Technical Investigation Report

on the Train Collision that occurred on

11 October 2006

on the French/Luxembourg Border

at Zoufftgen (Moselle)

February 2009

General Council of the Environment and Sustainable Development

Land Transport Accident Investigation Bureau (BEA-TT)

Ministry of Transport

Technical Investigation Department (AET)

Case No.BEATT-2006-013

28 February 2009

Technical Investigation Report on the Train Collision that occurred on 11 October 2006 on the French/Luxembourg Border at Zoufftgen (Moselle)

BEA-TT – Land Transport Accident Investigation Bureau

Tour Pascal B – 92055 La Défense cedex
Tel: +33 (0)1 40 81 21 83
Fax: +33 (0)1 40 81 21 50

email: cgpc.beatt@developpement-durable.gouv.fr

www.bea-tt.developpement-durable.gouv.fr

AET – Technical Investigation Department

B.P. 1388 L – 1013 Luxembourg
Tel: +352 247 84417
Fax: +352 264 78975

email: info@aet.etat.lu

www.mt.public.lu/transports/AET

List of Documentation

Commissioning Organisations:
For France: Ministry of Ecology, Energy, Sustainable Development and Land-use Management (MEEDDAT)
For Luxembourg: Ministry of Transport

Author Organisations:
For France: Land Transport Accident Investigation Bureau (BEA-TT)
For Luxembourg: Accident/Incident Investigation Body (EEAI) and, from June 2008, Technical Investigation Department (AET)

Title of document: Technical Investigation Report on the Train Collision that occurred on 11 October 2006 on the French/Luxembourg Border at Zoufftgen (Moselle)

N°ISRN: EQ-BEATT--09-3--FR

Key words: freight train, wrong-track working, ground-train radio, passing through a signal, regulation, verification, training, and experience feedback, etc.

Note

In France, the technical investigation covered by this Report is conducted in accordance with Title III of Law No. 2002-3 of 3 January 2002, amended, and Decree No. 2004-85 of 26 January 2004, amended, relating in particular to the technical investigations conducted after a land-transport accident or incident.

In Luxembourg, the technical investigation was initiated by the Accident/Incident Investigation Body (EEAI) in accordance with the Law of 8 March 2002. The investigation was then resumed after the creation of the Technical Investigation Department (AET), in accordance with the Law of 30 April 2008 and the Grand-Ducal Regulation of 7 November 2008 covering supplementary specifications relating to railway accidents and incidents.

The sole object of this investigation is to prevent future accidents, by determining the circumstances and causes of the event in question, and by establishing the necessary safety recommendations. It does not aim to determine responsibility.

Consequently, the use of this report for purposes other than prevention could lead to erroneous conclusions.

Contents

Glossary

*The terms below are marked in the report with an asterisk**

Aiguillage : il colle lorsque la lame mobile est au contact du rail et il est verrouillé lorsqu'un dispositif mécanique le maintient dans cette position.	**Switch**: adheres when the movable blade is in contact with the rail and locks when a mechanical device holds it in this position.
BAL (SNCF) : Block Automatique Lumineux (système d'espacement automatique des trains).	**LAB** (SNCF): Light Automatic Block (automatic train spacing system)
Block de section (CFL) : système d'espacement des trains ayant pour but d'avoir la certitude, par des conditions réalisées matériellement, que le train entier à quitté la section de block.	**Section Block** (CFL): train spacing system that has the purpose of knowing for sure, by conditions that occur physically, that the entire train has left the block section.
Canal UIC (radio sol-train) : fréquence radio définie dans le cadre de l'Union Internationale des Chemins de Fer.	**UIC Channel** (ground-train radio): radio frequency set by the International Union of Railways (UIC).
CFL : Société Nationale des Chemins de fer Luxembourgeois	**CFL**: National Luxembourg Railway Company
Canton radio (SNCF) : zone couverte par une ou plusieurs stations fixes reliées entre elle et calées sur le même canal.	**Radio Block** (SNCF): zone covered by one or more fixed stations connected together and tuned to the same channel.
Circonscription radio (CFL) : terme utilisé aux CFL, équivalent au terme « canton radio » à la SNCF.	**Radio Area** (CFL): term used by CFL, equivalent to the term "Radio Block" used by SNCF.
CRO (SNCF) : Centre régional des opérations.	**ROC** (SNCF): Regional Operations Centre.
CSS (SNCF et CFL) : Central sous-stations. Organisme qui gère l'alimentation électrique des caténaires.	**SU** (SNCF and CFL): Substation Unit. Body that manages the electrical supply to the catenaries.
COFRET (SNCF) : correspondant fret auprès du C.R.O.	***COFRET*** (SNCF): Freight Manager at the ROC
Dépendance (CFL) : terme utilisé aux CFL, équivalent au terme « enclenchement » à la SNCF.	**Dependence** (CFL): term used by CFL, equivalent to the SNCF term "interlock".
Enclenchement (SNCF) : un enclenchement est une liaison électrique ou mécanique entre des organes de commande de dispositifs de sécurité (notamment aiguillages et signaux), destinée à empêcher physiquement les manœuvres qui ne respectent pas les conditions de sécurité.	**Interlock** (SNCF): an interlock is an electrical or mechanical connection between the control mechanisms of safety devices (notably switches and signals), designed physically to prevent manoeuvres that are unsafe.
EPSF : Établissement Public de Sécurité	**EPSF**: *Établissement Public de Sécurité*

Ferroviaire. Autorité de sécurité nationale française.	*Ferroviaire*. French national safety authority.
FEM (SNCF) : fiche événement matériel.	**EIS** (SNCF): Equipment Incident Sheet.
GM Gestionnaire des moyens Engins Moteurs (SNCF**) :** Agent chargé de l'affectation des engins moteurs (EM**)** sur les trains, du suivi opérationnel des EM (notamment lorsqu'un système repris dans ce document est isolé ou en dérangement) et des conditions de réutilisation des EM afin de les acheminer vers un centre de maintenance.	**TUM**: Traction Unit Manager (SNCF): Person responsible for assigning traction units (TU) to trains, monitoring the operation of TUs (particularly when a system referred to in this document is isolated or faulty) and the conditions for re-using TUs so that they can be sent to a maintenance centre.
GRP (CFL) : Permanence du service « Gestion Réseau ». Elle est chargée de la surveillance générale de l'exécution du service de la formation et de la circulation des trains sur l'ensemble du réseau luxembourgeois.	**NMH** (CFL): "Network Management" Headquarters. Responsible for generally overseeing the make-up and movement of trains throughout the entire Luxembourg network.
HLP (SNCF) : désigne un train constitué par une machine ou un groupe de deux machines pouvant, dans les cas prévus par les règlements, remorquer un ou deux véhicules.	**ERT** (SNCF): An Empty-Run Train comprising one or a group of two engines which, in the cases covered by the regulations, can pull one or two vehicles.
IPCS (SNCF) : Installations Permanentes de Contresens.	**WWFE** (SNCF): Wrong-track Working Fixed Equipment
Itinéraire-train (CFL) : itinéraire commandé par un SFP.	**Train Route** (CFL): Route controlled by an MFS.
Itinéraire de manoeuvre (CFL) : itinéraire commandé par un SFVb.	**Shunting Route** (CFL): Route controlled by an FHS.
Marche à vue (SNCF) : l'obligation de « marcher à vue » impose au conducteur:	**Visual Running** (SNCF): the need for "visual running" requires the driver:
- de s'avancer avec prudence, en réglant sa vitesse, compte tenu de la partie de voie qu'il aperçoit devant lui, de manière à pouvoir s'arrêter avant une queue de train, un signal d'arrêt ou un obstacle,	- to proceed with care, regulating his speed, observing that part of the track that he can see in front of him, so as to be able to stop before reaching the end of a train, a stop signal or an obstacle;
- de ne pas dépasser la vitesse de 30 km/h.	- not to exceed the speed of 30 km/h.
PD (CFL) : Poste Directeur. Un poste directeur est un poste de desserte occupé par un chef de circulation.	**CP** (CFL): Control Post. A Control Post is a work station manned by a Traffic Controller.
PDC (CFL) : Poste Directeur Central de Bettembourg.	**CCP** (CFL): Bettembourg Central Control Post.
PDT (CFL): Poste Directeur du Triage de	**MCP** (CFL): Bettembourg Marshalling Control

