστροφών (ΟΑΘΥΚ)
OSE	Hellenic Railway Organisation of Greece - Organismos Sidirodromon Ellados (see EL)	Οργανισμός Σιδηροδρόμων Ελλάδος
PIA	Preliminary Investigation Authority	Προανακριτική Αρχή
PTSD	Post-Traumatic Stress Disorder	Διαταραχή Μετατραυματικού Στρες
RAS	Greek National Safety Authority - Regulatory Authority for Railways (see EL)	Ρυθμιστική Αρχή Σιδηροδρόμων (ΡΑΣ)

RI.SE	Research Institutes of Sweden AB	Ερευνητικά Ινστιτούτα της Σουηδίας, "RISE AB"
RST	Rail System Testing GmbH, "RST LABS"	Rail System Testing GmbH, "RST LABS"
RU	Railway Undertaking	Σιδηροδρομική Επιχείρηση
SCADA	Supervisory Control And Data Acquisition	Εποπτικός Έλεγχος και Απόκτηση Δεδομένων "SCADA"
SKA	Acharnes Railway Junction (see EL)	Σιδηροδρομικό Κέντρο Αχαρνών
SMS	Safety Management System	Σύστημα Διαχείρισης Ασφάλειας
SSC	Single Safety Certificate	Ενιαίο Πιστοποιητικό Ασφαλείας
TELOC	TELephone & LOComotive (data recording system)	Σύστημα καταγραφής δεδομένων "TELOC"
TSI	Technical Specification for Interoperability	Τεχνική Προδιαγραφή Διαλειτουργικότητας
TSI OPE	Operation and Traffic Management TSI	ΤΠΔ Διεξαγωγή και Διαχείριση της Κυκλοφορίας
UIC	International Union of Railways (French: Union Internationale des Chemins de fer)	Διεθνής Ένωση Σιδηροδρόμων
USB	Universal Serial Bus	Universal Serial Bus
VHF	Very High Frequency (radio)	Ραδιόφωνο VHF