BEA-TT

Bureau d'enquêtes sur les Accidents
de transport terrestre

RAIB

Rail Accident
Investigation Branch

Technical Investigation Report concerning the Fire on Eurotunnel Freight Shuttle 7412 on 11 september 2008

This document is a translation of the French original report

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Ministère
de l'Écologie,
de l'Énergie,
du Développement
durable
et de la Mer

RAIB
Rail Accident Investigation Branch

Department for Transport

Conseil général de l'Environnement et du Développement durable	**Department for Transport**
Bureau d'enquêtes sur les accidents de transport terrestre	**Rail Accident Investigation Branch**

Affaire n° BEATT-2008-015

Technical Investigation Report concerning the Fire on Eurotunnel Freight Shuttle 7412 on 11 September 2008

(translation of French original)

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Notice

The technical investigation covered by this report was performed by collaboration between the competent French and UK organizations in charge of railway accidents investigations.

In France, the investigation was performed by the Bureau d'Enquêtes sur les Accidents de Transport Terrestre (BEA-TT) according to Section III of Law No. 2002-3 of 3 January 2002 as amended, and Decree No. 2004-85 of 26 January 2004 as amended, relating in particular to technical investigations following an accident or incident involving land transport facilities.

In the United Kingdom, the investigation was performed by the Rail Accident Investigation Branch (RAIB) according to the "Railways and Transport Safety Act 2003" and the "Railways (Accident Investigation and Reporting Regulations) 2005".

In accordance with French and UK legislation, the sole purpose of this report is to prevent future accidents, by determining the circumstances and causes of the event analysed, and drawing up the relevant safety recommendations. It is not intended to determine responsibility.

As a result, the use of this report for any purposes other than prevention could lead to its incorrect interpretation.

Contents

Glossary

- BEA-TT: Bureau d'Enquêtes sur les Accidents de Transport Terrestre – Land Transport Accident Investigation Bureau
- BINAT: Bi-national emergency plan
- BINAT POSS: Message warning of the impending implementation of the BINAT plan
- BINAT GO: Message triggering the implementation of the BINAT plan
- CP: Cross-passage
- Crossover: Installation allowing trains to pass from one tunnel to the other.
- DOS : Directeur des Opérations de Secours (French Republic) – Director of Emergency Operations
- EMS: Engineering Management System
- FD (Controller): Fire Detection (Controller)
- FEMC: Fire Equipment Management Centre (Eurotunnel)
- FLOR: First Line of Response (fire-fighters)
- IGC: Inter-Governmental Commission
- ICC: Incident Coordination Centre (located in the United Kingdom)
- ISIS: Integrated Staff Information System
- KFRS: Kent Fire and Rescue Service
- Mission: Eurotunnel train movement
- NVS: Normal Ventilation System
- PCO: Poste de Commandement Opérationnel = Incident Coordination Centre (located in France)
- PK : Point Kilométrique – Kilometric Point
- PRD: Piston Relief Duct
- RAIB: Rail Accident Investigation Branch
- RCC: Rail Control Centre
- REX: Return on Experience
- RTM : Rail Traffic Management
- SDIS : French fire and rescue service
- SEL: Elementary Section
- SLOR: Second Line of Response
- STTS: Service Tunnel Transport System
- SVS: Supplementary Ventilation System
- TCC: Terminal Control Centre
- TVM: Transmission Voie-Machine – track-to-train transmission system

Summary

On 11 September 2008, Eurotunnel freight shuttle 7412 departs from the English terminal of the Channel Tunnel at Folkestone on time (15:36 hrs[1]). It is carrying twenty-five lorries and two vans. The amenity coach, in which the lorry drivers are travelling, is in its normal position, immediately behind the leading locomotive.

At about 15:54 hrs, a fire is detected on board the train. The train stops just before 15:59 hrs near marker PK49, which is in the last third of the tunnel.

Of the 32 people on board the train, 28 are quickly evacuated to the service tunnel. Four passengers who had ventured into the rail tunnel are recovered a little later; the first two at about 16:13 hrs and the last two at about 16:26 hrs.

The operations involved in the evacuation to the French terminal end at 18:44 hrs, i.e. almost 3 hours after the start of the event.

Fire-fighting operations start at 16:56 hrs. They are fully operational by 17:53 hrs and end the next day at around 12:00 hrs.

The fire did not cause any deaths or serious injuries; 6 people with slight injuries were evacuated to hospital in Calais.

Regarding equipment, all the loaded wagons and lorries were affected by the fire. Both locomotives and the amenity coach suffered damage due to the high temperatures and smoke to which they were exposed. The North Tunnel, in which the shuttle was travelling, suffered considerable damage and could not be reopened to traffic until February 2009.

The initial cause of the fire is still not known exactly, but we suspect that a road vehicle caught fire and the fire spread to the whole of the rake. It should be noted that one of the vehicles on board had an electrical fault, resulting in it being impossible to turn off its headlights, and this vehicle was in the part of the rake where the fire appears to have started.

The investigation by the two French and UK organizations (BEA-TT and RAIB) was performed jointly, in accordance with the agreement between them. It mainly concerns the performance of the evacuation and fire-fighting operations, with particular attention paid to any factors that might have made these operations more difficult or more dangerous, and any mishaps that might have been observed.

Although the event only resulted in minor injuries to people, there were a number of factors that directly affected the evacuation process and fire-fighting operations.

The main factors identified by the investigation are:

- The stopping point of the shuttle, which meant that the amenity coach door normally used for evacuation was not opposite a cross-passage,
- The fact that the amenity coach door normally used for evacuation was locked out of use,
- Communication difficulties between the chef de train and the passengers,

[1] French time (Central European Time)

- The delay in opening the cross-passage door and starting the supplementary ventilation system,
- Excessive delays in attacking the fire, connected with electrical safety procedures,
- Numerous faults in technical systems.

Some organizational factors and areas for improvement in the safety management system were also identified.

The scope of the investigation does not cover an evaluation of the measures taken or planned by Eurotunnel (ET) after the fire and, in particular, the plan to create extinguishing stations (SAFE stations) in the rail tunnels.

The investigation has led to 39 recommendations being made concerning, in particular, the following areas:

- Evacuation,
- Fire-fighting,
- Rolling stock,
- Infrastructure and equipment,
- Procedures and tools used by the rail control centre,
- Safety management system.

1 Immediate findings and opening of the investigation

1.1 Circumstances of the fire

On 11 September 2008, a Eurotunnel freight shuttle (mission 7412) departs from the English terminal at Folkestone on time (15:36[2]). It travels in the North rail tunnel, the tunnel normally allocated for traffic from England to France. It is carrying twenty-five lorries and two vans. The amenity coach, in which the lorry drivers, the member of catering staff and the *chef de train* are travelling is in its normal position, in other words immediately behind the leading locomotive.

At around 15:54 hrs, the presence of a fire on board this train is detected. The train stops just before 15:59 hrs near marker PK 49 which is located in the last third of this tunnel (interval no. 6).

The 32 people on board the train are quickly evacuated to the service tunnel and then taken to the French terminal.

1.2 Loss of human life, injuries and damage to equipment

The fire did not cause any deaths or serious injuries; 6 people with slight injuries were evacuated to hospital in Calais.

Regarding equipment, all the loaded wagons and lorries were affected by the fire. Both locomotives and the amenity coach suffered damage due to the high temperatures and smoke to which they were exposed. The North Tunnel, in which the shuttle was travelling, suffered considerable damage.

1.3 Traffic measures taken after the fire

Three trains had entered the North Tunnel after mission 7412. They returned to England.

Three other trains had entered the South Tunnel. Once safety measures had been taken, these three trains continued on their journey to England.

The traffic was then completely stopped in both directions of travel.

1.4 Opening of the investigation

The decision to carry out a technical investigation was taken, on the French side, by the director of the Bureau d'Enquêtes pour les Accidents de Transport Terrestre (BEA-TT) [Land Transport Accident Investigation Bureau] on 12 September 2008 (see Annex No. 1).

On the UK side, the decision to participate in a joint investigation with the BEA-TT was taken by the chief inspector of the Rail Accident Investigation Branch (RAIB) on the same date.

This investigation is one that has to be performed in respect of article 19(1) of directive 2004-49 EC as the amount of damage came to more than two million Euros.

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[2] All of the times given in this report refer to French time (Central European Time).

2 Organisation of the investigation

2.1 Cooperation between BEA-TT and RAIB

Both investigation organisations, the French BEA-TT and the UK RAIB started an investigation in their own country.

They collaborated in producing a joint investigation report in accordance with the conditions specified in the heads of agreement previously produced (see Annex No. 2).

In application of this agreement:

- the investigation and the report have been completed jointly;
- the organisations jointly decided on the scope of the investigation and the methods to be used, how duties would be shared out and how the work would be organised. They consulted each other on reports and communications produced;
- as the shuttle had stopped in French territory, the BEA-TT was responsible for summarising the information produced by the two investigations and drafting the joint report;
- during the investigation, the two organisations regularly exchanged information obtained within the limits of national regulations.

2.2 Investigations carried out

As the judicial investigation is looking into the causes of the fire, and as this is still in progress, this technical investigation mainly concerns the performance of the evacuation and fire-fighting operations, with particular reference to any factors that might have made them more difficult or more dangerous and any mishaps that occurred.

Each organisation carried out its investigations in the areas agreed, with or without the assistance of an investigator from the other organisation, depending on requirements and availability.

A non-permanent technical investigator was appointed and commissioned by the French ministry of transport in an order dated 8 April 2009 to assist the BEA-TT throughout the investigation.

The investigators worked mainly on the basis of:

- interview reports from the judicial authorities,
- interviews they conducted themselves,
- working documents used by staff on the day of the fire,
- meetings with managers and other Eurotunnel members involved,
- regulations and technical documents applicable on the day of the fire.

The BEA-TT and the RAIB exchanged information and working papers. Many joint meetings were held on both an investigator and an organisation level and a progress report was presented to the IGC and Eurotunnel in October 2009.

2.3 Preparation of the report

In accordance with the cooperation agreement, the BEA-TT prepared the entire report using their usual format and presentation structure. The contents were drawn up during exchanges and joint meetings, and then validated in its final form by the two investigating organisations.

3 Context

3.1 Eurotunnel concession

Eurotunnel is the concessionaire responsible for the operation of the Channel Tunnel and associated facilities.

The Concession comprises the following installations:

- the two rail tunnels and the service tunnel,
- surface and underground installations,
- Folkestone and Coquelles terminals,
- connections with French and UK rail networks.

Eurotunnel has been operating and maintaining the Channel Tunnel since it opened in 1994. Eurotunnel is therefore:

- the infrastructure manager in accordance with European directive 91-440;
- a railway operator in respect of its own trains (freight or passenger shuttles).

3.2 The Folkestone – Coquelles section of the line

The tunnel is 50.6 km in length, 37 km of which are under the Channel. Figure 1 below shows the layout of the Channel Tunnel and its main technical facilities.

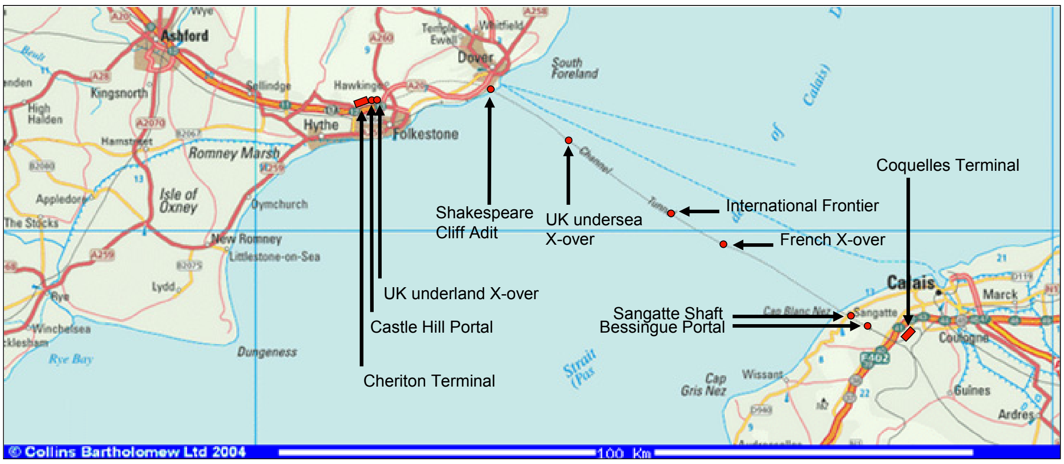


Figure 1: Layout of the Channel Tunnel

Rail traffic is managed by rail control centres located in each terminal. Only one of the two operates at a given time and manages all the facilities, in real time. Other control posts manage road traffic at the terminal.

The rail network is electrified at an alternating current of 25 kV fed to trains through an overhead a catenary system. The track gauge is standard.

3.2.1 Tunnels

Each rail tunnel is 7.6 m in diameter (see Figure 2 below) and comprises a single track.

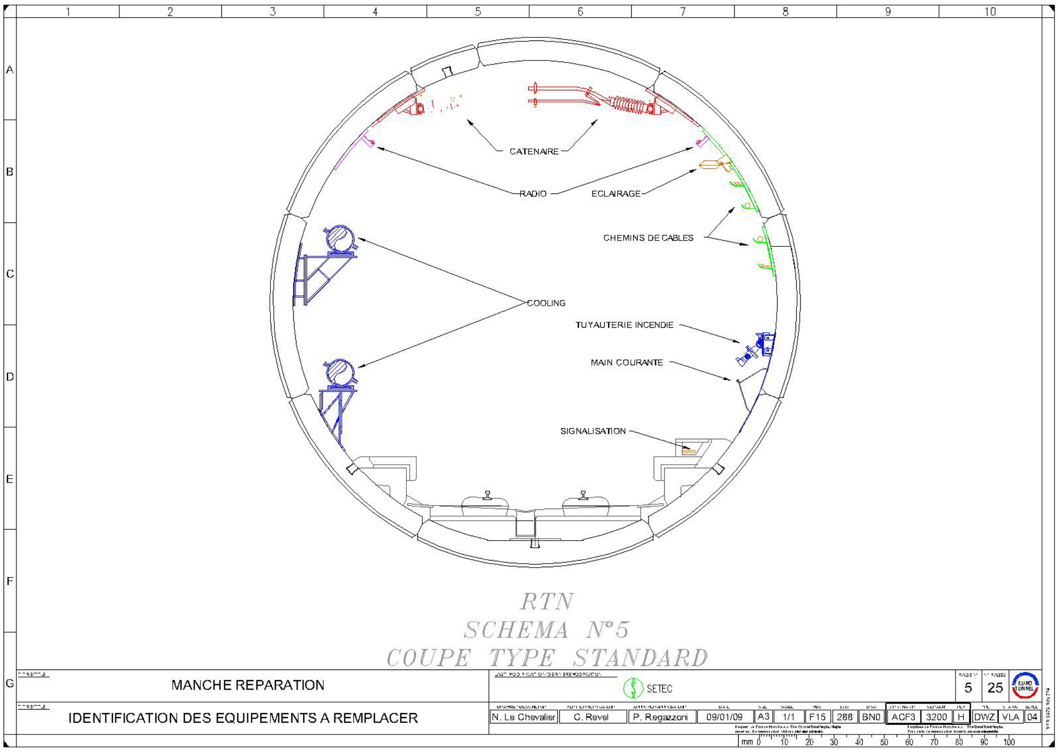


Figure 2: Standard section of the North rail tunnel

During normal operation, trains travel on the left track (the North Tunnel for trains from the UK to France and the South Tunnel for trains from France to the UK).

Each tunnel is divided into 3 sections, referred to as intervals. There are two crossovers enabling the trains to cross from one tunnel to the other. Doors, which are kept closed in normal conditions, separate the two tunnels at these crossovers.

Facilities at the terminal make it possible for trains to use either of the tunnels.

Figure 3 below shows the layout of the track.

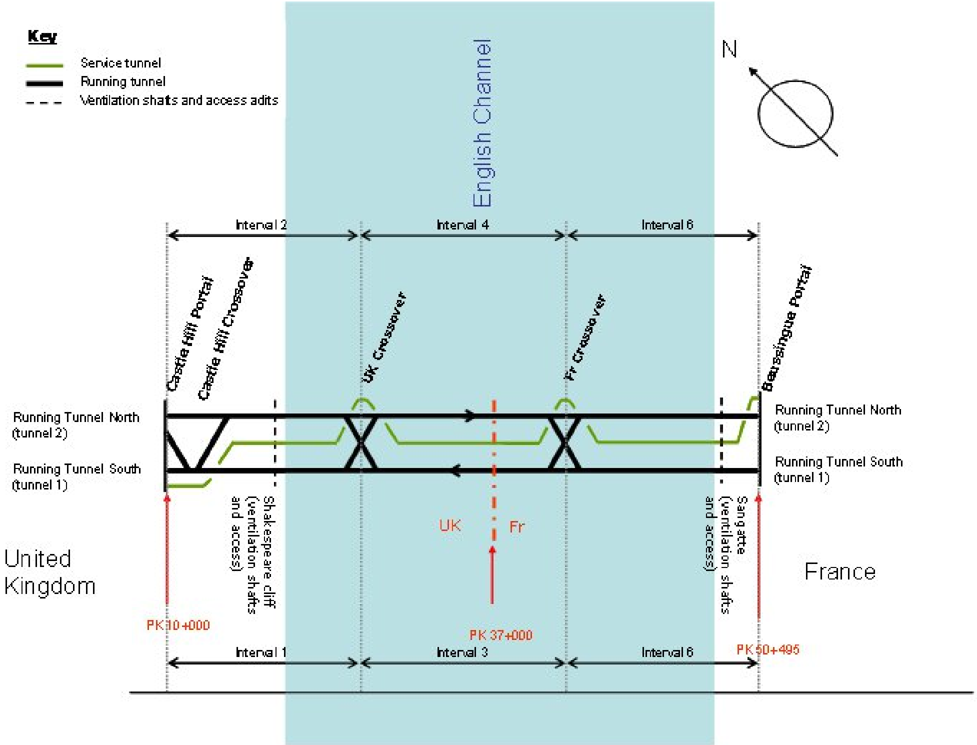


figure 3: Channel Tunnel, layout of the tracks

A third tunnel located between the two rail tunnels, except at the crossovers, acts as the service tunnel. It measures 4.80 m in diameter. It provides access to underground technical equipment, enables light maintenance of the rail tunnels and allows an emergency team to patrol and provide assistance in the event of an incident or accident involving the railway. Specialist tyred vehicles, referred to as the Service Tunnel Transport System (STTS) travel in this tunnel, as do conventional small cars (service cars).

Approximately every 375 metres, cross-passages (CP) connect the service tunnel to the rail tunnels. In normal conditions, these cross-passages are isolated from the rail tunnels by sealed, fire-resistant doors. These doors are normally controlled remotely from the rail control centre (RCC). They can also be operated in situ by two electrical or manual control devices, which takes a little under 2 minutes.

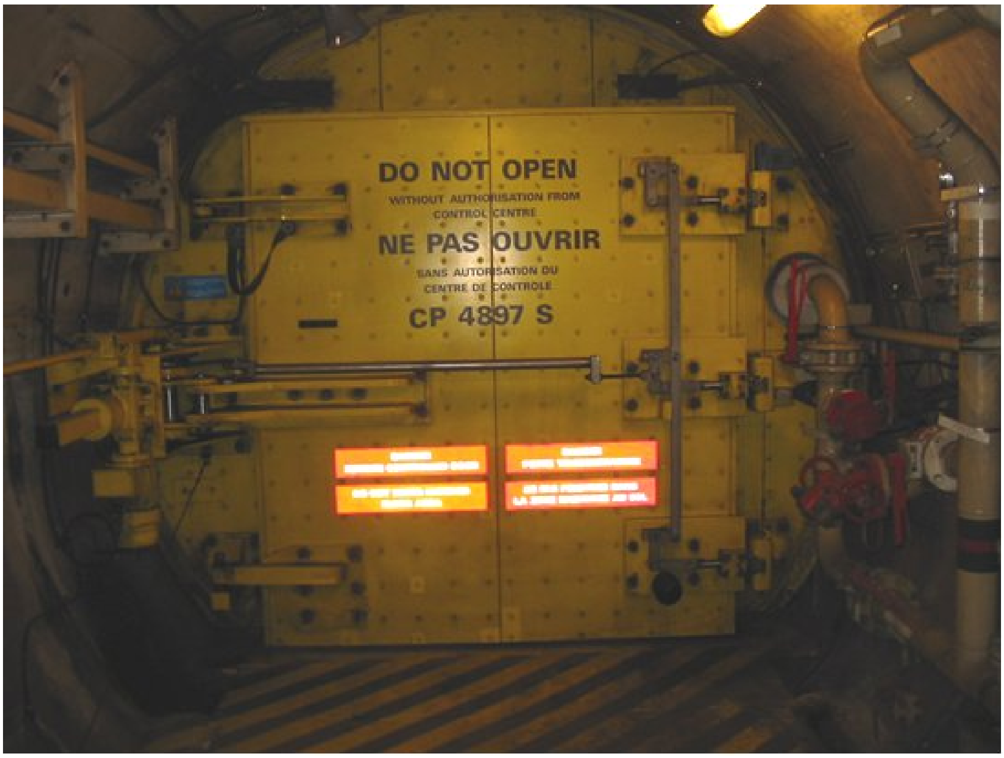


Figure 4: Cross-passage door

There is a direct connection between the rail tunnels every 250 metres using piston relief ducts (PRD) measuring 2 metres in diameter (see below). The PRDs can be closed by dampers which are open in normal conditions, and are operated from the RCC. These ducts reduce the aerodynamic effects caused by trains travelling in the running tunnels.

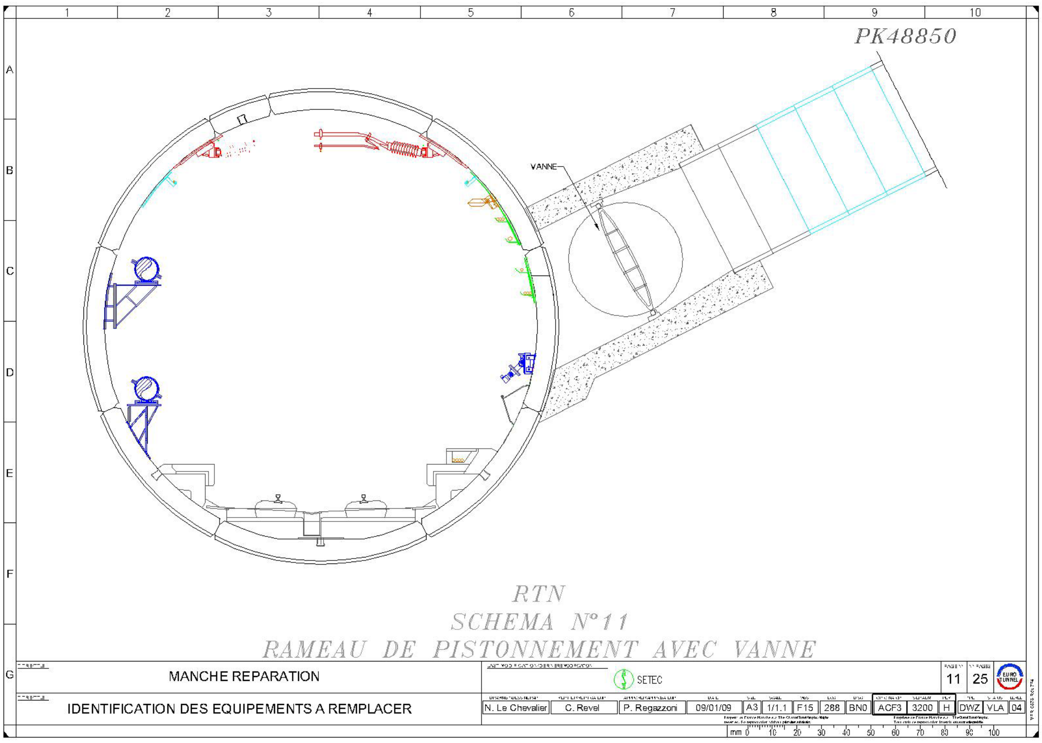


Figure 5: Rail tunnel and piston relief duct

Figure 6 shows a cross-section of the rail tunnels and the service tunnel, a PRD and two cross-passages.

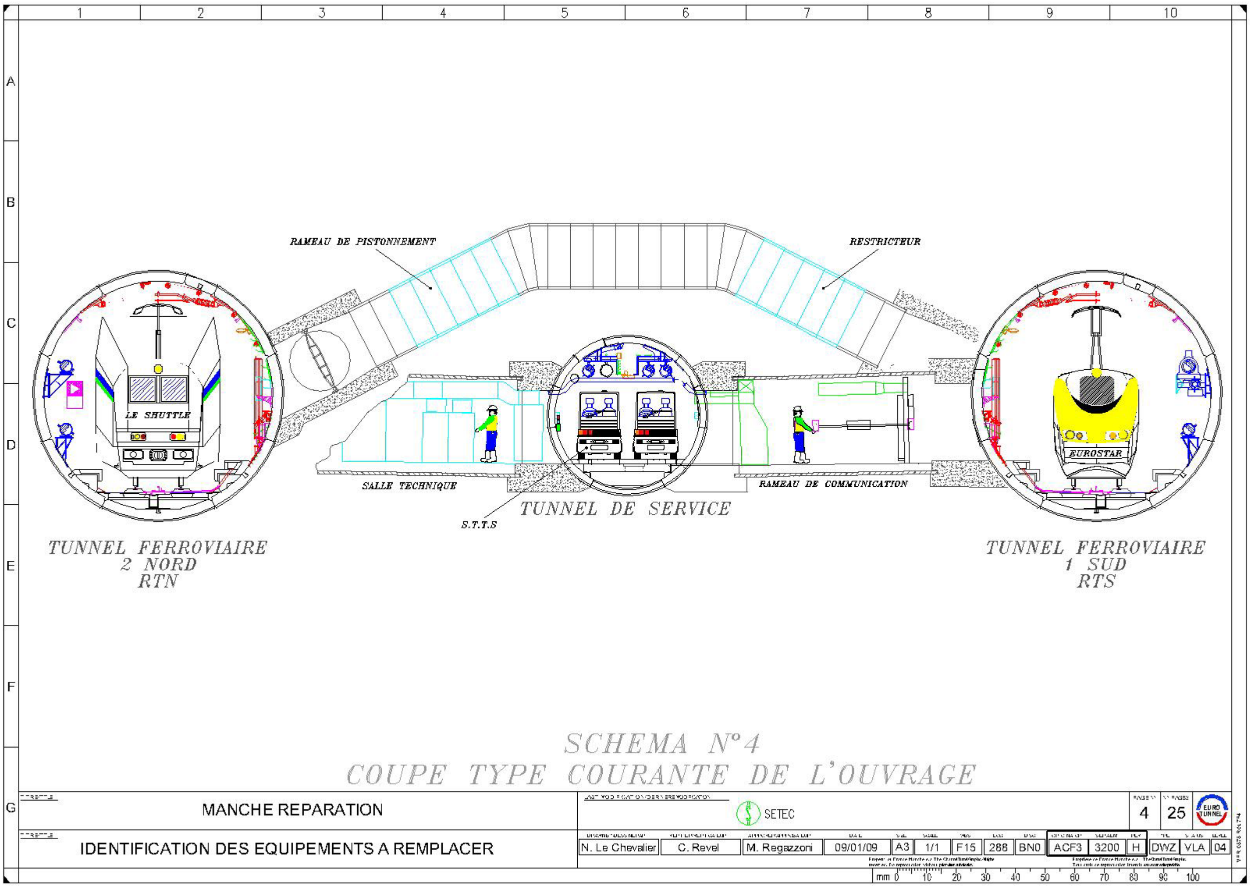


Figure 6: Channel Tunnel, standard section

The tunnels are mainly lined with reinforced concrete although some areas are lined with cast iron segments.

There is a walkway on each side of the two rail tunnels. One is on the side of the service tunnel. The surface of the walkway is 800 mm wide and it is located 2202 mm from the centre of the track and 805 mm above it. It is intended for use in the event of an emergency and for maintenance staff. The second walkway is on the other side of the tunnel at a height of 525 mm above the rail. It is for use only by tunnel maintenance staff.

3.2.2 Tracks

The tracks are laid on slabs to the standard gauge.

They are bidirectional lines, with signalling making it possible for trains to travel on them in both directions.

3.2.3 Signalling

The system installed is a Track-to-Train Transmission cab signalling system (TVM) which is very similar to that used on the French and UK high-speed lines.

Signals in the cab provide the following information in particular:

- instruction to stop,
- speed limit (30 km/h, 60 km/h, 100 km/h and 140 km/h),
- instruction to proceed with caution on a "marche à vue" (drive on sight) basis,
- information relating to electrical traction.

If these instructions are not obeyed, the speed control system causes the train to brake.

Other signs are located in the tunnel. These are either:

- markers associated with the TVM system,
- position markers located every 50 metres. The information provided on these signs is given in decametres in relation to the original datum point located 10,025 metres from the portal of the tunnel in England. So, the 49000 marker (referred to as the 'Point Kilometre' (PK) 49 marker is located exactly 38.975 kilometres from the UK portal in the direction of France.
- signs necessary for applying Eurotunnel's controlled stop procedure.
    - the approaching sign, located 100 m before the cross-passage door and bearing the number of the cross-passage[3] that the train is approaching.

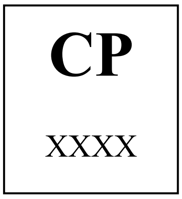


Figure 7: Cross-passage approaching sign

    - the stop sign, located 25 m after the cross-passage door to show the driver the exact point where he has to stop.

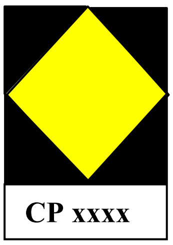


Figure 8: Stopping point sign

[3] The number of the cross-passage is also shown on the door leading to it.

3.2.4 Electrical traction equipment

3.2.4.1 Details of the electrical traction equipment

Locomotives are powered by a catenary with a nominal alternating current of 25 kV.

The catenary comprises six sectors, four of which cover the two North and South rail tunnels (two per tunnel). The mid-point of both sectors in each tunnel is at PK 35.3.

Each sector is divided into elementary sections approximately 1200 metres long.

When the tunnel was opened, in 1994, the power supply to the two sectors on the UK side was provided from England whilst that for the two sectors on the French side was provided from France. This method of operation is known as "symmetrical mode". Figure 9 below shows this method of operation.

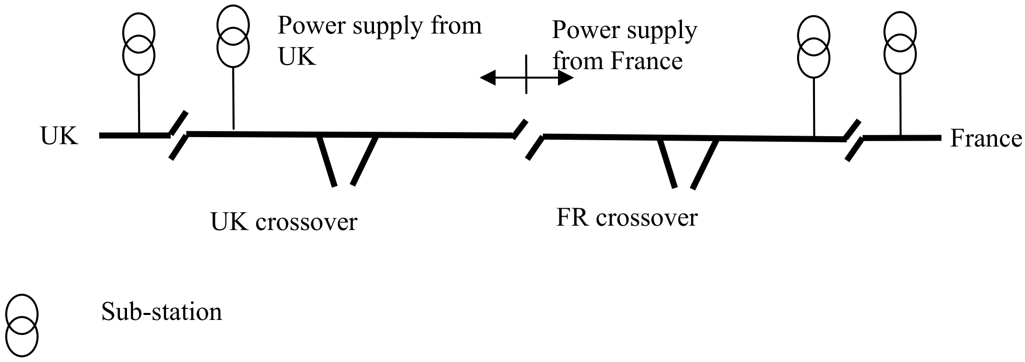


Figure 9: Power supply in the North Tunnel in symmetrical mode

If necessary, one or both of the tunnels could be supplied by one or other end, with a risk of a voltage drop on the line, the effect of which was to reduce the operating capacity of the Channel Tunnel.

In 2007, Eurotunnel upgraded its equipment by installing feeders in the service tunnel in order to be able to feed current inside the rail tunnels at the UK and French crossovers. This modification makes it possible, if necessary, to operate the Channel Tunnel by supplying all equipment from France without any loss of power and therefore without any loss of capacity. This method of operation is known as "extended mode". Figure 10 below shows this method of operation.

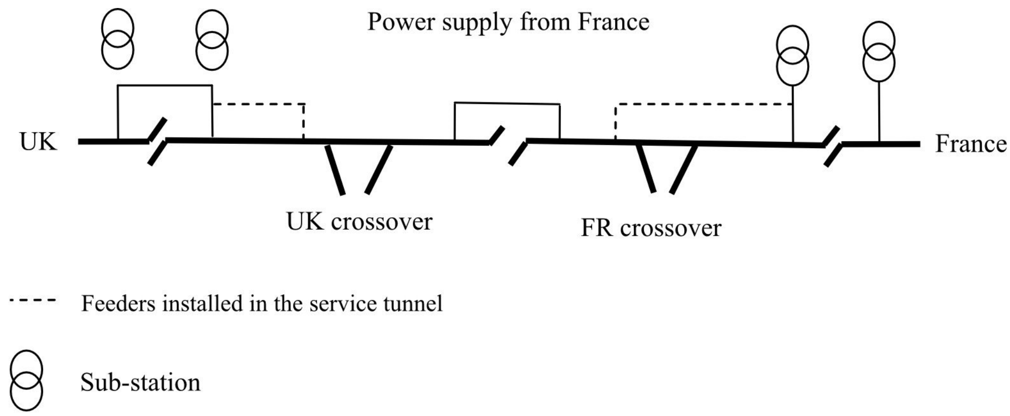


Figure 10: Power supply in the North Tunnel in extended mode

Since that date, the power supply for the electrical traction equipment in the Channel Tunnel has generally been provided from France, where electricity is cheaper.

3.2.4.2 Management of electrical traction equipment

The electrical traction equipment is controlled by the EMS controller from the rail control centre (see Section 3.3.3).

In the event of a catenary incident in the tunnel, when operating in extended mode power supply, the EMS controller should:

- restore the power supply from the UK,
- cut off the power to a minimum of 3 elementary sections (SEL) around the area in which the incident has occurred, the section of the incident and either side of this.
- restore the power supply for sections required for other trains which have stopped in the tunnel.

3.2.5 Power supply to auxiliary equipment

Auxiliary equipment, such as for ventilation and drainage, is supplied by a 21 kV network from two sub-stations located in the UK and France.

Different cables in the three tunnels supply the sub-stations located in and at the end of these tunnels. For example, certain items of equipment at Sangatte are supplied from the UK in order to ensure that at least some of the equipment operates if one of the two power sources is lost.

Connecting the French and UK networks is prohibited. On the other hand, there are a number of possibilities, as shown in the diagram in Figure 11 below, for providing a discrete section with its normal power supply.

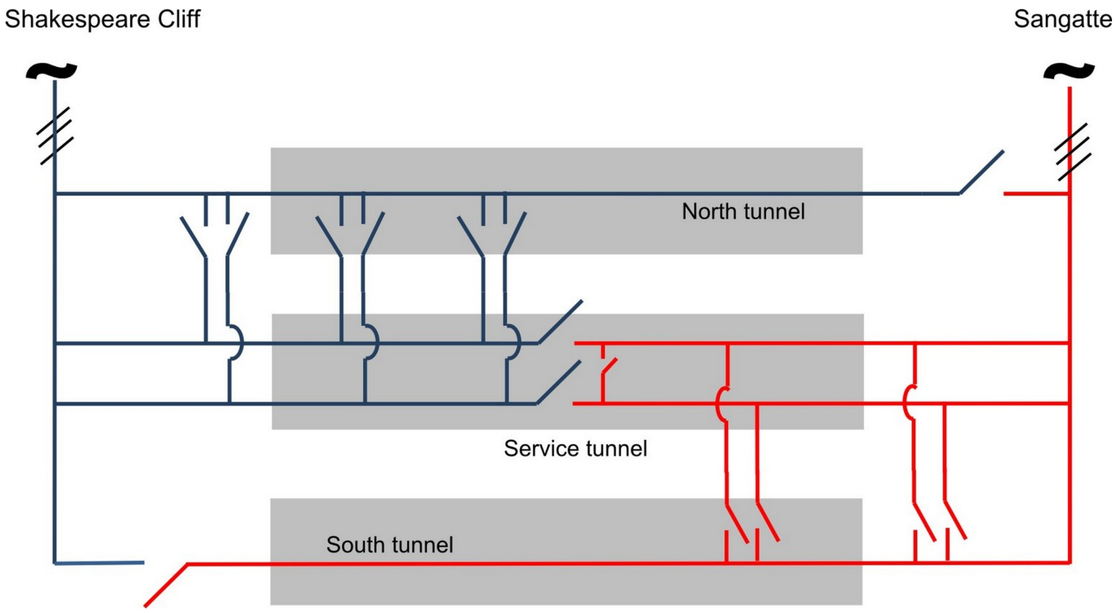


Figure 11: Diagram of the 21 kV network in the tunnels

3.2.6 Ventilation equipment

Ventilation of the tunnels plays a fundamental role:

- during normal operation,
- when normal operation is disrupted.

In the second case, not only is it able to provide fresh air for people in the tunnel, but it is used to control the removal of smoke and thus facilitate the evacuation of people present and fire-fighting operations.

Ventilation equipment is operated by the EMS controller.

3.2.6.1 Ventilation principles

The rail tunnels are at natural pressure and as shown in section 3.2.1, are connected by piston relief ducts to reduce pressure in front of trains.

The service tunnel is kept at all times at a higher pressure than the rail tunnels. It is closed at both ends by air locks.

This higher pressure ensures that the service tunnel is free from smoke in the event of a fire in one of the rail tunnels and can be considered as safe refuge. It also makes it possible to create an air ‘bubble’ 4 to 5 m in length at the rail tunnel end of a cross-passage (CP) when the door to the latter is open. In the event of a fire in a tunnel, the evacuation door of the amenity coach of a freight shuttle should normally stop opposite this air bubble, allowing the occupants of this coach to evacuate safely into the service tunnel. To guarantee that this high pressure is maintained, specific rules for opening cross-passage doors must be applied. Two and only two doors giving access to one of the rail tunnels must be open at the same time[4] and no doors into the other tunnel must be open.

[4] Opening just one door would generate too fast an air flow through that door while opening more than two doors would risk reducing the high pressure in the service tunnel, or even reversing the direction of pressure so that smoke could get into the service tunnel.

Two ventilation systems can be used in the Channel Tunnel:

- the normal ventilation system (NVS),
- the supplementary ventilation system (SVS).

The normal ventilation system provides air in the service tunnel from two units located at Shakespeare Cliff in the UK and Sangatte in France. Air flow in the service tunnel is fed to the rail tunnels by 39 pairs of air distribution units (ADU). Air supplied into the rail tunnel is then driven by the trains towards the exit portals and towards the other rail tunnel via the piston relief ducts (PRD). One of the roles of the NVS is to maintain high pressure in the service tunnel. The NVS is operational at all times and the fans are always set in the 'supply' position.

The supplementary ventilation system supplies the rail tunnels directly from the two units at Shakespeare Cliff and Sangatte. It is normally switched off and is turned on only when smoke is present or if it is necessary to provide fresh air to trains that have stopped. Its main function is to protect passengers and staff but once this priority has been met and the speed of all other trains has been reduced to the level specified in the regulations, it can be used for smoke extraction purposes. The two units are capable of providing air to one of the rail tunnels, or to them both. The SVS is designed to achieve this result even if one or more of the dampers of the piston relief ducts, or the underwater crossover doors, remains open.

3.2.6.2 Ventilation equipment

The diagram below shows the ventilation equipment in the Channel Tunnel.

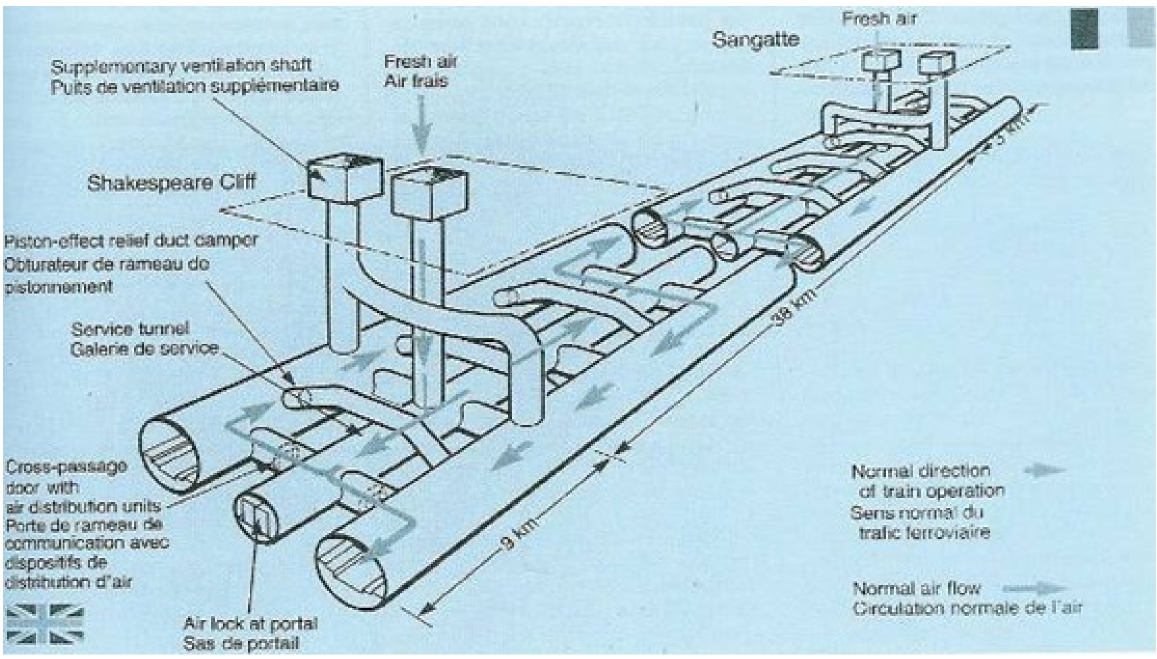


Figure 12: Channel Tunnel ventilation equipment

Fans

Four fans, two at each end, supply air for the normal ventilation system NVS. The two fans at one end, installed in parallel, cannot operate simultaneously. The pitch of the blades is adjustable and they are reversible. During normal operation, they operate in blowing mode.