Bettembourg.	Post.
Piquet de dégagement (CFL) : il indique le point jusqu'où une voie peut être occupée sans entrave pour les mouvements sur la voie voisine.	**Clear-track Marker** (CFL): indicates the point up to which a track can be occupied without hindering movements on the neighbouring track.
PRCI (SNCF) : Poste d'aiguillage tout Relais à Commande Informatique.	**CCRP** (SNCF): Computerised Relay Switch Post.
Poste de desserte (CFL) : Postes installés en pleine ligne ou dans les gares disposant d'installations techniques servant à régler directement la circulation des trains et des manoeuvres et à en assurer la sécurité.	**Service Post** (CFL): Posts installed on the open line or in stations having technical systems designed directly to control train traffic and shunting operations and to ensure the safety thereof.
RAT (CFL) : Registre d'annonce des trains au Luxembourg.	**TAL** (CFL): Luxembourg Train Announcement Log.
RFF : Réseau Ferré de France. Gestionnaire d'infrastructure du réseau ferré national français.	**RFF**: *Réseau Ferré de France*. Manager of the infrastructure for the national French railway.
RGE (CFL) : Règlement Général de l'Exploitation technique.	**GRO** (CFL): General Regulations for Technical Operation.
RGS (SNCF) : Règlement Général de Sécurité.	**GSR** (SNCF): General Safety Regulations.
RST : radio sol-train.	**GTR**: Ground-Train Radio.
SAAT (SNCF) : Système d'Annonce Automatique des Trains.	**ATAS** (SNCF): Automatic Train Announcement System.
SDIS (France) : Service Départemental d'Incendie et de Secours.	**DFES** (France): Departmental Fire and Emergency Service.
Secteur (de traction électrique) (SNCF) : Ensemble des installations alimentées normalement par un ou plusieurs disjoncteurs. Un disjoncteur est un appareil d'interruption, manoeuvrable à vide ou en charge, destiné à ouvrir ou fermer un circuit et capable d'interrompre automatiquement un courant de défaut.	**Mains Power (for electric traction)** (SNCF): All of the systems normally powered by one or more circuit breakers. A circuit breaker is a cut-off device that can be operated with or without a load, is designed to open or close a circuit and is capable of automatically interrupting a fault current.
Section de block ou d'espacement (CFL) : tronçon de ligne qui ne doit être occupé que par un seul train.	**Block or Spacing Section** (CFL): a stretch of line that must only be occupied by one train at a time.
SFP (CFL) : Signal fixe principal. Il est, entre autres, utilisé comme signal d'origine et de fin de section d'espacement.	**MFS** (CFL): Main Fixed Signal. This is used, amongst other things, as a start and end signal for a spacing section.
SFVb (CFL) : Signal fixe de barrage. Il est, entre autres, utilisé pour faciliter le service des manoeuvres.	**FHS** (CFL): Fixed Holding Signal. This is used, amongst other things, to facilitate shunting manoeuvres.

SNCF : Société Nationale des Chemins de fer Français.	**SNCF**: *Société Nationale des Chemins de fer Français* (National French Railway Company).
TCO : Tableau de contrôle optique.	**VCP**: Visual Control Panel.
TER (SNCF) : Train Express Régional.	**RET** (SNCF): Regional Express Train.
Transit (SNCF) : l'enclenchement de transit immobilise les différentes aiguilles de l'itinéraire parcouru par le mouvement. Il est dit « souple » lorsque chaque aiguille est libérée dès que le mouvement l'a franchi.	**Transit** (SNCF): the transit interlock immobilises the various switches on the train's route. It is called "flexible" when each switch is released as soon as the train has passed through it.
VACMA : Veille Automatique à Contrôle de Maintien d'Appui.	**VACMA**: Dead Man's' Switch.
Voies principales (CFL) : ce sont les voies entre gares pour les voies de pleine ligne et les voies équipées de signaux réglant l'entrée et la sortie des trains dans les gares.	**Main tracks** (CFL): these are the tracks between stations for open-line tracks and tracks equipped with signals controlling trains entering and leaving the stations.
ZOS (CFL) : zone opérationnelle sud.	**SOA** (CFL): Southern Operational Area.

Summary

On Wednesday 11 October 2006, extensive track works on the French network required one of the two tracks of the Thionville-Bettembourg section of international line to be neutralised from 8h50 to 16h30. Consequently, trains in both directions were using the other track under the Wrong-track Working Fixed Equipment (WWFE) system.

While an SNCF freight train was travelling on this track from Thionville to Bettembourg, a Regional Express Train (RET) was travelling in the opposite direction on the same track via Bettembourg station.

These two trains collided head on at around 11h44, on French territory at about ten metres from the border, near Distance Marker (DM) 203.700 (Commune of Zoufftgen).

As a result of this accident, six people died, one was seriously injured and fifteen others had minor injuries.

The first of the three carriages of the Luxembourg RET was totally destroyed; the other two were badly damaged. The French locomotive of the freight train was totally destroyed and the first eight wagons were totally destroyed or badly damaged.

The direct and immediate cause of the accident was human error: the Traffic Controller of the Bettembourg Central Control Post mistakenly issued the driver of the RET an order to pass through the 'danger' signal protecting the section of track on which the freight train was travelling.

The other causes and factors that contributed (or could have contributed) to this accident can be classified into four groups:

- direct causal factors relating to mistakenly issuing the pass-through order, and which concern the Bettembourg Central Control Post (CCP): the incorrect staff handover procedure just before the accident, the high frequency of signal faults, the poor ergonomics of the available documentation, and the ergonomics of the Visual Control Panel which could be improved;
- direct causal factors relating to the failure of attempts to rectify the situation: incorrectly pressing the radio warning button (or failing to press this button), delay in implementing the traction power cut-off procedure, failing to transmit the warning to the Thionville Control Post, and the limited capacity of the telephone system at the Bettembourg CCP;
- underlying causes regarding staff skills: insufficient knowledge by the CCP staff of the procedures to be followed, particularly for issuing pass-through orders or for handling emergency situations, and the absence of practical training in emergency procedures;
- organisational causes regarding the Safety Management System and the regulatory framework of Luxembourg Railways (CFL): unrealistic division of tasks between the Bettembourg CCP staff, lack of encouragement to gain experience and laissez-faire approach to monitoring staff and implementing management control.

Furthermore, the investigation highlighted several factors that, although they did not play a part in the development of the accident, would have compromised the effectiveness of any attempts to rectify the situation that should normally have been made: the hidden fault on the ground-train radio at the Bettembourg CCP, the fault on the ground-train radio of the freight train, the lack of continuous radio warning transfer near the border, and the lack of a direct connection between the Bettembourg CCP and the East-France Substation Unit.

This investigation makes twenty-two recommendations. They relate to preventive actions focused on the following objectives:

- to remind staff finding themselves in the position of issuing an order to pass through a signal set at ‘danger’ that they must not do so until they are sure that the reason for the signal remaining in ‘danger’ position is really the consequence of a fault in the equipment;
- to take the necessary steps to reduce the number of faults in the signalling equipment;
- to provide documents to help in the decision-making process;
- to improve the legibility of the Visual Control Panel at the Bettembourg CCP;
- to re-train the Bettembourg CCP staff;
- to review the consistency of the safety regulations at CFL and the role of the traffic controllers;
- to improve the reliability of the communication and warning equipment and procedures, particularly the cross-border aspects;
- to ensure that the systems made available to the staff work properly;
- to improve the protocol for staff handover and its implementation;
- to train staff in the emergency procedures that are most likely to occur;
- to review the experience feedback scheme;
- to ensure that checking and monitoring of staff by the management is as thorough as possible.

Immediate Observations and Opening the Investigation

Circumstances of the accident

On Wednesday 11 October 2006, extensive track works required one of the two tracks of the Thionville-Bettembourg section of international line to be neutralised from 8h50 to 16h30. Consequently, trains in both directions were sharing the same track. This had been the situation since 18 September 2006

While SNCF Freight Train 45938 was travelling on this track towards Bettembourg, a regional passenger train (RET 837617) was travelling in the opposite direction on the same track via Bettembourg station at 11h42.

These two trains collided head on at around 11h44, on French territory at about ten metres from the border, near DM 203.700 (Commune of Zoufftgen).

The Moselle Regional Emergency and Fire Service received the first call at 11h45 which reported a serious accident. Two more followed before noon and precisely pinpointed the location of the accident.

Fatalities, injuries and material damage

As a result of this accident, six people died, one was seriously injured and fifteen others had minor injuries.

The first of the three carriages of the CFL* train was totally destroyed; the other two were badly damaged.

The SNCF locomotive of the freight train was totally destroyed and the first eight wagons were totally destroyed or badly damaged. The remaining fourteen wagons suffered no damage

Damage to fixed equipment all occurred on the French side: 300 metres of catenaries were ripped out, destroying 5 catenary poles; one signal post was completely destroyed. Damage to the track was minor.

Traffic measures adopted after the accident

Both Bettembourg and Thionville stations adopted measures to suspend all rail traffic on this section of the line. A coach service was provided for the passengers.

The Traffic Controller at the Bettembourg CCP was immediately suspended from duty.

External circumstances

There was thick fog that day, resulting in poor visibility.

The works requiring trains to travel on the same section of track in both directions from 8h50 to 16h30 began on 18 September 2006 and were due to be completed on 27 October 2006.

Opening the investigation

The decision to open a technical investigation was taken, on the French side, by the Minister responsible for transport on the day the accident occurred (see Annex 1a).

On the Luxembourg side, Certificates of Legitimisation were issued by the Minister of Transport to EEAI investigators, on 4 December 2006 (see Annex 1b).

The Land Transport Accident Investigation Bureau (BEA-TT) and the Accident and Incident Investigation Body (EEAI), the rail accident investigation bodies of France and Luxembourg respectively, are handling this investigation. The Technical Investigation Department (AET) replaced the EEAI as Luxembourg's investigation body on 1st June 2008.

BEA-TT / EEAI Co-operation

The two investigation bureaux of France (BEA-TT) and Luxembourg (EEAI) opened an investigation in their own countries.

A protocol was established between the two bureaux in order to specify joint working practices (see Annex 2)

This protocol specifically states that:

- the investigation and report will be conducted jointly;
- the two bodies shall together determine the scope, modalities and methods of the investigation, and consult each other on the reports and communication support that they produce;
- as the crash took place on French territory, BEA-TT shall provide a summary of the information produced by both investigations and compile the joint draft report;
- during the investigation, both bodies shall regularly exchange the information obtained within the bounds of national regulations.

One investigator from each of the two bodies was appointed by the authorities of the other country.

Investigations conducted

Each body conducted its own research with or without the participation of an investigator from the other body, as required.

The investigators worked mainly with:

- the reports of hearings by the judicial authorities;
- the working documents kept by the staff on the day of the accident;
- the technical regulations and documentation applicable on the day of the accident;
- the report by the Dédale company (see point 2.3 below).

They exchanged the information that they obtained, as well as the results of partial studies that they were obliged to conduct.

Numerous joint meetings were held both at investigator level and between the two bureaux.

Analysis of aspects linked to human factors

From the very start of the investigation it was clear that the immediate direct cause of the accident was human error. Consequently, the two bureaux decided jointly to appoint a specialised company to conduct a study into the human factors that played a part in this accident.

The object of the study was to look into the causes and factors that could have contributed to the human errors that led to the accident, both as regards the staff themselves and their working environment (working practices, regulations, training, safety management, etc.). The reason why no remedial action could have prevented the accident, from the moment the Bettembourg CCP staff

realised that two trains were about to collide, was also examined.

The contractor appointed was Dédale. This company worked closely with both investigation bodies. It met the staff working at Thionville, Bettembourg and in the real-time central management organisations at Luxembourg (Headquarters and the Ground-Train Radio Unit) at the time of the accident and during the hour that preceded it. Dédale also interviewed staff who usually worked at these control centres as well as staff at the regional and central offices of CFL and SNCF.

The conclusions of Dédale's study were presented to the staff interviewed, before a final report was submitted to the two investigation bureaux.

Dédale's final report was used chiefly to deal with aspects connected with the human factors referred to in the present investigation report.

However, in view of further developments in the technical investigation and additional information gathered after Dédale's report had been compiled, the analyses and conclusions of the present report may differ on certain points.

Compiling the Report

As the co-operation protocol states, BEA-TT compiled the entire report which was put together during discussions and joint meetings, then approved in its final form by the two bodies handling the investigation.

The Thionville – Bettembourg Line

The section of international line from Thionville (France) to Bettembourg (Luxembourg) is about 17km long between the passenger station at Thionville and the line end, on the French side, of Bettembourg station (see Annex 3c). The border is located a just over a kilometre from the line end.

The border is located at DM 0 of the section of line leading to Luxembourg and at DM 203.756 of the section of line leaving Thionville.

Trains usually travel on the right hand side and this section of line is fitted with Wrong-track Working Fixed Equipment (WWFE), the operation of which is described in 3.2 below. This section of line is electrified and equipped with ground-train radio.

Track 1, where the collision occurred, is the one used by trains travelling in the normal direction from Bettembourg to Thionville while track 2 is the one used by trains travelling in the normal direction from Thionville to Bettembourg.

An intermediate stop point is located in France, just less than 7km from Thionville.

During the week, traffic is in the order of 160 journeys per day, evenly distributed in both directions. Passenger trains account for 50% of this traffic.

Safety systems and equipment

Open-line fixed safety systems

Spacing system

The section of line in question is equipped with an SNCF Light Automatic Block*. In the normal direction, it has seven blocks on track 1 and six on track 2. In the wrong-track working direction, each of the tracks has two blocks.

On track 1, the first SNCF light signal in the normal direction is located at Luxembourg DM 0.526 and the first CFL light signal in the wrong-track working direction is located at French DM 203.632.

On track 2, the first CFL light signal in the normal direction is located at French DM 203.632 and the first SNCF light signal in the wrong-track working direction is located at French DM 201.100. In the direction of France, two signs located at Luxembourg DM 1.136 announce that from this point the signals are SNCF signals.

Wrong-track Working Fixed Equipment (WWFE)

This equipment is installed on sections of line that are used for double-track working. It allows trains to travel on one or other of the tracks, in the opposite direction to the usual direction of travel, without having to adopt special measures. Permanently fixed safety equipment prevents two trains travelling in opposite directions from colliding with each other.

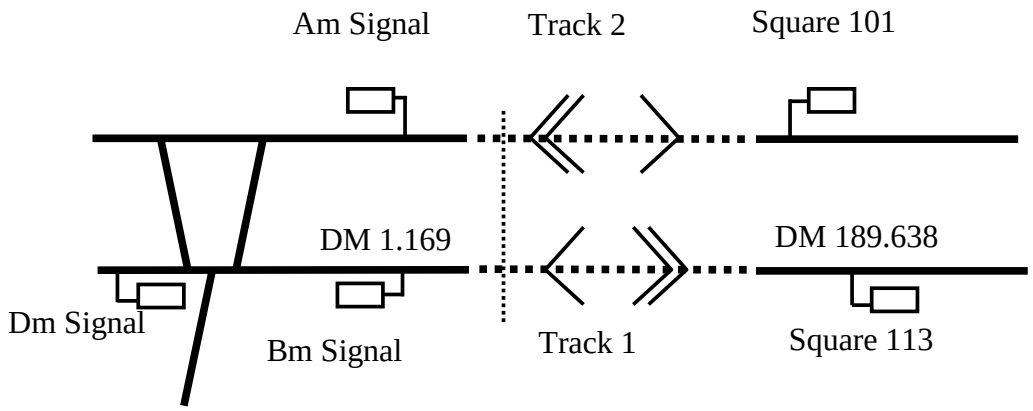
The Bettembourg and Thionville WWFE is made according to French technology and the regulations governing them are French.

Description

This WWFE* is the type whereby "the direction is selected by plotting the route, with the intervals being controlled by separate traffic operators[1]"

There are two WWFE intervals, one per direction:

- BM-113 WWFE interval on track 1 (Bettembourg-Thionville track) extends from the Bettembourg Bm signal to the Thionville Square 113;
- AM-101 WWFE interval on track 2 (Thionville-Bettembourg track) extends from Thionville Square 101 to the Bettembourg Am signal.



≫ Normal direction of travel

> Wrong-track working direction

..... Border
DM 0 at Luxembourg
DM 203.756 in France

Warning lights in various states indicate (see paragraph 3.3.4)[2]:

- the direction of the interval;
- whether there is movement between the two stations, track by track;
- whether the first block of each of the wrong-track working intervals on track 1 and track 2 is occupied.

*Direction interlock**

The wrong-track working interlock prevents two trains from being despatched in opposite directions towards each other on the same track. It maintains this impossibility for as long as the

[1] The term Traffic Operator at the Thionville CCRP corresponds to the term Traffic Controller at the Bettembourg CCP.

[2] Except in the event of a fault. Specific measures are adopted should it be necessary to know how the track is occupied.

interval concerned is occupied, by keeping the access signals to this interval at 'danger'.

This interlock comes into operation without adopting any special measures, as soon as a route using the track in question in the normal or wrong-track working direction is formed. The interval concerned automatically resumes the normal direction once it is cleared.

The Bettembourg Central Control Post

The Bettembourg Central Control Post (Siemens DrS Control Post) is responsible for ensuring safety in this station and, together with the Thionville CCRP*, on the Bettembourg-Thionville section of line.

The Bettembourg Switch Post is a Siemens sectional route-releasing* DrS relay post. The route and protection controls are not computerised. The WWFE direction controls and buttons have been added subsequently on the post's VCP* and are of French technology.

This post handles 293 train routes* and 919 shunting routes*.

In addition to the section of line towards Thionville, it is also connected to the Luxembourg rail network, by two sections of line, to two tracks signalled for two-way working (towards Luxembourg Town and Esch-sur-Alzette) and one single-track line (towards Dudelange). All these sections* of lines are fitted with automatic blocks* (see Annexes 3b and 3e).

During normal operation, the post is manned by four staff: one Traffic Controller, one Train Announcer and two Switch Tenders.

The Thionville Switch Post

The Thionville switch post is a computer-controlled sectional route-releasing relay post (CCRP).

It handles 574 routes and 3 authorisations. The same room houses a 56-route service-track computer-controlled post (STCP).

In addition to the section of line towards Bettembourg, it is also connected to the French rail network by a four-track section of line towards Metz and three two-track sections of line (towards Apach, Harteng Falck and Longuyon) (see Annexes 3a and 3d). All of these sections of lines are fitted with automatic blocks.

During normal daytime operations, the post is manned by six staff: one Traffic Controller, two Traffic Operators, one person responsible solely for works, one Switch Tender and one person responsible for announcements on the public address system.

Telephone Systems

Bettembourg CCP Telephone Connections

In addition to dial-up telephone lines, the CCP Controller has access to direct lines that enable him to communicate with:

- the Control Posts* at Dudelange, Esch-sur-Alzette and Luxembourg, as well as the Bettembourg Marshalling Control Post (MCP) and the Thionville CCRP;
- Headquarters in Luxembourg, the Luxembourg Substation Unit (SU) and the Luxembourg depot;

- the track telephones[1] on the lines controlled by the CCP.

The Bettembourg CCP Train Announcer Post has the following direct connections with:

- the Dudelange, Esch-sur-Alzette and Luxembourg Control Posts as well as the Thionville CCRP;
- the Ground-Train Radio Operator at Luxembourg.

In addition to these direct lines, an alarm telephone enables the CCP to call the SU Controller. A call made on this line is given priority treatment by the SU Controller.

The Traffic Controller of the MCP* is connected to the CCP by two separate lines: one, direct, to the Traffic Controller and the other to the Train Announcer. Neither of the two staff members at the CCP can take the calls of the other member when the latter is busy.

CCP Loud-speaker Connection

The Bettembourg CCP Traffic Controller has a loud-speaker connection with the Bettembourg MCP Controller.

Thionville CCRP Telephone Connections

Each of the three staff (Traffic Controller, Sector 1 Traffic Operator and Sector 2 Traffic Operator) have a direct line on their telephone console to:

- the Bettembourg CCP Train Announcer;
- Luxembourg Headquarters.

They also have easy access to the public telephone numbers of the Traffic Controller at the Luxembourg Control Post (CP*), Headquarters and the Luxembourg Substation Unit.

Bettembourg CCP Visual Control Panel

General

The Bettembourg CCP is equipped with a Siemens S2000 wall-mounted Visual Control Panel. In the station crossing, it chiefly covers the following tracks:

- Luxembourg to Thionville,
- Bettembourg passengers to Esch-sur-Alzette,
- Bettembourg passengers to Dudelange,
- Esch-sur-Alzette to Dudelange,
- together with the MCP, the tracks leading to the shunting tracks.