Supplementary ventilation (SVS) is supplied by fans, the power of which can be modulated by changing the blade setting (7 positions). In the event of supply at the maximum setting at one end and extraction at the other end, the flow rate in the rail tunnel is in the order of 2.5 m/s. The seven intermediate speeds are essentially proportional.

Two identical fans at each end operate the SVS. If this system starts up, one of the fans at each end starts to operate whilst the other is normally on stand-by. The electricity supply to the fan in operation is provided by the network for the country in which the fan is located, whereas for the stand-by fan, this is supplied from the other country's network. Fans are reversible and can be used in one direction or the other, as required. Both fans at one end can operate simultaneously if necessary. Operation with one fan is referred to as "simplex mode" and with both fans, "duplex mode".

Dampers for the ventilation plant

Air ducts for the ventilation plants can be blocked by dampers which have two settings, open or closed.

The circuits for these ducts, and therefore these dampers, are different at Shakespeare Cliff and Sangatte. They are shown in the diagram below:

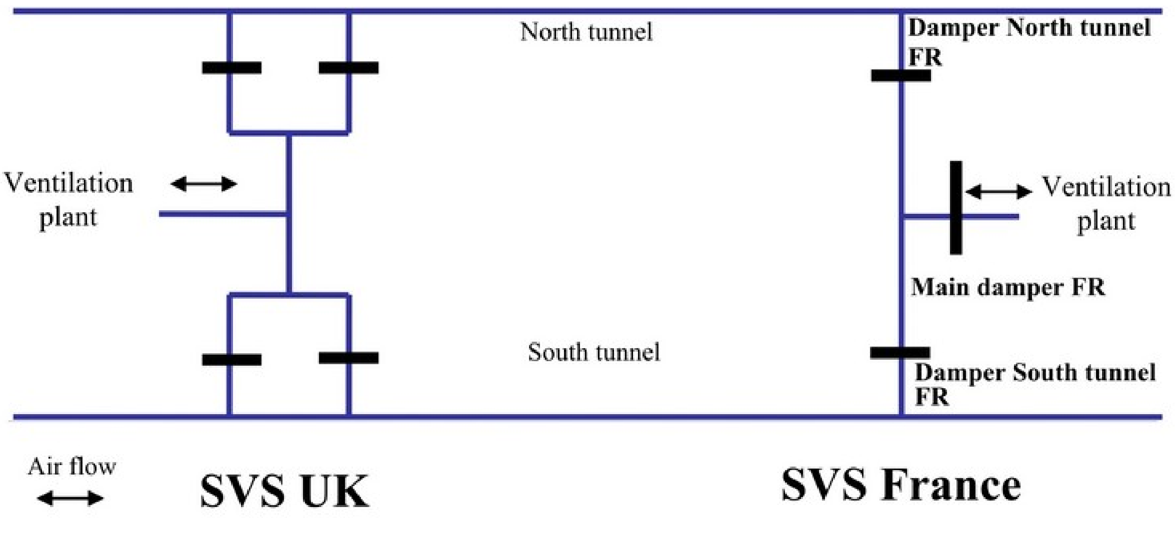


Figure 13: Ventilation dampers on the French and UK sides

The difference in the design of the SVS on the French side and the UK side is due to constraints imposed during tunnel construction and the different ventilation shafts on each site. The main damper in the French SVS plant is there to protect the plant against pressure.

Independent nature of the tunnels

In the event of smoke in one of the running tunnels, it is essential that this does not spread to the other rail tunnel or the service tunnel. For this purpose:

- pressure relief ducts can be blocked by dampers,
- cross-passages are isolated from the rail tunnels by doors which are normally closed,
- rail tunnels are isolated from each other at the crossovers by sliding doors, which are open only when a train passes from one tunnel to the other.

Air distribution units (ADU)

Air distribution units are fitted in the sealed wall above the cross-passage doors. They distribute air in the rail tunnels. An ADU is installed every 1,100 to 1,500 m, except in the central part of the tunnel where each cross-passage door is fitted with an ADU.

The ADUs are fitted with fire-check dampers which are shut by the rail control centre (RCC) in the event of a fire and non-return dampers preventing the transfer of air from a rail tunnel.

3.2.7 Cooling equipment

In order to maintain the average temperature inside the tunnels between 15°C and 30°C, water cooling equipment has been installed in the tunnels. This equipment comprises:

- two cooling units,
- two cooling pipes in each of the rail tunnels,
- leak detectors.

3.2.8 Communications equipment

All communications equipment in the tunnels uses the data transmission system installed in the tunnels.

The global communications system comprises three radio networks, two telephone networks and a public address system:

- track-to-train radio,
- concession radio,
- tactical radio,
- operations and emergency telephone system,
- administration telephone system,
- public address system.

3.2.8.1 Data transmission network

This network comprises two fibre optic cable loops.

The first is located in the North rail tunnel and the service tunnel, while the second is in the South rail tunnel and the service tunnel. The two fibre optic loops are independent, although they are physically installed in the same cable sheath in the service tunnel.

Under normal circumstances, information travels from France to the UK in the North rail tunnel for the loop using this tunnel while it travels from the UK to France in the loop in the South Tunnel. In the event of one of the two cables breaking, information can still travel along these cables, but is routed in such a way as to avoid the damaged section.

Every 750 metres, an electrical room is located where it is possible to connect these cables to different equipment. The radiating cables for the track-to-train radio and concession radio are connected alternately to these electrical rooms.

3.2.8.2 Track-to-train radio

The track-to-train radio system provides voice and data communications between the rail control centre (RCC) and the trains in the rail tunnels and at the terminals. Communications are transmitted by 750 metre radiating cables connected to the fibre optic cable in the electrical rooms. Two radiating cables lead out from each side of each electrical room.

3.2.8.3 Concession radio

The concession radio allows verbal communications at any part of the Concession by Eurotunnel staff and the staff of various organisations working on the Concession, using portable equipment. In the tunnel, the radio signal is carried by radiating cables run in the rail tunnels. These cables, measuring 750 metres in length, are connected to the fibre optic cable in the electrical rooms. Two radiating cables lead out from each side of each room.

Figure 14 below shows the layout of the two sets of radiating cables.

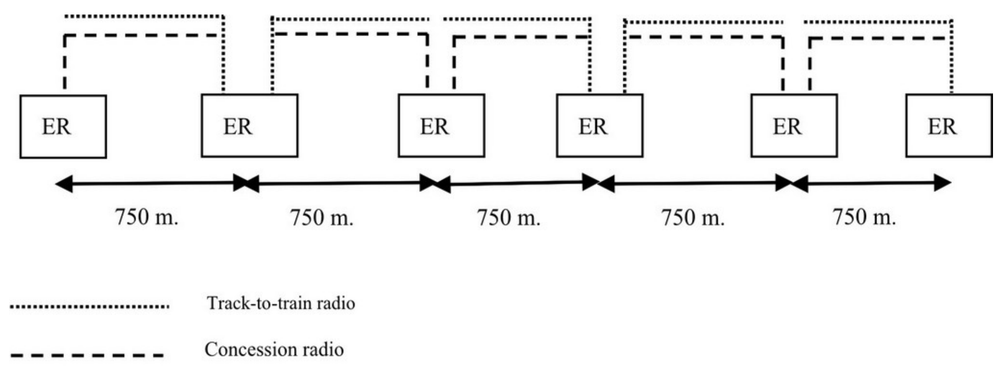


Figure 14: Layout of the sets of radiating cables

The maximum number of simultaneous communications in all tunnels is five.

3.2.8.4 Tactical radio

The tactical radio is a UHF network which can be used in the service tunnel and covers an area wide enough for combined local operations of the emergency services of one or both countries. Members of the emergency services (fire brigade, ambulance and police) are equipped with mobile radios connected to this network. The main functions of this network are as follows:

- direct communications between two mobiles in close proximity,
- communications between the rail tunnels and the service tunnel,
- communications between the site of the incident and control posts,

- communications between the service tunnel and control posts.

Operation of the tactical radio requires the presence of one or two STTS-communication vehicles, acting as relays to connect with Eurotunnel's own telephone network.

3.2.8.5 Operations and emergency telephone system

The operations and emergency telephone system allows automatic connection to the active rail control centre (RCC), simply by picking up the handset of one of the telephones installed in the tunnel. It is not necessary to dial a number and all calls are logged in writing and recorded. These telephones are installed at each cross-passage, as well as other places. In exceptional circumstances, they can be used by passengers. From his desk, the operator is able to identify the origin of the call and select which call to take. Several calls can be made simultaneously.

3.2.8.6 Administration telephone system

The administration telephone system is a network of several switchboards which are connected to the France Telecom and British Telecom public networks, amongst others. Each of the two French and UK terminals has its own system independent of that in the other terminal. It can be connected to all communications networks both inside and outside the Channel Tunnel system. Telephones are installed, amongst other places, in tunnel technical rooms. It is also possible to connect using points at each cross-passage.

3.2.8.7 Public address system

A public address system covers the entire concession, with the exception of the rail tunnels. It can be used to broadcast to all areas, or to selected areas, in particular in the service tunnel and the cross-passages. Access to the PA system is via the rail control centre (RCC) operators or electrical room operators or else at each cross-passage.

3.3 Rail Control Centre (RCC)

Real time rail traffic management is undertaken from a rail control centre (RCC). Two locations, one in Folkestone in the UK and the other at Coquelles in France can fulfil this role. These two centres do not operate at the same time but at least one member of staff is present in the centre which is not operational. The switchover from one centre to another is immediate. The operational centre may change with each shift; it is defined on a rotation basis.

Each centre has equipment to monitor the status of the facilities and to allow remote control operation.

The RCC on duty comprises six positions:

- supervisor,
- rail traffic management (RTM) controller,
- engineering management system (EMS) controller,
- fire detection (FD) controller,
- information system (ISIS) controller,
- train crew management controller.

3.3.1 Supervisor

The supervisor is responsible for monitoring the progress of operations and giving instructions to the other controllers in the event of any disruption. In the event of a fire in the tunnel, he must confirm each instruction to be followed to each controller in order to ensure that they are carried out in the order stipulated in the procedures.

3.3.2 Rail traffic management controller

The RTM controller is responsible for the management of rail traffic across the entire Concession during normal operations and in degraded conditions.

In addition to Eurotunnel's own traffic (passenger shuttles, freight shuttles and works trains), he also manages passenger trains and conventional freight trains when they use they Channel Tunnel system.

At the control centre in France[5], which was operational on the day of the fire, the equipment available to him includes:

- monitors showing the status of the equipment, track occupancy status, traffic graph,
- a panel above his monitors giving him information on the electric traction supply,
- control and signalling equipment (TVM),
- track-to-train radio equipment allowing him to contact the trains,
- computer terminals allowing him to activate procedures, in particular emergency procedures.

In the event of a fire on a train in one of the tunnels, the RTM controller is responsible for authorising the train in question to stop and for managing the movement of the other trains so that the incident can be dealt with. This will be affected by the evacuation of passengers from the train in question, the operation of the ventilation system, the status of cross-passage doors and crossover doors, and the position of the trains. The authorised speeds for movement of other trains in the tunnel during an incident are set out in a "speed table" (see Annex No 4); the supervisor advises the RTM controller of the speeds to be applied to each train.

3.3.3 Engineering management system controller

The EMS controller manages fixed systems associated with tunnel operations (electrical traction, ventilation, lighting, drainage, pumping, cooling, etc.), in normal circumstances and in degraded conditions.

In particular, he is responsible for implementing emergency measures relating to the protection of individuals and equipment in the event of degraded conditions or in an emergency and managing::

- the general electricity supply (21 kV),
- catenary supply (25 kV),
- normal and supplementary ventilation systems,

---

[5] The same resources for each controller are installed in the RCC in the UK.

- piston relief ducts,
- crossover doors,
- cross-passages,
- fire hydrant water supply system,
- cooling system,
- drainage system,
- miscellaneous installations (air distribution grilles, technical room ventilation system).

At the control centre in France, the equipment available to him includes:

- monitors showing the status of the equipment under his supervision (cross-passage doors, crossover doors, pressure relief duct dampers, electrical traction equipment, ventilation systems, etc.) and rail traffic in the tunnel,
- control devices for this equipment,
- computer terminals allowing him to activate procedures, in particular emergency procedures.

3.3.4 Fire detection controller

The FD controller manages the fire detection system in the rail tunnels and the service tunnel. He is also responsible for managing vehicle traffic in the service tunnel and for calling the emergency services in the event of an emergency.

In the event of an alarm in one of the systems for which he is responsible, he immediately advises the other controllers verbally. In an emergency, he is responsible for the correct deployment of emergency services to the areas identified.

3.3.5 Information system controller

The ISIS controller is responsible for supervising the operation of the integrated staff information system (ISIS). This allows him to process and supply information relating to the quality of the rail service in real time to the staff concerned. He is responsible for providing information relating to dangerous substances to other RCC controllers and to the emergency services if necessary.

3.3.6 Train crew management controller

This controller is responsible for real-time management of Eurotunnel train crews (passenger shuttles and freight shuttles).

3.3.7 Tools available to controllers

Each controller has specific tools, but the layout of workstations is similar[6].

Each workstation has a number of computer screens for displaying the necessary information.

[6] This is the description of the French RCC. In the RCC on the UK side, there are some significant differences, but it still performs the same functions.

Figure 15: Rail traffic management (RTM) controller's workstation at the RCC on the French side

Other screens, like those shown in Figure 16 below, can be used to trigger procedures. Details of alarms are also shown on these screens. Some procedures are automatically activated as soon as the controller has validated the situation concerned.

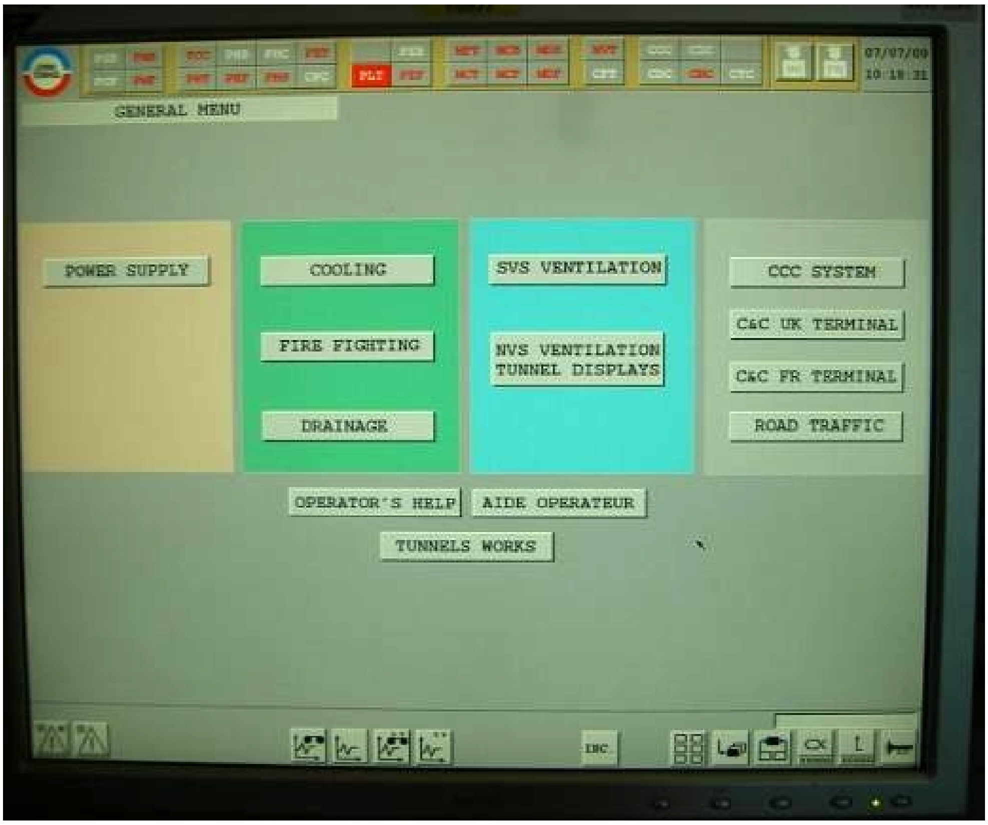


Figure 16: An EMS operator's terminal at the RCC on the French side

3.4 Road terminals

Equipment at both the French and UK road terminals can handle:

- the collection of tolls,
- the allocation of lorries to the shuttles,
- safety operations such as
    - the logging of any dangerous materials declared,
    - checking, on some lorries, of the CO level,
    - scanning of approximately 20% of lorries in order to detect the presence of certain goods such as firearms or explosives,
    - scanning with a millimetre wave passive scanner
- customs and police operations,
- checks for illegal immigrants.

The layout of the equipment at Folkestone is shown in Figure 17 below:

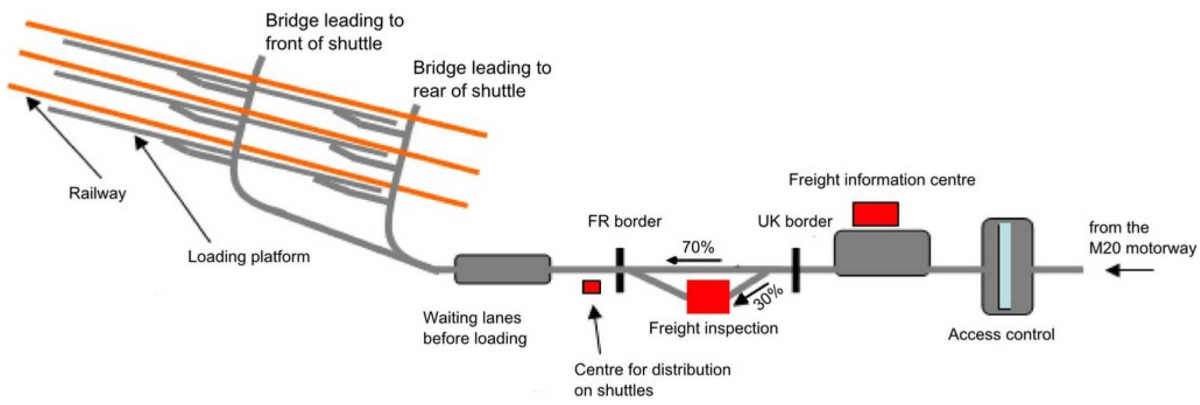


Figure 17: Route taken by road vehicles through the Eurotunnel terminal at Folkestone

Two traffic control centres (TCC), at Coquelles and Folkestone, monitor and coordinate all road activities in their area.

3.5 Fire safety

3.5.1 Managing trains in the event of a fire

When a second level fire alarm (see Subsection 3.5.3.3) is given for a freight shuttle, the train in question must continue as far as the emergency siding in the destination terminal if the leading locomotive has passed the last ventilation shaft located 6.4 km from the French portal, for a train travelling from the UK to France, and 9.95 km from the UK portal, for a train travelling from France to the UK. In other cases, the driver must perform a controlled stop (see Section 3.2.3) when he receives the order from the RTM controller.

All other types of traffic must continue their journey to the emergency siding at the destination terminal.

3.5.2 Fire safety devices

In addition to most of the equipment described above which plays a part in rail safety in the tunnel, two other devices also help to ensure the safety of the operations.

3.5.2.1 Smoke and flame detectors

Static smoke and flame detectors are fitted approximately every 1,500 m in each rail tunnel. These detectors record the presence of ionised particles, the reduction in the transparency of the air (due to the presence of smoke) and carbon monoxide levels. As soon as a value reaches a threshold which is considered to be outside the normal range, the RCC is alerted.

Smoke detectors are installed in the leading and rear loading wagons of freight shuttle trains. In the event of detection, an alarm is activated on the control board at the chef de train's workstation in the amenity coach.

3.5.2.2 Fire-fighting water system

There is a main pipe in the service tunnel. This is supplied from both ends, thus enabling a flow rate of twice $120m^3$ per hour (see section 4.2.2.6). This pipe supplies two branch lines, one to the north running tunnel and the other to the south running tunnel beside each cross-passage. In each of the running tunnels, these two branch lines divide again to supply two fire hydrants situated 125 metres either side of the passage. These fire hydrants are each fitted with French and UK type connectors.

Under normal circumstances, the branch lines to the running tunnels do not carry water.

3.5.3 Procedures if a fire is detected on board a freight shuttle

3.5.3.1 Procedure for the chef de train

The chef de train can be informed of a fire on a freight shuttle in two ways:

- signal from detectors fitted in his shuttle,
- by the driver, if a signal from fixed detectors has been transmitted to the RCC and then on to the driver.

In all cases, the chef de train must respond by closing the air dampers in the amenity coach and shutting down the air conditioning system.

If the signal is from one of the detectors on board, he identifies the detector(s) which emitted the alarm and advises the train driver.

If passengers are to be evacuated to the service tunnel, as soon as the driver informs him that he is getting ready to perform a controlled stop, he prepares the passengers by reading them the pre-evacuation message. The chef de train then waits for the controlled stop to be completed.

He must then:

- provide information to the passengers using the public address system,
- put on his high visibility waistcoat,
- request assistance from a certified "Channel Tunnel" agent (for example, the catering agent or any other qualified member of staff travelling on the train at the time) if there is one on the train. This agent must:
    - take up a position behind all passengers,
    - check that the amenity coach is empty,
    - bring up the rear when passengers are being evacuated into the service tunnel.
- in the absence of certified staff, appoint a passenger, to whom he gives a harness, who goes to the back of the evacuation line,
- ensure that the shuttle is immobilised by checking that the general operating manometer is set to 0,
- ensure that defined external conditions regarding visibility and temperature are satisfactory for the evacuation,

If they are, he evacuates the coach (see Annex No. 3).

Otherwise, he must:

- close the blinds on the amenity coach to limit any increase in temperature in the amenity coach,
- inform the RCC using any of the communications methods available to him,
- distribute breathing masks, if he considers it necessary, with a further information message,
- wait for the SVS to improve conditions for evacuation and as soon as these are satisfactory, he should proceed with evacuation of the coach.

3.5.3.2 Procedure for the shuttle driver

Response to an alarm

As soon as the "wagon fire alarm" message is received from the chef de train, the driver is required to:

- press the "Fire in Tunnel" button,
- close the locomotive air dampers,
- comply with the cab-signalling instructions,
- report to the RCC using the track-to-train radio or the concession radio by sending the following message: "**Wagon fire alarm**",
- prepare to evacuate the locomotive,
- wait for the order to stop from the RCC,

- proceed with a controlled stop and inform the chef de train using the emergency telephone that he is making a controlled stop in order to evacuate (see Section 3.2.3),
- memorise the cross-passage number shown on the approach marker and the cross-passage itself,
- record the cross-passage number as soon as the train stops,
- call the RCC as soon as the train stops to advise the number of the cross-passage to be opened (or indicate the number of the last PK marker seen before stopping) and advise the number of his portable concession radio,
- apply the instructions to be followed for evacuation purposes.

Evacuation of the driver

The driver must, amongst other things:

- wear a breathing mask only if the situation requires,
- ensure that conditions outside, with regard to visibility and temperature, are satisfactory in order to leave the locomotive.

If the conditions are satisfactory, the driver must evacuate.

Otherwise, the driver must:

- wait in the driving cab,
- inform the RCC,
- close the blinds in the driving cab in order to limit the effects of radiation and the rise in temperature in the driving cab,
- wear a breathing mask if necessary,
- put on protective equipment if necessary,
- wait for the SVS to improve conditions outside for evacuation,
- make regular contact with the RCC and the chef de train to exchange information on how the situation is progressing,
- check at regular intervals whether conditions outside have become satisfactory for leaving the locomotive.

Once out of his cab, the driver must:

- make visual contact with the chef de train,
- wait for the chef de train to open the door of the amenity coach,
- go to the amenity coach,
- stand by the carriage end door of the amenity coach and count the number of people,
- ask passengers to follow the chef de train,

- check that the amenity coach is empty as soon as the last passenger has left (including the toilets),
- evacuate using the cross-passage used by the chef de train.

Once he has arrived in the service tunnel, the driver must assist the chef de train to:

- protect passengers from hazards associated with the operation of vehicles in the service tunnel,
- ensure that no-one stands in the yellow cross-hatched area which marks out the safety area to allow the door of the cross-passage to close,
- remain in the cross-passage awaiting the arrival of the emergency services.

3.5.3.3 Procedures at the Rail Control Centre (RCC)

Two alarm levels have been defined.

Level 1 corresponds to one of the following alarms being given by one detection station:

- ionic or optical detection of smoke,
- smoke confirmed,
- flames confirmed,
- carbon monoxide level above 50 ppm.

Level 2 corresponds to at least one of the following situations:

- level 1 alarm confirmed by a second level 1 alarm in the adjacent detection station within 3 minutes,
- any combination of several alarms by one detection station,
- report of flames or smoke from any person.

Measures to be taken depend on the alarm level.

According to information given by the FD controller, the Supervisor defines the alarm level and verbally informs all controllers of this at the same time. He has to decide whether the shuttle which is on fire should continue with its journey and emerge from the tunnel, or whether it should stop in the tunnel. The decision depends on the shuttle's position when the fire was detected on board. It continues on its journey if it has passed the last shaft to the SVS, i.e.:

- PK 54.14 when travelling from the UK to France,
- PK 21.82 when travelling from France to the UK.

Action to be taken in the event of a level 1 alarm

The EMS controller uses his control screen to indicate the tunnel in which the alarm was activated. The system then automatically:

- closes the air distribution grilles in the other tunnel,

- sets the NVS to level +5 on both the French and UK side,
- turns on the lights in the tunnel in which the fire has occurred.

The RTM controller:

- checks that the automatic stop order for all trains travelling behind the train in question has been given, and if not, issues this stop order by radio,
- suspends all train departures from both terminals,
- slows down all trains in the tunnel to 100 km/h by radio,
- reminds the drivers of all trains in the tunnel to close all ventilation dampers,
- operates the terminals in manual mode rather than automatic mode.

Action to be taken in the event of a level 2 alarm

The EMS controller:

- uses his emergency screen to close the dampers of the piston relief ducts in order to ensure the physical isolation of the two tunnels,
- closes any crossover doors and cross-passage doors which may be open,[7]
- as soon as the RTM controller has ordered trains to slow down to 10 km/h, starts up the SVS in the two tunnels, at the power determined according to the position of the train concerned in the tunnel and any crossovers or cross-passages which may be open,
- as soon as the RTM controller has confirmed that the train has stopped and its position, the EMS controller, first of all, opens the door of the first cross-passage after the point where the shuttle on fire has stopped, in the direction in which it was moving, and then opens the door of the cross passage which is opposite the shuttle's amenity coach.

The RTM controller:

- gives an order, using the track-to-train radio, to the train concerned to make a controlled stop and to the other trains, if they have not already stopped, to limit their speed to 10 km/h,
- is told the point where the train has stopped by the driver and then tells the EMS controller so that the appropriate cross-passage door can be opened,
- once advised, on his screen, that the safety measures for which the EMS controller is responsible have been put in place, he authorises the trains travelling in front of the train involved in the incident and in the other tunnel to travel at the speeds defined in a 'speed table' (see Section 3.3.2),
- receives from the driver of the train involved in the incident the number of the cross-passage where it has stopped and gives him the concession radio number for the first line response team (FLOR).

[7] In practice, these doors are unlikely to be open, unless an incident has occurred, except during maintenance work which is carried out overnight, during periods when there is less traffic.

The FD Controller, once level 2 has been declared, is required to:

- call the French and UK Eurotunnel emergency centres so that a FLOR team is deployed,
- open the outside doors of the air locks,
- advise the FLOR teams of the number of the cross-passage where the train involved in the incident has stopped,
- advise the FLOR teams of any dangerous substances on the train in question, once notified by the ISIS controller,
- advise the UK emergency services[8],
- continue to monitor the alarms, in particular the carbon monoxide level, and inform the Supervisor and FLOR teams immediately.

3.6 Rolling stock

3.6.1 Carrier wagons

Carrier wagons are not closed (unlike passenger shuttle rakes). They do not have any bulkheads or barriers at the ends; the lorries can therefore travel internally along the entire length of the shuttle. Their gauge is larger than the standards in force on the UK and French networks; they cannot leave the concession network therefore.

Two series of wagons are currently in use.

The first generation wagons, produced by the BREDA company, comprise a solid roof and have recessed faces. The roof and the recessed faces contribute to the strength of the unit.

The second generation wagons, produced by the ARBEL company, differ significantly from the first generation wagons. The strength of the unit is provided by the structure and floor of the wagon. The role of the roof is limited to protecting vehicles or people from the catenary, for example, if someone had climbed on a lorry or to stop a radio aerial creating a short circuit with this catenary. The side structures serve to hold up the roof and protect the people on board, during loading, from falling.

A freight shuttle consists of a single type of carrier wagons.

[8] The French emergency services are advised by the duty officer* at the emergency centre at the French terminal.

Figure 18 : Carrier wagons and loading wagon

3.6.2 Loading wagons

Loading wagons are flat wagons which are permanently incorporated in the rake. A rake of 30 carrier wagons has three loading wagons. They are located at the head, in the middle and the back of the rake. It is thus possible to load or unload two lines of lorries at the same time.

They are fitted with side panels which are lowered during loading and unloading operations, thus making it possible to provide a ramp for moving between the platform and the wagon. They are also fitted with propping jacks which are lowered during loading and unloading operations.

The two end loading wagons are equipped with a smoke detection device. Visual and audible alarms are sent to the chef de train if smoke is detected.

3.6.3 The amenity coach

3.6.3.1 General description

The amenity coach is a passenger coach which conveys the lorry drivers during the journey through the Channel Tunnel.

This coach includes:

- seats for the lorry drivers,
- a catering area where food can be stored, heated and distributed to drivers in their seats if they so wish,
- toilets,
- a workstation for the chef de train.

It is coupled immediately after the leading locomotive and in front of a loading wagon. In exceptional cases, with “en tiroir” operation (reverse), it is at the rear, just in front of the trailing locomotive.

There are four side access doors: two on each side at the ends of the coach. Also, two end doors, located along the centre line of the coach, allow evacuation longitudinally in the event of the side doors not being useable.

Two types of coach with similar characteristics are used by Eurotunnel: the Breda coach and the Costa coach.

Amenity coaches are equipped with automatic coupling equipment. This is designed to allow uncoupling, when stopped, of the amenity coach from one of the two adjacent vehicles from a control panel located at each end. This option is used only in the sidings at Folkestone and Coquelles for maintenance purposes.

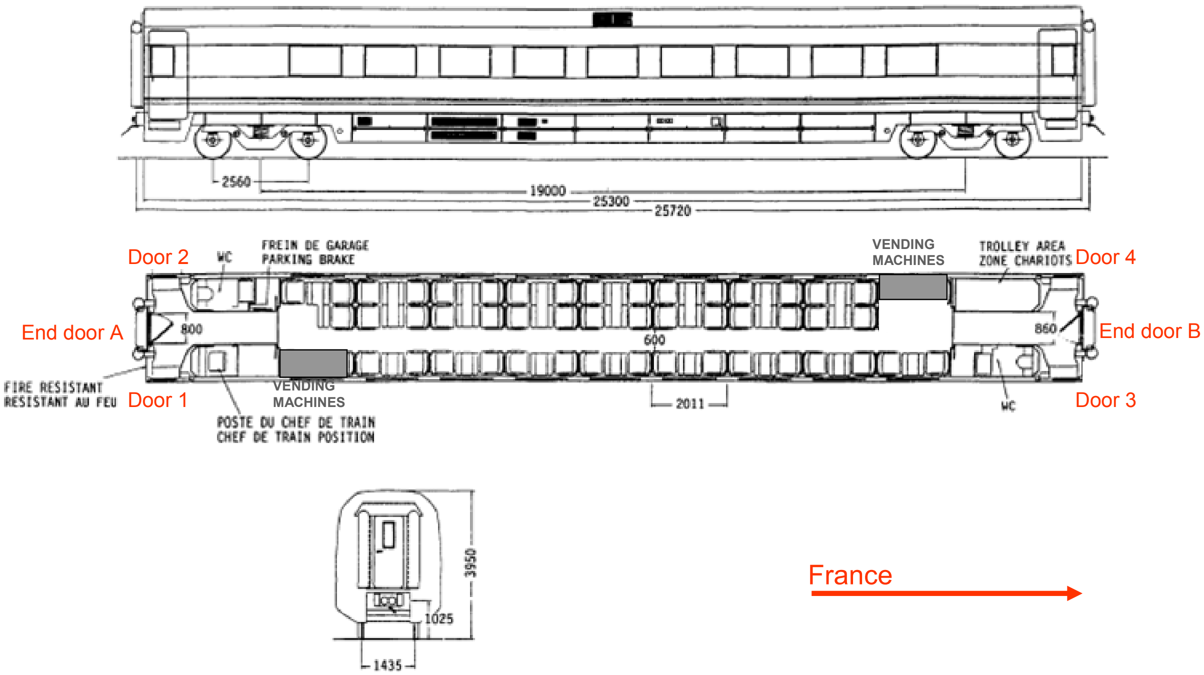


Figure 19: An amenity coach, set up in the same way as that of train 7412

Figure 20: Amenity coach, internal view

3.6.3.2 Side doors of the amenity coaches

In normal conditions, the opening and closing of these doors is controlled by the chef de train from his control panel.

They can also be opened by devices located near each door:

- electrical control by pressing a button after opening a flap with a flat key,
- emergency mechanical control by turning a handle which is available to passengers. This device does not work when the train is travelling at a speed of more than 5 km/h.

Figure 21: Amenity coach, manual door-release device, operated by a handle

3.6.3.3 Arrangements associated with fire hazards

The outside doors are fitted with seals and ventilation air inlets are fitted with dampers that close automatically if a fire alarm is activated by the driver or by order of the chef de train.

If smoke is detected by one of the detectors fitted on the loading wagons, an audible alarm and a visible alarm alert the chef de train.

He is able to advise the driver of a fire alarm simply by pressing a button on the control panel.

The chef de train can make verbal contact with the shuttle driver in three ways:

- direct emergency telephone,
- concession radio,
- the freight shuttle internal radio (SIR), if this is available.

In the event of a total loss of the communication methods listed above, a controlled stop can be requested by turning a selector switch (mode selector) to position TC.

The amenity coach is equipped with individual breathing masks, in sufficient number for all passengers and crew.

3.6.3.4 Safety information

The amenity coach has a public address system operated from the chef de train's workstation.

General safety instructions are displayed on each table and on the walls of the amenity coach. They convey two basic messages: the first is that it is necessary to follow the instructions of the chef de train in the event of an emergency and the second is that the service tunnel is a place of safety. It is also made clear that breathing masks are available on board.

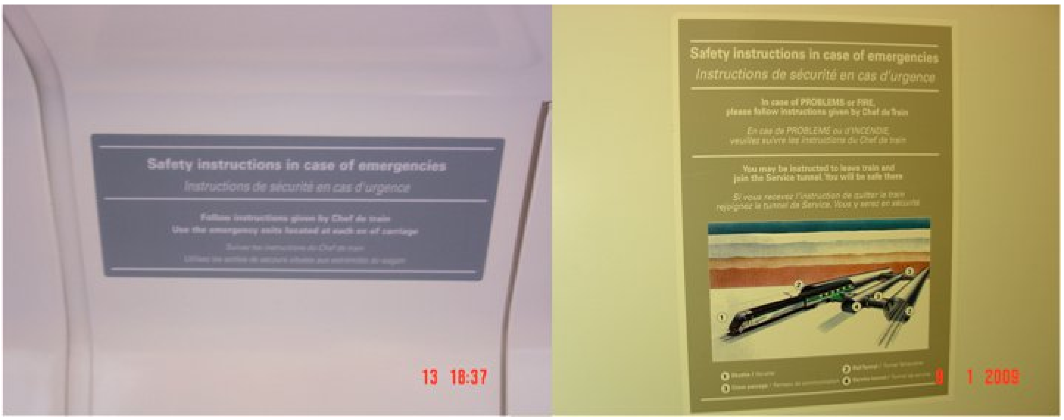


Figure 22: Amenity coach, general evacuation markers

There are fixed markings to show the direction of the door but they do not indicate which door to use in the event of an emergency.

Figure 23: Amenity coach, evacuation, direction arrows

Special markings indicate how to open the door using the manual device (see Figure 21).

Special markings show how to break a glass pane with a hammer fixed to the wall of the coach to make it possible to get out of the window concerned in an emergency.

Figure 24: Amenity coach, emergency evacuation procedure

Figure 25: Amenity coach, hammer for breaking windows

Special markings show where emergency equipment is stored, such as breathing masks.

A visible thermometer is located at each of the access doors in order to indicate the temperature outside. Instructions are provided alongside each of these thermometers showing measures to be taken according to visibility and the temperature outside.

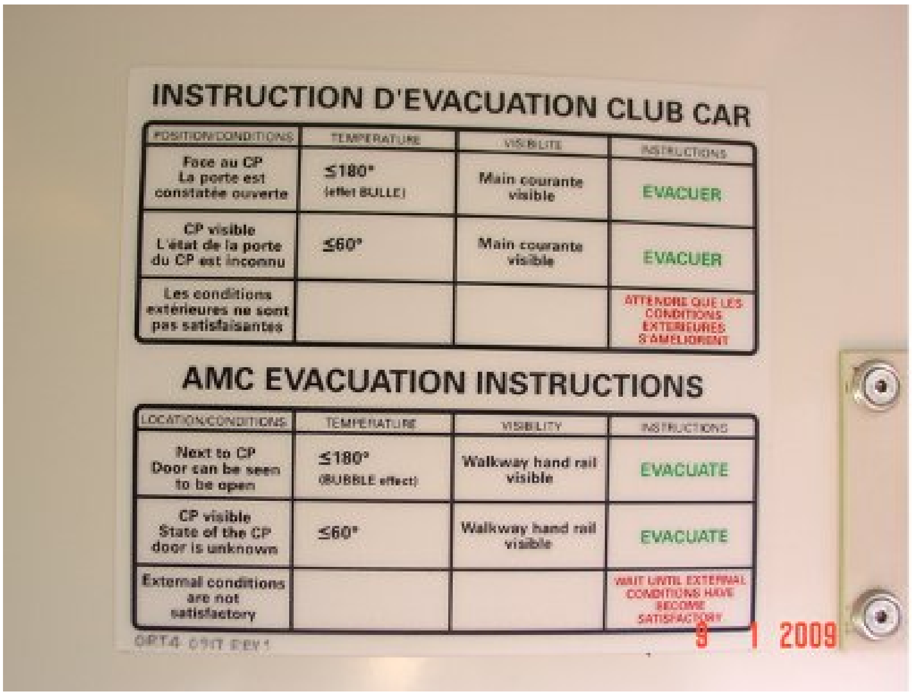


Figure 26: Amenity coach, evacuation instructions

All safety information is in French and English, with diagrams or pictograms in some cases.

3.7 <u>Train formation</u>

3.7.1 General rules

The formation of freight shuttles, from front to rear, is as follows:

- a locomotive,
- an amenity coach for lorry drivers during the crossing,
- a loading wagon to allow lorries to get on or off the train,
- a first group of 15 carrier wagons,
- a second loading wagon,
- a second group of 15 carrier wagons,
- a third loading wagon,
- a second locomotive.

Both terminals have track loops which, under normal circumstances, make it possible to use the formation described above. In certain circumstances, it may not be possible to use a loop at one of the terminals and freight shuttle trains then operate ‘en tiroir’. This means that for one mission in two, the shuttle leaves the other way round to the way it arrived, so that the amenity coach is at the rear of the shuttle.

3.7.2 Crew

Under normal circumstances, a freight shuttle crew consists of the driver on board the leading locomotive and a chef de train in the amenity coach.

In the event of “en tiroir” operation, an additional crew member must be present in the amenity coach.

There may also be a member of catering staff in the amenity coach.

3.7.3 Degraded conditions

A certain number of conditions must be met as a minimum for a freight shuttle to be able to travel:

- at least one of the two access doors on each side of the amenity coach is operational,
- the seals for each access door are correctly inflated (Breda) or correctly compressed (Costa),
- two means of communication are working between the chef de train and the driver of the shuttle,
- emergency lighting in the amenity coach is working,
- two of the five portable extinguishers in the amenity coach are operational (they are sealed and have been inspected within the last 12 months),
- the FDE (fire detection and extinguishing) system is operational and no faults in this system have been detected at the chef de train’s workstation. If on one trip, five unscheduled FDE alarms are detected lasting more than five seconds, intervention by the maintenance team is required upon arrival,
- the “converters failure” lamp is not on. If this lights up during the crossing, the trip can be completed,
- no configuration faults detected at the chef de train’s workstation,
- manual uncoupling tools are present in the amenity coach,
- the four dampers of the ventilation system are operational,
- the four storage areas containing the breathing masks are sealed. If the seal has been broken on one or more of the storage areas containing the breathing masks, the number of masks available must not be less than the number of people in the amenity coach.

In the event of one or more of these conditions not being met, the shuttle must not leave the terminal. In the event of a fault during the journey, the chef de train must follow the instructions relating to the fault reported.

3.8 <u>Dangerous goods</u>

3.8.1 General regulations

The carriage of dangerous materials by road and rail is governed by two agreements in Europe:

- European agreement concerning the international carriage of dangerous goods by road (ADR),
- Regulations concerning the international carriage of dangerous goods by rail (Annex No. 1 to Annex B of the COTIF Agreement[9]).