The VCP provides the personnel at the post, particularly the Traffic Controller, information (in the form of a synoptic representation) on the safety systems at Bettembourg Station that it covers.

It also displays:

- the state of occupation of each of the track sections shown on this VCP;

[1] On-track telephone circuit linked to telephonic alarm circuit, installed in boxes located at appropriate intervals along the open line tracks and in the stations.

- whether a route has been set[1], including the position and locking of the track equipment;
- the state of the signals: proceed or at danger;
- the number of trains that are in the station area, that are soon to arrive in the area or that have just left it for tracks fitted with the Automatic Announcement System, which is not the case for the Bettembourg-Thionville section of line;
- the state of certain interlocks, particularly those relating to the WWFE of the Bettembourg-Thionville section of line.

Other information is also provided on the VCP, either in the form of lights or by applying magnetic plates.

A special module on the VCP, described in point 3.3.3 below, enables the state of operation of the WWFE on the line to Thionville to be displayed.

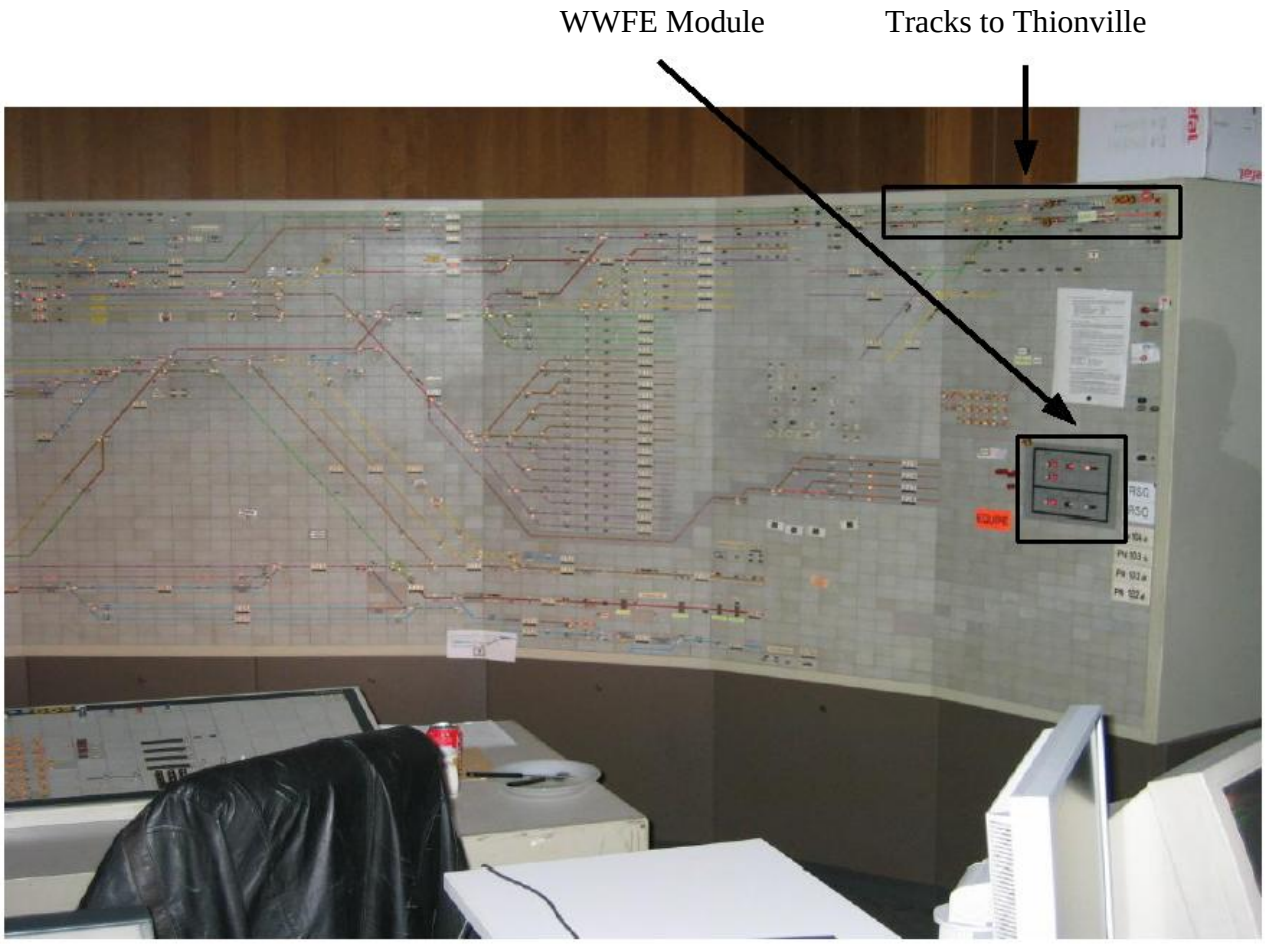


Figure 1: Bettembourg VCP, partial view (West side)

The VCP also alerts the operators to trains arriving from France on wrong-track working by means of the two lights on the extreme right of the VCP going red as soon as the portion of track between DM 202.604 and the Bm signal (DM 1.169) is occupied by at least one axle of the incoming train, followed by a gong sounding when the front end of the train passes DM 202.604. The said lights remain red until all the train axles have passed through the Bm signal.

[1] A route is said to be set when, on the one hand, it is formed, i.e. all the track equipment is properly set and interlocked and, on the other, when the command to open the original route signal has been given.

Checking the routes in Bettembourg station

Various indications can be read on a VCP. The main ones are explained below.

Position and locking of the track equipment

Both branches of the equipment are marked out on the VCP and a light comes on white on the branch that corresponds to the route marked. The fact that it comes on provides the assurance that the equipment is set in the right direction, that the switch blade adheres to the rail and that it is mechanically locked. This light changes to red if a train goes past the equipment or in the event of a fault (see Figure 2).

Status of a signal

A specific warning light for each controlled signal can assume two colours (see Figure 2):

- red, if the signal is set at 'danger' position or is faulty;
- green, if the signal is set at the 'proceed' position.

Anti-repeater Interlock

A hardware dependence* called an "anti-repeater interlock" prevents a signal that controls entry into a block section* from indicating that the track is clear until the section has been opened after the previous train has passed. A blue warning light on the VCP displays the status of this dependence.

This blue light flashes when a route command is entered; it becomes a solid blue light when all the required conditions of the interlocks for the route/outgoing train are met. Towards Thionville, it checks the status of:

- the mechanical and electrical interlocks of the track equipment;
- the interlocks of the elements that provide side protection;
- the occupation of the station- and open-line track circuits, which must not be occupied;
- the direction, which must correspond to the Bettembourg to Thionville direction;
- the blocking of the section of track.

A solid blue light confirms that all the conditions required to set the MFS* to 'track clear' are met.

This blue light continues to flash after the time required to set the route if one of the above-mentioned conditions is not met.

Occupation of tracks

The occupation status of the tracks on practically the entire VCP at the Bettembourg Control Post is indicated by lights that use a triple-status code (see Figure 2):

- light off: the portion of track being checked is not occupied and no route has been set;
- white light on: the portion of track being checked is clear and a route has been set;
- red light on: the portion of track being checked is occupied or experiencing a fault.

The indication of track occupation follows the above indications, from the exit signals from Bettembourg to France (Cm and Dm signals) up until the Am and Bm signals (see Figure 3).

By contrast, for the last zone of each of the tracks to Thionville before the border, zones that

originate at DM 202.604, (zones coloured brown in Figure 4), the occupation status of the tracks is indicated by lights that are similar but with a dual-status code:

- white lights on: the portion of track being checked is not occupied;
- red lights on: the portion of track being checked is occupied or experiencing a fault.