Furthermore, the transport of dangerous substances must also comply with Eurotunnel regulations because of the context in which dangerous goods are carried in the Channel Tunnel:

- confined nature of the tunnels,
- presence of staff and passenger trains,
- absence of any diversionary routes,

3.8.2 Eurotunnel procedures

Goods with a UNO (United Nations Organisation) number are classified by Eurotunnel when they are authorised for carriage as:

- dangerous materials accepted without any restrictions, or
- dangerous materials accepted subject to restrictions, which may be:
  - a limit on the total quantity transported,
  - a limit on the maximum quantity transported in one consignment,
  - a limit on the quantities transported with a limit on the maximum quantity transported in one consignment.

Any forwarding agent passing dangerous goods to a haulier to be taken through the Channel Tunnel is required to comply with the ADR and confirm compliance with Eurotunnel regulations on the transport of dangerous goods. Road hauliers are required to check that the goods transported comply with ADR and Eurotunnel regulations prior to their arrival at the concession.

Freight shuttle customers must declare dangerous goods transported upon arrival at the concession.

Using the ISIS information system, Eurotunnel logs the presence of dangerous goods in road vehicles.

[9] COTIF: Convention relative aux transports internationaux ferroviaires: Agreement relating to international rail transport

3.9 Loading of road vehicles

3.9.1 Process prior to loading on the wagons

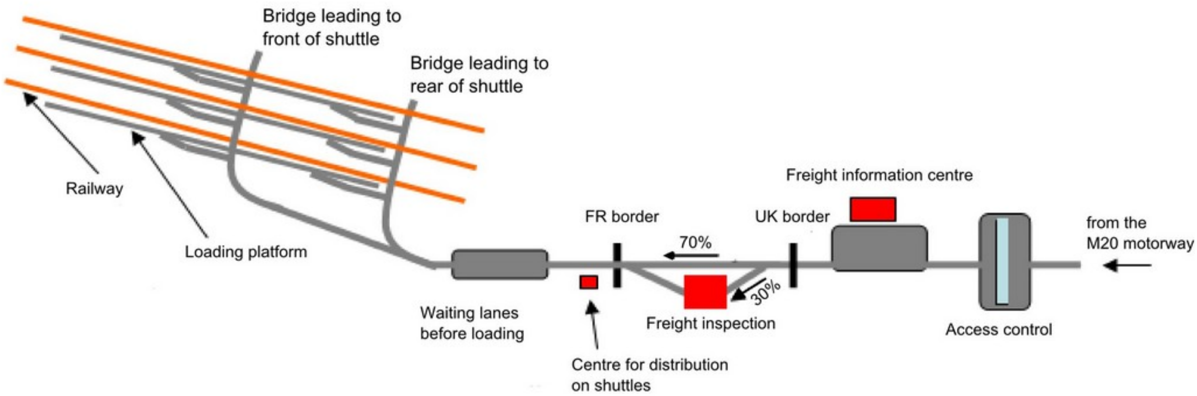


Figure 27: Road facilities at Folkestone

Upon arrival at the site, vehicles firstly go to the toll booths. They then go through police and security control points and then move on to the parking lanes until called for loading.

Random inspections of goods transported are carried out by the security staff. The purpose of these inspections is firstly to check that the consignment is as declared and to confirm its nature rather than to check fire aspects.

3.9.2 Vehicle loading operations

When a shuttle is ready to be loaded, the lorries are instructed to join the loading platform via access ramps at the rear and in the middle of the platform.

The lorries access the carrier wagons by driving onto a loading wagon. They then travel from carrier wagon to carrier wagon until they get to the one indicated by the loading team. The drivers immobilise their vehicles. The loading team examines and chocks the lorries. If necessary the team draws the drivers' attention to any irregularities observed.

The drivers then alight onto the platform and are taken to the amenity coach in a minibus.

Once they have boarded the amenity coach, the chef de train checks that their number matches that recorded at the toll booths.

3.10 Departure of the train

Before giving the "all clear" signal to the shuttle driver, the chef de train must check that the following information:

- loaders closed,
- safety inspection completed,
- no-one detected on board (in France only)

is recorded on the "loading report" [10]

He must also remind the driver of whether the amenity coach is located at the "front" or "rear" of the train.

The chef de train gives the "all clear" signal by turning the key provided for this purpose.

Departure of the shuttle is supervised by two members of the loading team, called "agents de feu" (fire agents), one normally standing on the platform and the other on the road bridge over the tracks, on the departure side. These two crew members are looking for any indications of a fire.

If the shuttle has to stop due to an emergency, the RCC is contacted by radio or telephone and the request is forwarded to the RTM controller who immediately takes measures to stop the shuttle.

When leaving Folkestone, in the event of an emergency stop, the train is generally at least partly in the tunnel given the proximity of the platforms to the tunnel portal.

3.11 Role of crew members on board the train while it is travelling

The driver starts the train when the signal allows him to do so, subject to having received the "all clear" instruction from the chef de train. He drives his train according to the signals. He is vigilant at all times, looking out for any unusual situations occurring in particular by listening for noises and checking for smells and smoke.

The chef de train remains at his workstation unless called away for a particular task. He monitors correct operation of the shuttle's equipment. He checks for any alarms.

The member of catering staff does not have any safety duties under normal conditions. If there is no member of catering staff on board, the role of providing assistance in evacuating passengers falls to the driver.

3.12 Role of the crew in the event of an evacuation

The chef de train notifies the driver if he thinks an evacuation is necessary.

The driver notifies the supervisor of the RCC with whom he comes to an agreement. He then advises the chef de train of the decision regarding evacuation.

[10] The loading report is the document given to the chef de train by the head of the loading team.

The driver performs a controlled stop. He advises the chef de train once this stop has been made.

The chef de train leads the evacuation into the service tunnel. He is assisted by any certified agent present on board the train (the member of catering staff is a certified agent) who follows his instructions. He notifies the RCC once all of the passengers are in the service tunnel. He also advises the RCC that all of the passengers are on board the assisting train if this is how the passengers are being evacuated to the outside.

When it arrives, the first line of response team (FLOR) takes over the management of the evacuation in the service tunnel and assists the chef de train, as required.

3.13 Organisation of rescue operations in the event of a fire

3.13.1 Organisation principles

Eurotunnel is responsible for calling the emergency services in an emergency.

As a general rule, the RCC is responsible for coordinating rescue operations in the tunnel.

If the accident is serious enough to require the intervention of emergency services from outside Eurotunnel, and if the accident has occurred in the French part of the concession, the Prefect in the Pas de Calais region, or his representative, may decide to implement the specialist emergency plan (PPS) if he considers that French resources alone will be sufficient, or the bi-national emergency plan (BINAT) if he considers that UK resources will also be required.

When the BINAT plan is implemented, the incident control centres are activated (PCO in France, ICC in the UK) to take control of the emergency services and coordinate with Eurotunnel. Representatives from the emergency services that are alerted arrive and take their positions. The incident control centre in the country in which the incident occurred becomes the lead coordinator while its counterpart takes a supporting role while continuing to coordinate its staff and resources.

3.13.2 Special emergency plan (PSS)

The purpose of the "Channel Tunnel" Special Emergency Plan (PPS) is to organise and put in place all of the resources necessary for assistance and evacuation of the people on board the trains, within the shortest time, in the event of a crisis situation or disaster in the tunnel.

Until the PSS is activated by the Prefect, the Concessionaire alone is responsible for making the decisions and assistance is therefore managed by Eurotunnel personnel. Responsibility is transferred by means of a formal exchange by fax.

The main duties to be performed by the various services involved under the PSS are:

- providing assistance and care to people,
- fighting the fire,
- putting in place the means of controlling passenger and third party traffic coming to the terminal,
- keeping public order,

- implementing any additional plans, such as the road plan for managing incoming lorries,
- immigration control.

3.13.3 The bi-national emergency plan

The purpose of the bi-national emergency plan (BINAT) is to define arrangements relating to the bi-national coordination of French and UK emergency services in an emergency involving the Channel Tunnel.

A bi-national emergency is an incident – which has actually occurred or a potential incident – which causes death, injury or endangers life within the boundaries of the Channel Tunnel fixed link or which causes or threatens to cause any disruption to the fixed link and which requires or may require the joint intervention of the French and UK emergency services.

The following plans are interfaced with the BINAT plan:

- Eurotunnel's internal operation plan (volume E of the Safety Regulations),
- Channel Tunnel specialist safety plans – Prefecture of the Pas-de-Calais region,
- The Channel Tunnel Emergency Plan – South East Coast Ambulance Service, NHS Trust
- The Channel Tunnel Emergency Plan – Kent County Constabulary,
- The Channel Tunnel Emergency Plan – Kent Fire and Rescue Service,
- The Channel Tunnel Emergency Plan – National Health Service,
- Kent County Council.

The decision to end the bi-national emergency is taken by the relevant authority in the country that has been designated to lead the incident, who informs the relevant authority in the other country.

3.13.4 Implementation of the bi-national emergency plan

If the bi-national emergency plan (BINAT) appears to be required, a BINAT alert message is issued by the authority in the lead country. Two messages may be issued: BINAT Poss or BINAT Go.

The BINAT Poss message means that the bi-national emergency plan (BINAT) may be put into operation shortly. The services put on stand-by may start their own mobilisation procedures according to their own emergency plan.

The BINAT Go message means that the BINAT plan has been put into action.

Deployment – Lead country

STTS control vehicles (STTS-CC) from the lead country are deployed as part of the SLOR intervention procedure and used as a forward control post (PCA/FCP).

The person responsible for emergency services must define the limits for the area affected by the incident and determine the best position in the service tunnel from which to deal with the emergency.

Deployment – Support country

The support country deploys its second line of response team together with its STTS-CC according to the nature of the incident.

Upon arrival at the scene, the managers of the support country's emergency services team report to their counterparts from the lead country and put their services at their disposal.

Additional resources may be deployed in the tunnel. These resources are made available to the emergency response organisations by the Eurotunnel On-Call Coordinator in the PCO/ICC.

Detailed information relating to the deployment of STTS vehicles and their crews must be included in all emergency plans of the emergency services.

Management of operations

The role of the PCO/ICC is to take charge of and manage operations (see Section 3.13.5).

Through its representatives in the PCO/ICC, Eurotunnel retains responsibility for operation of its rail and road services and for control of its equipment and facilities.

The RCC supervisor delegates management of the incident to the PCO/ICC. Duties are handed over as soon as the PCO/ICC managers have received sufficient information to enable them to take charge of and manage the incident.

3.13.5 Coquelles Poste de commandement operationnel (PCO) (French Incident Coordination Centre)

This is located on the floor above the RCC.

It comprises two rooms (see Figure 28 below):

- the control room,
- the operations room.

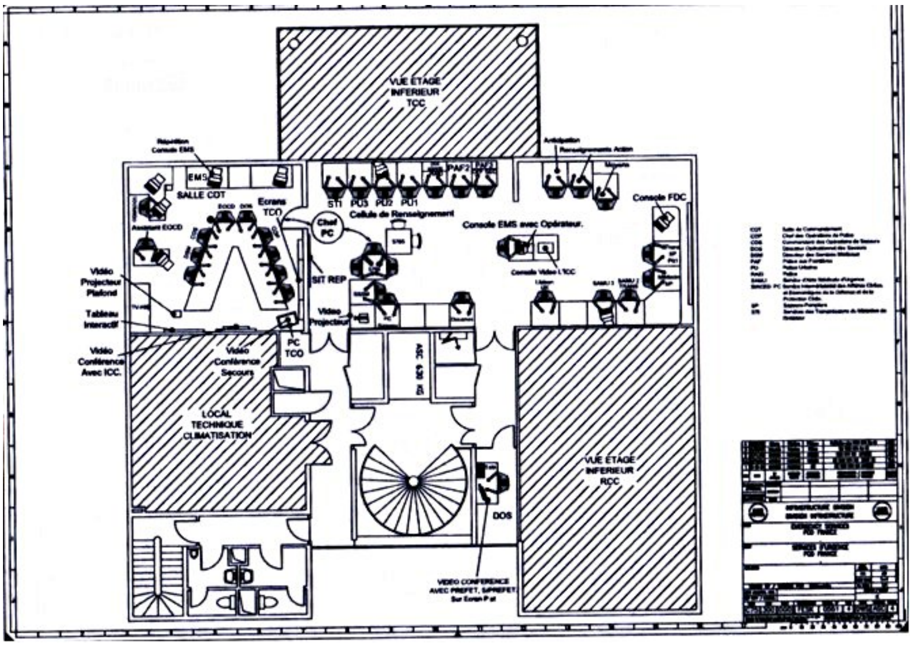


Figure 28: Poste de commandement operationnel (French Incident Coordination Centre)

3.13.5.1 Control room

It is from the control room that decisions are taken on the management of rescue operations.

The people listed below are present in this room:

- the Directeur des Opérations de Secours (DOS). This position is held by the Prefect or his representative,
- the Eurotunnel On Call Director (EOCD). He is responsible for assisting the DOS as the Eurotunnel representative,
- the Commandant des Opérations de Secours (COS). This is a senior fire officer who is responsible for organising and coordinating rescue operations reporting to the DOS. He has an assistant who is in the tunnel, the COSA (Commandant des opérations de secours de l'avant),
- the Directeur des Services Médicaux (DSM), doctor responsible for the management of medical emergencies reporting to the DOS and the COS. The DSM is independent in performing his duties,
- le Chef des Opérations de Police (COP),
- the Eurotunnel On Call Coordinator (EOCC). He provides the link between the national emergency service management present in the PCO/ICC and the Eurotunnel operations teams present in the RCC and in the road control centre.

3.13.5.2 Operations room

The operations room is adjacent to the control room.

A number of groups are in this room:

- a police unit,
- a customs unit,
- a fire brigade unit, which is responsible for producing strategy on an hour-by-hour basis,
- a health unit.

Each of these units provides assistance to the control room and carries out the duties associated with their own role.

There is an EMS console showing the status of key equipment and facilities.

3.13.6 Other control stations

The PCO/ICC is supported by various control structures set up in each country by the emergency response organisations.

In this respect, the following control posts are involved in France:

- a "Forward Control Post" (Poste de Commandement Avancé - PCA), located as close as possible to the scene of the incident. It is managed by the COSA (see Subsection 3.13.5.1). It is used as an assembly point for all emergency organisations and the central telecommunications hub between the scene of the incident and the PCO/ICC and the various Eurotunnel management centres (RCC, terminal, fire safety);

- an "External Control Post" (Poste de Commandement Externe), the purpose of which is to coordinate resources in order to manage events outside the concession. This is activated by order of the Director of emergency operations (DOS);
- a "Fixed Control Post" (Poste de Commandement Fixe) located at the Pas-de-Calais prefecture, which deals with general strategy and provision of resources. It is activated by order of the Director of emergency operations (DOS) in the case of a serious crisis.

3.13.7 Emergency resources

3.13.7.1 Emergency centre

An emergency centre (FEMC) is located in each of the terminals at Folkestone and Coquelles.

The emergency centre is adjacent to the tunnel portal. It acts as an operations base for the FLOR teams and a place for parking the STTS vehicles.

One fire-fighter (the duty officer) is present at all times at the FEMC in Coquelles[11]. He has the same information relating to smoke and flame detectors as the FD controller at the RCC. Unless the PCO/ICC has been activated, he manages the first and second lines of response (FLOR and SLOR).

3.13.7.2 Emergency personnel

The fire-fighting system is based on two levels of staff that may be required to intervene:

- the first line of response (FLOR). These are fire-fighters from the national fire-fighting services but who work for Eurotunnel 24 hours a day. Nine French and eight UK fire-fighters are available at all times. They carry out regular patrols in the tunnel, with French and English patrols alternating. During the day, the team in the tunnel is around the centre point and 3 other teams are on standby in the emergency centres. At night, all 4 teams stay in the emergency centres. Each team consists of 4 fire-fighters and an STTS vehicle equipped with fire-fighting equipment. In an emergency, the 4 teams can respond rapidly.
- the second line of response (SLOR). These are national emergency services personnel (police, fire brigade or ambulance) who provide assistance if called in by Eurotunnel. They come with their own vehicles, but have to use the specialist vehicles (STTS) to operate inside the tunnel.

3.13.7.3 Resources available to the fire-fighters

Seven emergency STTS vehicles are present at each of the emergency centres, i.e. 14 for the whole tunnel. These are as follows:

- 4 STTS fire and rescue vehicles used by the FLOR teams,

[11] It should be noted that at the FEMC in Folkestone, there is no permanent fire-fighter present. If necessary, the Kent fire brigade sends an officer to man the post.

- 2 STTS ambulances,
- 1 STTS control and communication vehicle (STTS-Com). In a bi-national emergency, the STTS-Com vehicle for each country is used to set up a joint forward control centre.

If necessary, the emergency services can use Eurotunnel's STTS maintenance vehicles or service cars to gain access to the service tunnel.

3.13.8 Protection of emergency services from electric traction current

The fire-fighters must be protected from any electrical hazards before they can work near the catenary or with their fire hoses. To provide this protection, the traction current must be isolated in the area concerned and it must be ensured that the catenary cannot be accidentally reconnected while they are working.

Precise procedures must be implemented to ensure this protection.

In France, to fight a fire on or near an electrified line on the national railway system, the fire-fighters may be protected using a procedure differing from the usual rules for electrical safety:

- Either by the emergency isolation procedure, where the catenary is not initially earthed but neutral operating safety sections (SNOP) are set up either side of the working area,
- Or by the consignation procedure which involves earthing the catenary on either side of the working area.

In the United Kingdom, the catenary must be effectively earthed at each end of the working area before fire-fighting can begin.

In the Channel Tunnel, the regulations call for the catenary to be earthed on either side of the working area, in accordance with the rules in force in France and the United Kingdom. A Eurotunnel technician has to go into the running tunnel concerned in order to earth the catenary.

3.14 Eurotunnel's safety management system

At the time of the fire on 11 September 2008, Eurotunnel's safety management system was defined in a document entitled "Channel Tunnel Safety Case" SAFD 019. This document dated back to 1997 and had been revised 5 times, the last revision being dated 17th November 2005.

3.14.1 Principles of the safety management system

- Return on experience system (REX)

The objective of this system is to learn from incidents and accidents. It is supported by the UPES database (Unplanned Events Planning System) which records all incidents and the action taken after analysing these incidents.

- Feedback system

This is based on formal or informal meetings with personnel, during the rounds and inspections performed by the managers.

- Internal and external audit system.
- Safety results follow-up meeting

These meetings are organized at six levels of responsibility within the company, including Executive level. Some of these meetings are attended by the personnel responsible for implementing procedures.

- Education and training tools

Such tools include the RCC simulators for reproducing emergency scenarios, driving simulators, full scale passenger rail vehicle mock-up in a tunnel environment, including a device that can generate artificial smoke, and computer-assisted training systems.

- Process of validating and managing technical changes and changes to procedures

This includes safety analyses and submitting plans to the relevant authorities both inside and outside of ET.

- Personnel management system, covering, selection, training and assessment

In particular, this system stipulates that all team members undergo an annual skill assessment.

3.14.2 General approach to risk control

One of the basic hypotheses of Eurotunnel's safety management system is that, in principle, the technical systems and operating procedures must be satisfactory as they have been approved by the IGC, unless experience proves otherwise.

Consequently, Eurotunnel focuses on the following factors to guarantee safety:

- ensuring members of staff have the skills to operate systems in accordance with the procedures,
- measuring and assessing the level to which the tasks performed comply with the relevant standards and procedures,
- when modifications are made to technical systems, standards or procedures, ensuring that the overall level of safety is at least as high as before (in accordance with the French safety principle of "globalement au moins equivalent – GAME"- "overall at least the same").

3.14.3 Assessment process

Eurotunnel's safety assessment is aimed at:

- identifying safety-critical functions in order to monitor their performance,
- ensuring that the risk arising from various activities (existing activities or proposed activities) is acceptable within the context in which those activities are performed,
- ensuring that all foreseeable risk is taken into account when examining new proposals.

This process is based on UK and French practices, and in particular:

Deterministic analysis which aims at identifying and analysing critical safety functions.

Eurotunnel has performed a detailed analysis aimed at identifying the following factors, for each hazard associated with the operation of the Channel Tunnel:

- the safety functions concerned,
- the standards and procedures necessary to ensure these safety functions,
- associated systems and processes.

A designated department is allocated the management of each hazard.

Indicators relating to each hazard are monitored in documents called “Score Boards” which are reviewed at least once a year.

Risk assessment following the approach suggested in article R 4121-1 of the Code du Travail in France and by the Health and Safety Commission in its Code of approved practice entitled “Management of Health and Safety at Work” in the UK.

The risk associated with each hazard takes account of two elements:

- the frequency with which the hazard appears,
- the seriousness of the consequences with regard to personal injury.

The principle of “as low as reasonably practicable” (ALARP) which is practiced in the United Kingdom is based on such a risk assessment. This principle involves systematically reducing the level of risk until it reaches a level that is “as low as reasonably practicable”.

3.14.4 Management of recommendations

The recommendations made in reports from the national investigation organisations are examined by Eurotunnel and passed to the relevant managers. Each manager is responsible for making proposals and then implementing the actions decided on.

These actions are monitored centrally by Eurotunnel’s safety management team.

The safety management team provides the Intergovernmental Commission’s safety committee Eurotunnel’s with a response to the recommendations and reports to it periodically on the actions taken.

The relevant working group within the safety committee examines the actions proposed by Eurotunnel in order to ensure that the solution is appropriate. In many cases, this process involves discussions between Eurotunnel and the specialists in the security committee.

4 The investigation

4.1 Summary of witness statements

The summaries given below have been drawn up by the technical investigators on the basis of the statements given by the various people they have met. They retain the details given by the person that appear useful in clarifying the action of those involved and their perception of the course of events. There may be discrepancies between these various statements; or with the observations given elsewhere. Chapter 5 below (final report on the chain of events) gives the version of events established by the investigators as a result of their investigations.

4.1.1 Witness statements from the personnel on board shuttle 7412

4.1.1.1 The chef de train

The chef de train starts work at 14:30 hrs. He calls the “crew management” controller who tells him to go to platform B4 from where his train should leave. This train is the first train that he operates that day.

When the train arrives he boards the amenity coach. His workstation is at the rear of the coach. He conducts a handover with his colleague who arrived with the previous mission, who tells him verbally that all is normal except for a door which is not working properly and which the maintenance department has isolated and attached a sign to it indicating that it cannot be used.

He watches the first fifteen lorries coming onto the loading platform and then goes back into the amenity coach. Shortly afterwards he welcomes on board the twenty-nine drivers who have arrived in the two minibuses. The driver of the second minibus gives him a loading form showing the number of passengers and vehicles and the presence of dangerous materials in one of the lorries loaded at the back of the front rake. He counts the passengers and compares the number counted with the number reported on his paperwork. The two numbers correspond.

He closes the doors of the amenity coach, checks that all of the indicator lamps are normal and then informs train control at Folkestone, by radio, that the information on the document corresponds to the number of people in the amenity coach. He then telephones the train driver to tell him how many people are on board and the location of the dangerous goods. By turning a button he gives his authorisation for the train to depart.

He plays a pre-recorded announcement in English and French telling the passengers what to do in the event of a smoke alarm and about the use of the breathing masks, this being backed up by a visual demonstration.

The train sets off at about 15:36 hrs. It enters the Channel Tunnel, everything is normal. About half way through there are a few banging noises, but that is usual. However, shortly afterwards, he thinks he hears a noise like a gust of air, but believes it is nothing unusual. He looks around him, everything is normal. A minute later, the fire alarm goes off. He immediately looks towards the wagons. He sees a fire at around the area of the first loaded wagon where there is one lorry. That is as much as he can see from the window in the area he is in. He closes the ventilation dampers in the amenity coach and calls to the member of catering staff to get out the breathing masks. The passengers have seen the fire and are moving away from it towards the front, thus creating a blockage between the chef de train and the member of catering staff.

He immediately calls the shuttle driver using the emergency telephone to tell him there is a wagon on fire. He advises the passengers that they are going to have to evacuate and starts to hand out the breathing masks, showing how to use them. He is helped in this by the member of catering staff.

Noticing that the train is still moving, the chef de train contacts the driver again, with the emergency telephone, and asks him to stop the train as there is a confirmed fire. The driver tells him that he cannot make contact with the RCC. The chef de train insists on the need to stop.

He asks whether all of the passengers have put on their breathing masks, but as they are all standing he cannot get near to those who are at the back of the group.

The train stops two or three minutes later. The chef de train takes steps to ensure that the train cannot move any further. The driver asks the chef de train whether he can see the cross-passage. As he cannot see it from his position he asks the member of catering staff whether she can see the cross-passage. She replies that she can by giving a thumbs-up. All of the drivers are at the front end where the door is locked. He calls to them to follow him, opens the right-hand rear door, checks that the conditions for evacuation have been met and leaves. As soon as the door opens smoke sweeps through the amenity coach. He believes that the passengers are following him and that the member of catering staff is leading the passengers towards this rear door. He takes the safety cord but cannot attach it. When he arrives at the cross-passage, the passengers and the member of catering staff are already there, having left through a window which the passengers have broken.

When they arrive at the door to the service tunnel, as it is open, he and the passengers have fresh air. The chef de train then asks the passengers to follow him into the service tunnel. One of the passengers indicates that there are still people in the train or in the tunnel.

The chef de train tries to count the passengers but there are four missing. He returns to the amenity coach, with the train driver, and calls these passengers by shouting to them to come out. Nobody comes out. He returns to the service tunnel but there are still four people missing.

It is then that the specialist French FLOR vehicle arrives. He explains to them that there are four people missing. The FLOR team goes to look in the running tunnel, where there is thick smoke. After a while, two fire-fighters arrive with two drivers who, they think, had got out on the other side of the train. The other two drivers were found but the chef de train does not know exactly where.

All the drivers are present. Help arrives and they are all evacuated.

The chef de train thinks that there was not enough information on what was done to ensure evacuation and that communication with the surface was difficult.

He had difficulty communicating with the drivers and with the French FLOR because they did not speak English.

He considers that the evacuation from the service tunnel to the surface took a long time. First of all, the chef de train was told that an assisting train was going to come into the South Tunnel, and then he was told that this train had been cancelled.

He was evacuated with the other crew members in a service car two to three hours later and examined by a medical team.

4.1.1.2 The member of catering staff

The member of catering staff comes on duty at Coquelles at 13:55 hours to work on a shuttle at 14:36 hrs. This shuttle arrives in England at 15:10 hrs. She does not notice anything particular on this journey from France to the UK. There are 32 passengers on board and she sells 6 meals. At Folkestone she stays on the shuttle waiting for the next departure, which is scheduled for 15:36 hrs. During this stop she heats up dishes for the return journey. A member of the "ISS" cleaning company arrives to clean the coach.

The chef de train and the train driver are relieved by a new crew, which is normal.

On the return journey, there are 29 lorry drivers plus the chef de train, the locomotive driver and herself, so 32 people on board. She does not notice anything unusual in the behaviour of the people present in the amenity coach.

At the end of her service, while returning her cart to the place provided, she feels a bump, which happens regularly. But immediately after there is a "boom", like an explosion, quite close by. She thinks it is in the first rake. She is standing looking back through a small window and sees flames near the lorries, not the first but the second or third maybe. She notices that the rake is not fully loaded but cannot see how many empty spaces there are. She cannot say whether the flames were coming from a HGV because they could be seen behind the first HGV and as the lorries are in line, it was not possible to see more. The flames were coming out from underneath the lorry.

She then thinks "we are going to evacuate". She puts her cashbox in a bag. A passenger pulls her by the arm to show her the flames and she tells him to calm down. She applies the instructions she has learnt for such circumstances, i.e. she locked the wheels of her cart and switches off the oven. The drivers were all standing. The chef de train was in a small recess at the back of the car, but he could not see well because the drivers were moving about. She hears the fire alarm go off and the chef de train shouting "breathing masks". These masks are kept together in a small sealed cabinet, a driver broke the seal and the member of catering staff set about handing them out to all of the occupants of the wagon.

At this time she is with the majority of the passengers, beside the front right-hand door, which is normally used for evacuation. But that door has a sticker on it stating "door isolated, do not use". She says that this situation is not unusual. This door cannot be opened, but the three other doors are working and are open. Smoke is sweeping through the wagon. Everyone is panicking at this point because the smoke is making it impossible to distinguish the access doors correctly. Suddenly a passenger grabbed hold of a hammer and broke the window beside the toilets, these being beside the locked door. That passenger got out first, a second followed together with the others. Two of them were helping the passengers down onto the platform because it was a significant drop from the window to the platform. She thinks that all the passengers left by this broken window except for four who left by a door on the left. However, these doors do not give access to the service tunnel. She was one of the last to leave and left when the passengers told her "come on, Madame, get out". Given the height between the window and the platform, she got out, afraid that she would be left alone in the amenity coach and not able to get out. Behind her there were still maybe five or six drivers, who followed straight away.

Then they were all in the service tunnel. She helped count the drivers with the chef de train and it was then that they realised that four were missing. She went back with the locomotive driver and the chef de train to call the four missing people but there was so much smoke that they could not see anything.

Assistance arrived maybe five minutes after and it was later that they learned from the emergency services that two of them had been found first of all and two others later. She also says that between 10 and 15 explosion sounds had been heard while they were still in the amenity coach and maybe even in the service tunnel.

4.1.1.3 The driver of shuttle 7412

On 11 September 2008, the driver of mission 7412 comes on duty at 14:30 hrs at Folkestone.

The rake arrives at 15:10 hrs. The driver receives instructions from his incoming colleague. He is not told about any problems. There is nothing entered in the instruction log. He does not perform any tests before leaving given that this train has already been in operation for several hours.

The train leaves on time, at 15:36 hrs. At about 15:58 hrs the driver receives a call from the chef de train on the emergency telephone. The chef de train tells him that there has been a confirmed wagon fire alarm. According to the procedure, the driver must immediately contact the rail control centre (RCC). He tries to do so with the radio but the radio is not working. He tries several times, in vain. He continues to drive at normal speed. Meanwhile, the chef de train calls to tell him that now all of the alarms indicate a fire and that he can see the fire from the amenity coach.

He brakes and the train reduces speed rapidly. The brake is working normally. The driver notes that the maximum speed displayed by the TVM went from140 km/h to 100 km/h, but the speed of his train was already below 100 km/h.

During this braking time, the RCC was able to contact him and ask him to perform a controlled stop immediately, which the driver was in the process of doing. He performs a controlled stop and not an emergency stop because, as the procedure specifies in this case, he must stop beside a door to a cross-passage. He stops at PK49. It is 16:00 hrs. The RCC asks him to give his radio number. He confirms to the chef de train that the train has stopped.

The driver then opens the locomotive’s external door to exit into the tunnel. He sees a lot of black smoke. He then closes the door and stays in his cab to put on his mask as specified. In this case, it is the chef de train who takes the decision to evacuate everyone towards the cross-passage door. The evacuation is the responsibility of the chef de train.

The driver leaves his cab and makes his way towards the cross-passage on his knees. As he approaches it he starts to see the light from the service tunnel and feel the flow of fresh air.

The chef de train left with the passengers and they met up in cross-passage 4898. The driver asks the member of catering staff and the Chef de Train to count the passengers. One of the passengers tells the driver that one of his friends is not there. After another count it appears that four people are missing. He returns to the amenity coach and call out: nobody replies. Until these people are found it is not possible to give the order to close the cross-passage door again. When it arrives, he advises the French FLOR that four people are missing.

Shortly afterwards, two passengers arrived through the cross-passage telling the driver that they left the train from the side opposite the cross-passage, that they crossed the track in front of the train and came back towards the cross-passage.

Then, two other passengers joined the group; the driver does not know where they came from or how they reached them.

Communications were limited during the time when the passengers and crew were waiting to be evacuated from the service tunnel. The driver used the emergency telephone in the cross-passage to confirm to the RCC that all the passengers were present.

The train crew and passengers were in the service tunnel for almost three hours and during this time the driver tried to speed up the evacuation of the passengers, by making contact with his manager, because of the condition some of them were in.

The driver was then taken to the surface in a service car and underwent a medical examination in the French terminal.

The driver stated that he had not heard or felt anything unusual while driving the train.

4.1.2 Witness statements from the lorry drivers

4.1.2.1 Summary of the lorry drivers' statements

The drivers did not notice anything particular until about 15:54 hrs. At that time, they hear an audible alarm and notice flames through the window in the rear passenger access door of the amenity coach. They also hear several noises that sound like explosions.

The chef de train and the member of catering staff hand them breathing masks. Once the train has stopped they try to open the front right-hand door but cannot do so.

Five of the drivers used the door on the left to leave. One quickly got back into the amenity coach. The other four headed in the direction of France. The smoke then got into the amenity coach as the door had been opened.

During this time the other drivers who were still in the amenity coach saw the cross-passage, the door of which had been opened by the RCC. It was beside the front right-hand window of the amenity coach. They broke the window so that they could escape. They did not hear the instruction from the chef de train to evacuate the train through the rear door of the amenity coach. They left through the window with the broken glass and headed towards the service tunnel.

Of the four drivers who left the train on the left-hand side and were walking towards France, two were found by the FLOR fire-fighters in the service tunnel near the next cross-passage (4932). The other two, who initially left in the same direction, turned around and went into the service tunnel through cross-passage 4898 (the one used by the passengers who were still in the amenity coach).

All passengers were evacuated towards the French terminal in two groups in road vehicles.

4.1.2.2 The driver of the refrigerated van

The statement below is limited to details concerning the loading of this vehicle. Once the driver was on board the amenity coach his statement corresponds to those from the other drivers.

After the driver has parked his van on the shuttle, a Eurotunnel official alerts him to the fact that the front lights are still on. He goes back to his vehicle and tries to turn them off with the switch on the dashboard. The lights do not go out. He then opens the bonnet to disconnect the battery but as it is not under the bonnet he cannot do so.

Due to lack of time, he closes the bonnet again and gets into the Eurotunnel minibus.

4.1.3 Witness statements from the agents responsible for loading and checking the lorries loaded on mission 7412 at Folkestone

During the security check on board the shuttle, one of the agents responsible for loading the lorries notices that the lights are on, on a light commercial vehicle on wagon no. 5. He calls the driver of that van to ask him to turn them off. The driver is not able to do so, either from the driver's position or after trying from under the bonnet. After closing the bonnet, the driver goes back to the amenity coach. A second agent confirms these facts.

One of the minibus drivers saw that the front lights of the van on wagon no. 5 were on. After the van driver had gone under the bonnet, the bus driver saw that the back lights had gone out and assumed that the front lights must have gone out as well.

The two agents responsible for observing the departure of mission 7412 to look for any malfunctions that might be a reason to stop the train do not remember seeing a vehicle with its lights on.

Note: However noticing that lights were on would not have caused them to stop the train because Eurotunnel procedures do not call for this.

4.1.4 Witness statements from the troubleshooters

4.1.4.1 The first troubleshooter in England

In the morning, a first[12] troubleshooter was called together with a colleague to repair a fault at Folkestone. They were shown a door problem on the amenity coach of the rake that was later to form shuttle 7412. They arrive before loading takes place.

They notice that the front right-hand door is still closed although the step and the handrail are deployed, which is not normal as the door should open once the step and handrail have been deployed.

They then got into the amenity coach and went to the door concerned and tried to open the door locally with the key. The door did not open.

After various investigations on the door's mechanical, pneumatic and electrical systems, they find that a sensor was not activated because the door was not completely locked. They manually force the locking of the door. The sensor is then activated.

This troubleshooter says that he has never seen this particular fault before. The two troubleshooters therefore decided to place a white 'Colson' collar (similar to a cable-tie) on the inside of the door so that the lock is held in position and the door will not open during the journey.

His colleague then locked the door's emergency handle in the isolated position using a carriage key. That means that the door's emergency opening handle could not be activated without a key of this type. *Note: this key is held by chefs de trains.*

The two troubleshooters then filled out the logbook, mentioning that the door was isolated. They gave the chef de train a sticker which he stuck onto the window of the door concerned. They did not do it themselves because they were short of time.

[12] No hierarchical aspect is intended in the terms first and second troubleshooter.

They then checked the “electronics rack” and the touch-screen to ensure that everything was as it should be. The chef de train’s screen showed the message “Door isolated”. They therefore authorised the departure of the train, knowing that they had followed all the procedures. Once a troubleshooter has been called, the train cannot set off again without his authorisation.

Before departure, the troubleshooters reported their action to the dispatcher, who noted it down. They explained the locking problem and that a Colson collar had been fitted. The dispatcher decided to have another troubleshooter work on it in France when the train arrived.

Then, he reported the intervention with a restriction sheet which is recorded on the computer system.

4.1.4.2 The second troubleshooter in the UK

He confirms the statements of the first, together with the following additional details.

He explains that in France a second Colson collar was added and that, once the isolation handle had been locked it could only have been unlocked again with a carriage key.

4.1.4.3 The troubleshooter in France

The shunt installed in the UK is removed and a new Colson collar put in place on the locking mechanism. The locking control circuit is OK. The door is still isolated.

4.1.5 Witness statements from the agents in the rail control centre (RCC)

4.1.5.1 The supervisor

At 15:54 hrs, the fire detection (FD) controller declares a first alarm in the North Tunnel.

The rail traffic management (RTM) controller stopped the train following mission 7412. He used the railway signalling to stop other trains from entering the tunnel. He also took manual control of the switches and made a general call in the tunnel for the trains to slow to 100 km/h.

The electrical and mechanical systems (EMS) controller started a sequence of reflex actions, i.e. putting on the lighting in the tunnel where the incident had occurred, reducing the level of the normal ventilation system (NVS) and closing the air distribution units (ADU).

The FD controller sent the first line response team (FLOR) to the scene for inspection; he stopped other vehicles from entering the service tunnel and optimised the lighting in the service tunnel.

Within the same minute, the supervisor announced a second alarm, this time from cross-passage 4202, with a rise in the carbon monoxide level. He then looked to see whether there was a train at that location, which there was. He then announced a second alarm and declared a “Stopping train incident” on train 7412 in the North Tunnel. He then declared a “reflex action” which causes the emergency procedure to be followed. At that moment, the RCC knows that there is a real fire in the tunnel.

The RTM controller called the driver of train 7412 to ask him to perform a controlled stop. He got through to the driver and the chef de train on the radio. He asked the driver to call him back when he had stopped beside a cross-passage.

The EMS controller configured the supplementary ventilation system (SVS) in the France-UK direction to blow the smoke towards the rear of the rake so that the passengers could evacuate in good conditions. He closed the piston relief ducts. The RTM controller also asked other trains present in the tunnel to travel at 10 km/h and announced this to the EMS controller. The EMS controller then activated the supplementary ventilation system (SVS) and specified the direction. The FD controller triggered intervention by the second line of response (SLOR). He called the FLOR, telling them that there was a “Stopping train” procedure and giving them the number of the cross-passage where the train had stopped. He told them that the driver of the train had not performed a controlled stop because he could not make out the cross-passage door due to the smoke and that he announced that he had stopped at PK 49.

After examining diagrams of the tunnel, the supervisor determines which cross-passage doors to open (4932 and 4898) given the point at which shuttle 7412 has stopped and opens them for evacuation of the passengers.

The RCC agents were waiting for the chef de train to call them to tell them the evacuation was over. But, as they did not receive a call, the supervisor called the chef de train because he thought that the evacuation was taking some time. The chef de train confirmed to him by radio that he was with the fire-fighters and said that there were two passengers missing who were being sought by the FLOR fire-fighters.

Within a minute of the train stopping, the catenary failed, so there was no longer any traction current inside the tunnel. The EMS controller was supported by a colleague who took on the job of resupplying sections of the catenary so that following trains on the UK side could leave. The trains that had entered the tunnel were brought out without incident and without being troubled by the smoke which was being driven back by the SVS. Around 16:20 hrs, the supervisor was advised that two people had been seen at PK 50 by the emergency services. Towards 16:35 hrs, there was confirmation that all of the passengers had been recovered. At that moment the remote work was finished as far as passenger safety was concerned.

During the same time, the supervisor reported the facts to his superiors and the BINAT plan was put into action. He then received a fax stating that the crisis cell had taken over and his work was over. His only role then was to ensure that the instructions issued by the PCO were safely implemented.

As the fire-fighting phase is the responsibility of the fire-fighters, it is they who gave the RCC instructions to open the doors, change the direction of the ventilation, according to the strategy decided on for fighting the fire.

The supervisor states that the RCC had a lot of electrical problems to manage and that he lost remote control of the doors of certain cross-passages. They therefore had to be opened manually, which took longer. However, to his knowledge, there were no major incidents.

He explains that the incident was not easy to manage, especially as there were passengers missing at the time of the count.

4.1.5.2 The “fire detection” controller

The fire detection (FD) controller comes on duty at 14:30 hrs at the Coquelles RCC.

At 15:54 hrs he observes a first alarm on the screen that monitors the carbon monoxide rate. As soon as he sees this alarm, he calls out “first alarm” “CP 4132”. Immediately afterwards, the supervisor called out “reflex action”. For the FD controller, the first alarm reflex action involves sending the FLOR to the scene inside the service tunnel. To alert the fire-fighters, he radios to the patrol, who that day is English. The patrol immediately acknowledges receipt and sends a team to the site; this team consists of four fire-fighters.

Immediately afterwards the second alarm went off. The English fire-fighters had not even had time to arrive. He calls out "second alarm" and the supervisor in turn immediately calls out "second alarm reflex action".

As a consequence of this second alarm, the "STOPPING TRAIN" procedure begins. He then calls the "France" FLOR as reinforcements and then the second UK team. He quickly opens the France and UK airlocks so that the fire-fighters can enter the service tunnel. He then calls the UK second line of response (SLOR).

He tells the French and UK fire-fighters that the fire is real and that the first alarm was triggered at PK 41.32 and the second at PK 42.82. He then tells them that there is a dangerous substance (phenol) on the train, but cannot give the quantity. He also tells them that the train has stopped at PK 49 for evacuation.