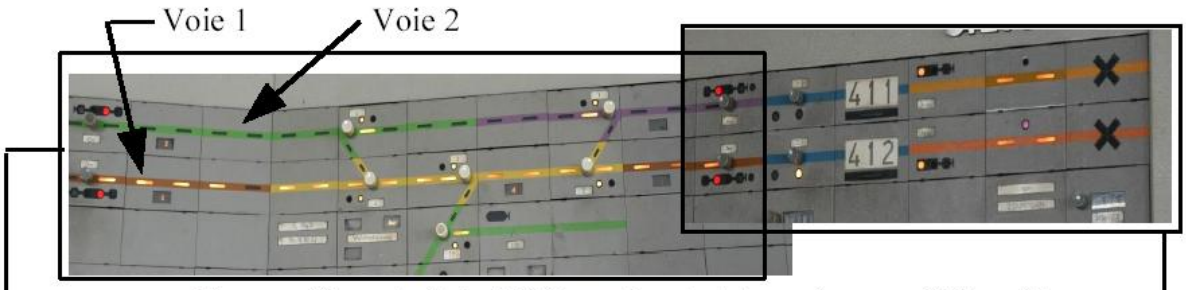


Figure n°2 : extrait du TCO représentant les voies vers Thionville

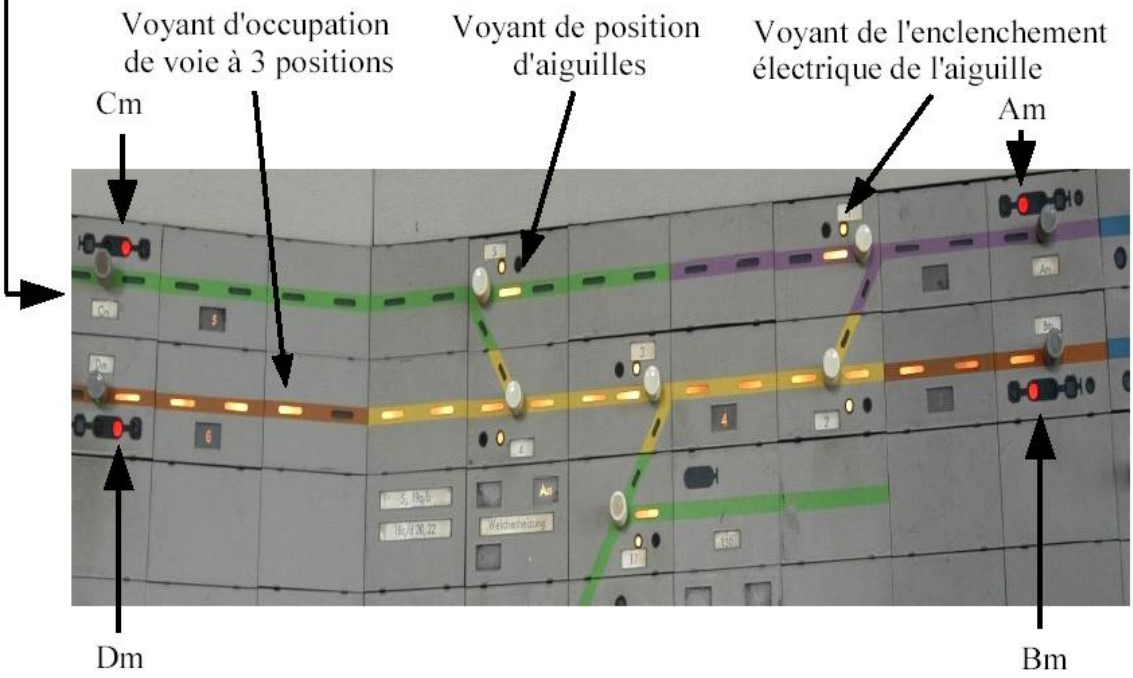


Figure n° 3 : Détail du TCO, des signaux Dm/Cm aux signaux Bm/Am

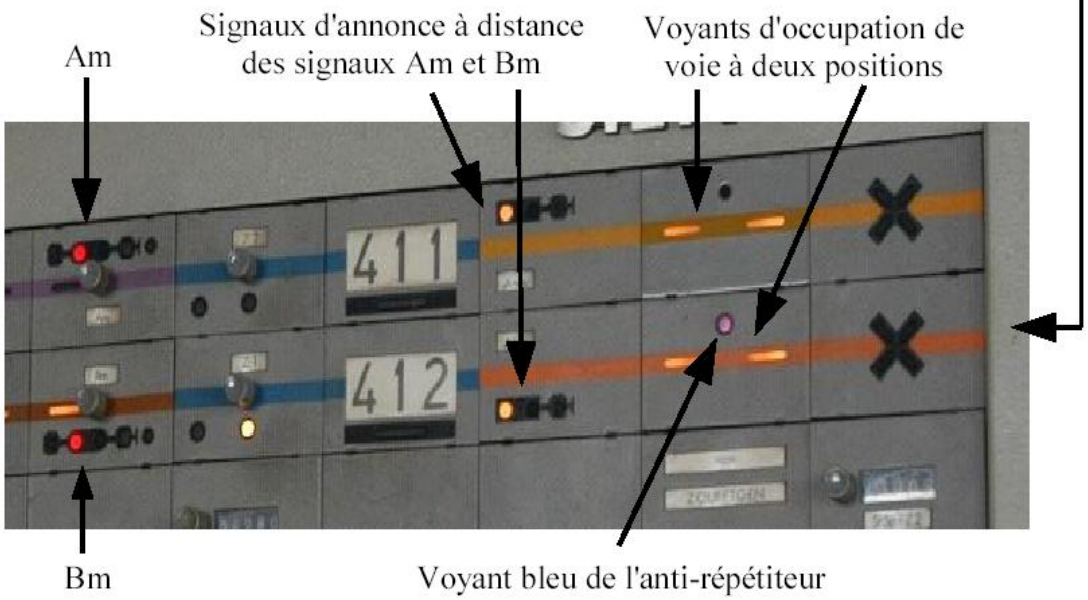


Figure 4: Detail of VCP, Border zone

Key to Figure 2	
FRENCH	**ENGLISH**
Figure no.2…	Figure 2: Extract of VCP showing the tracks to Thionville
Voie	Track
Key to Figure 3	
Figure no.3…	Figure 3: Detail of VCP, from Dm/Cm signals to Bm/Am signals
Voyant d'occupation…	3-position track occupation light
Voyant de position…	Switch position light
Voyant de l'enclenchement…	Switch electrical interlock light
Key to Figure 4	
Signaux d'annonce…	Remote announcement signals of Am and Bm signals
Voyants d'occupation…	2-position track occupation lights
Voyant bleu…	Blue light of anti-repeater
Key to Figure 5	
FRENCH	**ENGLISH**
voyants de contrôle…	check lights for occupation of Bm-113 interval
commutateur…	"emergency-direction" switch of track 1
voyant…	check light for direction of Bm-113 interval

Status of the WWFE

The status of the WWFE is indicated on a special module.

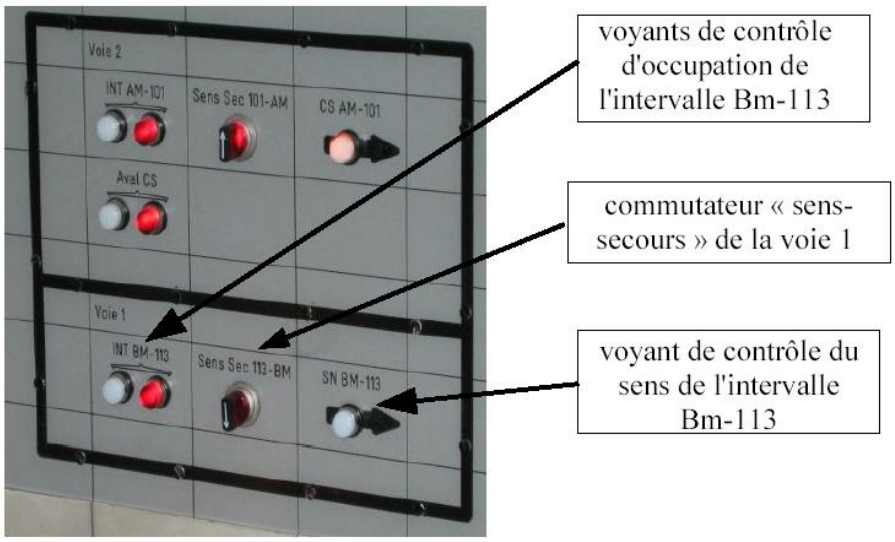


Figure 5: The WWFE Module

This module was installed when WWFE was introduced in 2003, a long time after the CP Siemens DrS Post was introduced in 1982.

Indications are given for each track in the form of lights that are white, red or off (see Figure 5).

Track 1 (normal direction track for Bettembourg to Thionville trains), where the accident occurred

Checking the occupation of the Bm-113 interval

Shown as INT BM-113:

The white check light comes on when the section of track between the Bm signal (end signal of the WWFE on the Bettembourg side) and 113 signal (end signal of the WWFE on the Thionville side) is clear of all rolling stock.

The red check light comes on when the section of track between the Bm signal (WWFE end signal on the Bettembourg side) and 113 signal (WWFE end signal on the Thionville side) is occupied by rolling stock.

Checking the direction interlock between Bettembourg and Thionville on track 1

Shown as SN BM-113:

The white check light comes on when Bettembourg has the direction: a train can then be despatched towards Thionville in the normal direction. It goes off when wrong-track working is adopted by Thionville.

Track 1 Emergency-direction switch

Shown as Sens Sec 113-Bm:

This switch enables the emergency direction to be engaged. Its use enables a train to be despatched towards Thionville along track 1 when the direction is set from Thionville to Bettembourg (rescuing a train in distress, for example)[1]. In this case, a red light comes on.

Track 2 (wrong-track working for Bettembourg to Thionville trains)

Checking occupation of the Am-101 interval

The indications given by the WWFE module provide information on:

- the state of occupation of the WWFE AM-101 interval on track 2;
- the state of occupation of the first block (from the Am signal to the square at DM 199.350) of this same interval;
- starting wrong-track working by the Bettembourg CCP.

Using the emergency-direction switch for track 2 enables a train to be despatched towards Thionville when the direction is set from Thionville towards Bettembourg. In this case, a red light comes on.

Ground-Train Radio

The Bettembourg-Thionville section of line is equipped with ground-train radio in Luxembourg and in France.

The purpose of ground-train radio is to enable radio links between places on the ground (relay post, train stations and mobile control posts held by staff) and mobile units (locomotives, reversible-configuration driver cabs).

Radio coverage of the Bettembourg-Thionville section of line

This section of line is divided into three blocks *:

- a Luxembourg area* between Bettembourg and the border. Its channel is "UIC Channel 65*";
- two blocks in France (Channel 1 and Channel 4) which for the traffic operators make just one channel (Channel 1+4). The Thionville Traffic Controller divides calls between Channel 1 or Channel 4[2].

[1] The procedure for using this switch is described in the Border Operation Instruction

[2] A third channel (Channel 3) covers other parts of Thionville Station. Some sections of lines at Thionville station are covered by two or three channels.

The following diagram illustrates this division.