Next, he asks the French fire-fighters whether everyone has been evacuated. He learns that two people were missing, that they were seen in the service tunnel by the fire-fighters and that they were recovered by the STTS CC crew.

He then asks for assistance from the fire-fighters, asking them to de-activate the Halon cylinders in the equipment rooms.

4.1.5.3 The rail traffic management controller

The rail traffic management (RTM) controller comes on duty approximately five minutes before the fire starts. On the day of the fire, he actually had a "back-up" role (successively replacing other agents to give them a break).

As soon as the alarms are announced he takes reflex actions, in particular slowing down the trains to 100 km/h, ordering the closure of the ventilation dampers on all the trains and then stopping the trains.

He calls the driver of mission 7412, without success, to ask him whether he has stopped at a cross-passage or whether he can give a PK number (*to locate the point at which the train has stopped*). After a while he manages to make contact again and learns that the train has stopped. The driver gives him the number of his concession radio and that of the chef de train. He then tries again for about five minutes to contact the driver, but without success.

The first train following mission 7412 stops well before the France crossover. He asks the driver to implement the CHEX procedure (changing end), to return to the terminal he came from. He did the same with the second train in the same tunnel as mission 7412, which was a tourist shuttle. Twenty minutes later, the driver of the first train indicates that he is ready to leave. It took quite a long time for the second train because there was a problem resupplying the brake.

In the South Tunnel a driver calls to say that it is beginning to get hot (his train was opposite the fire). He was travelling at 10 km/h for aerodynamic reasons. He had to call at least three times. There were three trains in the South Tunnel.

Once the trains have left the tunnels the RTM controller no longer has anything to do.

When asked about requests, the RTM controller explained:

- when there is a call from a driver, the screen shows “driver request” and there is a short beep. You then pick up the phone. The word “request” remains on the screen until someone has answered. One screen page contains twenty “requests” and there may be several pages,
- on the day of the fire, the track-to-train radio was working well. In general, the number of faults depends on the day, but the radio is not very good although there has been some improvement,
- sometimes there are “drivers requests” but nobody at the other end, especially at the crossover because of the change of channel,
- the “track-to-train transmission” (TVM) signalling works well,
- as soon as first alarm is announced, the RTM controller confirms this first alarm on his emergency screen. The first train following the train involved in the incident performs a normal stop which is controlled automatically,

  [Note: The normal stop is controlled automatically by the signalling system once the RTM controller has confirmed the alarm.]
- the order to slow to 100 km/h is immediately given to the drivers through the track-to-train radio and then confirmed three minutes later with the TVM.

4.1.5.4 The duty EMS controller

At about 15:55 hrs, the FD controller, who is responsible for monitoring fire alarms in the tunnels, issued a first alarm indicating a fire in the North Tunnel, at CP 41, he believes, followed closely by the announcement of a second alarm. The supervisor asked all controllers to perform their reflex actions.

The purpose of these actions is to prepare for an intervention in the tunnel in case it should prove necessary. The EMS controller must put on the lighting in the tunnel where the alarms have occurred and reduce the ventilation in the service tunnel. He must then close the air inlets to the piston relief ducts.

Alarms continued to go off as the train went further into the tunnel. The supervisor identified the number of the train that was triggering them. He then ordered another reflex action, a “Train stopping incident” in order to stop the train.

After he had confirmation that the latter procedure had actually taken place, the EMS controller followed the protocol by activating the SVS in the North and South running tunnels.

As soon as the exact location where the train had stopped was known, the EMS controller opened two doors adjacent to the service tunnel to enable the evacuation to take place. It is not permitted to open more than two doors. The opening operations took place normally.

The EMS controllers (*duty and backup*) then waited for the report on the evacuation ordered by the chef de train to find out whether everyone had been accounted for and were in the service tunnel so that the doors of that tunnel could be closed again. It was at around 16:30 hrs that they received this information. At first they knew that there were people missing, but these people were subsequently found.

The fire-fighters were in the service tunnel to fight the fire and the EMS controller received the instruction to leave the two cross-passage doors open.

Between 16:00 and 16:30 hrs, his control screens showed various details of malfunctioning equipment, but that was a consequence of the fire and of the heat caused by the fire. He indicates that a colleague who has the same qualification as him, i.e. an EMS controller, came to help. It was he, for example, who dealt with bringing the other trains out of the tunnel.

4.1.5.5 The backup EMS controller

On 11 September 2008, the backup EMS controller is not on duty in the RCC but is working on maintenance supervision. Towards 16:00 hrs, he receives a telephone call from a colleague telling him that a train is on fire in the tunnel and that the EMS controller needs backup. It takes him two minutes to get to the RCC where he joins his colleague who is the duty EMS controller.

When he arrives he sees on the control screens that the train has stopped and that the cross-passage doors have already been opened. He assumes that the evacuation is in progress.

The duty controller tells him that there are problems with the SVS. He says that the fans are working but that the dampers on the French side are still closed and consequently the ventilation is not working. However, the ventilation system on the UK side is working and extracting air from the tunnel. He asks the duty EMS controller whether he has contacted the technicians. As the answer is no, he does it himself.

At the same time, the catenary fails. The backup controller takes manual control of the electric traction system. He cuts off a section of the catenary in order to isolate the interval where the train involved in the accident is located. He then restores power to the other two intervals (two and four) so that the two trains following the train involved in the accident can move. Once the current has been restored, these trains can change direction and exit the tunnel at Folkestone.

He then contacts the catenary technicians so that they can earth the section of the catenary that has been isolated.

Having no further information on the position of the door of cross-passage 4898 and the piston relief duct damper, he asks the technicians to go and verify their condition in situ. They say that the door is closed and that the damper must be closed because as soon as the supply is cut off the dampers close mechanically. As there is no pollution in the South Tunnel, the EMS controllers assume that the damper is in fact closed.

They then learn that the two people who had disappeared have been found.

The technicians responsible for earthing the catenary have to go back into the North Tunnel to place a rod on the catenary and connect it to earth. However it is not possible to open more than two cross-passage doors at the same time in order to maintain pressurisation in the emergency tunnel. But the fire-fighters already have two open. With their agreement, they close one for the time needed to perform this earthing operation.

The French incident coordination centre (poste de commandement opérationnel – PCO) asks the EMS controller for assistance, i.e. to isolate the catenary on the UK side as quickly as possible[2]. However, that was not possible as two trains had not yet left the tunnel.

He then notes that there is a significant flow of water at the Sangatte fire-fighting station. He concludes that the fire-fighters are attacking the fire. As the rate of flow is too great, the station has stopped. In fact, as the electrical supply on the north side had been lost, only one of the two pumps in the plant was working. This failed as it could not provide the flow on its own. He tries to start it again but in vain. He then reconfigures the fire-fighting flow by using the second station on the French side, at Beussingue. That one is working. The fire-fighters must just have noticed a drop in pressure for about thirty seconds.

At 17:40 hrs, as the two trains have left the tunnel, he reconfigures the electric traction system to isolate the catenary along the whole length of the North Tunnel. The UK technicians were then able to carry out the earthing operation at their end.

The fire-fighters then ask for a second cross-passage door to be opened so that they can attack the fire. This door has a fault. The technician at the scene tells him that there is a fault with the electric control. The technician then opens the door manually with the wheel provided for that purpose.

The fire-fighters ask for the water supply system to be reconfigured so that they can connect to the water inlet in this second cross-passage. A technician manually closes a valve between the two cross-passages. The backup controller then increases the supply pressure on the UK side. The PCO then informs him that the fire-fighters do not have any water. He diagnoses that a manual valve must still be closed between the open passage and the UK end of the tunnel. He asked technicians to check all of the valves. After a while the fire-fighters have water, but he has no idea how long it took to carry out this check.

Once the fire-fighters have attacked the fire, the PCO asks for the intensity of the ventilation to be lowered so as not to feed the fire. It should be noted that, at that moment, the technicians had managed to power up the faulty fan again and that consequently the ventilation was fully effective.

He states that all of this happened very quickly, that he had a lot of technical problems, that he is not certain of the chronology of events. He might have got one or two of the actions described in the wrong order.

4.2 <u>Summary of the information recorded by the investigators</u>

4.2.1 Composition and load of mission 7412

The composition of the rake was in accordance with the rules (see section 3.7.1).

The locomotives were Eurotunnel class 9/8 locomotives.

The wagons and the amenity coach were of the Breda type.

As operations were normal, the amenity coach remained at the head of the rake throughout the day of 11 September 2008.

The rake had been stabled for the night of 10 and 11 September on a siding in the UK terminal. It had returned to service on the morning of 11 September on mission 7292, departing at 09:40 hrs.

When the chef de train of this mission got on board and performed his inspections before starting, he noticed that the front door on the right-hand side of the amenity coach (door 3) was not closing correctly; he therefore called the troubleshooters to deal with the door. As the malfunction could not be corrected (see section 4.2.3.2), mission 7292, and then the subsequent missions travelled with the front right-hand door locked.

The load on mission 7412 consisted of 25 heavy goods vehicles and 2 light utility vehicles.

The load summary specified that the lorry loaded on the 13th wagon was carrying dangerous materials: 100 g of phenol[13], 100 g of turpentine[14] and an additional 200 g of flammable liquids[15].

4.2.2 Operation of the technical installations

4.2.2.1 Signalling

The signalling operated normally.

Mission 7412 performed a controlled stop as specified in the instructions. Between kilometre 47 where the driver started braking and kilometre 49 where he stopped, the driver encountered the following trackside signals:

PK	Signal
46.94 [16]	Board signalling approach of CP 4704
47.065	Board marking CP 4704
47.36	Intermediate marker
47.36	Board signalling approach of CP 4746
47.485	Board marking CP 4746
47.74	Board signalling approach of CP 4784
47.865	Board marking CP 4784
47.88	Intermediate marker
48.12	Board signalling approach of CP 4822
48.245	Board marking CP 4822
48.40	Intermediate marker
48.54	Board signalling approach of CP 4864
48.665	Board marking CP 4864
48.88	Intermediate marker
48.88	Board signalling approach of CP 4898
49.005	Board marking CP 4898

- Marker: track section and route entry block marker.
- Intermediate marker: track section entry marker.
- Board signalling approach of a CP: board installed 100 metres before a CP indicating the number of that CP

[13] Class 6.1, toxic material (number ONU 2821)
[14] Class 3 (Packaging group III), highly flammable liquid (number ONU 1299)
[15] Class 3 (Packaging group III), flammable liquids (number ONU 1993)
[16] The positions of the marker boards and approach boards were determined by assuming that they were positioned according to Eurotunnel rules. The investigator was aware that approximately 6% of boards do not observe the rules laid down exactly, but it was not possible for him to know whether this was the case for the boards listed in this table.

- Board marking a CP: board (yellow diamond) installed 25 metres after a CP indicating the number of that CP.

4.2.2.2 Electric traction

Catenary supply

On 11 September there was no breach of the catenary in Running Tunnel North, but there was a failure of the traction current 30 seconds after the train stopped.

The supply arrangement for the North Tunnel before the disconnection is as follows:

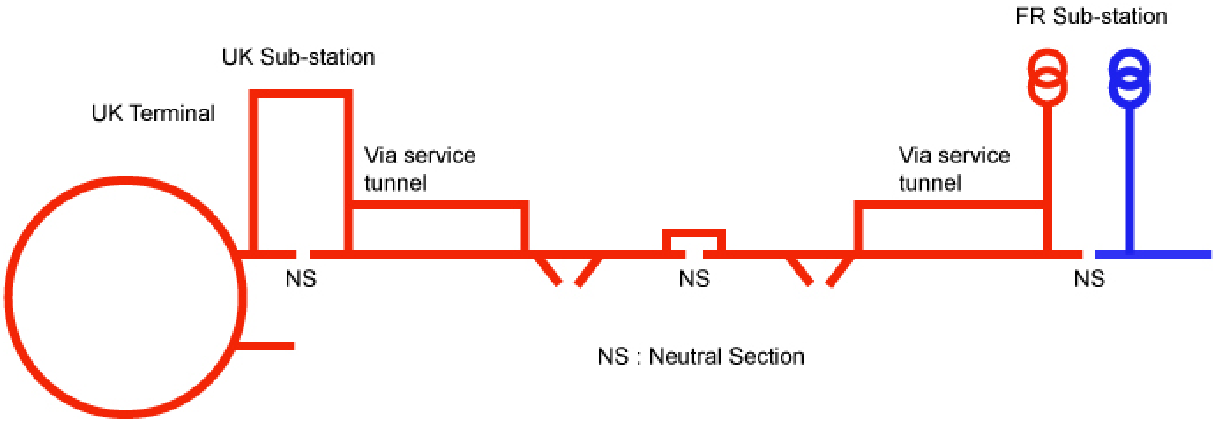


Figure 29: North Tunnel electric supply before the fire

After the disconnection, no electricity is supplied to the whole of the North Tunnel. But there are trains inside the tunnel behind mission 7412. It is therefore necessary to restore the supply to the catenary so that the trains can be sent back to the UK.

To achieve this it is necessary to:

- isolate the interval where mission 7412 is located (or at least a portion either side of the fire) and where the catenary has failed,
- re-supply the North Tunnel upstream of that interval and the UK terminal.

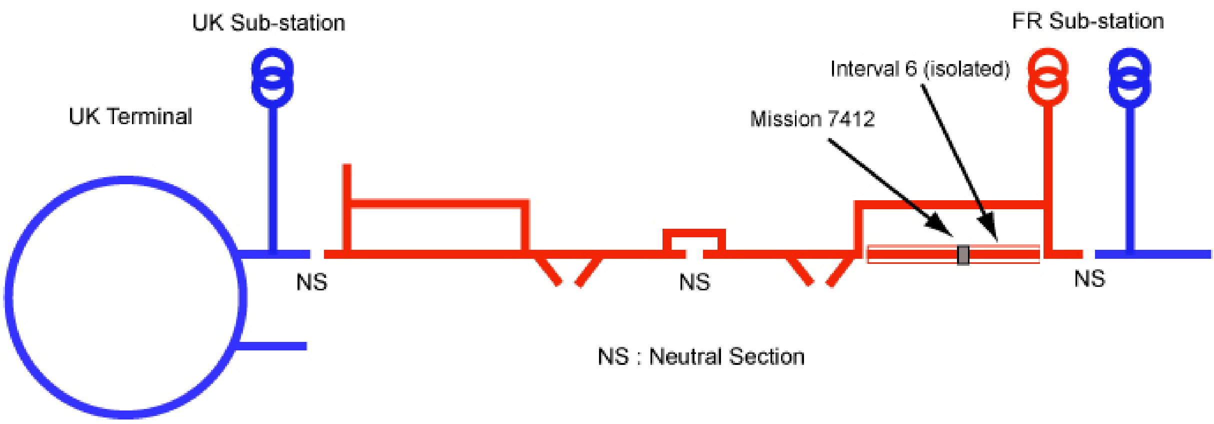


Figure 30: North Tunnel electric supply during evacuation of the two missions inside the tunnel

A little before 16:16 hrs, the catenary in the North Tunnel is reconfigured, i.e. supply is restored to the catenary on the UK side of interval 6.

4.2.2.3 21 kV supply

At 16:09’17’’, the 21 kV electric power supply provided by the conductor in the North Tunnel fails as a result of the fire.

This results in several key pieces of equipment ceasing to work at Sangatte:

- one of the two fans in the supplementary ventilation system,
- one of the two fans in the normal ventilation system,
- a high pressure pump and a low pressure pump in the fire hydrant water supply circuit.

Furthermore, incorrect information regarding problems with the ventilation dampers on the French side appears on the EMS controller’s terminals.

4.2.2.4 Telecommunications

Track-to-train radio

When notified by the chef de train, at about 15:54’30’’, that there was a fire in the train, the driver immediately tries to contact the RTM controller, but is not able to do so. He tries again several times but without success. The same applies to his attempts using the concession radio.

When mission 7412 has almost stopped he hears the RTM controller on the track-to-train radio, instructing him to perform a controlled stop. He cannot respond, as he is in the braking phase which is a delicate operation to ensure that the train stops at a precise point.

Once mission 7412 has stopped, its driver makes contact with the RTM controller using the track-to-train radio, the radio connection having returned to normal.

Concession radio

As indicated in the paragraph above, the concession radio could not be used between the RTM controller and the driver of mission 7412 during the stopping phase. Nor was it possible during the evacuation phase.

However, during this same period, the RTM controller was able to contact the UK FLOR which was patrolling in the tunnel, as well as during its journey towards the scene of the fire.

Three of the five concession radio channels were lost within the first 15 minutes following the destruction of the fibre optic cable in the North Tunnel. The network was then saturated.

Communications between the chef de train and the driver of mission 7412

After having detected a fire on board, the chef de train contacted the driver by the shuttle’s internal emergency telephone.

Tactical radio

The batteries of some portable radios discharged very quickly although the telephones were taken directly from chargers in the emergency centres (FEMC).

As the fire had damaged certain antennae in the North Tunnel, communications between this and the service tunnel by tactical radio were significantly disrupted.

Two of the four tactical radio channels connecting the emergency teams and the PCO/ICC were lost following the destruction of the fibre optic cables in the North Tunnel.

Command and Communication STTS

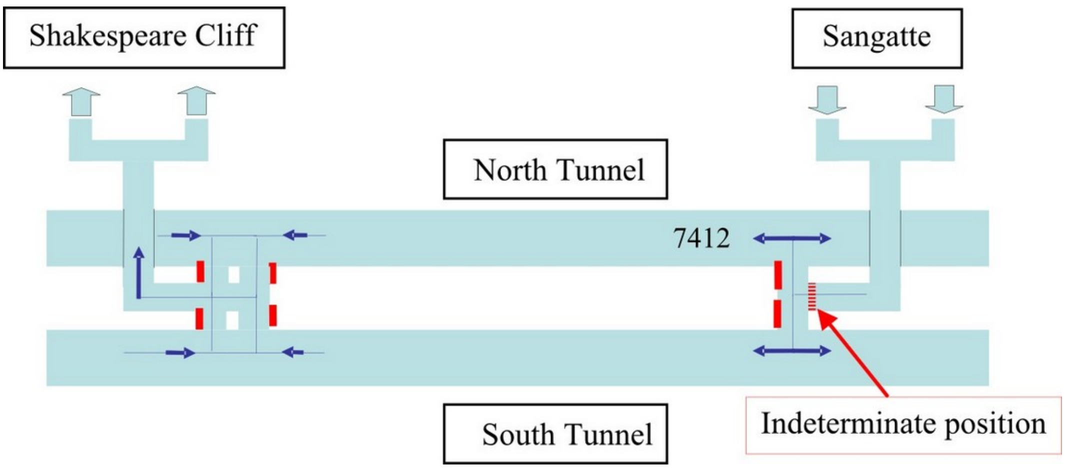
The UK STTS-Com communication module failed after an initial period when it had operated satisfactorily, resulting in degraded operation of the tactical radio and loss of two telephone lines between the service tunnel and the surface. A technician re-initialised the system, which restored the two telephone lines and the tactical radio channels.

4.2.2.5 Ventilation

Supplementary ventilation system (SVS)

As soon as the conditions were right for using the supplementary ventilation system (SVS), the EMS controller started it by clicking on the relevant icon on his terminal. The SVS dampers on the UK side open at 16:02'43'' and those on the French side at 16:03'15''.

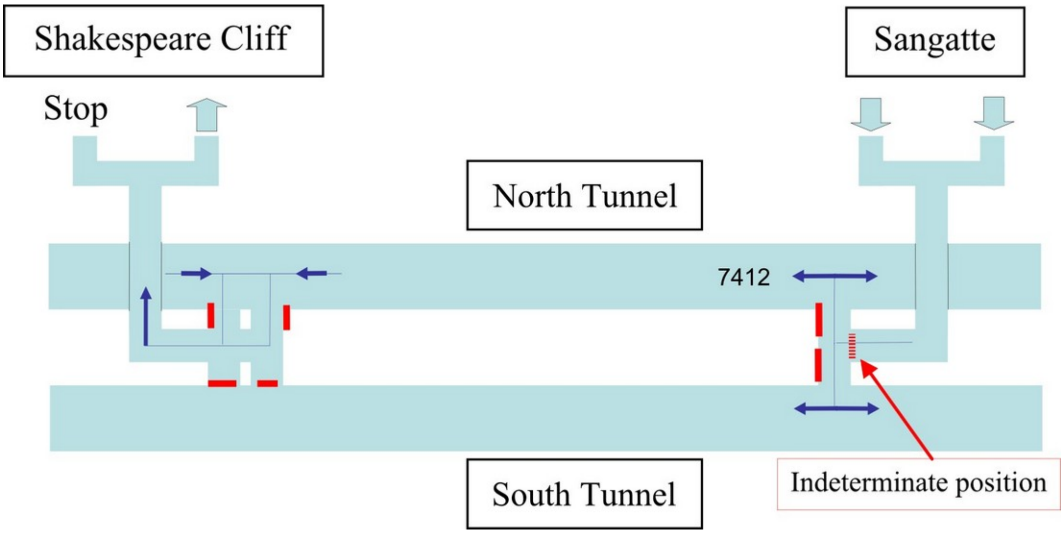
The configuration is then as follows:



A malfunction in the main French damper is signalled at that time. The controller therefore concludes, as his instructions specify, that this damper is still closed and that there is no ventilation being provided on the French side[17]. To compensate for this assumed fault, he decides to have the two Shakespeare Cliff fans working in extraction mode in the North Tunnel only.

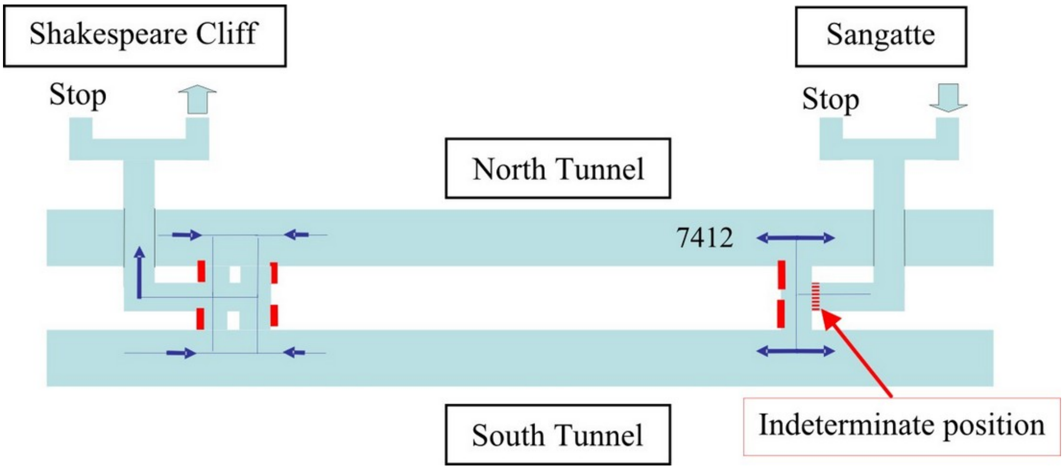
The controller first closes the dampers on the UK side, connecting the SVS to the South Tunnel. However, he stops one of the UK fans (at 16:07'53''). Between 16:07 and 16:09'17'' the situation is therefore as follows.

[17] (it should be noted that the EMS controller does not think of checking the information on the rate of air being blown in on the French side. Had he done so, he would have noticed that the rate was normal and could have concluded that the main damper was open.)



At 16:09'17'' a fan on the French side breaks down following the failure of the 21 kV cable. As the damper supplying the South Tunnel at Sangatte is still open, there is reduced air flow in the North tunnel.

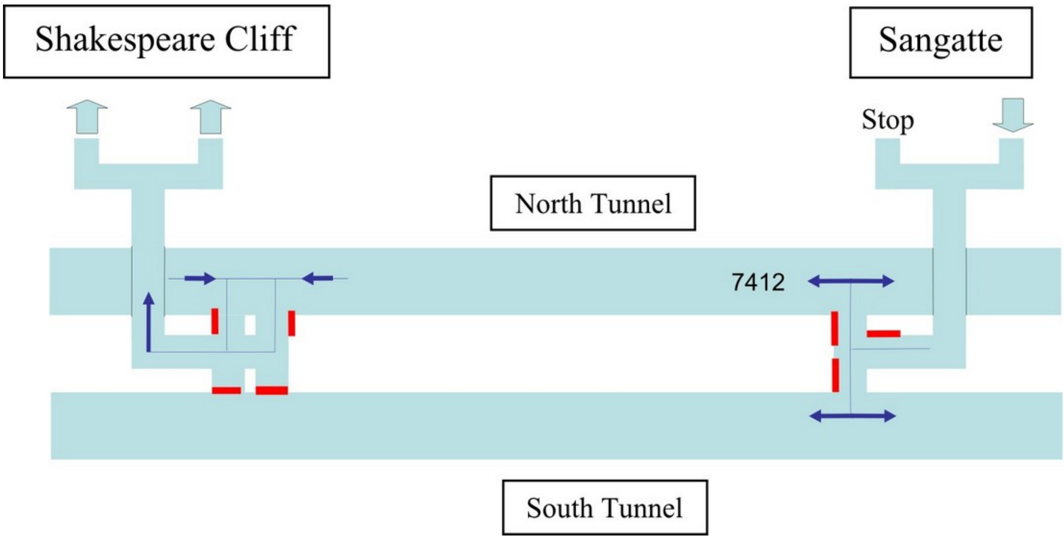
The situation is then as follows:



At 16:11 hrs, although nobody knows why, the incorrect message regarding the main damper on the French side disappears but the EMS controller does not notice this until fifteen minutes later.

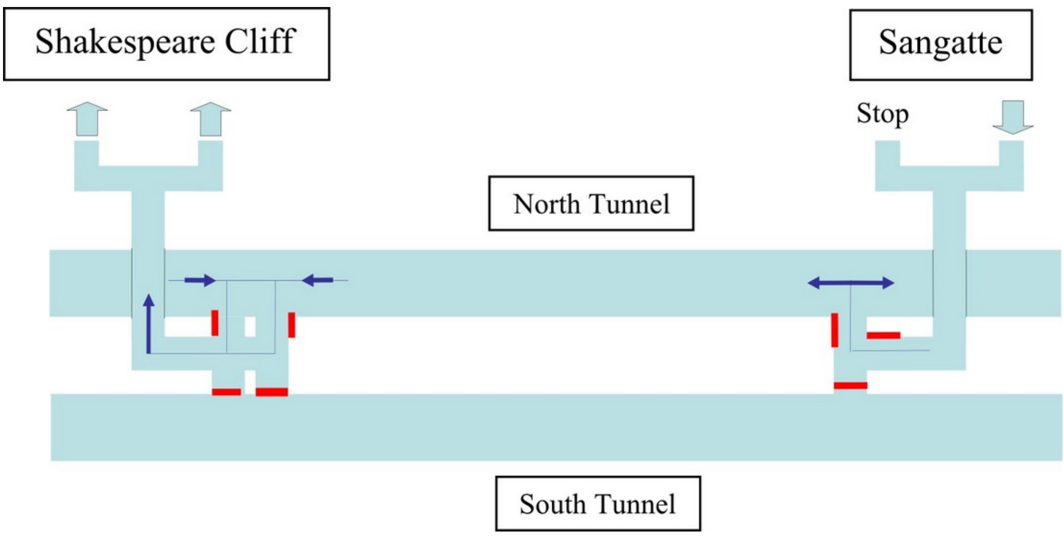
At 16:13 hrs, the second UK fan is started again by the EMS controller, increasing the air flow in the North Tunnel.

The situation is therefore as follows:

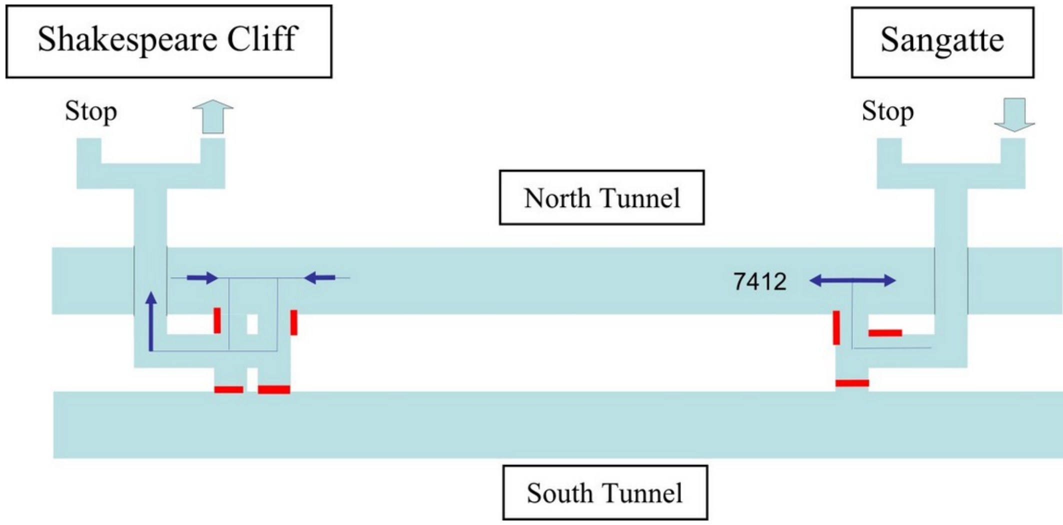


At about 16:26 hrs, the EMS controller realises that the French main damper malfunction message has disappeared. He then closes the damper for the Running Tunnel South, thus directing all of the air towards the North Tunnel. Although the SVS configuration on the French side is operating as it should, he keeps the UK SVS in Duplex mode, thus increasing the airflow in the North Tunnel. The configuration of the SVS is therefore still not compliant with Eurotunnel's rules for this scenario.

The situation is as follows:



The above configuration is maintained for almost two hours. At 18:39 hrs, the EMS controller stops one of the UK fans. The SVS is now running according to the regulations. The situation is therefore as follows:



At the request of the fire-fighters, air flow is gradually reduced between 18:41 hrs and 19:20 hrs.

Piston relief ducts (PRD)

All the PRD are shown as closed at 15:56'10'', i.e. slightly more than two minutes after mission 7412 stops.

At 16:23'20'', damper 4860, located towards the centre of mission 7412, is indicated as having a malfunction. The same happens at 17:20'21'' with damper 4810, located 149 metres behind the rear of that same rake.

In both cases the system shows that the dampers are in the process of opening and then that they are open. The EMS controller then confirms the instruction to close. In reality, the dampers are still closed and the incorrect messages are the consequence of the cables being affected by the fire.

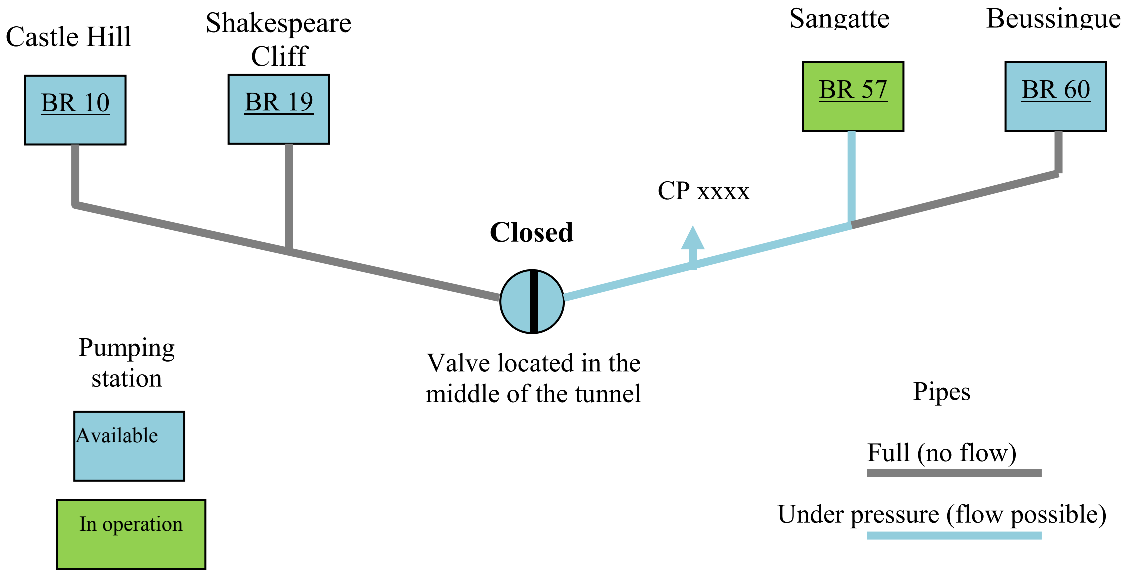
Although none of the dampers has displayed a malfunction connected with the fire, at times there has been some dispersion of smoke towards the South Tunnel.

4.2.2.6 Fire-fighting water system

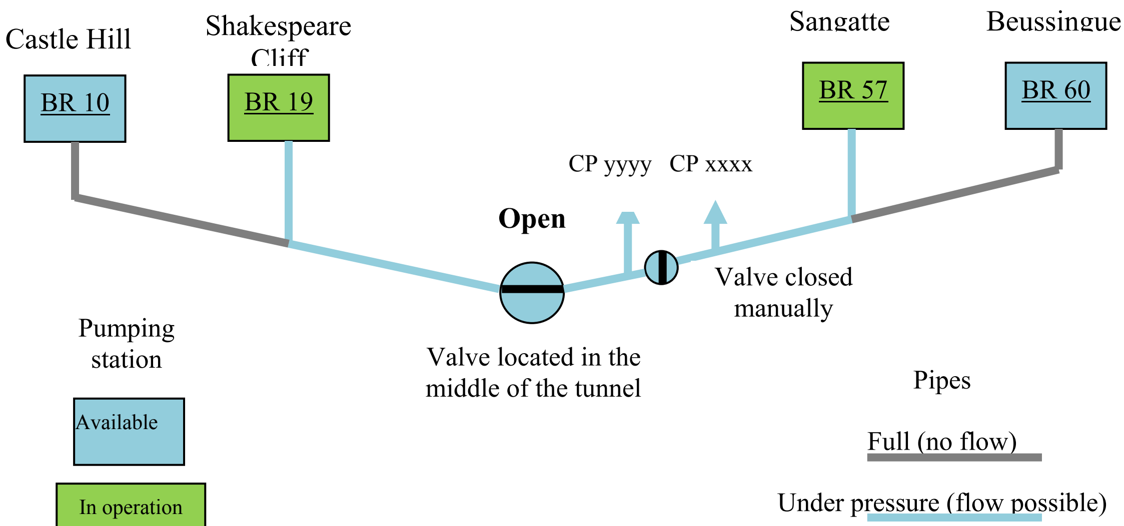
The diagrams below show the water system as it is normally configured for attacking a fire in the French part of the tunnel, through one cross passage, or through two cross passages respectively.

In the first case, only the pumping station at Sangatte is active, with the Beussingue station acting as backup.

In the second case, the Sangatte and Shakespeare Cliff stations are active with the Beussingue and Castle Hill stations acting as backup.



Fighting a fire in the French part of the tunnel
Attacking the fire through one passage (CP xxx)



Fighting a fire in the French part of the tunnel
Attacking through two passages with additional supply from UK pumps

At 18:39 hrs, a fire hydrant located in cross-passage 4864 begins to leak under the effect of the heat, causing a sudden loss of pressure.

Shortly after, the Sangatte pumping station stops automatically.

The faulty fire hydrant is isolated manually and the back-up pumping station at Beussingue is then activated. Supply is restored to the fire-fighting water pipes at 19:00 hrs.

At 19:01 hrs, the EMS controller closes the mid-point valve so that the fire can be attacked from both ends and opens the valve for the pipe in passage 4822 to be supplied for the UK fire-fighters. However, there is no water getting to this location. After investigating in situ[18], it is found that one valve, at PK 36.21, is closed. At 19:35 hrs, the Eurotunnel technicians open it locally.

The diagram below shows the situation of the water system at 19:01 hrs and 19:35 hrs.

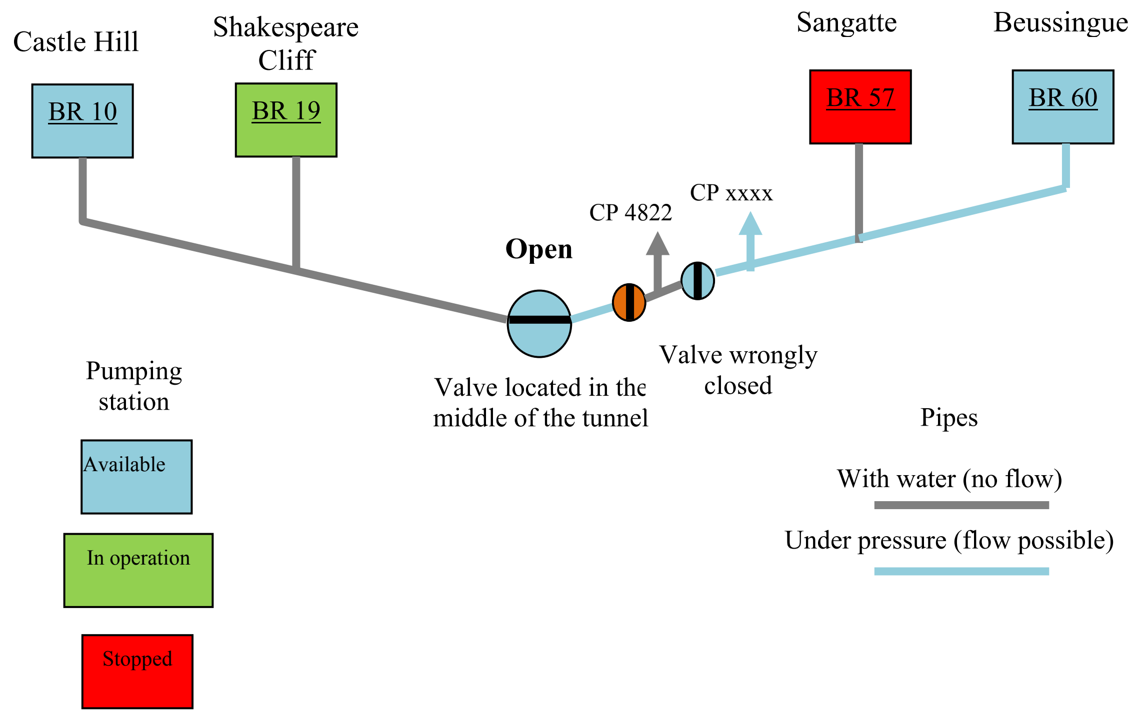


Figure 31: Loss of water supply at cross-passage 4822 between 19:01 hrs and 19:35 hrs

4.2.2.7 Cooling installations

Despite the intensity of the fire, the pipes inside the rail tunnels were not damaged and did not leak to any significant degree.

4.2.2.8 Cross-passage doors

At 16:01’14’’ and 16:01’22’’, the EMS controller orders the opening of the doors to cross-passages (CP) no. 4932 and 4898 once the defined conditions regarding ventilation, piston relief ducts and train speeds have been met. The doors open normally.

In the event of a fire, the rule is to open two doors, and only two, in order to achieve acceptable air flow speeds in the cross passages. The doors selected are those beside the amenity coach (4898) and the next door (4932) until the evacuation is completed. It is through the latter door that two drivers who had gone into the tunnel on foot were able to gain access to the service tunnel. In the transitional phase only one can be open. During the fire-fighting

[18] There is no way of knowing whether this type of valve is open or closed, other than going to inspect it in situ.

operation, this rule is not always observed, so long as not doing so does not hinder the emergency services.

At 18:09 hrs, the FLOR asked for the door to CP 4864 to be opened. The remote and local electric controls did not work (a consequence of the fire). The door was therefore opened manually at 18:24 hrs, the door to CP 5876 being closed at 18:19 hrs.

The door of CP 4822 also had to be opened manually; with the exception of this control difficulty, the cross passage doors played their part.

The diagram below shows which doors were open between the start of the fire and 20:00 hrs and it can be seen that the rule of only having 2 doors open at the same time was observed.

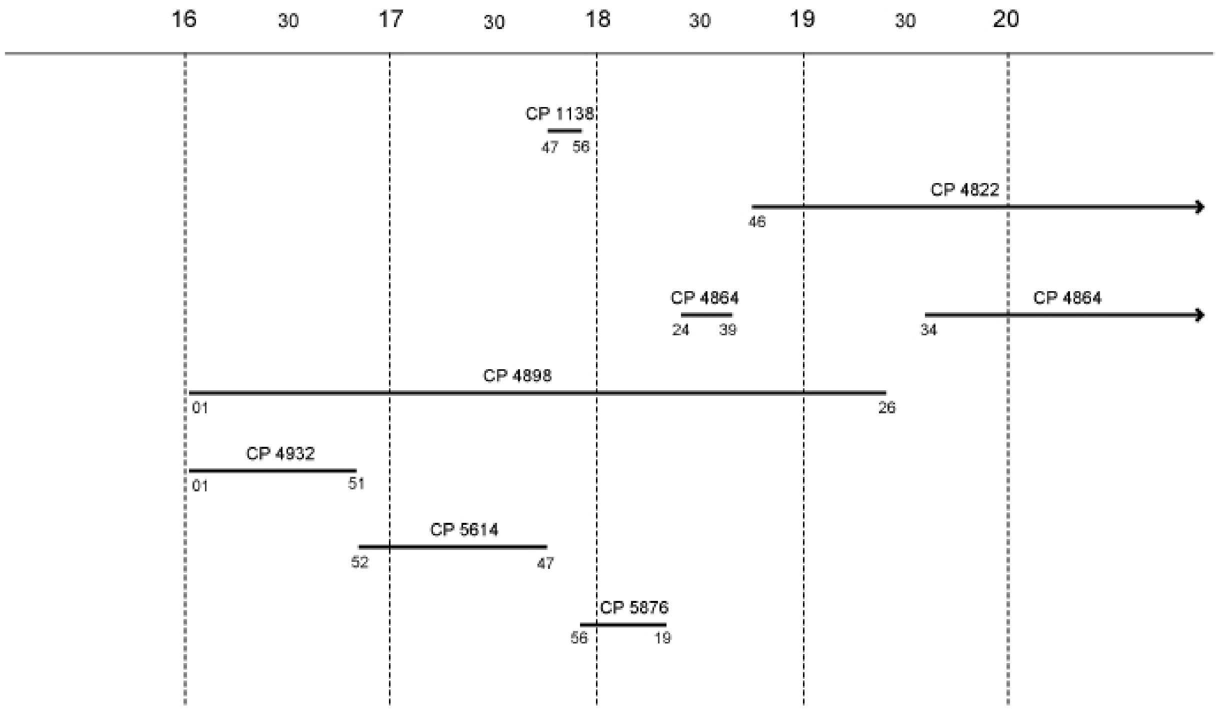


Figure 32: Opening of the cross-passage doors

4.2.2.9 Fire and smoke detection

The fixed and on-board fire and smoke detection systems worked correctly.