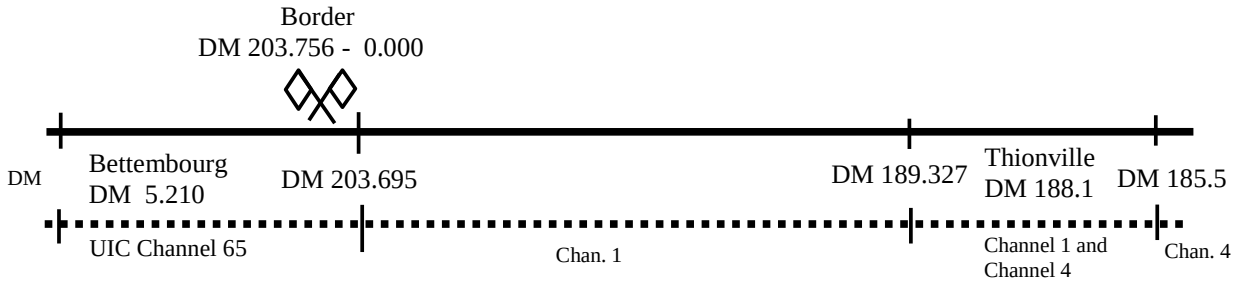


Figure 6: Bettembourg – Thionville, Ground-Train Radio Coverage

A driver from Luxembourg must change channel around DM 203.695 (by switching his selector to "Channel 1") and he need not adjust it again until beyond Thionville (DM 185.5).

Radio signals are transmitted via relay stations located at various points so that radio coverage is continuous. Several radio stations may be required to cover the one radio block*.

In France, a radio warning broadcast within the range of the last fixed station of a block (or of the fixed station for blocks covered by just one fixed station) is automatically transferred by cable to the first fixed station of the neighbouring block: this is a longitudinal warning transfer. There is no warning transfer towards Luxembourg of the French border block or towards France for the Luxembourg border area. Consequently, radio warnings issued in France and Luxembourg are not relayed beyond the border. However, CFL's GTR* is usually picked up around French DM 202.2 and SNCF's around Luxembourg DM 4.3 (Bettembourg CCP) thanks to the overlap.

Using GTR in France

Thionville CCRP Fixed Sets

Each of the two Traffic Operators has two GTR sets, one for Channel 1+4 and the other for Channel 3, and the Traffic Controller has a console that enables him to communicate via GTR on each of three channels 1, 3 and 4.

From these fixed sets it is possible to telephone the drivers of trains travelling on the Thionville-French border section of line. They hear the radio and VACMA (Dead Man's Switch) warnings issued by the trains in their area.

CCRP personnel cannot issue a radio warning signal. If required, they contact the train drivers travelling in their area by telephone. Note that, unlike the drivers, these personnel know of all of the trains that are travelling in the area. They can therefore choose the driver or drivers to be contacted.

GTR on board the trains

A driver may always telephone:

- the Thionville CCRP;
- the drivers of other trains travelling within the same "radio block".

Two special radio signals may also be emitted from the trains:

- the radio warning signal, emitted via a pushbutton by the drivers in the event of danger requiring traffic to stop. While emitting this signal any voice communication is impossible;

- The VACMA* alarm signal, emitted automatically if a train is stopped as a result of the Dead Man's Switch being triggered.

Broadcasting and recording conversations

Telephone conversations and radio-warning and VACMA signals are heard by all trains within the radio block.

GTR communications in the Thionville area are recorded at the Regional Operations Centre of the SNCF Metz-Nancy region located at Nancy.

Using GTR in Luxembourg

Fixed sets

Bettembourg CCP has:

- three warning buttons enabling a GTR warning call to be issued which will be received by all the mobile units located in the ground-train radio area of Luxembourg, of which the Bettembourg-French Border section of line forms a part;
- three warning buttons enabling a GTR warning call to be issued which will be received by all of the mobile units located in the ground-train radio area of Belval-Usines;
- equipment enabling it to contact one or all of the trains on the telephone by asking the Luxembourg GTR exchange to establish the connection. It can use this function to transmit written orders.

Pressing a warning button for at least 0.6 of a second has three effects, independent of each other:

- a signal is sent to the GTR Exchange at Headquarters where a light comes on and a warning buzzer sounds;
- a signal is sent to the mobile units within the radio area (alarm signal to the trains);
- a counter increases by one unit each time the button is pressed, even if this is less than 0.6 of a second.

GTR on board the trains

A driver may always telephone the Luxembourg GTR Exchange which will establish the required connections.

He can also issue a warning call, particularly in the event of danger, that all the other mobile units in the radio block can hear. He is put into priority telephone contact with the Luxembourg GTR Exchange.

Broadcasting and recording conversations

The standard operating mode is Mode A which is characterised by:

- the selective calling of trains based on the train's number;
- the transmission of coded messages from and to the trains;
- duplex verbal communications[1];
- the secrecy of conversations between the GTR exchange operator and the Traction Unit

[1] A connection is called duplex when two people can converse simultaneously.

Driver (TUD) of the train in question.

Another operating mode is Mode B. This mode, which is not used on the Luxembourg railway network, is a semi-duplex[1] mode, reserved for connections between the SNCF GTR exchanges and traction units travelling into the French railway network. It enables the same functions between mobile and fixed sets as the French system.

In Luxembourg, GTR conversations in the Luxembourg area are recorded at the Luxembourg GTR Exchange. All the conversations of the Bettembourg CCP Traffic Controller on the main telephone lines and those of the Bettembourg CCP Train Announcer on the train announcement lines are recorded at the Bettembourg CCP.

Electric traction

The Bettembourg – Thionville section of line is electrified at 25 kV 50 Hz.

It is powered by:

- the Luxembourg Substation Unit, from Bettembourg to the dividing section located at DM 0.314 in Luxembourg;
- the East-France Substation Unit located at Pagny-sur-Moselle, from DM 0.314 to Thionville.

A diagram of the catenary supply is provided in Annex 7.

The supply to main track* catenaries can only be cut by:

- the Luxembourg Substation Unit for the Luxembourg-Bettembourg Border mains power*;
- the East-France Substation Unit for the Thionville North and Thionville Beauregard mains power.

In order to cut the power on the main tracks, Bettembourg Station must give the order to do so to the Luxembourg Substation Controller (see Annex 13). He himself can cut the power on the tracks located in Luxembourg but must ask the East-France Substation Unit to do so for tracks located in France.

In order to cut the power on the main tracks, Thionville Station must request the East-France Substation Controller to do so. He himself can cut the power on the tracks supplied by France but must ask the Luxembourg Substation Unit to do so for tracks located in Luxembourg.

[1] A connection is called simplex or semi-duplex when two people cannot converse simultaneously

Background information on railway operation

Only those factors that played a role in the accident under investigation will be analysed below. The role of personnel is described only as regards the tasks involving the movement of trains. The movement of traffic inside the station and that of the works trains have not been investigated.

The Luxembourg and French Operation Regulations, as well as the Joint Border Operation Instructions, are analysed below.

CFL Operation Regulations

For historic reasons, CFL regulations can be regarded as "Germanic", similar to those of DB (Germany), ÖBB (Austria) and CFF (Switzerland). The philosophies behind CFL and SNCF regulations therefore differ widely and consequently result in the adoption of different techniques with different behaviour required of the service personnel handling the technical systems. These differences have necessitated more detailed Border Instructions.

Documentation

The main documents used by personnel to perform their duties in matters connected with safety are:

- *The General Regulations on the Technical Operation of the CFL (GRO)*:

These comprise 14 sections and an appendix. They are approved by the Ministry of Transport.

They contain the basic provisions concerning the technical operation service on the CFL network. They do not contain the rules to be observed by personnel to ensure their personal safety, nor explanations on the operation and directives governing the use and service of the technical systems and equipment.

Section 4 deals with the "Trains travelling to their operation posts" and Section 11 with the "Incidents and accidents of technical operation".

- *Bettembourg Station Instructions:*

Its purpose is to provide all the information required for the operation of Bettembourg Station. It comprises seven chapters and numerous annexes.

Chapter I (General Information) chiefly lists the addresses of the railway and administrative departments, the powers of each staff member of the administrative department and the arrangements for cleaning the station.

Chapter II (Installations and outbuildings of Bettembourg station) chiefly describes:

- the premises;
- the characteristics of the tracks;
- the general characteristics of the various switching posts and the signalling systems;
- the areas of action covered by the posts;
- the LCs communicating with Bettembourg;
- the details of electric traction, telecommunication and the public address system.

Chapter III (Organisation of the Technical Operation Department) covers the organisation of the Department, the measures to be taken in the event of freezing conditions, installing train queuing signals, organisation of the "Equipment" Division, handling electricity and water supply failure situations and organising first aid in the event of a fire

Chapter IV (Train Traffic Department) covers anything relating to train traffic, namely issuing order forms, the use (or "service") of safety systems, train announcements, using the block, the LC, wrong-track working, the measures to be adopted in the event of track works, checking routes, exceptional transport arrangements and the information to be given to passengers.

Chapter V (Shunting Department) covers everything related to shunting, including marshalling but excluding "precision shunting"[1].

Chapter VI (Organisation of the Computerised Goods Traffic Management Department) covers matters relating to monitoring goods wagons and the make-up of goods trains.

Chapter VII covers the organisation and operation of marshalling.

- *Blue Instructions (line and local) for electric traction:*

These provide, for Bettembourg Station and the Bettembourg section of line - DM 0.314, the measures to be adopted in order to cut the power to a catenary and prevent an electric-traction train from being directed towards this catenary. They are presented in the form of tables with no other information.

- *Technical Notice of the Bettembourg CCP:*

This describes the systems at the Bettembourg Central Control Post and their operation.

A copy of this document is kept at the CCP.

- *Dependency table:*

This describes the Control Post interlocks. In relay-type electric Control Posts, under normal circumstances, routes are set automatically in accordance with the Dependency Tables, approved by the infrastructure manager. Under these conditions the Traffic Controllers need not check the compliance of the dependencies set. A copy of this document, signed by the Traffic Controllers to confirm that they are aware of its existence, is kept at the Control Post.