At about 15:54 hrs, a fire alarm detected on the rear loading wagon is reported to the chef de train by means of an audible alarm and also an alarm on his control panel.

The RCC fire detection controller receives the following:

- at 15:54’21’’, a first alarm (flames), detected by detector no. 40 at PK 41.3;
- at 15:54’43’’, a second alarm (ionisation) detected by detector no. 42 at PK 42.

Other alarms are sent by the next five detectors located before PK 49, the point at which mission 7412 stops. The detectors located after that point do not signal anything.

The detectors that have been passed by mission 7412 continue to send data after the mission has stopped. They enable the controllers and fire-fighters to track the movement of the smoke.

4.2.2.10 Movement of the smoke

In Running Tunnel North

The information provided by the various flame and smoke detectors makes it possible to reconstruct the movement of the smoke.

Between 15:51 hrs and 16:03 hrs, when the supplementary ventilation system (SVS) was started, the smoke is moving in the direction in which mission 7412 is travelling, and accompanying it. The amenity coach and the locomotive are therefore in a smoke-filled atmosphere when mission 7412 stops.

After 16:03 hrs, the smoke is pushed back towards the UK portal. It moves at a speed in the order of 2.7 metres per second. It reaches the point at which mission 7414 stopped approximately forty-five minutes after that mission started to return towards the UK. The differences are even greater with the two other missions in the same tunnel that have had to return.

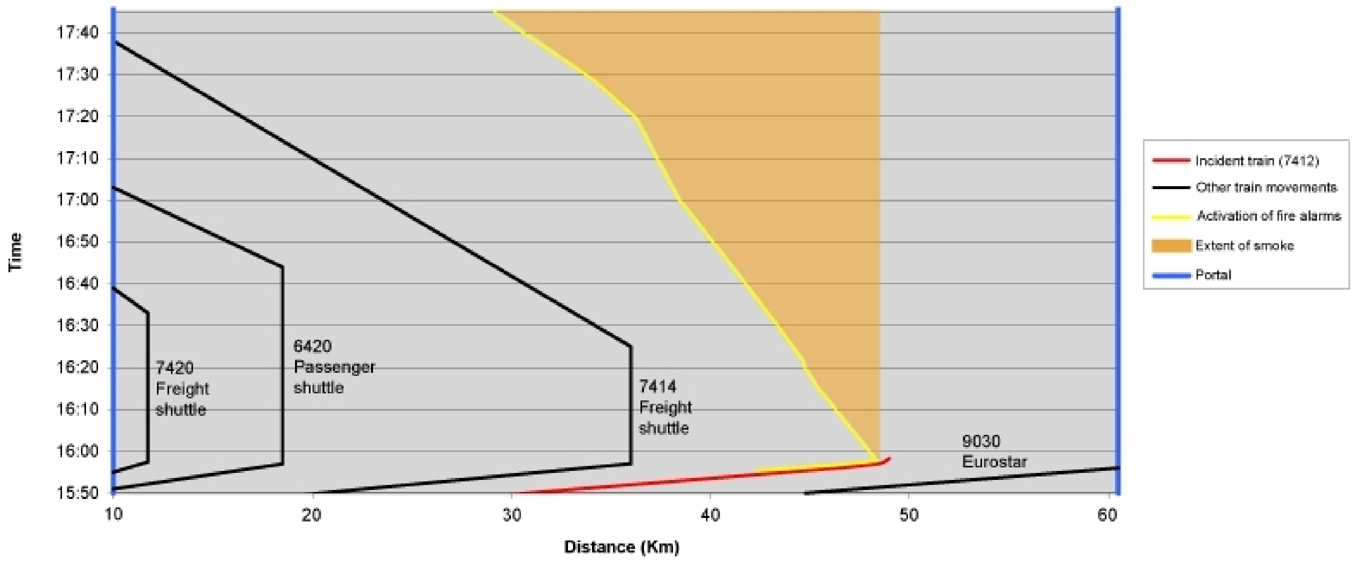


Figure 33: Spread of smoke in the Running Tunnel North

In Running Tunnel South

All of the piston relief duct dampers did close after the initial detection of a fire on board mission 7412, but not all of them were totally effective and a certain amount of smoke spread into the South Tunnel.

Carbon monoxide levels of between 50 and 100 ppm were detected by the sensors fixed in Running Tunnel South opposite the fire from the first minutes of the incident (members of the crew on mission 6419 also smelled smoke).

However, no penetration of smoke into Running Tunnel South (RTS) was detected for almost 90 minutes. After this time, there was a gradual accumulation of smoke over practically the whole length of Running Tunnel South (as testified by the data recorded by the fire detection system based in the tunnel).

Between PK 23 and PK 50, the CO level reached dangerous thresholds between 19:00 hrs and 23:00 hrs. At this time the only people in the tunnel are the fire-fighters who are equipped with breathing apparatus.

Note that the last mission to travel in Running Tunnel South (mission 6419) passed near PK 23 at about 17:40 hrs.

4.2.3 Operation of the rolling stock

4.2.3.1 Effect of fire on the rolling stock

Until shuttle 7412 stopped, the fire did not compromise its capacity to travel, either structurally or by interference with the running, braking and traction apparatus or control circuits.

However, once it had stopped, the loaded carrier wagons suffered significant damage. For the most part, the side walls and the roofs were deformed by the heat of the fire and by debris falling from the roof of the tunnel.

Figure 34: Damage suffered by one of the carrier wagons and its load

The three leading carrier wagons which are not carrying any lorries, the leading loading wagon, the amenity coach and the two locomotives did not suffer damage from flames. However, the long exposure to the heat and smoke has caused considerable damage to the trailing locomotive.

4.2.3.2 Operation of the amenity coach

Doors

The troubleshooters were not able to solve the problem of the amenity coach door in Folkestone on the morning of 11 September between 9:15 hrs and 9:40 hrs, before the departure of mission 7292. They locked the door in the closed position by immobilising the locking mechanism with a plastic Colson collar so that the door could not open under the effect of vibrations. They also placed a label on the door indicating that it was out of operation. The information recorded in the logbook is “door isolated”.

When mission 7292 arrived at the French terminal, it was examined by another team of troubleshooters who were not able to solve the problem either. They fastened the door mechanism with a more solid collar and the shuttle remained in operation, travelling between the two terminals.

Smoke

As the ventilation dampers closed immediately, the penetration of smoke into the amenity coach was very limited. This was no longer the case once a door was opened.

Lighting

This continued to operate correctly, on batteries, after the loss of power supply to the rake from the catenary.

4.2.4 Effect of fire on the infrastructure

The tunnel lining was destroyed over a length of 750 metres in Running Tunnel North (RTN), with the greatest damage over a length of 16 metres between PK 48.417 and 48.433 (area of carrier wagon 24) and over a length of 284 metres between PK 48.417 and PK 48.701. The apparent depth of spalling varied, but in certain cases it extended to the whole depth of the concrete lining, i.e. approximately 40 cm (see figures 35 and 436).

The equipment fastened in the area of the fire was destroyed.

Figure 35: Damage suffered by the tunnel lining at the level of the tunnel roof

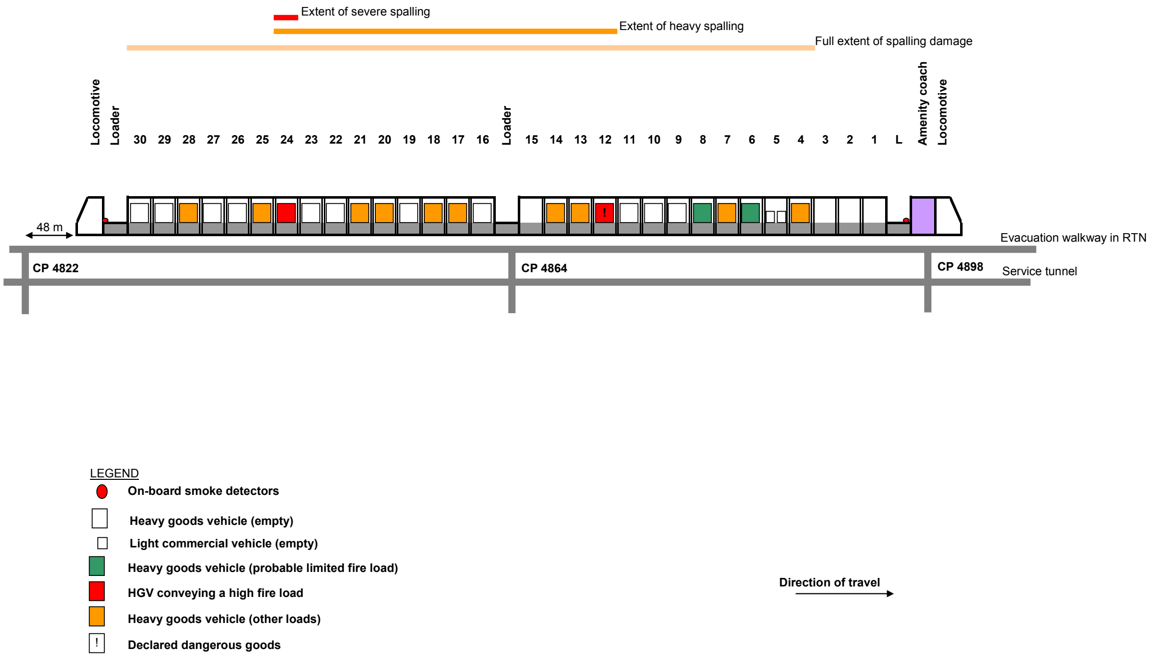


Figure 36: Location of mission 7412 when stopped in the Running Tunnel North (RTN) and the associated damage suffered by the tunnel lining

4.2.5 Summary of the reports by the emergency services

4.2.5.1 Alarm and activation of a rescue operation

At 15:54 hrs, the rail control centre (RCC) activates the rescue operation.

The two French first line response teams (FLOR FR) head for the scene. One UK first line response team (FLOR UK), on patrol in the service tunnel, is also alerted and goes to the scene.

Each of the FLOR teams consists of a driver, a leader and a two-person team. They travel on a special vehicle referred to as the “service tunnel transport system (STTS)”.

At 16:00 hrs, numerous detection events, particularly the detection of carbon monoxide, suggest a large fire. Reinforcements are requested and the first level of the specialised emergency plan (PSS) is activated.

At 16:04 hrs, the tunnel officer confirms the request for reinforcements and then asks for the bi-national emergency plan to be activated (BINAT); activation of this is official at 16:25 hrs.

In the UK, the Kent police immediately put in place a qualified officer to activate the incident coordination centre (ICC) to support the French authorities in the PCO, the role of the Kent police being to provide coordination for the UK emergency services.

At 16:13 hrs, having travelled the 12 km between the emergency centre and the site of the intervention, the FLOR FR (consisting of STTS no. 34 and no. 32, and the Communication STTS, i.e. a total of 9 fire-fighters: 4 + 4 + 1) arrive at cross-passage 4898.

The FLOR UK team, which was on patrol, arrives on the scene at about 16:15 hrs and makes contact with the French FLOR. It provides a link with the train crew and first aid for the injured passengers.

The other FLOR teams who come to the scene are sent to the adjacent cross-passages to look for the missing passengers.

The first information confirms the extent of the occurrence:

- the fire and smoke detectors at the various monitoring stations are reacting,
- the FLOR teams hear successive explosions coming from the North Tunnel,
- initial information from the ISIS system indicates the presence of dangerous materials being transported (100 kg of phenol in wagon no. 13)[19].

The date of the incident (anniversary of the attacks of 11 September 2001), is also a reason to fear an attack on the tunnel. In anticipation, at 16:30 hrs, the officer from the Centre Opérationnel Départemental d'Incendie et de Secours [Regional Fire and Emergency Operations Centre], (CODIS), alerts the decontamination services.

The incident coordination centre (PCO) at the French Coquelles terminal is opened at 16:33 hrs. The first officer from the Service Départemental d'Incendie et de Secours (Departmental Fire and Rescue Service) (SDIS) arrives at 16:35 hrs.

The préfecture activates its Defence Operations Centre. The SDIS dispatches a high-level officer there at 16:42 hrs.

At 17:24 hrs, the sous-préfet arrives at the PCO, activates the incident coordination centre (PCO) and takes control of the emergency operations.

On the UK side, the ICC is connected to the PCO by video conference. It is clearly understood that the PCO is managing operations, with the ICC in support. Translators are provided by Eurotunnel and by the Kent police to facilitate verbal communication.

The Minister of the Interior is at the scene during the evening to take stock of the crisis together with the emergency operations director (directeur des opérations de secours) and the emergency operations commander (commandant des opérations de secours).

4.2.5.2 Aid to personnel

When it arrives at CP 4898, the FLOR sees that the chef de train has been able to assemble 27 people. There are four people missing. Very quickly, at about 16:13 hrs, two of those passengers appear at CP4898, having made their own way back from RTN. The last two, who have started to walk in RTN towards France and reach the service tunnel by their own means at CP 4932, are recovered at 16:26 hrs.

At 16:44 hrs, a message from the FR FLOR officer indicates that the casualties are being treated, that there is a major fire on a lorry, that all of the passengers are in the service tunnel (32 people including the crew), that there are three people who have been injured by glass and that some people are suffering from smoke inhalation.

[19] It has emerged that the ISIS system did indicate the presence of 100 grams of phenol and that this information is the result of a reading error.

At 17:00 hrs a report states there are 6 casualties: two people injured by glass and four suffering from the smoke. First aid is provided by the fire-fighter paramedics and by the Calais emergency medical services, who are at the scene at 17:04 hrs. The six casualties are evacuated at 17:45 hrs.

4.2.5.3 Putting out the fire

At about 16:30 hrs, the second FLOR UK team arrives at CP 4864. Through the closed door of the passage they hear and feel explosions, leading them to believe that the fire is close to that door.

The FLOR prepares to put out the fire. The teams assemble the pipes necessary to attack the fire through CP 4898 near to which the train has stopped.

Once the leader has made sure that the electricity has been effectively cut off, the two-man teams from the FR FLOR set up 2 hoses, then a third with the help of the UK FLOR and the backup teams from the French second line of response (FR SLOR).

The UK FLOR says that it cannot take part in fighting the fire until it has been confirmed that the catenary has been earthed on either side of the site in accordance with UK fire service rules.

At 16:55 hrs, the first assault on the fire is carried out from the front of the train using the three hoses that have been installed. The seat of the fire has already developed. It is more than one hundred metres from the access point and the progress of the personnel wearing personal breathing apparatus is very difficult given the heat, the smoke and the narrowness of the pathways in the tunnel.

At 18:20 hrs, a message from the emergency centre (FEMC) reports that the “fire has been brought under control on the front rake”. The information is passed on to the PCO as “fire under control”. The PCO asks for confirmation that the fire has been brought under control but does not obtain an immediate response. This interpretation, repeated on the official messaging system (SYNERGI) will subsequently be a source of ambiguity.

At 18:23 hrs, the DDIS takes command of emergency operations. He very quickly states that “the fire has not been brought under control”.

During this time, inside the tunnel, the fire-fighters continue to fight the fire. The size of the fire and its calorific potential mean there is a fear of the fire spreading to the whole of the train. To assess the progress of the fire, the commander of emergency operations at the front (COSA) asks for the cross-passage located at the middle of the train to be opened.

With the agreement of the PCO, the fire-fighting teams manually open the doors of cross-passages 4822 and 4864, as the electric control mechanism for the doors was out of action.

At 18:19 hrs, once the CP 4864 has been opened, the teams observe that the fire has already destroyed the lorries in the first part of the train and is spreading to the second part.

The French and UK teams decide that the French fire-fighters should redeploy to CP 4864 and start fighting the fire from the middle of the train towards the rear while the UK fire-fighters enter through CP 4822 and attack the fire from the rear of the train. It is also decided to gradually reduce the flow of air from the SVS.

At 18:46 hrs, when the UK teams enter through CP 4822, they find that the last lorry on the train is already on fire.

At 19:38 hrs, the system of a combined attack is in place. While getting into position, the emergency services are delayed by a problem with the water supply: the UK fire-fighters do not have any water at cross-passage 4822. After investigating it is found that a valve which should have been open is wrongly closed. A Eurotunnel technician finds the valve and opens it at 19:35 hrs.

The doors to CP 4864 and 4822 have to be operated by hand as the electric control is out of operation.

Overall, the work of the fire-fighters was made difficult by:

- debris on the walkways
- not enough space to deploy the pipes
- the distances between cross passages and the locations for fighting the fire
- poor visibility from both sides of the fire
- high temperatures

During this phase, the UK fire-fighters, who are downstream of the ventilation flow, are particularly exposed to the smoke and hot gases being pushed in their direction. The SVS is lowered to 2 to limit this impediment to their progress. Given these conditions, the firemen on the UK side cannot be in the tunnel for more than 10 minutes.

To improve the effectiveness of the system, the PCO develops a new fire-fighting strategy. This involves concentrating efforts to stop the fire with a view to saving the infrastructure and the trailing locomotive.

The UK advance is then stopped and 2 water curtain hoses are placed at the rear of the train on the loading wagon. The French and UK fire-fighters can then join forces to fight the fire in the middle of the train. The SVS flow is increased again in stages up to level 5 to reduce the CO level and the ambient temperature.

The fire-fighters with hoses advance with the help of two reinforced hoses and then a portable water canon brought in through CP 4864. The greater extinguishing capability means that conditions are more acceptable. At the same time, a new hose is brought into use through CP 4898 to complete extinguishing on the front rake.

The fire-fighting teams are relieved under health control conditions and additional personnel are brought in from the outside of the tunnel.

The fire-fighters advance towards the rear rake. However, they encounter difficulties at wagons 24 and 25, and at wagon 28 because of the very high calorific values of the goods on board and the heat reflected from the concrete. Once this point of resistance has been combated, their progress becomes more rapid.

At about 1:00 hrs on 12 September 2008, it becomes clear that there is no longer much point in fighting the fire from CP 4822. It is then decided to install a wall of water over the last carrier wagon to protect the rear locomotive and to close CP 4822 again.

All of the teams are then working from CP 4864 with 4 hoses in operation. Water consumption from this CP reaches $100m^3/h$.

At 7:50 hrs on 12 September 2008, the fire is effectively under control. At 11:46 hrs, after continuing operations on the residual hot spots, the fire is considered to have been extinguished.

The smoke manages to get into the technical rooms although they are equipped with fire doors, in particular at room W3 containing pumps and 21 kV electricity transformers. The penetrating smoke is examined by the UK fire-fighters who conclude that it does not present a hazard for personnel and that it is unlikely that it will get into the service tunnel.

4.2.5.4 Cooling and surveillance

At 13:00 hrs on 12 September 2008, the operation is nearing completion. The BINAT plan is stopped (BINAT STOP procedure) bringing an end to the support by the UK emergency services. Partial hot spots of the fire and materials where combustion is incomplete remain, which are still being fed by the effect of the ventilation. Regular spraying with water is therefore essential to prevent the fire from breaking out again.

The ground is strewn with piles of debris. Metal structural elements, deformed by the heat, are further complicating the progress and activities of the teams that are still working.

Residual combustion means that the fire-fighters have to perform their activities with breathing equipment and at a very high temperature given the heat absorbed by the structure.

These activities are undertaken while reducing the number in the relief teams which change gradually from 50 to 30, then to 20 fire-fighters.

It is followed by a surveillance operation which ends on Monday, 15 September 2008 at 20:00 hrs. It is then agreed with Eurotunnel that the public service will be withdrawn to leave the FLOR teams to perform alternating surveillance during their patrols.

The UK emergency forces consisted of 213 fire-fighters, 50 to 80 of whom were simultaneously involved in fighting the fire. The French emergency forces comprised 504 fire-fighters.

4.3 Conditions for resuming running

Immediately after the fire, the safety authority of the intergovernmental commission (IGC) has asked Eurotunnel to:

- ensure the traceability of all of the inspections performed and decisions taken,
- check that the operating procedures corresponding to each stage in the reopening of Running Tunnel North, are documented and that they observe the safety provisions and operating instructions previously approved by the IGC and the Safety Authority,
- make sure that, at each stage of the reopening, the public services in France and the United Kingdom are informed of the operating procedures applied and that they are reminded of the specific emergency procedures.

Traffic resumed on Saturday, 13 September 2008 with trains running in Running Tunnel South and intervals no. 2 and 4 in Running Tunnel North were opened on 22 September 2008 and 28 September 2008 respectively.

4.4 Safety management

The fire of 11 September 2008 reveals a certain number of important safety issues that have not been identified or properly dealt with within Eurotunnel's safety management system.

The following table lists these issues and, for each one, summarises the associated underlying factors that have been identified during this investigation as well as more general safety management problems.

Subject	Safety problems identified during the investigation	Underlying factors concerning safety management	Possible general safety management problems
Evacuation	The chef de train was not able to control the reactions of the passengers and play his part in organizing the evacuation. The chef de train was not able to access the front of the coach where the evacuation door and some of the breathing masks are normally situated.	The role of the chef de train in an evacuation has been subjected to job analyses. However, these have not realistically assessed the probable behaviour of the passengers when they perceive an imminent danger or the ability of the chefs de train to control the situation, despite the precedent of the 1996 fire, which demonstrated the extent of the problem. These details have not been sufficiently taken into account in the design of the coaches (for example, visibility through the window in the end door) and in their operating procedures (position of the chef de train's workstation). The impact of passenger behaviour was not taken into account in selecting and training personnel.	Insufficient account taken of the ability to control emergency situations when selecting, training and assessing personnel. Insufficient account taken of the recommendations from investigations into previous fires.
Driving procedures.	Even though the controlled stop procedure was applied correctly, the door for evacuation from the amenity coach was not in line with the cross passage.	The fault in the controlled stop procedure had not been identified by the managers although the drivers are obliged to practise a controlled stop once a year and the exercises involving evacuation of freight shuttles have been performed. Correct performance of the controlled stop was verified only by the position of the driver's cab with regard to the stop marker; the position of the amenity coach door compared to the cross-passage was not considered as a criterion for success.	Insufficient questioning of safety-critical hypotheses contained in the procedures. Insufficient use of return on experience in looking for latent faults in the system.

Subject	Safety problems identified during the investigation	Underlying factors concerning safety management	Possible general safety management problems
Rail control centre.	The EMS controller's high workload could not have been managed by one person, but the availability of a qualified assistant in case of need is not guaranteed in the current organization of the RCC.	The need for an additional qualified person to assist the EMS controller had been correctly identified after the 1996 fire. However, no reliable action had been taken to guarantee that this person would be available in all circumstances.	Insufficient account taken of the recommendations from invest-tigations into previous fires. No analysis of the RCC system's operating reliability, taking account of human factors in an emergency situation. Insufficient questioning of existing systems, rules and procedures.
Rail control centre (continued)	The breakdown of the 21 kV supply had a significant impact on the management of the incident by the RCC, particularly in generating fault messages which the EMS controller had to deal with. Faced with multiple faults, the EMS controller had insufficient guidance from the systems, or the procedures, to properly manage the equipment.	Eurotunnel was aware of the possibility of a 21 kV fault during a fire but had not performed any detailed analysis of the consequences on the various systems or their effect on the control of those systems. Eurotunnel had thought that its control systems and procedures were fit for purpose (despite the errors observed in the management of the 2006 fire). Before 11 September 2008, Eurotunnel had not planned to verify its control systems and procedures. An EMS simulator has been used for training since 2000. However, the number of scenarios that it is able to simulate is limited. In particular, it is not able to simulate complex and multiple failures in emergency situations.	No analysis of the operating reliability of critical systems in emergency situations. No search for any improvements that might reasonably be made to safety-critical systems and procedures. Insufficient training of personnel in complex emergency situations.
Technical management and maintenance	The troubleshooters used an unofficial method to lock the door from the amenity coach, thereby preventing its use in an emergency.	Eurotunnel thought that the coach door reliability problem was not connected with safety and so improving the doors was not a priority for the technical departments. The lack of reliability of the coach doors caused the troubleshooters to develop unofficial repair methods, the consequences of which were not analysed. The department responsible for rolling stock maintenance did not sufficiently supervise the troubleshooters' work.	Insufficient search for improvements that might reasonably be made to safety-critical systems and procedures. Inadequate engineering methods and resources. Ineffective control and audit procedures.

Subject	Safety problems identified during the investigation	Underlying factors concerning safety management	Possible general safety management problems
Operation of rolling stock	The coach was kept in operation even though its evacuation door could not be used in an emergency.	The procedures do not make a distinction between the case of a door that is isolated (can be used manually in an emergency) and the case of a door that is locked out (impossible to open).	Insufficient search for latent faults in the procedures.
Fire fighting	The catenary earthing procedures were not all completed until approximately 2 hours after the alarm was raised.	The need to improve the provisions for earthing the catenary had been identified after the fires in 1996 and 2006. None of these measures could be agreed on by the various parties before 11/09/2008. The procedures and resources for fighting a fire come within the competence of multiple decision-makers.	Insufficient account taken of the recommendations from invest-tigations into previous fires. No policy decision to settle the debate between ET, IGC and UK fire brigade.
	No supply of water for the UK fire-fighters when attacking the fire because a valve was unexpectedly closed.	Although the risk of a valve being closed had been identified, it had not been adequately mitigated despite the tendency of maintenance and cleaning teams to use the fire hydrants to get water.	No analysis of the operating reliability of systems concerned in the event of a fire in a running tunnel.
	The ventilation systems were not managed in the best way to limit the spread of the fire.	The need to specify ventilation management rules after the end of evacuation had been identified after the 1996 fire. However this did not lead to a clear set of rules being produced.	Insufficient account taken of the recommendations from invest-tigations into previous fires.
Change management	Assessment of the consequences of not having a member of catering staff in some missions was based on the hypothesis that the train driver would be available to perform certain tasks that previously fell to the member of catering staff. This assumes that evacuation would always take place in air that has been cleared of smoke by the SVS.	Eurotunnel has not performed an adequate prior evaluation of the risk connected with this change, nor a validation exercise showing that the safety tasks performed by the member of catering staff could be performed by the driver in all imaginable cases.	Insufficient quality of safety investigations connected with the change management process.

4.5 Previous events of a similar nature

There have been two freight shuttle fires, in 1996 and 2006.

In 1996, fire broke out on a lorry in the rear part of the shuttle, probably before the train had even entered the tunnel on the French side.

As the strategy at that stage was to bring the train that was on fire out of the tunnel, the train continued on its route. However, 19 km after entering the tunnel, the driver had to stop as the fire had prompted a signal that the wagon stabilisation jacks had lowered.

Despite a controlled stop beside a CP, evacuation was delayed and hindered by smoke which was present because of incorrect control of the SVS.

The smoke also penetrated into the neighbouring running tunnel as cross-over doors were open.

There were no casualties, although the damage was considerable.

In 2006, a fire started in a lorry located near to the back of the train; it was first detected 6.2 km after the train had entered the tunnel on the UK side.

The controlled stop rule was applied; evacuation took place normally.

There were no casualties and the damage was limited because the fire did not spread to the adjacent vehicles and extinguished itself once the train had stopped. Normal operation of the tunnel resumed the next day.

In 2006, the controlled stop rule was in force. The shuttle therefore stopped as specified once the detection devices indicated a fire on board.

As a consequence of these fires, various measures were taken, the main one being, in 1996, to change strategy and bring in the controlled stop rule.

The recommendations issued by the Channel Tunnel Safety Authority following the enquiry into the fire of 18 November 1996 are included in Annex No. 6 and those issued by the RAIB following the fire of 21 August 2006 are included in Annex No. 7.

4.6 Measures taken by Eurotunnel after the fire of 11 September 2008

On 11 March 2009, Eurotunnel presented the Safety Authority with its plan of action, drawing the first lessons from the 2008 fire.

This plan of action was called "Project Salamander" and was in three parts:

- Improving prevention,
- Accelerating and improving intervention by the fire-fighting services,
- Creating dedicated fire-fighting zones in the tunnel.

In parallel with this project, more immediate measures were taken concerning, in particular, rules on the maintenance and use of amenity coaches and the controlled stop procedures for freight shuttles.

5 Final report on the chain of events

In this section, the text in italics is a commentary on the facts set out.

5.1 Events prior to the detection of the fire

5.1.1 Loading of mission 7412

The rake that is to form mission 7412 arrives at the UK terminal at 15:10 hrs, after having already made several trips between the United Kingdom and France for most of the day. The rake is in the normal configuration with the amenity coach located behind the leading locomotive.

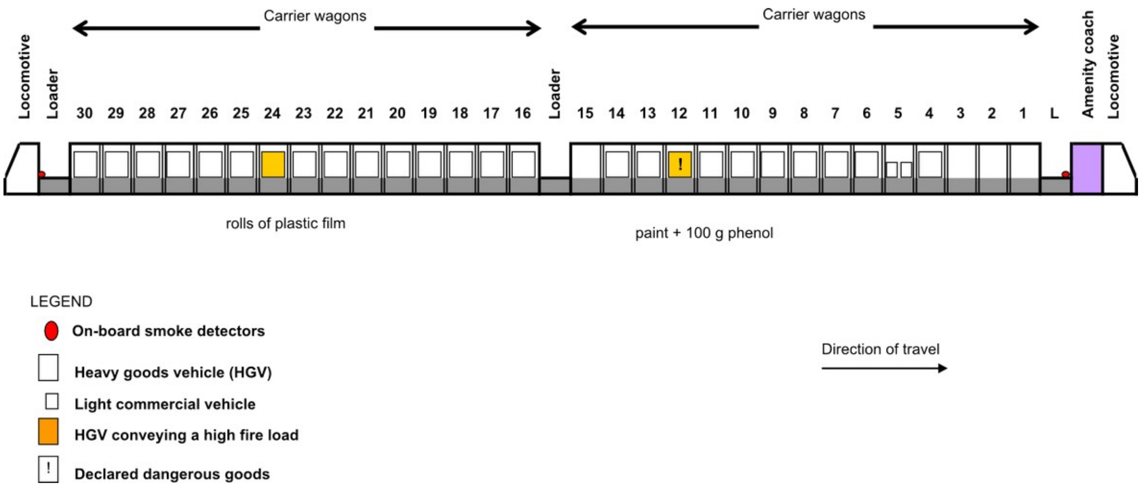


Figure 37: Composition and loading of mission 7412

The driver and chef de train on mission 7412 are performing their first trip of the day on this shuttle. The chef de train who is handing over alerts the new chef de train to the fact that door 3 in the amenity coach is defective and has been isolated.

The loading plan for mission 7412 specifies that there is a light utility vehicle (van) to be placed on the first wagon loaded (the 4th wagon in the rake) Eurotunnel's rules stipulate that the first vehicle on a shuttle must be a HGV. The van therefore has to be swapped with the HGV following it. This change results in two short vehicles being positioned one behind the other. They are permitted by Eurotunnel's rules to be loaded on the same wagon instead of being loaded on two different carrier wagons as originally specified. Consequently, all the vehicles on the first half-rake are displaced from wagon no. 6 onwards and wagon no. 15 is empty.

Mission 7412 starts loading at about 15:20 hrs. A total of 27 freight vehicles are loaded (see Figure 37). One of the vehicles, carrying dangerous goods that had to be declared on arrival at the terminal (see Section 4.2.1), is now on wagon no. 12 instead of wagon no. 13. The loading information is not amended in the ISIS database.

Loading takes place without incident, apart from the fact that the driver of the first of the two light utility vehicles (a Peugeot refrigerated van), loaded on the fifth carrier wagon, was not able to put out his headlights. Having been informed by the loading agent, he lifts the van's bonnet for a few seconds to try to disconnect the battery, but is not able to do so. The headlights remain on although the rear lights are off. The driver of this van then goes to the minibus to be transported to the amenity coach.

Believing that the headlights have been turned off, the loading agent declares loading finished.

29 passengers are taken from their vehicles to the amenity coach by minibus.

The rake therefore leaves with 32 people on board, counting the 3 crew members (chef de train, driver and the member of the catering staff).

5.1.2 Travel through the tunnel

Mission 7412 departs from the UK terminal, as planned, at 15:36 hrs. On departure, it is subjected to a visual inspection by two agents de feu (fire officers) from the loading team, for any sign of fire or other hazard. The shuttle enters Running Tunnel North.

A video-surveillance camera located just inside the tunnel portal confirms that the headlights of the first vehicle on the fifth carrier wagon (the refrigerated van) were on when mission 7412 passed by.

The shuttle travels without incident, until approximately 15:54 hrs.

5.2 Detection of the fire and stopping of mission 7412

5.2.1 On board the shuttle

In the amenity coach

Shortly after mission 7412 has passed the mid-point of the tunnel, the chef de train hears an unusual noise which only lasts for a very short time (later he will describe it as a dull bang, a "boom").

It is not unusual to hear noises from the shuttle while going through the tunnel: he does not see any reason to be alarmed.

At about 15:54 hrs, an audible smoke alarm coming from the last loading wagon sounds and is confirmed by a display on the chef de train's workstation. Through the window of the door at the end of the amenity coach he sees flames which seem to be coming from a road vehicle located at the front of the shuttle. In accordance with Eurotunnel procedures, he reports the fire to the driver of mission 7412, using the intercom, and closes the ventilation dampers in the coach; as he is expecting a decision to stop the train and evacuate the passengers he tries to advise the passengers that they are going to be evacuated to the service tunnel.

This information is difficult to convey as several passengers do not speak English. However, several passengers are already aware of the fire as some have heard the alarm and have also seen the flames through the window in the end door.

After about a minute, the chef de train realises that the shuttle is not slowing down; he therefore contacts the driver again to tell him that he can see the fire and that the shuttle must stop.

The chef de train and some of the passengers see that the first road vehicle on the shuttle (a HGV) is outlined against the flames, giving the impression of a major fire burning behind that vehicle and/or on the vehicles immediately behind. The crew and passengers also hear several explosions.

The source of these explosions cannot be determined with certainty, although it is probably connected with the explosion of tyres and or fuel tanks[20].

While the shuttle is slowing down, the chef de train, assisted by the catering agent, hands out breathing masks to the passengers. In accordance with Eurotunnel procedures, the chef de train tries to show the passengers how to use a breathing mask. The passengers are agitated and some of them are gathering in the central aisle of the amenity coach, thereby creating a blockage between the chef de train at the rear of the amenity coach and the catering agent at the front.

In the driver's cab

At about 15:54'30'', the driver of mission 7412 is first alerted to the fire by the message from the chef de train. In accordance with Eurotunnel's procedures, he tries to contact the rail control centre (RCC), but neither the track-to-train radio nor the concession radio are working. He continues travelling at normal speed (140 km/h) because Eurotunnel procedures stipulate that he must have permission from the RCC before stopping the shuttle. However, in the event of a total loss of radio communications in the tunnel and if there is a danger for passengers with the need to stop, the driver must perform a controlled stop and evacuate the locomotive.

The notion of need is not defined, nor is the time for which the driver must try to contact the RCC before deciding to stop. In particular it should be specified whether the activation of a fire alarm involves the need to stop or whether it is possible to continue until the fire is confirmed.

He continues trying to contact the RCC, but in vain, and does not hear the instruction given at about 15:57'30'' by the RTM controller ordering all trains to slow to 100 km/h (see Subsection 3.5.3.3).

After having been contacted for a second time by the chef de train one minute later, the shuttle driver decides to stop the shuttle without waiting for an order from the RCC.

At about 15:58 hrs, the RTM controller manages to contact mission 7412 and orders a controlled stop. At that moment the shuttle is approaching CP 4898 and is travelling at less than 30 km/h. The driver decides to perform a controlled stop beside that cross-passage.

At about 15:58'30'', the driver stops the shuttle in the position stipulated, with the driver's cab window beside the controlled stop marker. At this stopping point, he can see the marker indicating PK 49 but has not spotted the number of the cross-passage.

[20] This statement is confirmed by the results observed in fire tests on vehicles carried out by Eurotunnel in 1992 and by the experience of the fire-fighters.

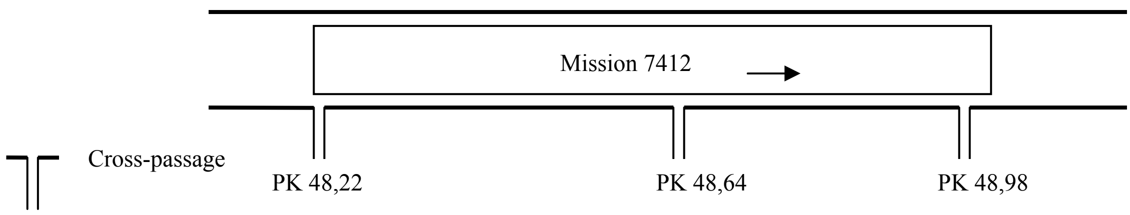


Figure 38: Position of the shuttle

5.2.2 In the rail control centre

At 15:54'21'', the fire detection (FD) controller receives a "fire" alarm coming from the detector located at cross-passage 4132, followed 22 seconds later by a "smoke" alarm at cross-passage 4202. The FD controller alerts the rail control centre (RCC) Supervisor of a first alarm and then of a second alarm.

The Supervisor does not announce these two alarms to all of the staff in the RCC.

According to Eurotunnel procedures, he should have made these two announcements. However it was of little consequence as the controllers had heard the message from the FD controller to the Supervisor.

The FD controller continues to monitor the fire and smoke alarms in the tunnel, some of which have been triggered as mission 7412 passes by.

At 15:55'15'', the Supervisor announces that the freight shuttle must stop and the evacuation of passengers and crew must take place.

The purpose of this announcement is to trigger several actions by the RTM and EMS controllers (see point 3.5.3.3).

The EMS controller

At 15:56'10'', the EMS controller has finished:

- putting on the lighting in the tunnel;
- closing the piston relief ducts connecting the two running tunnels;
- adjusting the normal ventilation system in the service tunnel.

The RTM controller

At 15:57'30'', the RTM controller has finished:

- taking steps to prevent any new train from entering the tunnels,
- instructing all of the trains travelling behind mission 7412 in Running Tunnel North to stop,
- instructing other trains travelling in the tunnel (including mission 7412) to limit their speed, first to 100 km/h, and then to 10 km/h.

At 15:58 hrs, he instructs the driver of mission 7412 to perform a controlled stop beside a cross-passage in order to proceed with the evacuation.

At that time the driver had already decided to stop and his shuttle had slowed to 30 km/h.

The Supervisor

The Supervisor monitors the actions of the three controllers during the initial phases of the incident, as specified by the Eurotunnel procedure.

In reality, given the number of actions performed by the controllers at the same time, it is not realistic to believe that he can supervise each of their actions.

5.3 Notice to the emergency services

When the first fire alarm goes off, there is a UK first line of response team (UK FLOR) carrying out a routine patrol in the service tunnel. It is approximately 15 km from mission 7412. The FD controller contacts them at 15:55 hrs and asks them to go to the site where the alarms have gone off (interval 6).

Immediately afterwards, the FD controller contacts the French FLOR team, which is in the emergency centre (FEMC), near the French portal, and sends them into the tunnel.

At 15:56 hrs, he calls the Kent Fire & Rescue Service and informs them of the incident. He then contacts the South East Coast NHS Trust (ambulance service) to inform them of the fire in the tunnel. Shortly afterwards, the Kent Police control centre calls him, trying to get more information following a call from Eurotunnel. These three calls take about 7 minutes.

It takes this long because he has to give the information and make sure that the nature and location of the incident have been correctly understood three times (once for each of the emergency services). The process is faster on the French side because the emergency services are notified by the "stationnaire", a fire-fighter stationed in the French FEMC.

5.4 Evacuation of mission 7412 to the service tunnel

5.4.1 Stopping and first reactions of the passengers

The shuttle stops at 15:58' 41''; straight away, there is smoke surrounding the amenity coach, but it does not get inside as the chef de train has closed the coach's ventilation dampers.

At this stage, the chef de train does not know when the cross-passage door will be opened, nor, moreover, whether the shuttle has in fact stopped beside a cross-passage. He is not therefore able to give any reassuring information to the passengers. In any case, his ability to communicate with the passengers is limited because many of the passengers are wearing breathing masks and the chef de train only speaks English (his French is very limited). Furthermore, almost 60% of the passengers come from countries where the language is neither English nor French. There is no pre-recorded announcement available to cover this situation.

At about 16:01 hrs, the driver transfers control of the shuttle to the chef de train. After that time the driver can only move the train once he has received a new authorisation from the chef de train.

Some passengers are starting to get agitated. Because of the density of the smoke around the amenity coach it is impossible to see through the windows.

One of the passengers tries to open the front right-hand door of the coach and finds that he cannot open it as it is locked.

During an evacuation, the Chef de Train would normally be positioned at this door through which evacuation would be expected to take place. On 11 September 2008, he has been unable to reach this door because of the number of passengers standing in the gangway and leading vestibule.

Some passengers open the front left-hand door manually, using the emergency control, as the chef de train has not released the normal opening system. Five passengers leave by that door onto the maintenance walkway and head towards the front. One very quickly comes back into the amenity coach.