There is no other document, such as a check-list, that provides personnel with all of the interlocks likely to prevent a signal from opening when commanding a route that gives rise to this signal. However, there are some sheets that indicate the operating mode to be adopted for certain operations in the Border Operation Instructions. A list of these sheets is given in Annex 14.

- *Joint Service Instructions 81 GR/IF/MA/TR for the ground-train radio*:

Joint Service Instructions 81 GR/IF/MA/TR for the ground-train radio describes the operation and use of the ground-train radio in Luxembourg. These are National Instructions which, for the operator, are the only instructions available to him, together with the Station Instructions. The operation of the latter is described in point 3.4 above.

- *Joint Instructions for the border operation of the Thionville-Luxembourg border section:*

The purpose of these Instructions is to stipulate the operation conditions for the border section between Thionville and Bettembourg. They are described in point 4.3 below.

[1] Precision shunting is an automated method of marshalling wagons.

Staff Handover

Paragraph 4, Section 4 of the GRO* covers the handover procedure for staff involved in safety duties. It chiefly covers the points described below.

Each operating post has its own "Duty Roster". A staff member must not leave his post until he has personally handed over to the person relieving him. His replacement must be informed of the incidents, irregularities in the running of trains, the occupation of the main tracks, the introduction of extraordinary trains, faults and works on track, safety, telecommunication systems and overhead contact lines, etc.

The replacement, for his part, must not depend solely on the information received from his predecessor. He must in all cases ensure that he is fully aware of matters relating to his period of duty. When he comes on duty, he must be acquainted with the station orders and other notices and documents concerning his period on duty.

For certain posts stipulated in the Station Instructions, the person going off duty shall make a brief note in a "Change of Duty Register" of the subject matter of the documents, orders and notices concerning the period of duty of the person taking over, unless this information is recorded in the Train Announcement Log.

The change of duty shall be certified by the two individuals concerned, by their signing and noting down the exact time, in all the Train Announcement Logs at the post and in the Change of Duty Register.

Operating methods at CFL

In this chapter, only the operating methods relating to the accident of 11 October 2006 are described.

Train Announcement

This is included in the regulations defined in Chapter 6, Section 4 of the GRO.

Announcement Systems

The CCP has an automatic train monitoring and announcement system "ZNL800 Zugnummernmeldeanlage" on the tracks that lead to the lines to Luxembourg and Esch-sur-Alzette.

During normal duty, the entries to be made in the Train Announcement Log with regard to the Luxembourg LCP[1] and Oetrange are replaced by a print-out produced by the train number reporting system ("Zugnummernmeldeanlage"). The numbers of the trains must be entered before setting the MFS, controlling the exit from the track where the train is to depart, to 'track clear'.

The visual display board announcing the train numbers is designed to replace the offer and acceptance process. However, trains travelling in the Bettembourg-Noertzange direction must be offered and accepted in accordance with the GRO, Articles 04.31.18 to 26.

For each of the sections of line originating at Bettembourg, the Station Instructions specify the post that answers the call by a bell.

Train Announcement Log

All trains entering and leaving Bettembourg Station are recorded in the Train Announcement Log (see Annex 11). Two facing pages enable information relating to the train

[1] Luxembourg Town

announcement, departure and arrival times to be recorded.

One of the pages is used to record the times of the trains from Luxembourg Town and those heading for Noertzange and Thionville. A separate area is provided to record the trains to and from Alzingen.

The other page is used to record the times of the trains from Thionville and Noertzange and those heading for Luxembourg Town. A separate area is provided to record the trains to and from Dudelange.

In a normal situation (with the printer and visual display device announcing the train numbers), only those columns relating to trains from and to Thionville and to Dudelange are used, as these two sections of line are covered by an announcement procedure (see point 4.4.4 for the procedure between Bettembourg and Thionville). For trains to Dudelange, the announcement is one of the elements of the "offer and acceptance" procedure which is applied on this section of line whereas for those travelling to Thionville the procedure simply involves announcing the trains at the other station.

Checking a route

In certain situations, particularly before issuing an order to pass through a signal that has failed to set at 'proceed' when commanded to do so, checks must be carried out to ensure that the route is safe for the next train. These involve ensuring that:

- the portion of track to be used is clear of all rolling stock and will remain so;
- the equipment is correctly set and locked, if applicable;
- the portion of track to be used is protected from sequent movements under the prevailing conditions (equipment or signals).

At the Bettembourg Control Post these assurances are given automatically when the route lights up white (as this confirms that all these conditions have been met) and by the information concerning the open line (see paragraph 3.3) displayed on the synoptic part of the VCP, as well as on the WWFE module (see 3.3.3). Should the lights fail to come on, the Traffic Controller will check those that he can find on the VCP (some of the lights will be white) and check, or order a check to be made on the ground, that those conditions which the VCP cannot confirm do in fact exist. If a visual check of the route is not possible, the trains must be warned by a written order to pass through the route on visual running *.

The list of assurances to be obtained is not given in a mandatory document.

Conditions for giving an order to pass through an MFS that cannot be set at 'track clear' at CFL

General Rule

If, after having given the command to set a route, an MFS fails to set to 'proceed', the Traffic Controller is authorised to issue a train driver, waiting at the signal, a written order to pass through it. This order shall only be given to the train if:

- the route has been checked and immobilised;
- the train is waiting at the MFS;
- the conditions for authorising the train to pass through are met;
- if transmitted via ground-train radio, the conditions stipulated in ISC Ex /IF/MT 81, Chapter 6, are met (the Traffic Controller must be certain that no justified radio warning

has already been issued);

- on an electrified line, the power has not been cut on the contact line and the contact line is live (Article 06.34.01 of the GRO).

The Traffic Controller shall only give this written order when he is convinced that the impossibility of setting the signal at 'proceed' is not the result of a **normal interlocking of the signal in the stop position**.

This written order takes the form of Written Order A (see Annex 12). This order is issued by hand to the train driver or transmitted to him via radio or telephone. He must then fill in a written order himself, blank copies of which can be found in the cab or in the telephone box next to the signal where he has stopped.

Special Case of tracks fitted with WWFE

When a signal gives access to tracks heading to France, the checks performed prior to issuing a pass-through order must take the WWFE into account by ensuring that the last train despatched from Thionville has actually arrived at Bettembourg and is complete.

The procedure to be applied is detailed in the Joint Railway Operation Instructions for the Thionville-Bettembourg border section.

The Traffic Controller must ensure that he has priority as regards direction, i.e. to Bettembourg, that the CS BM-113 light is white to despatch a train along track 1 or that the CS AM-101 light is white to despatch a train along track 2 on wrong-track working. If the light in question is not white and if the Traffic Controller considers that there is a fault on the system, Sheets 303A and 306A of the above-mentioned Instructions shall be applied for track 1 and Sheets 302B and 305B for track 2.

Application in the case of a Written Order A to pass through the Dm Signal to Track 1

In accordance with of the above-mentioned regulations, the Bettembourg Traffic Controller must proceed as follows if the Dm MFS fails to set at 'proceed' when a route command issued.

Checking and immobilising the route

To check that the track up to the Clear Track Markers* is not occupied, he must check the VCP to ensure that the lights for the areas between the Dm signal and the French border are all white. He must also check, on the WWFE module, that the direction arrow light SN BM-113 is white. Lastly, he must check the Train Announcement Log to ensure that no train is travelling between Bettembourg and Thionville (and vice-versa) on track 1.

As regards immobilising the route, he must check Switches 4 and 1 to ensure that they are in the "left" position and that Switches 1, 2, 3, 5 and 17 are in the "right" position. He must also check that they are locked in these positions. These assurances are given to him by the lights located near the Switch icon on the VCP.

Checking the conditions for submitting Written Order A, Box 1 (see Annex 12)

The Bettembourg Traffic Controller must check:

- that the "Emergency-Direction" switch is in the normal position and that the check light behind it is off;
- that the blue light of the anti-repeater is not flashing (see paragraph 3.3.3);
- that no catenary protection measure has been ordered for the route to Track 1.

With all of these assurances, he can then issue Written Order A, Box 1, for the Dm signal via

radio.

If the SN BM-113 light is off, it normally means that wrong-track working has been taken up by Thionville. It is therefore normal for the Dm MFS to stay 'at danger' to protect existing traffic and the Bettembourg Traffic Controller need not issue a pass-through order.

In exceptional cases, the SN BM-113 light going out may be due to a fault on the system. If the Traffic Controller considers that such a fault may have occurred, which could justify a pass-through order being issued, he must then proceed to conduct a series of additional checks described in Sheets 303A and 306A accompanying the Joint Border Operation Instructions, which essentially involves contacting the Thionville CCRP.

French Operation Regulations

General Safety Regulations (GSR)

On the date of the accident[1], Decree 2000-286 stipulated that the General Safety Regulations (GSR) of the French National Railway Company (SNCF) constituted the safety regulations for operating on the national rail network.

These GSR contain documents concerning the Infrastructure. A list of applicable documents accompanies the Decree of 23 June 2003 relating to the safety regulations applicable on the national rail network.

The GSR are approved by the Ministry of Transport.

Texts called **professional documents** are used at SNCF. These documents contain the provisions, including the regulatory requirements, needed by an operator performing one or more safety functions. They comply with the entire body of regulations.

As soon as they are made available to the operators, these texts replace, for these operators, the corresponding parts of the GSR. The interest of these "professional documents" lies in the fact that they describe the concrete actions to be taken in a given situation in a consultable form in real time, and guarantee that the regulations are observed.