5.4.2 Evacuation of the passengers still in the amenity coach

At 16:01’22’’the door of cross-passage 4898 opens. The air bubble effect (see section 3.2.6.1), plays its part and the smoke is moved away for some metres on either side of the door. Through a side window in the amenity coach, the passengers see that the cross-passage door is open. Although the driver has stopped the shuttle correctly at the place indicated by the stop marker, the front right-hand door of the amenity coach is approximately 4 metres past the cross-passage. The cross passage is opposite the first window in the amenity coach.

This incorrect position is due to an error in document ORT2/0001 describing the controlled stop procedures. The document instructs drivers to stop with the side window of the cab beside the stop marker. This does not result in the amenity coach evacuation door being opposite the cross-passage.

Although the chef de train has called to the passengers to follow him and leave the amenity coach through the rear right-hand door, they instead break the glass of the first window using a hammer provided for that purpose. The holes made by the hammer are not big enough for a person to pass through. One of the passengers kicks most of the remaining glass out of the window. It is approximately 16:03’30’’, twenty-five passengers and the catering agent evacuate the amenity coach through this window in approximately two-and-a-half minutes. Some of them cut themselves on bits of glass still in the window frame and others suffer bruises when they fall onto the walkway.

The chef de train leaves the amenity coach through the rear right-hand door and heads for the cross-passage by walking along the evacuation walkway. None of the passengers follow him. After having covered 20 metres in the smoke he enters the area of fresh air around cross-passage 4898, at about 16:06 hrs. All the passengers who left through the window are already in the cross-passage or the service tunnel.

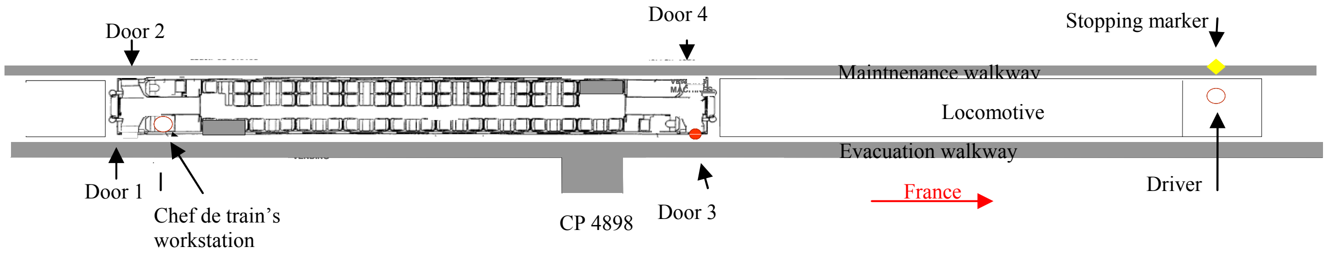


figure 39: Position of the amenity coach after shuttle 7412 has stopped

During evacuation of the amenity coach on mission 7412, the doors are used as follows:

- door no. 1 is opened by the chef de train and used by him,
- door no. 2 stays closed,
- door no. 3 is locked
- door no. 4 is opened by the passengers and used by five of them; one person quickly comes back into the coach, the four others head towards the front of the train,

Also, the window beside the cross-passage is broken by the passengers and used by 25 passengers and the member of the catering staff.

Figure 40: View of the amenity coach from the service tunnel through cross-passage 4898 (showing the window through which the majority of the passengers left)

5.4.3 Evacuation of the passengers who left the shuttle prematurely

The four passengers who left the shuttle by the maintenance walkway, which on the other side of the train from the evacuation walkway connected to the service tunnel, split into two groups.

Having started to walk along Running Tunnel North, in the smoke, towards France, the first group finally turns around and returns to CP 4898 at about 16:16 hrs, the smoke having been dispersed by the SVS in the meantime.

The second group continues to walk towards France and gets into the service tunnel through the open door of the next cross-passage (CP 4932), after having spent about 6 minutes in the smoke before it is cleared by the SVS; that door had been opened as part of the procedure which calls for the opening of two doors at the same time. They have covered approximately 340 metres in the tunnel. At about 16:26 hrs, they are collected by a FLOR emergency team deployed to the incident through the service tunnel, and are reunited with the other passengers who have been evacuated.

At 16:37 hrs, all of the passengers are together at CP 4898.

5.4.4 Evacuation of the driver of mission 7412

When the shuttle stops, the driver sees the PK 49 marker in front of his train. One or two seconds later the smoke envelopes the locomotive.

The driver notifies the RTM controller that he is at PK 49 but he cannot identify the cross-passage at which he has stopped because the controlled stop marker is no longer visible[21].

The driver lowers the pantograph on the front and rear locomotives, shuts down his driving panel and immediately transfers control of the train to the chef de train, i.e. the chef de train becomes responsible for the safety of the passengers. The chef de train is thereby assured that the train will not start up again without his agreement.

Normally the driver must not leave his cab if he cannot see the handrail on the walkway outside. He must stay in his cab and wait for the SVS to clear the smoke.

Because of the density of the smoke in the tunnel, the driver cannot see the handrail. Although there is little penetration of smoke into the cab, as time passes the driver starts to worry that conditions are not improving and decides to evacuate. At 16:04 hrs, he asks the EMS controller to open the door of the closest cross-passage. The EMS controller tells him that the cross-passage door is actually open. He puts on his breathing mask and leaves the driver's cab at about 16:06 hrs. Because of the low visibility he has to crawl, holding on to the handrail for approximately 25 metres and reaches CP 4898 at about 16:08 hrs, around the time when the SVS is starting to clear the smoke.

[21] The number of the adjacent cross-passage is displayed on each controlled stop marker.

5.5 Management of the shuttle evacuation by the Rail Control Centre

5.5.1 The RTM controller

The driver informs the RTM controller that the shuttle has stopped at PK 49. The RTM controller passes the information to the EMS controller.

5.5.2 The Supervisor

Only knowing the PK at which mission 7412 has stopped, he looks for the corresponding cross-passage number in the tunnel pocket book[22]. This takes about two minutes. He concludes that the relevant cross-passage is CP 4898. He tells the EMS controller.

During this search, the Supervisor is not able to supervise the actions taken by each of the controllers in the rail control centre and, in particular, the very important actions such as the rapid activation of the SVS.

5.5.3 The EMS controller

While waiting for the number of the cross-passage where mission 7412 has stopped, the EMS controller starts the SVS fans in order to push the smoke back towards the rear of the shuttle. At 16:00’52’’, the two fans at Sangatte have received the command to start in blowing mode and the two fans at Shakespeare Cliff to start in extraction mode.

When the Supervisor has informed him of the cross-passage where the shuttle has stopped, the EMS controller opens first the door of CP 4932 (located beyond the front of mission 7412) at 16:01’14’’ and then the door of CP 4898 (beside mission 7412) at 16h01’22’’. Mission 7412 has stopped for almost three minutes.

5.6 Exit of other missions

There are four missions inside Running Tunnel North and three others in Running Tunnel South when the fire is detected.

5.6.1.1 Missions in the North tunnel

At 15:54’50’’, activation of the “second alarm” screen by the RTM controller immediately generates a stopping sequence for the following missions. There are three missions in the tunnel behind mission 7412. Mission 7414 (also a freight shuttle), the closest, stops at PK 38.64, i.e. approximately 10 km from mission 7412. Missions 6420 and 7420 stop at PK 19.62 and PK 13.34 respectively.

Eurostar 9030 is travelling in front of mission 7412 and leaves the tunnel at 15:56 hrs, before mission 7412 has stopped.

At 16:01 hrs, the RTM controller instructs the driver of the following mission (7414) to change ends. Then, at 16:05 hrs and 16:07 hrs, he gives the same instruction to missions 6420 and 7420, to prepare for their evacuation by reversing.

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[22] The tunnel pocket book is a document with simplified information on the fixed installations in the tunnel, covering the areas of track, signalling, catenary and other installations.

At 16:16 hrs and at 16:20 hrs, reconfiguration of the electric traction system and signalling to allow reversal of trains in Running Tunnel North has been completed.

At 16:18 hrs, the driver of mission 7414 confirms that he has changed ends. The mission departs back to the UK at 16:24 hrs after a stop of 27 minutes.

At 16:30 hrs, the driver of mission 7420 confirms that he has changed ends and he leaves for the UK, while at 16:32 hrs the driver of mission 6420 confirms that he has changed ends and leaves in turn.

In accordance with Eurotunnel's rules, the RTM controller authorised the departure of these three shuttles at a speed of 20 km/h to avoid interfering with the ventilation regime established. They leave the tunnel at 16:40 hrs (mission 7420), 17:02 hrs (mission 6420) and 17:38 hrs (mission 7414).

Analysis of the data extracted from the fire detection system indicates that mission 7414 started to return towards the UK approximately 40 minutes before the dense smoke reached the place where it stopped.

5.6.1.2 Missions in the South Tunnel

There are three missions in Running Tunnel South when the fire breaks out.

At 15:55 hrs, the RTM controller puts out a general call to ask trains in both tunnels to travel at 100 km/h and to close the ventilation dampers on their trains.

At 15:58 hrs, the RTM controller puts out a general call, which now only concerns trains in Running Tunnel South, to travel at 10 km/h, which will enable the EMS controller to start the SVS. Mission 6419, a tourist shuttle, is in interval no. 5 while missions 7413 and 7411 are in interval no. 1[23], and mission 7409 has just left the tunnel. The two missions 7411 and 7413 leave the tunnel at 16:30 hrs and 17:02 hrs respectively. They have travelled at the speed of 10 km/h as instructed by the RTM controller, although according to the procedures (speed table), they could have travelled at 20 km/h.

This imposition of a 10 km/h speed limit is due to an error by the RTM controller.

Mission 6419, a tourist shuttle, is near PK 50, i.e. approximately 1 km before the point at which mission 7412 has stopped in the other tunnel. Its driver saw a little smoke in Running Tunnel South when his train passed near to the fire (at 16:05 hrs), and a member of the crew noticed a burning smell. He reports infiltration of smoke into the South Tunnel at PK 47.

At 16:31 hrs, the driver of mission 6419 informs the RTM controller of a rise in temperature and asks to increase his speed. The RTM controller tells him to keep his speed at 10 km/h. At that moment, mission 6419 is at the crossover on the French side, approximately 4 km from the fire and the speed could have been increased to 20 km/h according to the speed table (see Annex No. 4).

This 10 km/h speed limit is also due to an error by the RTM controller.

At 16:36 hrs, the RTM controller authorises mission 7413 to run at 20 km/h.

At 17:21 hrs, a second request is made by the driver of mission 6419 to be able to increase his speed in that interval: another refusal is explained, wrongly, as being due to aerodynamic constraints.

[23] Last interval before the exit from the tunnel on the UK side.

At 17:35 hrs, the RTM controller authorises mission 6419 (now the last mission still in the South Tunnel to travel at 60 km/h. This speed should have been authorised from 16:26 hrs, the time when the SVS was configured to ventilate the North Tunnel alone[24].

The three missions[25] in the South Tunnel left the tunnel, on the UK side, a little after 16:30 hrs (mission 7411), a little after 17:00 hrs (mission 7413) and 17:50 hrs (mission 6419).

The RTM controller mistakenly asked the driver of mission 6419 to keep to a speed of 10 km/h for approximately 90 minutes, although Eurotunnel procedures allow the speed to be increased to 20 km/h once the SVS has been started (at 16:01 hrs), and then to 60 km/h once Running Tunnel South has been isolated from the SVS (at 16:27 hrs).

5.7 Evacuation of passengers and crew to the French terminal

In principle, the passengers on a shuttle that has stopped inside the tunnel should be evacuated from the service tunnel by an assisting shuttle that is sent into the other running tunnel for that purpose. This shuttle enters the Running Tunnel South at 16:52 hrs.

The PCO incident coordination centre decides that the passengers should be evacuated by vehicles in the service tunnel; this decision has the advantage of not having to open a CP door to Running Tunnel South and therefore having to close a door to Running Tunnel North. The assisting shuttle is therefore stopped at 17:00 hrs at CP 5877, from where it returns to the French terminal at 17:29 hrs.

A first STTS vehicle takes 15 passengers to France at 17:45 hrs and a second transfers the other 14 at 18:30 hrs. The three crew members were taken out in a service car at 18:44 hrs.

Two hours and 46 minutes elapsed between mission 7412 stopping and the last person on board that shuttle leaving the tunnel.

5.8 Organisation of rescue

A few minutes after the initial alarm, the rail control centre (RCC) asks for the Eurotunnel senior management team.

In accordance with Eurotunnel’s own emergency plan, a senior manager quickly arrives at the RCC (16:13 hrs) while the Poste de Commandement Opérationnel (PCO) (French incident coordination centre) was being set up.

At 16:25 hrs, the bi-national emergency procedure is started (BINAT Go).

At 16:35 hrs a head fire-fighter arrives and takes stock of the situation. The PCO is functioning, although does not take control of operations. A first head of emergency operations (COS) arrives at 16:45 hrs. The sous-préfet of Calais arrives at 17:24 hrs and the PCO is activated. The sous-préfet assumes the role of Director of Emergency Operations (DOS).

[24] It should be noted that the driver of mission 6419 did not obey the instructions from the RTM controller and travelled at 20 km/h from the moment he reached interval no. 3 (a little after 16:31 hrs) until the time he was authorised to travel at 60 km/h.

[25] Mission 7409 was in the process of leaving the tunnel at the time of the fire.

In the UK, as soon as "BINAT Go" was declared, the Kent Police sent an officer to activate the ICC. On receiving notice of the fire, the Kent Fire and Rescue services send an officer to manage the emergency services. The National Health Service does the same to manage the ambulances. Eurotunnel also sends a manager.

Inside the tunnel, the leader of the French FLOR, which arrived on the scene at 16:13 hrs, takes control of fighting the fire until the French SLOR team arrives on the scene at 16:52 hrs. The commander of that second team then takes the function of commander of emergency operations, in liaison with the PCO incident coordination centre.

5.9 Management and operation of tunnel installations

5.9.1 Traction electricity supply

At 15:59 hrs, approximately thirty seconds after mission 7412 has stopped, the 25 kV supply cuts off in the whole of the Running Tunnel North.

We can assume that while the train was running, the temperature of the catenary and its supports that are exposed to the fire is not high enough to cause them to fall or melt. Conversely, when the train stops, the temperature above the wagons on fire rises rapidly, damaging the catenary.

Between 16:11 hrs and 16:16 hrs, the supply to the catenary is reconfigured to enable the trains present in the North Tunnel behind mission 7412 to return to the UK terminal. The presence of an additional qualified EMS controller meant that this task could be performed within a reasonable time.

5.9.2 21 kV supply

At about 16:09 hrs, the 21 kV supply from the UK is cut off as the 21 kV cable had failed in interval 6 of Running Tunnel North, close to mission 7412, because of the fire. This cable supplied half of the fans and two of the three fire pumps at Sangatte. The failure of the 21 kV supply also causes incorrect information on the EMS controller's screens in the RCC. He is therefore no longer sure of the status of certain key elements in the tunnel installations, such as the ventilation dampers, the cross-passage doors and the piston relief duct dampers.

This loss of current lasts for almost two hours. It ends when the technicians reconfigure the French part of the 21 kV network so that the whole electricity supply is fed from the Sangatte station.

5.9.3 Telecommunications

As the fire developed, the communication capacity inside the service tunnel and between the service tunnel and the PCO/ICC incident coordination centres gradually deteriorated.

These difficulties did not cause any major problem with regard to this particular fire. That would probably not have been the case if it had been an accident where it was necessary to organise the evacuation of seriously injured people from the tunnel.

5.9.4 Normal ventilation system

Less than one minute after receiving the first fire alarm in the control centre, the EMS controller activates the automatic sequence to set the fans in the normal ventilation system (NVS) to the specified level (+5 on the French and UK sides) taking account of the position of the detection station that sent the first alarm, and he closes all of the air distribution units (ADU) between the service tunnel and the running tunnels.

At 16:10 hrs, as specified by Eurotunnel procedures for the tunnel involved in the incident, only the ADU grilles between PK 37.80 and 57.25 are still closed.

At 16:09'17'', the loss of the 21 kV conductor in Running Tunnel North caused the loss of one of the two NVS fans at Sangatte. The absence of this second fan did not affect the normal ventilation as one fan was still in operation. This would not have been the case if it had been undergoing maintenance or if it had had a fault.

At 16:11 hrs, the power levels of the fans in the NVS are brought to the values specified in the procedures (+3 on the UK side and +6 on the French side).

This reconfiguration took a little longer than envisaged as the EMS controller had to deal with the messages regarding failure of the dampers in the SVS. These departures from the configuration specified by the procedures for this type of situation did not have any significant consequences.

5.9.5 Supplementary ventilation system

At 16:00'52, the fans in the SVS are started in duplex configuration, i.e.:

- the two fans in the French shaft are supplying both running tunnels with air,
- the two fans in the UK shaft are extracting air from both running tunnels.

Once the starting command was sent to the SVS fans, it took about 2 minutes for the dampers in the shafts to open, then 4 to 5 minutes more for the smoke to clear away from the area around the amenity coach. It was therefore 9 to 10 minutes after mission 7412 stopped before the smoke cleared in the area of the amenity coach, at around 16:08 hrs, although the passengers evacuated through the window of the amenity coach between 16:03 hrs and 16:06 hrs. However, as the door of CP 4898 was opened at about 16:01 hrs, an "air bubble" brought fresh air into the running tunnel and cleared the smoke away over a length of about 4 metres centred on CP 4898.

The EMS controller started the SVS approximately 2'30'' after the RTM controller ordered all the trains to slow to 10 km/h because he thought it was necessary to wait until these trains had actually slowed to 10 km/h, although this condition is not mandatory. The consequence of this action was that there was smoke for approximately 600 metres downstream of the train, and this smoke then had to be pushed back upstream of the train by the SVS. Protected by the air pocket effect, the passengers did not suffer from the effects of this smoke while they were being evacuated; however it did cause problems for the driver of mission 7412.

At 16:03'15'', a damper in the Sangatte SVS shaft is reported to have a fault. The controller does not know whether this damper is closed (in which case it would not have been possible for air to be supplied to the running tunnels) or open[26].

At about 16:08 hrs, the controller stops one of the two UK SVS fans and the dampers to Running Tunnel South are closed, so that the air was now only being extracted from Running Tunnel North (the tunnel with the fire).

[26] The EMS controller could have known that the main dampers in the French SVS were in fact open by referring to the airflow control, but he did not do this. It should be noted that the procedures do not specify taking account of this control.

Given the lack of information on the SVS on the French side, the EMS controller considers it not to be available and continues taking measures for this scenario. Probably interrupted in the course of taking action, he leaves the system in a configuration which does not correspond to what he intended. This deviation does not have any great consequences, but it placed the SVS in a configuration that did not comply with the procedures.

At about 16:09 hrs, the loss of the 21 kV electricity supply causes one of the two fans in the SVS at Sangatte to stop. Furthermore, the main damper and the South damper at Sangatte are displaying malfunction messages.

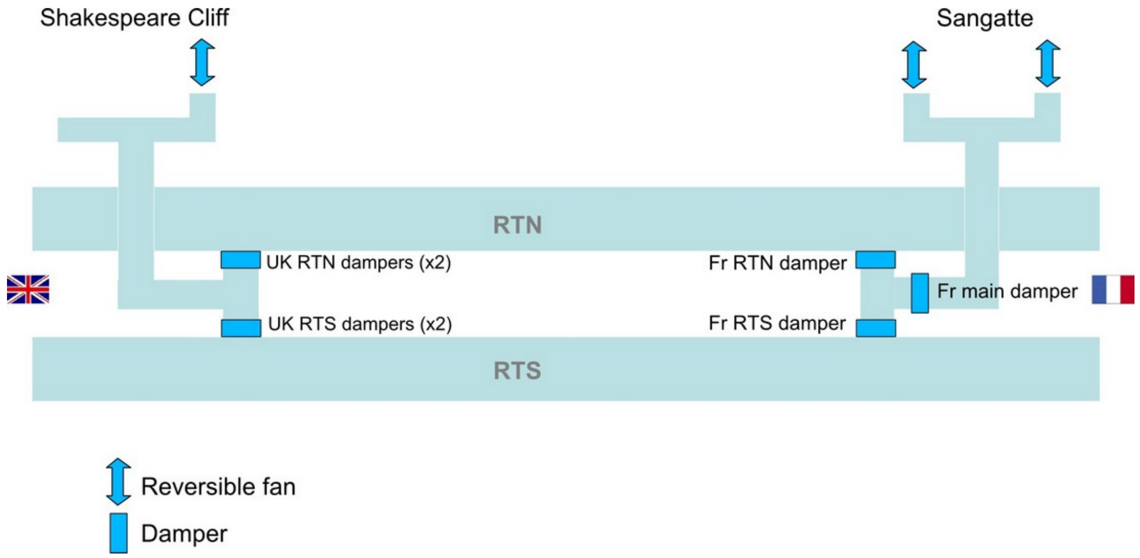

Figure 13 from paragraph 3.2.6.2)

As with the fault that occurred at 16:03'15'', the EMS controller has no information telling him whether the dampers have failed in the open or closed position. The controller does not have any procedure for situations of uncertainty regarding the condition of the fans or dampers.

At 16:11'01'', the messages regarding a malfunction in the dampers in the French SVS shaft disappear, but the controller does not notice. Working on the assumption that Running Tunnel North might still not be being ventilated on the French side, the controller starts the second fan on the UK side, in extraction mode, at 16:14 hrs.

In reality, the French SVS fan was supplying both tunnels with air and continued to do so for Running Tunnel North.

At 16:26 hrs, the EMS controller realises that he has regained control of the dampers on the French side. He stops ventilation of Running Tunnel South on the French side, sends all of the flow towards Running Tunnel North, but forgets to stop the second fan on the UK side. From that moment on, the condition of the SVS is as follows:

- one fan supplying Running Tunnel North on the French side,
- two fans drawing air from Running Tunnel North on the UK side.

This situation of excessive ventilation lasts until 18:39 hrs, when the EMS controller notices that a fan on the UK side is still working. He stops it. The SVS is then correctly configured.

The steps taken between 16:08 hrs and 18:39 hrs led to a SVS operating mode that did not comply with the procedures. There were no significant consequences for the time taken for the smoke to clear, or loss of control of the smoke or penetration of smoke into the service tunnel; however, the fire was fanned by this level of ventilation which should have been lower.

5.9.6 Piston relief duct dampers

At various times during the first 90 minutes of the fire, the EMS controller's terminal shows that the dampers of piston relief ducts 4810 and 4860 are open and faulty.

Only a small amount of smoke got into Running Tunnel South as these dampers were in fact closed. The reports indicated above were the consequence of a fault in the information transmission system.

A reduction in the effectiveness of the joints should be noted, however, probably due to their exposure to the heat.

5.9.7 Fighting the fire

5.9.7.1 Preparations for fighting the fire

As soon as they arrived at CP 4898, the FLOR teams go into Running Tunnel North and observe the fire. They are not aware of the scale of the fire and its spread towards the rear of the shuttle. At 16:30 hrs, a UK FLOR team hears sounds of explosions. To this team it is clear that the fire is quickly spreading along the shuttle.

To ensure electrical protection for the fire-fighting teams, the procedures in force in the Channel Tunnel provide for earthing the catenary. To perform this earthing operation it is necessary for a Eurotunnel technician to go into the running tunnel concerned. As there was smoke in the tunnel, it was decided that the earthing mechanisms would be placed near the French and UK portals. This decision means that earthing can only be performed once all of the trains have left Running Tunnel North.

Once mission 7412 had stopped, there were no trains still to exit on the French side; conversely there were three trains still to exit on the UK side:

- freight mission no. 7414 which was immobilised in interval no. 4 near PK 38,
- passenger mission no. 6420 which was immobilised in interval no. 2 near PK 20,
- freight mission no. 7420 which was immobilised in interval no. 2 near PK 13.

At 16:54 hrs, the catenary is earthed at CP 5614 (on the French side).

Mission 7414, the last mission to evacuate the North Tunnel, leaves at 17:38 hrs. At 17:53 hrs, the catenary is earthed on the UK side at CP 1138.

5.9.7.2 Fighting the fire

The French fire-fighters start fighting the fire at 16:56 hrs (before the earthing procedure has formally finished, but considering that the catenary being earthed on the French side and having failed in the vicinity of the wagons that were on fire was sufficient to guarantee there was no voltage). Their UK counterparts start at 17:53 hrs.

Information concerning the position and quantity of the dangerous substances being carried in the vehicles is needed by the fire services so that they can organise their work. The FD controller had provided the FLOR teams with this information. Unfortunately, the information on the position was incorrect because the vehicles had been displaced during the loading operations and the information on the quantities was incorrectly interpreted.

However, these errors do not have any consequences as far as the fire-fighting operations are concerned.

At 18:00 hrs, the French fire-fighters, who entered the tunnel at CP 4898, approach the middle of the shuttle (near CP 4864), the fire having now spread to the rear of the rake. At 18:09 hrs, the French FLOR asked for permission to open the door of CP 4864, which it opened (using the local control device) at 18:24 hrs.

At about 18:19 hrs, the fire-fighters enter Running Tunnel North at CP 4864 and realise that the fire has spread to the rear half of the shuttle.

At about 18:46 hrs, the UK fire-fighters enter Running Tunnel North through CP 4822, located towards the rear of the shuttle, to start fighting the fire. They notice that the vehicle on the last carrier wagon is already on fire.

The French and UK fire-fighters continue fighting the fire for several hours, attacking it from the front and from the rear respectively.

At 23:00 hrs, the fire is still intense in the vicinity of carrier wagon 24 (the HGV on this wagon was carrying a cargo consisting of rolls of plastic film).

At 3:00 hrs on 12 September 2008, a "water wall"[27] is installed on the rear loading wagon to protect the trailing locomotive and fire-fighting continues from CP 4864 alone.

The fire is declared under control at 8:00 hrs on 12 September 2008, and extinguished at 11:24 hrs.

Only slight injuries are reported by fire-fighters during the operations inside the tunnel.

The sequence of fire-fighting operations is shown in Figure 41.

[27] This is a "wall of water" (generated with a flat jet) which acts as a barrier to prevent flames and smoke from spreading.

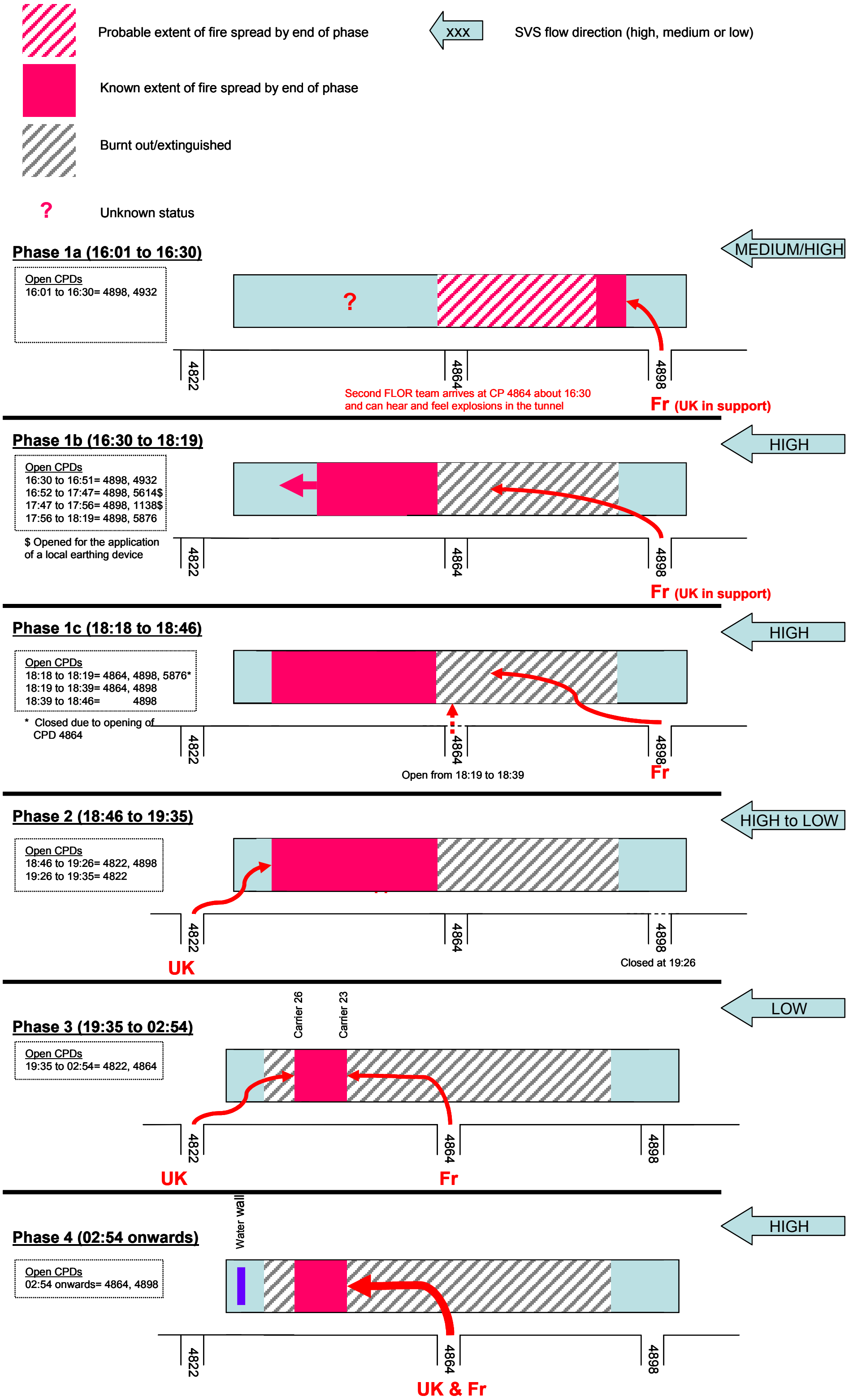

Figure 41: Overview of the fire-fighting operations

Water supply

At 18:39 hrs, a fire hydrant located at CP 4864 fractures under the effect of the heat. Pressure drops to 2 bars instead of 6, which is not sufficient to effectively fight the fire.

Pressure is re-established at 19:00 hrs after the failed hydrant has been isolated and the Beussingue pumping station activated.

At about 18:50 hrs, the PCO decides to attack the fire from both ends, with the UK teams being supplied from the Shakespeare Cliff station. To do this, the main water pipe has to be reconfigured (see Section 4.2.2.6) which is performed at 19:01 hrs.

When the valve controlling supply to the pipe in CP 4822 for the UK fire-fighters is opened, there is no water getting to that fire terminal. After investigating in situ, it is found that there is a valve closed, at PK 36.21. At 19:35 hrs, Eurotunnel technicians open it locally.

Ventilation management

Up until 18:39 hrs, the configuration of the SVS is not optimal, causing an airflow that is higher than the level specified.

Between 18:41 hrs and 19:29 hrs, the SVS flow rate is gradually reduced, at the request of the PCO incident coordination centre and in agreement with the manager on site who is responsible for the fire-fighting operation.

The SVS flow rate is increased again in the early hours of the next day to reduce the CO level which was tending to increase.

Although the question of reversing the flows was raised, the ventilation flow from France to the UK was maintained throughout the operation.

5.10 Resumption of traffic

Once safety inspections have been performed, commercial traffic resumes on 13 September 2008 in the whole of the Running Tunnel South. On 22 September interval 2 in Running Tunnel North is opened and on 28 September, interval 4 is opened. The level of traffic that can be accommodated is in the order of 40% of normal traffic.

Interval 6 of Running Tunnel North is returned to commercial traffic on 9 February 2009.

6 Analysis and recommendations for preventative measures

Examination of how the fire occurred and the response to its occurrence results in consideration of improvements that could be made in the following areas:

- Evacuation of people;
- Fire-fighting;
- Rolling stock
- Fixed installations;
- Telecommunications;
- RCC's work, procedures and tools;
- Respective roles of the command organisations;
- Strategy in case of a fire on board a freight shuttle;
- Prevention of fires on the vehicles transported;
- Safety management.

6.1 Evacuation of people

6.1.1 Controlled stop procedure

Even though the stop procedure was correctly observed (locomotive's window beside the marker board), the front right-hand door of the amenity coach was not beside a cross-passage but about 4 metres beyond it, which meant that it was not in the space protected from the smoke by the air bubble created by the normal ventilation system.

The controlled stop procedure applies to different types of train (Eurostar, tourist shuttle, freight shuttle, etc.). The purpose of the marker boards is to enable the driver to stop in the best position for passengers to be evacuated.

These boards are placed 25 m downstream from the centre of the cross-passage door and the controlled stop procedure stipulates that the driver must stop with his side window beside the marker. But the distance between this window and the first evacuation door is not the same for the different types of train (23.70 metres for a Eurostar train, approximately 19 metres for a Eurotunnel freight shuttle).

It follows that, in the case of freight shuttles which are the type of train most likely to have to perform a controlled stop following a fire, the evacuation door of the amenity coach is normally outside of the air bubble.

Recommendation No. 1 (Eurotunnel): Ensure that application of the controlled stop procedure by freight shuttles results in the evacuation door on the amenity coach being opposite a cross-passage.

6.1.2 Information and instructions given to the passengers

Once the fire alarm had gone off, the passengers received very little information from the chef de train on the evacuation procedures. Before and during an evacuation, it is essential for the chef de train to be able to communicate with the passengers, either to give them instructions or to inform them about how the evacuation is taking place, thus limiting the risk of panic.

It should be noted that about one third of the drivers did not speak either English or French and that, for his part, the chef de train only spoke English and a little French.

The chef de train was not able to make himself heard by the passengers to give them the safety instructions. He was not able to influence the self-evacuation through the broken window or prevent some passengers from leaving through the front left-hand door and setting off into the running tunnel. Finally, he was not followed by a single passenger when he evacuated through the rear right-hand door.

Recommendation No. 2 (Eurotunnel): With support from specialists in human factors, improve the distribution of information and instructions to passengers in the event of an evacuation, taking account of those who do not speak English or French and the predictable behaviour of passengers in a stressful situation.

6.1.3 Information for the chef de train on the progress of operations with a view to evacuation

Evacuation of the passengers from the amenity coach to the service tunnel is the responsibility of the chef de train who normally has the means of achieving this on his own. When evacuation conditions are not as normally envisaged, as was the case on 11 September, it is desirable for the chef de train to be advised of this very quickly.

The RCC can contact the chef de train via the concession radio, but there is no specific procedure that calls for the RCC to keep the chef de train informed if there is likely to be a delay in achieving the necessary conditions for evacuating the train (opening of cross passage doors and, in some circumstances, activation of the supplementary ventilation system). The chef de train therefore did not have any information on the steps that were being taken and this affected his chances of communicating with the passengers and reassuring them.

Recommendation No. 3 (Eurotunnel): Review the instructions and means of ensuring that the chef de train is informed of delays in achieving the necessary conditions for evacuation so that he can take this into account in performing his duties.

6.2 Fire-fighting

6.2.1 Electrical protection for the emergency services

Before any fire-fighting intervention, the fire-fighters must be assured that the catenary has been de-energised and that there is no risk of it being re-energised, either:

- by the untimely operation of a switch by remote control from the RCC, or
- by one of its ends being bridged by the pantograph on a traction unit, or
- by induction caused by an adjacent conductor.

Eurotunnel's procedure for the Channel Tunnel involves earthing the catenary on either side of the area where the fire-fighters have to work. This earthing operation currently requires intervention by specialist Eurotunnel agents in the running tunnel concerned.

Because of the presence of smoke, and as these agents were neither equipped nor trained to work in a polluted atmosphere, they could not work near to the site of the fire and their intervention was naturally made at the ends of Running Tunnel North. This constraint meant that it was necessary to wait until all of the trains had evacuated from the tunnel affected by the incident before it was possible to proceed with the earthing operation.

In the case of 11 September 2008, the electrical protection procedure was not therefore completed until 17:53 hrs, and it was only then that all of the fire-fighting teams started to fight the fire.

On the national French rail network, the rules for intervention by fire-fighters enable them to fight a fire near to the catenary under the system of "emergency isolation" without prior earthing. Such a procedure would have saved more than an hour on the response time.

Recommendation No. 4 (Eurotunnel, SDIS, Kent Fire and Rescue Service, Office of Rail Regulation, IGC): Examine regulatory, organisational or technical changes that would make it possible to reduce the time needed to provide electrical protection for the fire-fighters and enable them to fight the fire as quickly as possible.

Of the possible areas for improvement, three are given below:

- *remote earthing with switches operated from the service tunnel or by remote control,*
- *operation in situ performed by personnel who are on the scene more quickly (FLOR),*
- *change to the regulations, dispensing with earthing for rescue and fire-fighting operations.*

6.2.2 Information on dangerous substances

It is necessary for the emergency services to know the position and quantity of any dangerous substances on board for them to organise their operations. These data are managed by the ISIS information system.

For mission 7412, only one driver had declared the presence of dangerous substances. These were in a very small quantity in the order of 100 g. The lorry in question should have been loaded on the 13^{th} wagon.

Because of the re-positioning of a van, this lorry was loaded on the 12^{th} wagon. The ISIS database was not updated.

The quantity of dangerous substances taken into account by the emergency services was 100 kg following a reading error.

Overall, the information on dangerous substances that was given to the fire-fighters on the scene was incorrect.

Recommendation No. 5 (Eurotunnel): Look at what steps need to be taken to ensure that information entered into the ISIS system is correct and to prevent any ambiguity in the interpretation of the data by the emergency services.

6.2.3 Making the equipment used in the fire-fighting operation more reliable

At 18:25 hrs, the door of CP 4864 has to be opened manually as the electric control has failed, as was the case later with the doors of CP 4898 and CP 4822. The loss of electrical control seems to be the consequence of the fire, as the three doors are located near the shuttle that is on fire. It takes 200 turns of the control wheel to open the door manually.

At 18:39 hrs, a fire hydrant close to CP 4864 breaks causing a sudden drop in pressure (2 bars instead of 6 before). This is not enough pressure to enable the fire-fighters to work effectively. The cause of the fracture seems to be connected with the high temperature that the hydrant had to withstand before it had any water.

Shortly afterwards, the pumping station at Sangatte stops automatically and cannot be started again. The back-up station at Beussingue then has to be activated. The water supply does not return to normal rate until 19:00 hrs.

Recommendation No. 6 (Eurotunnel): Look for ways of making the various elements used to fight the fire more reliable (valves, fire hydrants, pumping stations, etc.), especially those that could be subjected to high temperatures.

6.2.4 Fire-fighting system valve control

At 19:00 hrs, it was decided that the UK fire-fighters should attack the fire from the back of the shuttle through CP. 4822, with a water supply coming from the UK. After closing the mid-point valve, they noticed that there was no water at that location.

At 19:30 hrs, a valve at CP. 4523 is found to be closed. It is opened and the water then gets to CP 4822.

The valve at CP 4523 is a valve in the main circuit. It is not known why it was closed; probably somebody forgot to reopen it when maintenance work was performed previously.

Recommendation No. 7 (Eurotunnel): Implement a procedure to ensure that the fire main manual valves are in the position specified by the procedures and known to the personnel concerned so that water can be supplied immediately when needed.

This control could involve indicator lamps or another easily visible indication installed in the service tunnel. The FLOR teams could be given the job of checking the status of these controls during their patrols in the service tunnel.

6.2.5 Reconfiguration of the fire-fighting system

Following the fracture of a fire hydrant, the water supply pipe for the fire-fighters lost pressure in Running Tunnel North at 18:39 hrs (see Section 0 above). It was therefore necessary to reconfigure the water supply circuit to take account of this fracture. The reconfiguration took about 25 minutes, which is a long time in a fire-fighting situation.

Recommendation No. 8 (Eurotunnel, SDIS, Kent Fire and Rescue Service): In agreement with the emergency services, re-examine the means of rapidly reconfiguring the fire-fighting system according to requests from the fire-fighters.

6.2.6 Management of the supplementary ventilation system in the event of a fire

On 11 September, at 16:00 hrs, the SVS starts at level 7. It will remain at that level until the PCO incident coordination centre asks for its power to be reduced, at about 18:39 hrs. It is then reduced gradually down to level 1 which is reached at about 19:30 hrs.

At the start of the evacuation phase, the SVS is automatically set to level 7. Such power is useful for clearing away the smoke and facilitating evacuation. On the other hand, it then makes the work of the fire-fighters more difficult and increases the speed at which the fire progresses. A rapid, systematic return to a lower value, according to a preset process, would save time and improve efficiency.

Recommendation No. 9 (Eurotunnel, SDIS, Kent Fire and Rescue Service): Review the supplementary ventilation system management procedures in the event of a fire on a freight shuttle with a view to limiting the development of the fire and enabling it to be fought effectively.

These procedures must include an evaluation of fire-fighting methods and may envisage a rapid reversal of the flow of the supplementary ventilation system to protect the majority of the train and limit the amount of damage to the tunnel.

6.2.7 Knowledge of the location of the fire

The emergency services have to define a policy for attacking the fire which depends, amongst other things, on the size of the fire and its location. The first few minutes are vital.

In a fire situation it is not permitted to open more than two cross-passage doors. But the doors of CP 4898 and CP 4932 had to be open until the RCC was sure that all of the passengers and crew were in the service tunnel. The amount of time needed to obtain this assurance varies depending on the circumstances. On 11 September it took a little over half an hour.

The position of the fire on the shuttle also plays an important role in the choice of tactics for attacking the fire. It was not until 18:25 hrs, when they were able to open the door of CP 4864 manually, that the emergency services knew that the fire had reached the second part of the shuttle. This fact was important nonetheless in making the appropriate decisions for fighting the fire.

Recommendation No. 10 (Eurotunnel): Examine the feasibility of a system that would make it possible to know the location and progress of a fire so that it can be fought effectively.

The relevance of the absolute ban on opening a third CP door might be worth reviewing.

6.2.8 Role of the first line of response teams (FLOR)

The first attack on the fire could not be carried out until one hour after the first alarm went off. Studies by the emergency services seem to show that, to expect to put out a fire like the one on 11 September 2008, it must be attacked within the first 10 minutes of it starting. After that, given the difficulties of fighting a fire in a tunnel, the emergency services can only try to contain it.

The second line of response teams (SLOR) are unable to arrive at the scene for about an hour.

It is therefore the first line of response teams (FLOR) who are the most capable of combating a fire at its outset thanks to their knowledge of the tunnel and the speed at which they can reach it.

These two factors should therefore be taken into account in precisely defining the duties given to the FLOR teams. Once these duties have been defined, the work of these teams should be apportioned and organised so that they can fulfil all these duties within agreed timescales.

Recommendation No. 11 (Eurotunnel, SDIS, Kent Fire and Rescue Service): Re-examine the intervention conditions and resources of the first line of response teams with a view to reducing the time before a fire can be attacked.

This recommendation also involves improving the electrical protection times.

6.2.9 Taking account of experience from the emergency services on the fire of 11 September 2008

One of the main points raised concerns the amount of water made available to the fire-fighters. The current installations allow a flow rate of two times 120 m^3/h. These values limit the options available to the fire-fighters given that a "water wall" consumes about 80 m^3/h. However, this flow rate did allow the "water wall" in place on 11 September to play its part.

Another point concerns the difficulty of positioning and moving the flexible hoses due to the small amount of space available and the debris scattered on the ground.

Recommendation No. 12 (Eurotunnel, SDIS, Kent Fire and Rescue Service): Examine the relevance of improving the resources made available to the emergency services, particularly with regard to the points raised by their experience on 11 September 2008.

6.3 Rolling stock

6.3.1 Equipment in amenity coaches

The desk at the chef de train's workstation contains all the commands and controls for the safety functions and communication systems. The chef de train therefore needs to stay at this station for the phase prior to the evacuation.

On 11 September, the chef de train's workstation was at the back of the amenity coach, which made it difficult for him to control the movements of the passengers towards the evacuation door, which is normally situated at the front, and to access it to unlock it if necessary.

Furthermore, not all of the passengers could be given a mask from the batch available near the chef de train's workstation. An additional batch of masks was stored at the other end of the coach and was distributed by the catering agent. Distribution of these masks might have been compromised if that member of staff had not been there.

Recommendation No. 13 (Eurotunnel): Look for any modifications that might be made to the amenity coach and the distribution of equipment inside it, so that the chef de train has better access to the equipment necessary for an evacuation (including breathing masks) and can perform his duties in all situations, particularly opening the evacuation door.

These modifications might concern, in particular, the location of the chef de train's workstation and the remote control for the doors.

6.3.2 Reliability and maintenance of the amenity coach doors

The annual reliability report on Freight rakes produced by Eurotunnel for 2008 shows that there were 156 incidents caused by the doors of amenity coaches, representing 28% of the total number of incidents on these rakes. Of these 156 incidents, 92 concern the side doors of BREDA amenity coaches (36 doors in service), 51 incidents concern the side doors of COSTA coaches (40 doors in service), and 13 incidents concern communicating doors.

This high figure, especially on BREDA coaches, means that degraded situations are common and may lead operating maintenance personnel to underestimate the criticality of this equipment vis-à-vis passenger safety.

The doors are not systematically tested when the rakes are taken out of stabling. On 11 September 2008, this led to the problem being discovered late and a hasty intervention being performed so as not to delay the departure of the mission.

The use of Colson collars by the Folkestone troubleshooting team and then by the Coquelles team and the fact that there was no objection by the dispatcher indicate that this method of temporary repair is not unusual.

The use of means and methods that are not specified by the maintenance documents on equipment used to assure the safety of passengers leads suggests that the quality of troubleshooting and maintenance work is drifting.

Recommendation No. 14 (Eurotunnel): Examine what needs to be done to improve the reliability of the amenity coach doors, the consistency of the operational tests performed before freight shuttles restart service and the quality control of troubleshooting and maintenance work.

6.3.3 Minimum operating conditions for amenity coaches

Concerning the access doors of the amenity coach, the minimum condition for operation is to have one door operational on each side. If two access doors are isolated on the same side, the mission is not authorised to depart.

A coach with one isolated door is normally repaired when it passes through the Yard (maintenance stabling sidings). However, that is not obligatory and the coach might travel in this condition until the next scheduled maintenance operation (maximum 22 days).

The terms used in the regulatory texts to describe degraded door situations are not sufficiently precise: no distinction is made between the notions of "isolated door" (can be used for an emergency evacuation) and "locked" door (cannot be used at all).

No distinction is made between the case of the front right-hand door, which is normally used for evacuation, and the case of the other doors.

In short, the operating rules for amenity coaches regarding the isolation and locking of access doors are not clear or consistent with the passenger evacuation strategy. There is therefore a risk that a shuttle might be authorised to travel although the condition of its doors is likely to complicate evacuation in the event of a fire.

Recommendation No. 15 (Eurotunnel): Clarify the rules on isolating and locking out access doors and the rules for keeping amenity coaches in operation so that the rules are consistent with the passenger evacuation strategy in case of fire.

6.4 <u>Fixed installations</u>

6.4.1 21 kV network

A 21 kV network supplies the auxiliary installations, the main ones of which provide ventilation, drainage and the water supply to the fire hydrants (see Section 3.2.5).

On 11 September 2008, the 21 kV feeder in Running Tunnel North rapidly failed (16:09 hrs, i.e. quarter of an hour after the start of the fire) so that the following elements in the Sangatte plant were lost:

- one fan (of 2) in the normal ventilation system,

- one fan (of 2) in the supplementary ventilation system,
- a high pressure fire-fighting pump and a low pressure pump.

Furthermore, incorrect "failed" information on dampers in the supplementary ventilation system on the French side was probably a consequence of this loss of the 21kV supply.

Normal conditions were not completely re-established until about 18:00 hrs (i.e. almost 2 hours after the start of the failure) and the information disappeared approximately 3 minutes later.

The design of the Eurotunnel installations ensures that they operate with a partial loss of the 21 kV supply, although the system is made more fragile. This situation, when added to the incorrect failure information, adds to the EMS controller's workload when he already has numerous duties to perform. There is therefore an increased risk of an incorrect operation.

Recommendation No. 16 (Eurotunnel): Examine a modification to the 21kV network in order to make that network more reliable in the event of a fire and to be able to restore power quickly to equipment that has been cut off in the event of a failure.

Possible modifications might make it possible to:

- *make the system less vulnerable (for example by moving the 21 kV feeders out of the running tunnels into the service tunnel where they are less likely to be subjected to a fire).*
- *facilitate the return to a normal or less disrupted situation (for example through the remote control of equipment so as not to depend on manual interventions).*

6.4.2 Supplementary ventilation system

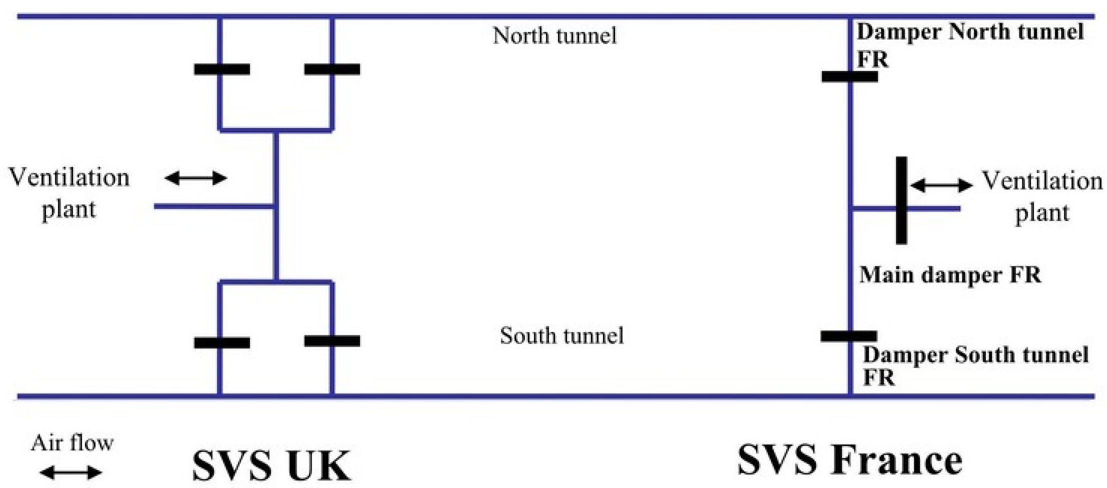

Figure 41: Ventilation dampers on the French and UK sides

The configuration of the supplementary ventilation system in the running tunnels is shown in the diagram above. This diagram shows that the malfunction of just one damper on the French side could mean that the operation of the French supplementary ventilation system is lost in both running tunnels (main Fr damper) or in one of the two running tunnels (North Tunnel damper or South Tunnel damper). This is not the case on the UK side where the loss of just one damper does not have any effect on the operation of the supplementary ventilation system.

Furthermore, the design of the system means that loss of control of the main Fr damper prevents the dampers in the North and South Tunnel from closing.

Recommendation No. 17 (Eurotunnel): Look at modifying the arrangement of the dampers in the supplementary ventilation system on the French side, or their control system, in order to limit the consequences of a fault.

6.4.3 Lighting in the running tunnels

The chef de train, some passengers and the driver reached the cross-passage in a smoke-filled atmosphere with little ambient light.

The EMS controller had actually turned on the lighting in the tunnel, but this lighting is installed at height. As the smoke rose the lighting quickly lost its effectiveness.

Recommendation No. 18 (Eurotunnel): Examine having lighting installed at a low level in the running tunnels, mainly near the evacuation cross-passages, in order to reduce situations where this lighting is affected by the smoke.

6.5 Telecommunications

6.5.1 Track-to-train radio

Examination of availability statistics for the track-to-train radio and the concession radio shows a significant improvement between 2005 and 2006 and between 2007 and 2008 respectively, thanks to the technical modifications made by Eurotunnel. However, the driver of shuttle 7412 was not able to contact the RCC either by the track-to-train radio or by the concession radio, from the moment when he knew there was a fire on board his shuttle to just before he stopped at PK49.

The track-to-train radio is central to the means of communication between trains travelling in the tunnel and the RCC. It appears that, at a crucial moment (on-board fire alarm), the driver was not able to contact the RCC to notify it. The RCC would then have been able to take the regulatory action and given the order to perform a controlled stop. The driver took the decision himself to stop in accordance with this "controlled stop" procedure. Shortly before stopping, he found that the track-to-train radio was working correctly again, possibly because the locomotive was in an area covered by another communications cable.

Recommendation No. 19 (Eurotunnel): Examine whether simple measures and rapid implementation could improve the current coverage of the track-to-train radio before installing GSMR or whether changes to the procedures are needed to take account of the frequency of faults.

If a fire is detected by the alarm system on board a freight shuttle and there is no radio connection between the driver of the shuttle and the RCC, there is a procedure specified for the train driver. The instructions given to him take account of the possible need to stop in the tunnel; however, the notion of "need" is inadequately defined. In particular, it is not clear whether a single alarm is enough to constitute the need to stop.

Recommendation No. 20 (Eurotunnel): Improve the wording of the procedure defining the action to be taken by a driver who cannot contact the RCC when a fire has been reported or has effectively broken out on his train.

6.5.2 Improvement of the tactical radio

A certain number of faults arose with the tactical radio while the fire was being fought, such as:

- rapid discharge of the battery in some portable radiotelephones,
- loss of connection between the service tunnel and Running Tunnel North,
- loss of 50% of the tactical network capacity,
- failure of the STTS-Com UK vehicle.

Some of these faults are a direct consequence of the fire (destruction of fixed installations such as cables and antennae). Others are directly connected with the equipment in question.

Recommendation No. 21 (Eurotunnel): Look for ways of reducing the risk of the tactical radio malfunctioning. In particular, examine the possibility of transferring all or part of the cables installed in the running tunnels to the service tunnel and improve the reliability of the communication modules in the specialised STTS-Com vehicles.

6.6 RCC work, procedures and tools

6.6.1 EMS controller

The EMS controller manages all of the fixed equipment in the tunnel, except for signalling and switching control. This equipment is controlled and operated remotely. If control is lost or there is an operating fault, the EMS controller must call an agent from the maintenance department concerned to work directly on the equipment, following his instructions.

As soon as a fire is found in a running tunnel, the EMS controller becomes extremely busy. In fact numerous installations have to be adjusted, mainly to:

- ensure evacuation of the passengers on the train affected by the incident,
- reconfigure the electrical traction installations so that trains inside the tunnel affected by the incident can leave it, particularly for those travelling behind the affected train,
- ensure the safety of the people present in the running tunnels from fire and smoke,
- give the fire-fighters the optimum conditions with which to fight the fire.

From about 16:00 hrs onwards, the EMS controller had a heavy workload. During the first two hours of the incident he had to acknowledge and respond to 194 alarms (102 of which were classed as “major”). He had peaks of activity: for example, 17 commands were executed between 16:06 and 16:16 hrs.

During the initial phases of the fire, this controller is responsible for actions which have a great impact on the safety of the people affected by the fire: for example, opening the cross-passage doors, controlling the tunnel ventilation systems and reconfiguring the electricity supply systems.

The partial failure of the 21 kV system meant, amongst other things, that the controller did not know the condition of certain items of equipment: for example the ventilation dampers which were shown as "malfunctioning" without his knowing whether they were open or closed.

On 11 September 2008, the 25 kV traction current was supplied in "extended mode", i.e. the whole of the system in the tunnel and in the two terminals was supplied from the French network[28]. Reconfiguration of the electric traction network is more complicated than in symmetrical mode. This option overloads the EMS controller at a time when his workload is already high.

The fact that a second qualified EMS officer[29] arrived on the scene very quickly proved to be an important favourable factor as it made it possible to relieve the workload of the duty EMS controller.

Recommendation No. 22 (Eurotunnel): Take steps to have a second officer, who is qualified to perform the EMS controller's duties in the rail control centre (RCC) on site within 10 minutes in emergency situations.

At the moment, this backup is generally provided by a "multi-tasking" controller.

6.6.2 Fire detection (FD) controller

The FD controller has a considerable workload at the beginning of a fire. In particular he must control the activation of the two "first line of response" FLOR teams. He is also currently responsible for notifying the various UK external emergency stations, which means having to call 999 three times.

On 11 September 2008, this task did not cause a delay in the performance of these other obligations as a trainee officer was with him and helped in the operations. This would probably not have been the case if the FD controller had been alone.

Recommendation No. 23 (Eurotunnel): In liaison with the emergency services, examine how the transmission of information to the UK external emergency services (Fire Brigade, Ambulance, Police) could be speeded up in order to limit the FD controller's workload.

For example, this might be transferred to the "Information system" ISIS controller who is less involved in the case of a fire on a freight shuttle.

6.6.3 Supervisor

The current arrangements for the rail control centre at the beginning of an incident mean that the supervisor has to monitor all of the actions taken by the other controllers. The importance of his role is made even greater by the fact that, in several procedures, the various controllers all have to refer to him.

This centralisation has, amongst other things, the following consequences:

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[28] "Extended operating mode" was introduced in 2007, following the installation of supplementary power supplies in the running tunnels.

[29] In the years prior to the accident there has not been a second qualified EMS controller systematically on duty despite the existence of an official job described as "Smoke management controller".

- loss of communication between controllers causing lack of decision-making, or delays,
- ineffective supervision as the supervisor cannot concentrate on the most important areas.

The slow authorised speed of other trains leaving the tunnel during the fire (see Section 6.6.7) is one example of a consequence of this arrangement.

Recommendation No. 24 (Eurotunnel): Examine the possibility of giving the supervisor greater autonomy, within a defined framework, in determining which actions by the controllers in the RCC he is going to monitor as a priority, particularly at the start of an incident.

This framework must specify that the supervisor must pay particular attention to the actions which are critical to the safety of the people in the tunnel.

6.6.4 Management of EMS alarms

On 11 September 2008, malfunctions affected the installations with varying degrees of seriousness, in particular:

- the general electricity supply (21 kV),
- the supplementary ventilation system,
- the piston relief ducts,
- the cross-passages,
- the fire-fighting water supply system,
- the pumping system,
- the fire-fighting system.

These malfunctions caused the appearance of numerous alarms on the EMS controller's screen. He then had to take the actions made necessary by the malfunctions indicated. The high number of these actions causes a risk of errors and delays in their implementation.

Recommendation No. 25 (Eurotunnel): Examine ways to improve the tools available to the EMS controller to lighten his workload, in particular to limit the information received to that which requires immediate action. Examine the possibility of a method of presentation according to the level of priority so that the controller has help in determining the order in which tasks have to be dealt with.

6.6.5 Supplementary ventilation system (SVS) control procedures and tools

In the event of an evacuation in the presence of smoke, the safety of the passengers and crew of a shuttle involved in an incident may rely upon the correct operation of the SVS. The correct control of this ventilation system is also essential for fighting the fire.

Numerous factors have to be taken into account by the EMS controller in controlling the SVS. These are mainly:

- The operation of the fans at Sangatte and Shakespeare Cliff and the adjustment of their blades,
- The position of the dampers in the ventilation shafts,

- The position of the piston relief duct dampers,
- The position of the cross-passage doors,
- The speed at which the trains are travelling.

6.6.5.1 Information on the status of the installations

In addition to the real faults, the EMS controller was faced with uncertainty regarding the status of certain important installations, in particular the position of the main damper in the Sangatte ventilation station.

On 11 September 2008, between 16:03 hrs and 16:11 hrs, the EMS controller had no information on the position of the main damper in the Sangatte ventilation shaft. The lack of this very important information led him to take inadequate action. Information was available from 16:11 hrs, but the controller did not notice until 16:26 hrs.

The lack of information on the status of a damper presents a significant danger, especially in the first few minutes of a fire where it may be necessary to create a smokeless zone with the SVS, in order to evacuate passengers from the amenity coach.

The information available on the air flow could have led the EMS controller to conclude that this damper was open, but the his heavy workload meant that he was not able to perform this reasoning and the relevant procedure did not call for the air flow to be checked if the damper was reported to have a fault.

It would be useful to examine drawing up procedures to apply in the event of information on the status of critical equipment in the SVS being lost.

Recommendation No. 26 (Eurotunnel): Look at ways of making information on the control of the supplementary ventilation system more reliable and explore whether new procedures could guide the EMS controller when there is incomplete information.

6.6.5.2 Information on slowing the trains to 10 km/h

The EMS controller may only activate the SVS when he knows that the RTM controller has instructed all of the trains to slow to 10 km/h in both tunnels. He is informed of this by a verbal announcement from the RTM controller to the whole RCC. There is no assurance that the EMS controller has heard this information in the middle of all the duties he has to perform. Furthermore, this controller has no permanent record of this information. He may therefore lose some minutes before starting the SVS.

Any delay in starting the SVS may mean that there is smoke surrounding the amenity coach for an indeterminate length of time, contributing to the anxiety of the passengers, as was the case on 11 September 2008.

Recommendation No. 27 (Eurotunnel): Examine the possibility of advising the EMS controller by more reliable means than is currently the case, of the moment when the instruction to slow the trains to 10km/h has been given.

6.6.5.3 Starting the supplementary ventilation system (SVS)

As indicated above, the flow of air from the SVS cannot start before there is assurance that the instruction to slow the trains to 10 km/h has been given.

Starting the fans when it is known that the SVS is going to be needed and then adjusting the blades and opening the dampers to the running tunnels when all of the necessary conditions have been fulfilled would speed up the process.

Recommendation No. 28 (Eurotunnel): Examine the possibility of being able to start the supplementary ventilation system fans as soon as a fire alarm is confirmed in a running tunnel.

This measure might be supplemented by keeping the SVS dampers closed until a moment to be defined.

6.6.6 Knowing the point at which the train stops

Having performed his controlled stop, the driver of mission 7412 was not able to give the number of the cross-passage beside which he had stopped. He was only able to give the kilometric point (PK) he was at.

Knowing only the PK meant that the supervisor did not automatically know which cross-passage to use for the evacuation of the passengers. The supervisor therefore had to search the plans for the number of this cross-passage. This took him about two minutes, which delayed the evacuation of the passengers and greatly increased their state of tension.

Furthermore, it is also necessary to envisage a case where radio communication between the driver and the RCC was not re-established, in which case it would not have been possible to give the number of the PK.

It therefore appears useful to examine the possibility of giving the RCC the means of quickly knowing the exact position at which the train affected by the incident has stopped, even if it cannot make contact with the crew.

Recommendation No. 29 (Eurotunnel): Examine the possibility of putting in place a system that would make it possible to identify, immediately and without any doubt, the exact position at which a train has stopped so that the door of the corresponding cross-passage can be opened as quickly as possible.

6.6.7 Use of the speed table

On 11 September 2008, passenger shuttle no. 6419, travelling in the South Tunnel, received an instruction to lower its speed to 10 km/h although it was approximately 40 km from the tunnel exit. On two occasions, its driver asked for authorisation to increase his speed as there was a little smoke and the temperature was rising. Permission was refused on both occasions. On his own initiative, he decided to run at 20 km/h.

As soon as a fire is declared in the Channel Tunnel, all trains must reduce their speed to 10 km/h on the instruction of the RTM controller[30]. Once the passengers have evacuated the train affected by the incident, the trains are authorised to run at 10 km/h, 20 km/h or 60 km/h depending on the following criteria:

- whether the train is travelling in the tunnel affected by the fire or in the other tunnel,
- whether or not there is any smoke,
- whether or not the piston relief ducts and crossover doors are closed,

[30] The purpose of this measure is not to disrupt the implementation of the ventilation system.

- operation and direction of the SVS in the tunnel concerned.

The speeds to be applied are defined in a Eurotunnel procedure (speed table) which is part of the duties given to the supervisor. He therefore has to give his instructions to the RTM controller, according to the situation at the time. On 11 September 2008, all the trains were travelling in the direction of the airflow imposed by the SVS. The speed to be applied was therefore 20 km/h.

The refusal to authorise the driver of passenger shuttle 6419 to run at a higher speed is the consequence of a lack of coordination between the supervisor and the RTM controller as the supervisor did not tell the RTM controller that the speed to be applied from then on was 20 km/h, as the evacuation of passengers from the amenity coach had been completed.

Recommendation No. 30 (Eurotunnel): Examine the possibility of improving the procedure for implementing the rules of the "speed table" by redistributing duties between the supervisor and the RTM controller.

6.7 Organization in the event of a bi-national emergency

In a normal or disrupted situation, staff in the RCC ensure operation of the Channel Tunnel, including emergency response.

In the event of a serious accident and, in particular, if emergency services external to Eurotunnel have to be involved as a matter of urgency, then another organisation, the incident coordination centre (ICC in the UK or PCO in France) is set up, under the management of the préfet or his representative. As soon as the PCO/ICC is officially active, the RCC automatically loses the initiative and becomes the body that executes the decisions of the ICC/PCO.

Furthermore, at the site of the accident, the commander of emergency operations from the front (COSA) manages the emergency teams on the ground.

Requests from the ground systematically go through the PCO/ICC to be validated and then implemented by the RCC.

This method of operation involves numerous intermediaries within the information network and increases timescales and the chances of misunderstandings, thus affecting the speed and relevance of the decisions made.

Recommendation No. 31 (Préfecture, Kent police, SDIS, Kent Fire and Rescue Service, Eurotunnel): Examine the possibility of improving information and decision-making channels between the site of the incident, the RCC and the ICC/PCO in order to limit the amount of time lost.

Once the strategies to be used have been determined by the ICC/PCO, their operational implementation might be left under the RCC's responsibility.

6.8 Strategy in the event of a fire on board a freight shuttle

As the fire broke out in the first forty kilometres of the tunnel, the driver of shuttle 7412 stopped by applying the "controlled stop" procedure when advised of the fire by the chef de train.

Until the fire in 1996, it was envisaged that a freight shuttle on fire should continue running in order to leave the tunnel and go to the emergency siding at the exit terminal.

However, in 1996, after travelling approximately 19 km, the shuttle that was on fire was immobilised in the tunnel by the indication that the stabilisation jacks (propping devices) had lowered. As the conditions for evacuating passengers and crew after this stop were difficult, a new strategy was implemented for freight shuttles. This new strategy requires making a "controlled stop" beside a cross-passage unless the train is within the last ten kilometres of the tunnel.

However, the 2008 experience shows that the controlled stop strategy is not without disadvantages, in particular:

- Safe evacuation of the passengers into the tunnel is still difficult and uncertain because of the human factors relating to staff and passengers,
- The damage to the installations and equipment is very serious because of the great difficulty of fighting the fire in the tunnel.

Furthermore, since 1996, shuttles have been modified to ensure that an involuntary stop in the event of a fire is not very probable and, as indicated in Section 5.9.1, the catenary withstood the fire until the train stopped.

Finally, this fire is the third major fire on a freight shuttle (1996, 2006 and 2008) since the tunnel was opened. The initial safety studies assumed that a fire on a freight shuttle would occur once every 22 years on average. It therefore appears that the risk of a fire starting on board a freight shuttle was underestimated in those studies.

Overall, it seems necessary to re-examine the relevance of the current strategy of a controlled stop by freight shuttles and assess alternative strategies in the light of a specific risk strategy, taking account of the updated information on the probability of fires occurring, the reliability of the technical systems and the human factors involved, and in particular:

- The probability of a fright shuttle being able to leave the tunnel by its own means after a fire has been detected,
- The probability of a freight shuttle having to perform an uncontrolled stop and the ensuing evacuation taking place satisfactorily.

Recommendation No. 32 (Eurotunnel, SDIS, Kent Fire and Rescue Service): Re-examine the different strategies for stopping a freight shuttle that is on fire and for putting out the fire, taking account of the conclusions of this report, return on experience and a review of the risk assessment.

Of the areas that seem of interest, consideration might be given to:

- *installation of fixed extinguishing equipment in the running tunnels,*
- *installation of extinguishing equipment on board the shuttles,*
- *systematic exit of the shuttle on fire and extinguishing on the terminal track.*

Depending on the strategy selected, including that of a controlled stop, it must be checked that the equipment is still compatible with the strategy selected and, if it is not, define the action to be taken to regain this compatibility.

6.9 Prevention of fires on the vehicles transported

The cause of the fire is not yet known as the judicial investigation is still in progress; any recommendations can be given once the conclusions of this investigation are known.

However it should be noted that, since February 2009, Eurotunnel has improved prevention by taking action on:

- *Providing clients with information and making them more aware of the risk of fire (signs on the platforms, letters to carriers, posters, videos),*
- *Increasing safety checks on vehicles by creating the position of platform safety controller,*
- *Improving detection equipment (based on thermal imaging technology).*

6.10 Safety management system

The investigators from BEA-TT and RAIB did not perform an audit of Eurotunnel's safety management system. However, the investigation into the fire of 11 September 2008 revealed a certain number of safety problems which had not been identified or which had not been satisfactorily dealt with. This led the investigators to look for areas of improvement at the level of the safety management system with a view to making recommendations in this respect.

The table in section 4.4 makes the link between the safety problems revealed by the investigation, the management factors that are directly associated with them and the wider areas to which they might relate.

Consideration of this table and additional investigations has led to the formulation of recommendations concerning six areas of safety management.

6.10.1 Principle of systematically looking for and dealing with faults concerning safety

The investigation has shown that Eurotunnel's transport system had latent safety faults which did not appear in standard operation but which might have been revealed during training, simulations, audits and in accident and incident analyses, but were not sufficiently investigated.

The investigation also revealed known faults which it was not considered necessary to eliminate on the grounds that, as the systems had been validated and had not caused any critical events, their safety level could be considered as satisfactory.

The main examples are as follows:

- The position of the stop markers which is not consistent with the controlled stop procedure, so that the door of the amenity coach was not opposite the cross-passage;
- Insufficient reliability of the amenity coach doors which caused operators to underestimate the criticality of this element and develop non-conformant troubleshooting methods;

- The 21 kV network which was vulnerable in the event of a fire, causing the loss of certain back-up elements and complicating the job of the EMS controller;
- The failure of items of equipment, putting the fire-fighting operations at a disadvantage because of their vulnerability to the fire or a latent fault which had not been detected,
- Management of passengers in an emergency which was not dealt with realistically, particularly in cases of unforeseen situations.

Examination of documents SAFD 0012 and SAFD 1000 (replacing SAFD 0019) shows that this principle of looking for and dealing with latent faults is no longer emphasised.

Recommendation No. 33 (Eurotunnel): State in the highest level documents in the safety management system (SAFD 0012 and SAFD 1000) Eurotunnel's intention to take every opportunity to look for any latent faults in the system[31] which might appear in emergency situations or in degraded operating modes, and the intention to eliminate them as soon as is reasonably possible.

These fault-finding operations should be implemented:

- *Through better use of information from experience, checks and audits (see Section 6.10.2)*
- *By taking more account of the recommendations given following the investigations into the fires in 1996, 2006 and 2008 (see Section 6.10.3).*
- *Then, through systematic analysis of the operating reliability of systems in emergency situations (see Section 6.10.4).*

6.10.2 Review of experience, controls and audits

It is probable that many of the malfunctions revealed by the investigators, although not common, have happened a certain number of times before but without being identified or dealt with at the correct level by the review of experience, control and audit systems. The following cases can be quoted by way of example.

A Colson collar locking the door so that it could not be opened was fitted at Folkestone and then again at Coquelles after the journey from the UK to France. This leads one to believe that this procedure was not unusual; however, managers have said that they did not know about this practice.

The driver of freight shuttle 7412 correctly performed a controlled stop: nevertheless, the front right-hand door was not opposite the cross-passage.

It has been found, in particular, that, in the controls and audits it performs, Eurotunnel is essentially looking for deviations from the rules and pays insufficient attention to the validity of the rules as validation by the IGC means that it can have total confidence in the rules.

[31] The system consists of the technical systems (rolling stock, infrastructure, signals), the procedures and the operators.

Recommendation No. 34 (Eurotunnel): Look for an improvement to the process of reviewing experience (REX) and control and audit procedures so that they are used more in systematically searching for hidden defects and underlying problems and in identifying possibilities of improving the transport system.

In particular, these improvements should include:

- *systematic evaluation of the quality of procedures during exercises and simulations,*
- *better definition of the success criteria associated with these exercises*.

6.10.3 Implementation of the recommendations from previous reports

Of the recommendations made at the end of the investigations performed after the fires in 1996 and 2006, some cover areas which were again affected by the 2008 fire (see Annex No. 7).

These areas are:

- Information to passengers,
- Organisation and resources of the RCC,
- Quality of the performance of emergency procedures,
- Reliability of the radio systems,
- Control of the ventilation system,
- The time necessary to provide electrical protection for the emergency services,
- Reliability of the fire-fighting water system.

Furthermore, according to the European directive concerning the safety of railways, the Safety Authority concerned should report to the investigating organisation, at least once a year, on the measures taken or planned as a result of the recommendations.

Recommendation No. 35 (Eurotunnel, IGC): Taking account of legal obligations, put in place a system for verifying that the recommendations made by the national investigation organisations are being correctly implemented, as well as the effectiveness of the measures taken vis-à-vis the problems referred to by these recommendations.

6.10.4 Analysis of the operating reliability of systems

Technical systems may have hidden defects which might have critical consequences in an emergency situation, but which have not yet become apparent in operation or during exercises and simulations or in the previous fires.

Furthermore, the investigation has shown that the criticality of certain known failure modes should be reassessed to take better account of the actual behaviour of passengers and crew and the ability of personnel to deal with complex situations with incomplete information and multiple faults.

Recommendation No. 36 (Eurotunnel): Initiate an analysis of the emergency operating reliability of the most critical systems in the event of a fire in the tunnel.

In particular, this analysis should take account of the following:

- *Equipment failure modes, effects and criticality,*
- *If this equipment were not reliable, the long-term impact that this and operating in degraded mode would have on the management of emergency situations,*
- *Performance of personnel when faced with incomplete information or multiple faults,*
- *Behaviour of passengers and personnel.*

6.10.5 Quality of technical, maintenance and safety studies

In several cases it appeared that the studies performed by ET had not make it possible to resolve the problem posed or had not been performed with suitable methods or sufficient rigour.

- The problems regarding the reliability of the amenity coach doors could not be resolved and had to be tolerated, although they accounted for a large part of the causes of incidents on Freight rakes,
- Changes to rolling stock maintenance rules are based on statistical methods and, in particular, on investigations on a sample that are not well adapted to the small size of the fleet. Conversely, methods based on failure modes, effects and criticality analysis (FMECA) have not been sufficiently developed,
- Safety studies justifying the transfer of safety duties from the member of catering staff to the driver (Abbeville project) were not sufficiently in-depth and were based on false hypotheses meaning that the procedure to be applied when the member of catering staff is absent could not have been implemented in reality on 11 September 2008.

Recommendation No. 37 (Eurotunnel): Check whether engineering methods and resources match the variety and complexity of the technical systems managed by Eurotunnel, in order to improve the quality of technical and maintenance studies.

This check must also be based on a sound knowledge of the actual performance levels and failure modes of Eurotunnel systems.

Recommendation No. 38 (Eurotunnel): Examine the change management process and its implementation in order to improve the quality and rigour of the safety studies performed to justify projects involving changes to procedures and practices.

In this context, special attention should be paid to the plausibility of the hypotheses and the rigour of the arguments.

6.10.6 Competence and training for the management of emergency situations

The evacuation of the amenity coach did not take place under the direction of the chef de train, whose role it was. He prepared the passengers by advising them that it was going to be necessary to evacuate and handing out the breathing masks. He had difficulty reaching all of the passengers given the position of his workstation (at the back of the amenity coach). Rather, the passengers left the coach prematurely causing the smoke to get in. The majority of the passengers left through a window they had broken, although the chef de train had asked them to follow him through the rear right-hand door.

Furthermore, a considerable number of the passengers did not speak either English or French. Insufficient notice was taken of this factor in Eurotunnel's safety procedures.

The passengers noticed the flames from the beginning of the alarm, which caused a high level of anxiety amongst them, linked to the lack of information. These last two points had not been adequately taken into account in the chef de train's training.

Several errors also delayed steps being taken at the RCC. In particular, these are:

- no announcement by the supervisor when the first alarms were received,
- keeping a train's speed at a level that is below the authorised speed,
- inappropriate measures connected with the failure of the 21 kV supply.

These various errors imply insufficient:

- consideration of the conditions necessary to enable the agents to do their jobs in an emergency situation,
- training and maintenance of the skills of Eurotunnel agents.

Recommendation No. 39 (Eurotunnel): Improve training and the processes for assessing the skills of operating personnel (particularly the RCC controllers and train crews) so that they are better prepared for emergency situations.

7 Conclusions

7.1 Cause of the fire

The initial cause of the fire is not yet precisely known, but it can be assumed that a road vehicle caught fire and that the fire spread to the whole rake. It should be noted that one of the vehicles being transported had an electrical fault, demonstrated by the fact that it was impossible to put out its headlights and that this vehicle was on the part of the rake where the fire seems to have broken out.

7.2 Negative factors

Although the event did not result in serious casualties, a certain number of factors had a direct adverse effect on the evacuation procedures and fire-fighting operations.

7.2.1 Factors with an adverse effect on the evacuation of personnel

The evacuation was made more difficult by:

- the poor positioning of the point where the train stopped relative to the cross-passage,
- poor understanding of the evacuation instructions by the passengers,
- communication difficulties between the chef de train and the passengers,
- the locking of the amenity coach door through which the evacuation should normally have taken place,
- delay in opening the cross-passage door,
- delay in starting the supplementary ventilation system.

7.2.2 Factors with an adverse effect on the fire-fighting operations

The fire fighting was hindered by:

- the slowness of the electrical protection procedures (earthing the catenary),
- the vulnerability of certain items of equipment to fire (electricity supply, communication, fire hydrants),
- the latent faults in, or inappropriate configuration of, certain pieces of equipment (water pipe valves, ventilation dampers),
- the difficulty in precisely locating the part of the train that was on fire.

7.3 Organisational factors

A certain number of organisational factors also hindered the progress or effectiveness of the operations:

- the time lost in communication between the ground, the RCC and the PCO,
- the lack of any pre-set strategy for managing the ventilation system during fire-fighting operations,

- weaknesses in the organisation of the RCC in an emergency situation, and in the ergonomics of the tools available to the controllers.

7.4 Safety management system

On the basis of the factors above, the investigation has led to a certain number of areas for improvement being revealed in connection with the safety management system.

These areas for improvement include:

- The principle of systematically looking for and dealing with faults that concern safety;
- Procedures for learning from experience, checks and audits;
- Implementing the recommendations resulting from investigation reports;
- The quality of technical, maintenance and safety studies;
- Training and assessing the ability of personnel to manage emergency situations.

7.5 Recap of the recommendations

The recommendations made in this report relate to the arrangements that were current on 11 September 2008.

Since that date, a number of actions have been taken by various bodies involved in the accident, based on the outcome of their own investigations and analyses. This is notably the case for Eurotunnel through its project 'Salamander' launched at the beginning of 2009.

Some of the recommendations below will have already been partially or fully implemented by the time of publication of this report.

Concerning the evacuation of personnel

Recommendation No. 1 (Eurotunnel): Ensure that application of the controlled stop procedure by freight shuttles results in the evacuation door on the amenity coach being opposite a cross-passage.

Recommendation No. 2 (Eurotunnel): With support from specialists in human factors, improve the distribution of information and instructions to passengers in the event of an evacuation, taking account of those who do not speak English or French and the predictable behaviour of passengers in a stressful situation.

Recommendation No. 3 (Eurotunnel): Review the instructions and means of ensuring that the chef de train is informed of delays in achieving the necessary conditions for evacuation so that he can take this into account in performing his duties.

Concerning fire-fighting

Recommendation No. 4 (Eurotunnel, SDIS, Kent Fire and Rescue Service, Office of Rail Regulation, IGC): Examine regulatory, organisational or technical changes that would make it possible to reduce the time needed to provide electrical protection for the fire-fighters and enable them to fight the fire as quickly as possible.

Recommendation No. 5 (Eurotunnel): Look at what steps need to be taken to ensure that information entered into the ISIS system is correct and to prevent any ambiguity in the interpretation of the data by the emergency services.

Recommendation No. 6 (Eurotunnel): Look for ways of making the various elements used to fight the fire more reliable (valves, fire hydrants, pumping stations, etc.), especially those that could be subjected to high temperatures.

Recommendation No. 7 (Eurotunnel): Implement a procedure to ensure that the fire main manual valves are in the position specified by the procedures and known to the personnel concerned so that water can be supplied immediately when needed.

Recommendation No. 8 (Eurotunnel, SDIS, Kent Fire and Rescue Service): In agreement with the emergency services, re-examine the means of rapidly reconfiguring the fire-fighting system according to requests from the fire-fighters.

Recommendation No. 9 (Eurotunnel, SDIS, Kent Fire and Rescue Service): Review the supplementary ventilation system management procedures in the event of a fire on a freight shuttle with a view to limiting the development of the fire and enabling it to be fought effectively.

Recommendation No. 10 (Eurotunnel): Examine the feasibility of a system that would make it possible to know the location and progress of a fire so that it can be fought effectively.

Recommendation No. 11 (Eurotunnel, SDIS, Kent Fire and Rescue Service): Re-examine the intervention conditions and resources of the first line of response teams with a view to reducing the time before a fire can be attacked.

Recommendation No. 12 (Eurotunnel, SDIS, Kent Fire and Rescue Service): Examine the relevance of improving the resources made available to the emergency services, particularly with regard to the points raised by their experience on 11 September 2008.

Concerning rolling stock

Recommendation No. 13 (Eurotunnel): Look for any modifications that might be made to the amenity coach and the distribution of equipment inside it, so that the chef de train has better access to the equipment necessary for an evacuation (including breathing masks) and can perform his duties in all situations, particularly opening the evacuation door.

Recommendation No. 14 (Eurotunnel): Examine what needs to be done to improve the reliability of the amenity coach doors, the consistency of the operational tests performed before freight shuttles restart service and the quality control of troubleshooting and maintenance work.

Recommendation No. 15 (Eurotunnel): Clarify the rules on isolating and locking access doors and the rules for keeping amenity coaches in operation so that the rules are consistent with the passenger evacuation strategy in case of fire.

Concerning fixed installations

Recommendation No. 16 (Eurotunnel): Examine a modification to the 21 kV network in order to make that network more reliable in the event of a fire and to quickly be able to return supply to equipment that has been cut off in the event of a failure.

Recommendation No. 17 (Eurotunnel): Look at modifying the arrangement of the dampers in the supplementary ventilation system on the French side, or their control system, in order to limit the consequences of a fault.

Recommendation No. 18 (Eurotunnel): Examine having lighting installed at a low level in the running tunnels, mainly near the evacuation cross-passages, in order to reduce situations where this lighting is affected by the smoke.

Concerning telecommunications

Recommendation No. 19 (Eurotunnel): Examine whether simple measures and rapid implementation could improve the current coverage of the track-to-train radio before installing GSMR or whether changes to the procedures are needed to take account of the frequency of faults.

Recommendation No. 20 (Eurotunnel): Improve the wording of the procedure defining the action to be taken by a driver who cannot contact the RCC when a fire has been reported or has effectively broken out on his train.

Recommendation No. 21 (Eurotunnel): Look for ways of reducing the risks of the tactical radio malfunctioning. In particular, examine the possibility of transferring all or part of the cables installed in the running tunnels to the service tunnel and improve the reliability of the communication modules in the specialised STTS-Com vehicles.

Concerning the RCC's work, procedures and tools

Recommendation No. 22 (Eurotunnel): Take steps to have a second officer, who is qualified to perform the EMS controller's duties in the rail control centre (RCC) on site within 10 minutes in emergency situations.

Recommendation No. 23 (Eurotunnel): In liaison with the emergency services, examine how the transmission of information to the UK external emergency services (Fire Brigade, Ambulance, Police) could be speeded up in order to limit the FD controller's workload.

Recommendation No. 24 (Eurotunnel): Examine the possibility of giving the supervisor greater autonomy, within a defined framework, in determining which actions by the controllers in the RCC he is going to monitor as a priority, particularly at the start of an incident.

Recommendation No. 25 (Eurotunnel): Examine ways of improving the tools available to the EMS controller to lighten his workload, in particular to limit the information received to that which requires immediate action. Examine the possibility of a method of presentation according to the level of priority so that the controller has help in determining the order in which tasks have to be dealt with.

Recommendation No. 26 (Eurotunnel): Look at ways of making information on the control of the supplementary ventilation system more reliable and explore whether new procedures could guide the EMS controller when there is incomplete information.

Recommendation No. 27 (Eurotunnel): Examine the possibility of advising the EMS controller by more reliable means than is currently the case, of the moment when the instruction to slow the trains to 10km/h has been given.

Recommendation No. 28 (Eurotunnel): Examine the possibility of being able to start the supplementary ventilation system fans as soon as a fire alarm is confirmed in a running tunnel.

Recommendation No. 29 (Eurotunnel): Examine the possibility of putting in place a system that would make it possible to identify, immediately and without any doubt, the exact position at which a train has stopped so that the cross-passage door can be opened as quickly as possible.

Recommendation No. 30 (Eurotunnel): Examine the possibility of improving the procedure for implementing the rules of the "speed table" by redistributing duties between the supervisor and the RTM controller.

Concerning the respective roles of the command organisations

Recommendation No. 31 (Préfecture, Kent police, emergency services, Eurotunnel): Examine the possibility of improving information and decision-making channels between the site of the incident, the RCC and the ICC/PCO in order to limit the amount of time lost.

Concerning the strategy in the event of a fire on board a freight shuttle

Recommendation No. 32 (Eurotunnel, SDIS, Kent Fire and Rescue Service): Re-examine the different strategies for stopping a freight shuttle that is on fire and for putting out the fire, taking account of the conclusions of this report, return on experience and a review of the risk assessment.

Concerning the safety management system

Recommendation No. 33 (Eurotunnel): State in the highest level documents in the safety management system (SAFD 0012 and SAFD 1000) Eurotunnel's intention to take every opportunity to look for any latent faults in the system which might appear in emergency situations or in degraded operating modes, and the intention to eliminate them as soon as is reasonably possible.

Recommendation No. 34 (Eurotunnel): Look for an improvement to the REX and control and audit procedures so that they are used more in systematically searching for hidden defects and underlying problems and in identifying possibilities of improving the transport system.

Recommendation No. 35 (Eurotunnel, IGC): Taking account of legal obligations, put in place a system for verifying that the recommendations made by the national investigation organisations are being correctly implemented, as well as the effectiveness of the measures taken vis-à-vis the problems referred to by these recommendations.

Recommendation No. 36 (Eurotunnel): Initiate an analysis of the emergency operating reliability of the most critical systems in the event of a fire in the tunnel.

Recommendation No. 37 (Eurotunnel): Check whether engineering methods and resources match the variety and complexity of the technical systems managed in order to improve the quality of technical and maintenance studies.

Recommendation No. 38 (Eurotunnel): Examine the change management process and its implementation in order to improve the quality and rigour of the safety studies performed to justify projects involving changes to procedures and practices.

Recommendation No. 39 (Eurotunnel): Improve training and the processes for assessing the skills of operating personnel (particularly the RCC controllers and train crews) so that they are better prepared for emergency situations.

ANNEXES

Annex No. 1: Decision to open an investigation in France

[stamp]

MINISTRY OF ECOLOGY, ENERGY, SUSTAINABLE DEVELOPMENT AND LAND MANAGEMENT

Land Transport Accident Investigation Bureau

La Défense, 12 September 2008

The Director

BEA-TT 2008 - 015

DECISION

The Director of the Land Transport Accident Investigation Bureau:

In view of Law No. 2002-3 of 3 January 2002, amended, on the safety of transport infrastructure and systems, and in particular section III on technical investigations;

In view of Decree No. 2004-85 of 26 January 2004, amended, on technical investigations following a land transport accident or incident;

In view of the circumstances of the fire on board an HGV shuttle in the Channel Tunnel on 11 September 2008:

HAVING DECIDED

Article 1: A technical investigation, performed in the context of section III of the aforementioned Law No. 2002-3 of 3 January 2002, has been opened into the fire on an HGV shuttle in the Channel Tunnel on 11 September 2008.

[signed]

Jean Gérard KOENIG

Tour Pascal B92055 La Défense Cedex
Tel.: 01 40 81 2327 – www.bea-tt.equipement.gouv.fr

Annex No. 2: Protocol between BEA-TT and RAIB

Memorandum of Co-operation between the Bureau d'Enquêtes sur les Accidents de Transport Terrestre (in France) and Rail Accident Investigation Branch (in the UK)

AGREED BETWEEN			
Jean-Gerard Koenig	....	*Directeur*	*BEA-TT*
Date	…………………………		
Carolyn Griffiths	....	*Chief Inspector*	*RAIB*
Date	…………………………		

1. PURPOSE OF MEMORANDUM

The Rail Accident Investigation Branch (RAIB) and the Bureau d'Enquêtes sur les Accidents de Transport Terrestre (BEA-TT) are the permanent investigating bodies for railway accidents and incidents in accordance with Directive 2004/49/EC of 29 April 2004 and the associated national legislation, in the UK and France respectively.

The purpose of this Memorandum of Co-operation is to organise co-operation between these two bodies in case of accidents or incidents in the Channel Tunnel System.[32]

1.1 Status of the memorandum

It is agreed that the status of this memorandum is that of an operational guidance document for the assistance of both parties and that it is not a legally binding contract or otherwise legally binding.

1.2 Application of this memorandum

Both BEA-TT and RAIB are agreed that this memorandum shall apply from the date of its signature; each party has a right to cancel it after a notification to the other party.

32 The term 'Channel Tunnel System' includes the actual Channel Tunnel but also the remainder of the concessions (including terminals and railway maintenance areas)

2. LEGAL FRAMEWORK FOR TECHNICAL INVESTIGATIONS

Requirements for co-operation between RAIB and BEA-TT exist at three levels:

1. European - through Directive 2004/49/EC of the European Parliament and of the Council of 29 April 2004 on the Safety of the Community's Railways (e.g. Article 22(1);

2. Bi-national through the IGC regulations;

3. National - in Britain and France, through the relevant national legislations.

2.1 European Directive 2004/49/EC

It is pointed out that Article 22 (1) of Directive 2004/49 provides as follows concerning cross-border co-operation between Member States:

"An accident or incident referred to in Article 19 shall be investigated by the investigation body of the Member State in which it occurred. If it is not possible to establish in which Member State it occurred or if it occurred on or close to a border installation between two Member States the relevant bodies shall agree which one of them will carry out the investigation or shall agree to carry it out in cooperation. The other body shall in the first case be allowed to participate in the investigation and fully share its results.

Investigation bodies from another Member State shall be invited to participate in an investigation whenever a railway undertaking established and licensed in that Member State is involved in the accident or incident."

Article 21 (5) goes further:

"If necessary the investigating body may request the assistance of investigating bodies from other Member States or from the Agency to supply expertise or to carry out technical inspections, analyses or evaluations."

2.2 Bilateral (cross channel) regulations

The Treaty of Canterbury (article 10) tasked the Intergovernmental Commission (IGC) with supervising, in the name of and on behalf of the UK and French Governments, all matters concerning the construction and operation of the Fixed Link.

The Treaty also provided (article 11) for a Channel Tunnel Safety Authority (CTSA) to be set up, with the following main tasks:

- to help and advise the IGC on all matters relating to the safe operation of the Fixed Link;
- to ensure compliance of the safety measures and practices applicable to the Fixed Link with the national or international laws in force;
- to examine reports on any incident affecting safety in the Fixed Link, conduct any necessary investigation, and report to the IGC.

The IGC have drawn up bi-national regulations in order to transpose the requirements of Directive 2004/49/EC in respect of the Channel Tunnel system (signed on 24 January 2007, ratified by both Parliaments and came into force on 4 July 2008). These regulations appoint the IGC as 'safety authority' with the roles and responsibilities as described in the Directive. These regulations recognise the role of BEA-TT and RAIB as the independent investigating bodies for the Channel Tunnel system (as provided for in their respective national laws and any necessary reciprocal co-operation arrangements).

2.3 National frameworks

2.3.1. France

The main legal texts governing BEA-TT investigations are:

- the Law of 3 January 2002 concerning, in particular, safety of infrastructure and transport systems and technical investigations after accidents or incidents on land;
- Decree 2004-85 of 26 January 2004 concerning technical investigations of events at sea and land transport incidents or accidents;

These texts have been amended when Directive 2004/49 was implemented in French law.

The institution responsible for retaining evidence is the judiciary, once a judicial inquiry is opened. When BEA-TT has opened an investigation, it has broad powers of access to this evidence and to investigate all parties concerned.

Although it is part of the Ministère des Transports, BEA-TT is entirely independent in the conduct of investigations.

2.3.2. The UK

In the UK articles 19 to 25 and Annex V (accident and incident investigation) of Directive 2004/49/EC have been transposed by the Railways (Accident Investigation and Reporting) Regulations 2005 (SI 2005/1992 as amended by SI 2005/3261 and 2006/557).

The Railways and Transport Safety Act 2003 set up the Railway Accident Investigation Branch (RAIB) to investigate railway accidents and incidents.

The Railways & Transport Safety Act 2003 and the Railways (Accident Investigation and Reporting) Regulations 2005 provide the legal framework allowing RAIB to work. In particular, the Regulations require railway industry bodies to notify RAIB of accidents or incidents, to preserve evidence and to co-operate with the RAIB in its investigations. In addition, there are certain legal requirements on statutory authorities in areas such as the preservation of evidence. These Regulations took effect on the UK part of the Channel Tunnel on 31 January 2006.

In particular the Regulations recognise the need for and require co-operation between RAIB and BEA-TT, (e.g. regulations 5(9)).

Although it is part of the Department for Transport, RAIB is functionally independent. The Chief Inspector reports direct to the Secretary of State for Transport on accident investigations.

3. EXCHANGE OF INFORMATION ON BECOMING AWARE OF AN ACCIDENT OR INCIDENT

When one of the investigating bodies is notified of an accident or incident it will inform the other in accordance with article 21.3 of the EU Directive 2004/49/EC. In the case of an event that is listed in Annex 1A this information shall be passed immediately and by the fastest possible means (i.e. by telephone). In the case of an event that is listed in Annex 1B this information shall be passed as soon as is practicable.

Contact details for BEA-TT and RAIB are set out in Annex 2.

4. OPENING OF INVESTIGATIONS

When either BEA-TT or RAIB plans to open an investigation, it shall contact the other to inform it of its position and consider which of the investigation strategies outlined in clauses 5.1 and 5.2 shall apply.

When deciding whether or not to open an investigation into an incident that has occurred on its own national territory within the Channel Tunnel Concession each investigating body will take into account the views of the other.

5. COORDINATION OF BEA-TT AND RAIB ACTIVITIES DURING AN INVESTIGATION

Article 22 of Directive 2004/49 indicates that an investigation can be opened by one body (clause 5.1 below) or by both bodies simultaneously (clause 5.2 below).

5.1 Investigation opened by one body

Such an investigation can only be opened by the investigating body in whose territory the accident has occurred (the “lead body”).

The “lead body” will involve the other investigating body ("partner body") in its investigation.

The partner body nominates a correspondent to serve as the contact between the two bodies.

In all such cases the partner body will have the right to be informed of progress and shall be consulted on matters of importance. If it wishes, it may attend the meetings held by the lead body. It will try as far as reasonably practicable to respond to requests from the lead body. It acts as a relay in its country for all needs for action, information or documentation, within the limit of its powers given that it has opened no investigation of its own.

5.2 Co-operative investigations opened by both bodies

When both investigating bodies open an investigation into the same accident or incident, they cooperate with a view to conducting a joint investigation and producing a joint report.

As soon as the two bodies decide to launch an investigation, they consult to decide how to ensure the cohesion of their investigation activities. They agree methods of investigation, and determine the principles of division of effort and work organisation. The two investigating bodies also examine the remit and scope of the investigation. The body leading the investigation will then draft a plan, which it refers to the other investigating body for its opinion.

During the investigation, within the limits of the applicable national regulations, they shall regularly exchange information gained. They will grant the fullest possible access to the documents and recordings in their possession. They will co-ordinate their work programmes and co-operate in writing the published documents (including communications with the parties concerned and drafting of the investigation report).

This Memorandum establishes the principle that one or other of the investigating bodies will always lead the management of a joint investigation and that this decision shall be taken quickly in order to facilitate an effective investigation.

The choice of body to lead the investigation depends on where the accident happened. BEA-TT will lead the investigation if the accident occurred in the French part of the Channel Tunnel; RAIB if it occurred in the UK part of the Channel Tunnel. If this in unclear (eg in the instance of a fire on a moving train that crosses the international frontier), the two investigating bodies will consult to agree which body will lead the investigation and any special management arrangements to apply.

5.3 Expenses incurred in investigations

These are of two types:

1- each body's own expenses; and
2- spending on external services.

For all types of investigation each body shall meet its own expenses, which are mainly the costs of the investigators and their travelling expenses.

If an investigation is opened by only one body (clause 5.1 above), the cost of external services will be met by the body requesting the service (in principle, this is the body implementing the investigation).

In the case of a co-operative investigation (clause 5.2 above), the cost-sharing formula for external services is decided jointly at the start of the investigation. This formula may be revised during the investigation, with the agreement of both parties.

6. LIAISON WITH NATIONAL AUTHORITIES AND OTHERS INVOLVED

The two investigating bodies will strive for effective working relations with the national police forces, the judicial authorities and other national authorities during an investigation into an accident. In particular, each body will endeavour to facilitate access to national officials for investigators from the other nation's investigating body if this is necessary to the conduct of an investigation.

Likewise the two investigating bodies will try to facilitate relations with other bodies (eg the railway companies) for the investigating body in the other country.

7. INVESTIGATORS' POWERS AND CONFIDENTIALITY

The investigators of each of the bodies act in their countries by the powers granted to them at national level, in accordance with the national regulations, especially concerning confidentiality.

Any activity by an investigating body outside its national territory will take place with the agreement of, and in co-operation with, the other. Clearly, therefore, this Memorandum grants no powers to investigators outside their national territories unless they have been formally appointed under the relevant national regulations.

The limit of each investigating body's territorial competence is the frontier as defined in accordance with Article 3 of the Treaty of Canterbury, namely PK 37+000.

8. MANAGEMENT OF EVIDENCE AND INFORMATION TO BE RELEASED

Both investigating bodies shall co-operate to ensure that both parties are content with any proposals to share information and evidence with external bodies. Information releases shall take into account the requirements of the EU Directive, national laws and the needs of both parties.

For investigations conducted under clause 5.1 above, the body conducting the investigation shall pass to the partner body any information it proposes to release. The partner may comment if it feels necessary.

For co-operative investigations as per clause 5.2 above, the information (eg press releases) proposed by either body must be referred to the other for approval before use or distribution. In case of difficulty, the two bodies will together seek joint wording.

In addition the timing and method of any planned release should be discussed by both bodies, and agreed so far as is reasonably practicable.

9. INVESTIGATION REPORTS AND RECOMMENDATIONS

The following arrangements apply:

- to final reports;
- to interim reports; and
- to urgent recommendations[33] or safety advice

Reports on investigations carried out as per clause 5.1 are drawn up under the direction of the investigating body responsible. Before any distribution, reports are passed to the partner body, which may comment.

Joint reports and recommendations on co-operative investigations as per clause 5.2. above are drawn up jointly and agreed by both bodies. If a difference emerges between the two investigating bodies, it will be submitted to the Director of BEA-TT and the Chief Inspector of RAIB, who will seek a common position. If the difference cannot be resolved:

- the main text is drawn up by the lead body with, as an annex, a statement of the viewpoint of the partner body;
- the existence of the disagreement is mentioned in the summary and conclusions.

Drafts of the reports and recommendations will be transmitted for consultation to involved or relevant parties; the list of consulted parties will be agreed jointly by RAIB and BEA-TT.

The body of a joint report will be published in both French and English. The partner body is responsible for translation. Bulky technical annexes are not automatically translated, unless this is essential for an understanding of the conclusions. The structure and presentation of the report will comply with the requirements of the Directive, unless deviations are agreed by the investigating bodies.

The two bodies jointly sign the submission to the IGC of their joint report.

Each investigating body distributes the report to the recipients it considers useful, in accordance with the established national rules.

Information on follow-up of the recommendations received by either body is passed to the partner body for information.

The investigating bodies will likewise seek agreement on the drafting of urgent recommendations which they consider need publishing during an investigation. If the need for such a recommendation is not recognised, each investigating body will have an opportunity to publish the recommendation to the appropriate bodies in its own territory.

33 During the investigation, it may prove vital for either or both investigating bodies to make one or more recommendations or issue advice, without awaiting an interim or final report. Such recommendation(s) are called urgent recommendations.

10. ANNUAL REPORTS

Under Directive 2004/49 and national law, each of the two bodies deals with investigations conducted concerning the Fixed Link, in its own Annual Report[34] [35], having referred the part of it relating to the Fixed link to the other investigating body for comment or input.

11. OPERATIONAL REVIEW

The Director of BEA-TT and the Chief Inspector of RAIB undertake a regular review of their work for the Channel Tunnel and the effectiveness of this Memorandum in the light of practical experience. The review is annual. It may take the form of a meeting, telephone call or e-mail exchange depending on the situation.

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34 Reports to the European Railway Agency, to the national safety authorities and to the IGC.

35 Stating "none" if no investigation took place during the year.

Annex No. 3 : Evacuation procedure

Evacuation (in the event of a fire alarm)

(1)- **EVACUATION**
- take the portable radio
- take the portable lamp
- take the "Mission report sheet" and the "Load summary"
- place the mode selector on "TC"
- **only if the tunnel environment makes it necessary**, ensure that everyone in the club car is wearing their breathing masks
    * do not delay the evacuation if one or more passengers refuse to wear a mask:
    * explain the risks incurred
    * continue with the evacuation process
    * put on your breathing mask
- have visual contact with the Driver unless:
    * the club car is at the rear or there is a certified agent in the club car.
    * in an emergency situation (e.g. discovery of a suspicious object, fire in the club car):
- choose the safest method of leaving the club car:
    * through the club car door that is furthest away from the danger, using remote control or the "Emergency opening" control (use if the emergency ramp or folding ladder is required)
    * through the loading wagon
- let in the Driver who will:
    * take up position at the passenger access door to count the number of people
    * tell the chef de train about the people who were in the driver's cab and who will be included in the evacuation of passengers.
- choose a cross-passage that will make it possible to move away from the danger or use a cross-passage that is visible from the club car if external conditions are satisfactory
- place the high visibility cord between the club car door and the handrail on the evacuation walkway on the **side opposite to the direction of evacuation**
- lead the passengers to the cross-passage selected (if the cross-passage door is closed, open it using the emergency opening control, or even the manual control if necessary)
- position yourself at the entrance of the cross-passage door to:
    * direct the passengers towards the service tunnel, asking them to pay attention to any vehicles that might be travelling in the service tunnel
    * count the number of people going into the service tunnel
    * wait for the arrival of the Driver or designated HGV driver (recover the sling).
- compare the number of passengers with the status report: recorded on the mission report sheet.

If the number of passengers does not correspond:
- advise the FLOR Manager
- prepare to identify and evacuate the missing person or persons (do not go back into the running tunnel without the agreement of the FLOR Manager or the RCC)

<u>If the number of passengers does correspond:</u>
- ask the Driver to:
  * keep the people together in the service tunnel, protecting them from the hazards connected with road traffic in the service tunnel
  * make sure that there is nobody standing within the yellow hatched areas showing the safety area for opening and closing the cross-passage doors
- make sure there is no-one inside the passage door's opening and closing area
- contact the RCC by pressing "E" or the orange button on the concession radio to:
  * inform the RCC that all the passengers are safe and that the cross-passage door can be closed again (only close it again manually if instructed by the RCC). **<u>In the case of a train with the club car at the rear, this information is urgent and a safety issue. It enables the RCC to reverse the direction of the SVS and thus improve the conditions for evacuating the Driver</u>**
  * ask for the concession radio number used by the FLOR Manager or Terminal Leader
- use the "Passenger announcement booklet" and read the message in Part C "On arrival in the service tunnel" through the PA system available in the service tunnel
- authorise the passengers to take off the breathing masks (if used).
- wait for the FLOR team to arrive
- tell the FLOR manager the location of the alarm:
  * "FDE alarm on loader at the front of the movement"
  * "FDE alarm on loader at the rear of the movement"
  * "FDE alarm unidentifiable due to configuration fault" if the FDE alarm and the "configuration fault" indicator are lit
- follow the instructions from the FLOR Manager and the RCC
- keep the people:
  * inside the cross-passage to protect them from road traffic
  * outside of the yellow hatched areas showing the safety area for opening and closing the cross-passage doors
- keep the passengers regularly informed of the conditions regarding their return to a Terminal.
- accompany the passengers to the Terminal

The chef de train is responsible for the evacuation until the Terminal Leader takes charge of the passengers at the Arrival Terminal.

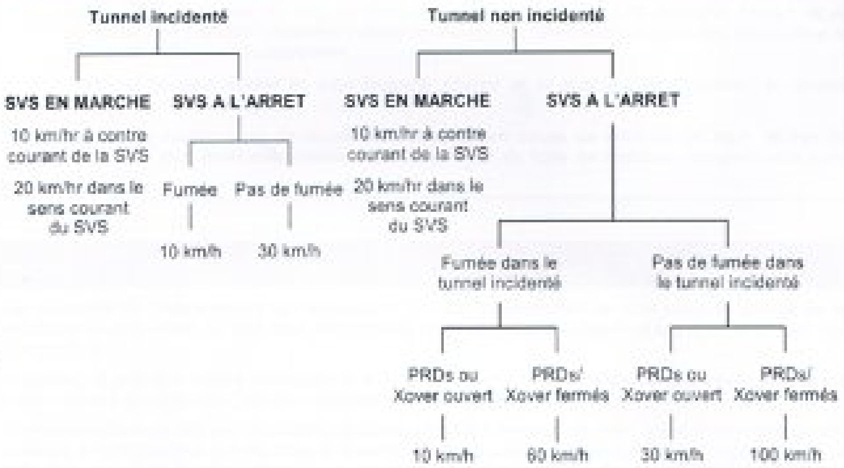
Annex No. 4: Speed table

INCIDENT EMS	SPEEDTABLE	80.56

Phase immédiate (dès l'arrêt du train incidenté)

- Le ***CONTROLEUR RTM*** fait mettre en place par dialogue informatique une limitation de vitesse de 30km/ h dans les six intervalles de tunnel.
- Le ***CONTROLEUR RTM*** refait démarrer les trains à la vitesse indiqué sur le schéma ci-dessous, dans un premier temps sans utiliser la procédure "VILI".

Phase post évacuation (lorsque tous les passagers du train incidenté sont évacués dans le tunnel de service)



En cas de fumée ou d'incendie, dans le tunnel non incidenté, dans les cas suivants, la vitesse doit être limitée:	
un CPD bloqué ouvert	**0 km/h***
une usine NVS indisponible	**30 km/h - Si une vitesse inférieure est déjà appliquée alors la maintenir**
un seul ventilateur SVS sur les 4 de disponible	**0 km/h***
au moins une porte de sas bloquée ouverte	**0 km/h***

*** Après confirmation locale que le flux d'air est suffisant dans les CPDs ouverts et que la fumée est sous contrôle, les trains peuvent repartir à 10/20 km/h comme définie dans la phase immédiate**

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Annex No. 5 : Recommendations following the fire of 1996

Recommendations from the report by the Channel Tunnel Safety Authority on the fire that occurred in the Channel Tunnel on 18 November 1996

5-1 - Fixed installations

Recommendation No. 1: Eurotunnel must review the tunnel fire detection system and abandon the notion of "single alarm" in order to give the rail control centre earlier warnings.

Recommendation No. 2: Eurotunnel must resolve the problems regarding the reliability of undersea cross-passage doors. They must be kept closed during normal operating periods. During periods of single line operation, Eurotunnel must ensure that they can be closed by remote control in the event of an emergency. Any fault in a cross-passage door, which is in the open position, confirmed locally, must result in the suspension of the HGV service.

Recommendation No. 3: Eurotunnel must review the maintenance schedule for piston relief duct dampers and their emergency closing system in order to improve the reliability of this device.

Recommendation No. 4: Eurotunnel must examine measures to reduce hazards, in the event of a fire, [in particular], the procedures relating to HGV shuttles specifying that the club car should be uncoupled and leave the tunnel with the adjacent locomotive.

Recommendation No. 5: Eurotunnel must improve the quality of radio connections and provide additional training for its users. Special attention must be paid to the discipline of utilisation, the use of standard messages and the use of the emergency call button on the concession radio. The number of users of the concession radio should also be revised downwards.

Recommendation No. 6: Eurotunnel must verify that the level of availability of the radio and telephone systems complies with the specifications. There must be automatic switching from the internal administrative telephone system to the public networks in the event of a fault.

Recommendation No. 7: Eurotunnel must draw conclusions from the loss of power in the fire-fighting water system and take the necessary action to minimise the effects of a fire on this essential system.

5-2 - Operation of the rolling stock

Recommendation No. 8: In order to ensure earlier detection of a fire, Eurotunnel must either review the calibration of the on-board detection system or replace the type of sensors. These modifications must be validated by realistic tests performed in the tunnel.

Recommendation No. 9: To ensure early detection of a fire, Eurotunnel must take account of the alarms given by the locomotive detection system, which must be treated in the same way as other fire alarms.

Recommendation No. 10: Eurotunnel must make the control circuit for the position of the jacks and folding bridge plates on loading/unloading wagons more reliable in order to limit the number of untimely stops in a tunnel.

Recommendation No. 11: Eurotunnel must abandon the current procedure involving having a HGV train that is on fire leave the tunnel. In its other procedures it must, in particular, take account of the following possibilities:

- failure of a locomotive,
- failure of the control circuit for jacks and folding bridge plates,
- failure of the braking circuit,
- failure of the catenary,
- risk from the smoke to passengers in the following train,
- risk due to the extent of the fire at the time of stopping (controlled or uncontrolled stop) for the passengers on the train affected by the incident.

Recommendation No. 12: To prevent smoke getting in in the event of an incident, Eurotunnel must carry out an exhaustive verification of the sealing of club cars and locomotive driving cabs, and correct any faults that might appear in the course of these verifications. Any new equipment of this type that is put into operation must have the same smoke seal characteristics.

Recommendation No. 13: Eurotunnel must review the maintenance procedure for ventilation dampers in tourist wagons to ensure they are working correctly.

Recommendation No. 14: To allow the passage from one rake to another under acceptable conditions, Eurotunnel must review its maintenance procedures to ensure the correct operation of the doors at the ends of tourist loading wagons.

5-3 - Behaviour of personnel

Recommendation No. 15: With the assistance of the emergency planning committee, Eurotunnel must review the alarm priorities and procedures of the public emergency services.

Recommendation No. 16: To reduce response times, Eurotunnel must improve the procedure for the first line of response to enter the service tunnel from the French terminal. The procedures for bringing the specialised “communication” vehicle and the second level assistance resources to the intervention site must be re-examined. Eurotunnel and the emergency planning committee must review joint training for the first lines of response and the second lines of response in the management of incidents, provision of breathing apparatus and all related operational procedures.

Recommendation No. 17: Eurotunnel must review the training of all its staff in the management of emergency situations and produce a training programme based on practical exercises.

Recommendation No. 18: Eurotunnel must record all radio and telephone conversations from or to the following centres: rail control centre, road control centres, fire equipment management centres, PCO, ICC, including the direct line between the latter two centres.

Recommendation No. 19: The agents who, because of their duties, are likely to notice fire or smoke on a train before it enters a tunnel, must be equipped with a means of direct communication with the rail control centre. This information must be dealt with in the same way as the other fire alarms. The procedures that can be applied by these members of staff must be brought up to scratch in this regard.

Recommendation No. 20: All crew members on trains belonging to Eurotunnel, or any other rail operator using the tunnel, must be given additional training on awareness of emergency situations. This training must be based on practical exercises. In particular, a mock-up reproducing the environment of a rail tunnel beside an evacuation passage must be constructed. This must have the facility for producing smoke in order to accustom the crews to a smoke-filled atmosphere.

Recommendation No. 21: Eurotunnel must improve the visibility of reflectorised markers and regularly clean them.

Recommendation No. 22: The training programme for Eurotunnel crews must include familiarisation with the breathing apparatus that they might have to use. Furthermore, Eurotunnel must improve the lighting beside the cross-passage doors and provide crews with powerful portable lamps.

Recommendation No. 23: The procedures for evacuating the club car must be brought up to scratch and must make it clear that the evacuation doors can only be opened if the chef de train has had visual contact with the driver or has first been able to ensure that the visibility of the walkway is sufficient and he has been able to spot the cross-passage.

Recommendation No. 24: Eurotunnel must update the procedures and the training of its staff with regard to information for passengers. Furthermore, safety instructions must be given out to passengers before that train departs. Standard messages to reassure the passengers in the event of an incident must be provided.

Recommendation No. 25: Eurotunnel and other rail operators using the tunnel must ensure that pre-established standard messages intended for the passengers are provided and updated in order to respond to emergency situations. The possibility of an evacuation in another train must be taken into account in these messages.

Recommendation No. 26: Eurotunnel must review its first aid training policy. Eurotunnel must ensure that all its crew members and the crew members of any rail operator using the tunnel have a sufficient level of competence to ensure that basic life-saving measures can be carried out in an emergency. Eurotunnel must also include “first aid” training in the training for its crews, within the next six months so that the following are qualified in first aid:

- the chef de train on an HGV shuttle;
- at least one crew member on a tourist shuttle.

Recommendation No. 27: The review experience (REX) system must be brought up to scratch. Operating incidents must be analysed and commented on by management, as must any modifications to operating procedures.

Recommendation No. 28: Eurotunnel must repeat and update the training of operators in the rail control centre. The supplementary training programme must include training in emergency situations and visits to the site of installations. It should be validated by a certificate attesting that the required level of competence has been reached. Maintenance courses must be held at regular intervals. Any member of staff who fails one of these training programmes should be pulled from service and put on a refresher course to improve their level of competence, followed by a new evaluation.

Recommendation No. 29: Procedures relating to the application of speed limits must be improved in order to prevent untimely emergency braking of a train due to the action of the speed control system.

Recommendation No. 30: The EMS management system must be modified to enable controllers to deal with an unexpected overload of work in an emergency situation. Eurotunnel must also develop and implement an alarm management system.

Recommendation No. 31: The EMS management system's software must be modified so that the operator can easily identify damaged areas and reconfigure the catenary if necessary.

Recommendation No. 32: Procedures relating to the exchange of information between drivers and the rail control centre must be brought up to scratch.

Recommendation No. 33: Eurotunnel must repeat the training of operators in the rail control centre so that, in such rare but potentially dangerous situations, they know by heart the standard responses necessary to make people and the system safe, without having recourse to written documentation. Periodic exercises must be held to verify and maintain this knowledge.

Recommendation No. 34: Eurotunnel must perform an in-depth review of the procedures concerning the rail control centre with a view to clarifying them, simplifying them and making them easier to use by the operators. Eurotunnel must provide the resources, in terms of qualified personnel, to rapidly perform this essential task and make undertakings in terms of timescales. Eurotunnel must carry out an analysis of the tasks performed by the various operators in the rail control centre to ensure that they can be performed satisfactorily in all circumstances.

Recommendation No. 35: Eurotunnel must update procedures relating to the controlled stop and make it clear that, unless it is impossible, the stopping point must be agreed beforehand between the driver and the rail control centre. In order to overcome any failure, Eurotunnel must examine the possibility of installing an improved system to mark the position of a train stopped in a tunnel. Eurotunnel must use the improvements thus obtained and instruct the opening of the appropriate cross-passage door at the moment the train stops.

Recommendation No. 36: One way of remedying work overloads would be the permanent presence of a fourth operator in the rail control centre, with "EMS" and "RTM" qualifications who, in an emergency, could provide assistance to one or other of these operators who would of course remain solely responsible for the tasks to be performed. Outside of periods when there is a work overload, this member of staff could attend training sessions in situ, or replace one or other of the members of staff on duty if they wanted to have a break.

Annex No. 6 : Recommendations following the fire of 2006

Recommendations from report 37/2007 by the RAIB of October 2007 relating to the fire that occurred in the Channel Tunnel on 21 August 2006

6-1 - Recommendations to address issues associated with detection and surveillance in the terminal

Recommendation No. 1: Eurotunnel should update the procedure for HGV loading staff to include the requirement to visually check the roof and doors of the load compartment for signs of smoke escaping.

Recommendation No.2: Eurotunnel should review alternative means of more reliably detecting signs of fire or other abnormal situations on the rear sections of departing shuttles, which would include the number and positioning of Agents de Feu and should implement improved measures as appropriate.

Recommendation No.3: Eurotunnel should investigate the possibility of providing the Agents de Feu with a direct method of stopping a departing shuttle and implement it if reasonably practicable.

6-2 - Recommendations to address issues associated with the management of incidents

Recommendation No.4: Eurotunnel should provide a means for the automatic transmission of alarms from the on-board fire detection system on the HGV shuttles to the RCC.

Recommendation No.5: Eurotunnel should ensure that the findings of this investigation are incorporated into the briefing and training of HGV shuttle drivers. This should include a re-briefing in topic areas associated with the non-compliance with Eurotunnel procedures.

Recommendation No.6: Eurotunnel should undertake a detailed survey of radio reception in the tunnel and make further improvements as necessary.

Recommendation No.7: Eurotunnel should examine the feasibility of using TVM to enforce a speed of 10 km/h and implement a modification to achieve this if it is found to be reasonably practicable.

Recommendation No.8: Eurotunnel should ensure that drivers are given a visual warning of the approach to the start and finish of go zones.

Recommendation No.9: Eurotunnel should ensure that all drivers routinely practise stopping at cross passage doors.

Recommendation No.10: Eurotunnel should ensure that the findings of this investigation are incorporated in the briefing and training procedures of RTM and EMS controllers. This should include a re-briefing in topic areas associated with the non-compliances with Eurotunnel procedures.

Recommendation No.11: Eurotunnel should review the design of the ventilation control system with a view to reducing the possibility of controllers selecting a sub-optimal configuration.

Recommendation No.12: Eurotunnel should ensure that the FDC has immediate access to the postcode of the Longport reception area.

Recommendation No.13: Eurotunnel, in consultation with the emergency services in France and the UK,should carry out a study to assess the feasibility of decreasing the time taken to earth the catenary during an emergency situation. The best solution identified should then be implemented if reasonably practicable to do so.

Recommendation No.14: Eurotunnel, in conjunction with the Emergency Services, should review its emergency plan (and associated bi-national arrangements) with a view to ensuring that accurate information from the incident site is available promptly to those making strategic decisions within the ICCs.

Recommendation No.15: Eurotunnel, in conjunction with the emergency services, should revise its arrangements for formal multi-party reviews of lessons to be learnt following major safety incidents.

6-3 - Recommendations to address other matters observed during the investigation

Recommendation No.16: Eurotunnel should modify the RTM procedure to incorporate an explicit requirement to advise the RCC Supervisor when a message regarding a fire alarm on an HGV shuttle has been received and clarify the sequence of actions to be taken by the RTM Controller in the event that a rolling stock alarm and a Level 2 alarm are declared almost simultaneously

Annex No. 7 : Main outstanding points

Main points outstanding from the recommendations made by the Channel Tunnel Safety Authority and the RAIB on the occasion of the 1996 and 2006 fires

Safety issue identified following 2008 fire	Linked recommendations following the 1996 fire		Linked recommendations following the 2006 fire	
	IGC	Eurotunnel	RAIB	Eurotunnel
Relevance of training personnel in emergency situations.	Eurotunnel must review the training of all its agents in the management of emergency situations and produce a training programme based on practical exercises. (Rec. 17)	Refresher courses should cover subjects such as emergency situations, radio communication and linguistic knowledge. Interactive simulation tools should be used more often as well as the organisation of practical exercises. (Rec. 9.1.2)		

Safety issue identified following 2008 fire	Linked recommendations following the 1996 fire		Linked recommendations following the 2006 fire	
	IGC	Eurotunnel	RAIB	Eurotunnel
Taking account of the behaviour of passengers during an evacuation.	Eurotunnel and other rail operators using the tunnel must ensure that pre-established standard messages intended for passengers are provided and updated in order to respond to emergency situations. The possibility of an evacuation in another train must be taken into account in these messages. (Rec. 25)	The procedures for informing clients must be supplemented to take account of the various scenarios in the event of an incident/accident. (Rec. 9.2.5)		
Fire-fighting on a freight shuttle.		Examine the possibility of installing a fire control system in the running tunnels or on board freight wagons, designed to ensure that the fire or the products of combustion could be controlled more quickly. (Rec. 9.6.1)		

Safety issue identified following 2008 fire	Linked recommendations following the 1996 fire		Linked recommendations following the 2006 fire	
	IGC	Eurotunnel	RAIB	Eurotunnel
The relevance of lighting near cross-passages.	The training programme for Eurotunnel crews must include familiarisation with the breathing apparatus that they might have to use. Furthermore, Eurotunnel must improve the lighting beside the cross-passage doors and provide crews with powerful portable lamps. (Rec. 22)	Examine the possibility of providing the chef de train with a remote control for opening the cross-passage doors and examine whether the current level of lighting at these doors is suitable for the requirements for an evacuation. (Rec. 9.8.1)		

Safety issue identified following 2008 fire	**Linked recommendations following the 1996 fire**		**Linked recommendations following the 2006 fire**	
	IGC	**Eurotunnel**	**RAIB**	**Eurotunnel**
Knowing the point at which the train stopped.	Eurotunnel must bring procedures relating to the controlled stop up to scratch and make it clear that, unless it is impossible, the stopping point must be agreed beforehand between the driver and the rail control centre. In order to mitigate the effects of any failure, Eurotunnel must examine the possibility of installing an improved system to mark the position of a train stopped in a tunnel. Eurotunnel must use the improvements thus obtained and give instructions for the opening of the appropriate cross-passage door at the moment the train stops. (Rec. 35)	The design of stop markers and cross-passage position indicators will be improved to help the train crew identify their position. Also examine the possibility of improving the RCC's or the SRCC's capacity to determine the exact place where a train has stopped in the tunnel, especially in emergency situations. (Rec. 9.8.2)		

Safety issue identified following 2008 fire	Linked recommendations following the 1996 fire		Linked recommendations following the 2006 fire	
	IGC	Eurotunnel	RAIB	Eurotunnel
EMS controller's workload.	The EMS management system must be modified to enable controllers to deal with an unexpected overload of work in an emergency situation. Eurotunnel must also develop and implement an alarm management system. (Rec. 30)	Examine the possibility of modifying the EMS software to provide the EMS controller with more simple commands for situations that are critical from the point of view of safety. The reliability and availability of these systems will be examined at regular intervals. (Rec. 9.8.3)	Eurotunnel should review the design of the ventilation control system with a view to reducing the possibility of controllers selecting a sub-optimal configuration (Rec. 11)	Remind all of the EMS controllers of the method to be applied to optimise the SVS from the EMS screens. (Rec. B)
Relations between the RCC and the PCO/ICC.		The provisions of the Channel Tunnel Bi-national Emergency Plan will be reviewed to include provisions for alerting the national emergency organisations in the event of a serious accident or incident. The formal process for transmission from the RCC supervisor to the PCO or ICC in an emergency situation will also be reviewed. (Rec. 9.14.1)		

Safety issue identified following 2008 fire	Linked recommendations following the 1996 fire		Linked recommendations following the 2006 fire	
	IGC	Eurotunnel	RAIB	Eurotunnel
Loss of capacity of the main fire-fighting system due to the consequences of a fire.	Eurotunnel must draw conclusions from the loss of power in the fire-fighting water system and take the necessary action to minimise the effects of a fire on this essential system. (Rec. 7)			
Number of controllers available to the RCC in an emergency situation.	One way of remedying work overloads would be the permanent presence of a fourth operator in the rail control centre, with “EMS” and “RTM” qualifications who, in an emergency, could provide assistance to one or other of these operators who would of course remain solely responsible for the tasks to be performed. Outside of periods when there is a work overload, this agent could attend training sessions in situ, or replace one or other of the agents on duty if they wanted to have a break. (Rec. 36)			

Safety issue identified following 2008 fire	Linked recommendations following the 1996 fire		Linked recommendations following the 2006 fire	
	IGC	Eurotunnel	RAIB	Eurotunnel
Time taken to isolate and earth catenary.			Eurotunnel, in consultation with the emergency services in France and the UK, should carry out a study to assess the feasibility of decreasing the time taken to earth the catenary during an emergency situation. The best solution identified should then be implemented if reasonably practicable to do so. (Rec. 13)	Together with the UK and FR emergency services, examine the conditions for working on a fire near the catenary, and the possibility of working without earthing the catenary. Examine the opportunity of de-energising the cables (voltages between 48 V and 21 kV) present in a running tunnel inside an intervention zone. Examine the installation of motorised catenary earthing devices that can be operated from the EMS. (Rec. A)

Safety issue identified following 2008 fire	Linked recommendations following the 1996 fire		Linked recommendations following the 2006 fire	
	IGC	**Eurotunnel**	**RAIB**	**Eurotunnel**
Difficult radio reception conditions.			Eurotunnel should undertake a detailed survey of radio reception in the tunnel and make further improvements as necessary. (Rec. 6)	