Documentation

The documents used to perform their tasks as regards safety are mainly:

- the General Safety Regulations (GSR);
- Regional Instructions S6A N°1 (Pink Instructions) of Thionville Station;
- the Set-up Instructions relating to the organisation of the Traffic Department at Thionville Station (CE S2A N°1);
- the Joint Instructions concerning operation in the Thionville-Luxembourg border section (cf. point 4.3 below);
- the Blue Local and Line Instructions for electric traction;
- the Instructions relating to the Ground-Train Radio.

The above-mentioned conditions concerning WWFE are identical to those set in the Joint Railway Operation Instructions.

[1] Since 19 October 2006, rail traffic safety has been governed by Decree 2006-1279.

Regional Instructions S6A N°1 (Pink Instructions) of Thionville Station

The purpose of these Instructions is to set the conditions for using the safety systems of the Thionville CCRP.

It does not include a general description of the conditions for using safety systems as this is given in General Instruction S6A N°1 "Using Safety Systems" (IN 1553).

By contrast, it describes all the details of the systems within the Post. In particular, Annex 2 lists for each of the Post's routes, the conditions for setting the route origin signal at proceed. The main conditions are:

- controlling and checking the position of the switches that are passed through or provide protection for the route;
- checking that a route has not been formed under wrong-track working;
- checking other conditions such as clearing through traffic;
- checking that the commanded route has been formed;
- clearing the areas;
- setting the signals encountered on the route at 'proceed';
- obtaining authorisation given by another post;
- releasing interlocks relating to wrong-track working routes (transit, occupied areas, etc.) including WWFE;
- conditions relating to level crossings;
- conditions relating to electric traction or the protection of personnel (ongoing protection, etc.).

For each of these conditions, Annex 2 gives the specific references (switch, zone, transit numbers, etc.) of each of the conditions for setting the origin signal at 'proceed'.

The Set-up Instructions relating to the Organisation of the Traffic Department at Thionville Station (CE S2A N°1)

The object of these instructions is to define the organisation of the Traffic Department at Thionville Station, particularly the tasks of the various staff members at the CCRP.

Blue Instructions (Local and Line) for Electric Traction

For Thionville Station and the Thionville to Zoufftgen section of line (from Thionville to the separation section located in Luxembourg at DM 0.314), these list the steps to be taken to cut the power to a catenary element and prevent an electric-traction train from being directed towards such an element.

Instructions relating to the Ground-Train Radio

Various national, regional or local instructions govern the use of the ground-train radio. These are principally:

- IN 1963: Definitions and rules for using tools relating to the radio connections between the ground and the trains;
- IN 1671 and IN 1672: Manning the trains, and its Annex 1;
- RA 0145: Regional Operations Centre, role, missions and organisation;

- MA 0151: Reporting faults on rolling stock;
- TT 0593: Traction reference material, Management of means – Chapter G;
- The Freight Locomotive Breakdown Guide;
- MN-IN-144: radio link with trains on the lines in the Metz-Nancy region;
- ST IN 242: radio link with trains on the lines in the Strasbourg region;
- Safety annex to the subcontracting agreement for services provided by SIBELIT on behalf of SNCF;
- Interface procedure between SIBELIT and the Nancy and Strasbourg Regional Operations Centres;
- Set-up Instructions S2B N°52 for setting up the "Radio warning ground-train radio" from Thionville.

Joint Border Operation Instructions

The SNCF/CFL Joint Infrastructure Instructions, reference SNCF-MN-IN 083 (CR SO N°11)/CFL, stipulates the operating conditions of the border section between Thionville and Bettembourg. It was drawn up jointly between SNCF and CFL. It is referred to as the "Joint Border Operation Instructions" in this Report.

It states that the safety of traffic and people is the responsibility of:

- SNCF, on French territory up to the border at Distance Marker SNCF 203.756 where, in principle, the regulations in force are French regulations;
- CFL, on Luxembourg territory from the border at Distance Marker CFL 0.000 where, in principle, the regulations in force are Luxembourg regulations.

It covers all the required subjects and in particular the traffic regulations and train announcement conditions. Annex 6 of the Instructions describe how to use Wrong-Track Working Fixed Equipment.

This annex also gives, in the form of sheets:

- a description and explanation of the normal use of the equipment;
- the steps to be taken in the event of a fault.

It must be consulted before the national regulations to which it refers in many cases.

Train traffic

General rule

The trains between Bettembourg and Thionville normally run in the order shown in the train timetables.

The trains are despatched in the order of succession shown in the Bettembourg and Thionville timetables, except in the event of delays that would risk overcrowding on that section of line. The steps taken are aimed in that case at improving traffic flow, for example by despatching groups of trains (in the same direction) when the section of line is being run using WWFE.

If WWFE is used, both switch posts mutually agree before taking the direction.

Changing the normal order of movement

In Luxembourg, a priority order of succession for the trains is set out in the GRO.

In order to decide whether a change in the order of succession of the trains is appropriate, the order of priority of trains as defined in the GRO should be taken into account. A delayed train, in particular, must be kept back if its routing, up to the next train announcement post where an avoiding action can take place, will cause a priority train that follows it to stop or slow down.

In France, the relative priority of each train in relation to the others is deduced from their classification in decreasing order of speed and, in the event of equivalence, priority is given to a train carrying passengers over one that is not. In the event of a new equivalence, the normal traffic order prevails. This rule is not absolute in that a Traffic Controller, SU Controller or Regional Co-ordinator may override it in the justified interest of improving the overall traffic flow or achieving a maximum flow rate.

The Joint Border Operation Instructions state that the Thionville Traffic Operator and Bettembourg Traffic Controller must first agree before despatching a train on the border section in derogation of the planned order of succession.

Movement of Trains when using WWFE

The Joint Railway Operation Instructions state that the decision to despatch a train for wrong-track working on WWFE must first be agreed between the Thionville Traffic Operator and the Bettembourg Traffic Controller.

Announcement of Trains

General Rule

Trains are announced at the latest after their departure or, on the Luxembourg side, a few minutes before it (two maximum).

The Joint Railway Operation Instructions state that the Thionville Traffic Controller must announce each train to the Bettembourg Traffic Controller (and vice versa), before it passes or departs in the following format:

"Track N°.... Train N° .... on wrong-track working (if applicable) at .... h .... min"

The Bettembourg Station Instructions states that the departure announcement must be made:

- at the point of departure or when the train actually passes, if the gate-keepers or maintenance crews do not need to listen to the departure announcements as the trains pass;
- before authorising departure and up to 5 minutes before the probable departure time, if the gate-keepers or maintenance crews need to listen to the departure announcements as the trains pass.

  The departure time is deemed to be the time at which the train starts moving; the passing time being the time at which the front end of the train passes the Central Control Post, DM 4.281.

Investigation Report

Summary of statements by railway staff

The following summaries have been compiled by the technical investigators on the basis of statements made by the staff they interviewed. They contain information provided by the staff member that appears useful in clarifying the actions of those involved and their perception of the sequence of events. There may be discrepancies between the different statements or with observations made elsewhere. Should these discrepancies call for the investigators to express an opinion regarding the sequence of events, this opinion is expressed in Chapter 6 below (Sequence and Reconstruction of the Accident).

Staff at the Bettembourg Switch Posts

The Morning Traffic Controller

The Thionville-Bettembourg track (track 2) is closed to traffic for maintenance work. The other track (track 1) is therefore used for two-way working of trains.

At 11h27, the Thionville Traffic Control Post announced to the Bettembourg Morning Train Announcer, the departure of Freight Train 45938 on wrong-track working. This train runs every working day and it was about 43 minutes late, due to trains travelling temporarily on just one track. The Morning Train Announcer immediately informed the Morning Traffic Controller of the departure of this train. The Morning Traffic Controller advised the Marshalling Control Post (MCP) Traffic Controller of the announcement of this train.

Around 11h30, the Evening Train Announcer arrived at the CCP. The Morning Traffic Controller handed over to the latter without awaiting the arrival of the Evening Traffic Controller, considering that this Train Announcer was qualified to occupy the post of Traffic Controller. The Morning Traffic Controller informed him, together with other information relating to traffic safety, of the fact that Train 45938 was on wrong-track working, information that he knew had already been provided by the Morning Train Announcer.

The Morning Traffic Controller had written on a piece of white scrap paper that Train 45938 was on wrong-track working. This is how he wrote down all the important ongoing operations for his colleagues on the afternoon shift. Before leaving, he left this sheet of paper on the CCP Traffic Controller's desk. He says that he did not cross out the entries on the sheet, nor did he write the last entry "44943 ready to depart".

Around 11h33, he left the CCP. RET 837617 had not yet been announced in the sector. Of the members of the evening team, only the Train Announcer and Switch Tender 1 were in the CCP at this time. He passed the Evening Traffic Controller in his car in the car park. He did not speak to him. The duty instructions clearly state that the handover procedure and the exchange of information must take place between two Traffic Controllers. The Morning Traffic Controller said that he is not obliged to wait for the second staff member (CCP Train Announcer).

The Morning Train Announcer

In the morning, the Morning Train Announcer received from Thionville the information that CCRP had to despatch Freight Train 45938 on wrong-track working to Bettembourg. The Morning Train Announcer informed the Thionville operator that RET 837615 had first to travel from Bettembourg to Thionville. This train was announced at 11h09. The Thionville operator then replied that he would re-propose this freight train again later on. A little after 11h20, this operator announced the departure of the freight train on wrong-track working for 11h27. The Morning Train

Announcer accepted this train and entered it in the TAL*. He informed the Morning Traffic Controller that he had done so.

At 11h28, the Morning Train Announcer was relieved by the Evening Train Announcer and informed him in particular of the arrival of Train 45938 on wrong-track working. Around 11h30, on going off duty, the Morning Train Announcer heard the Morning Traffic Controller inform the Evening Train Announcer of everything that concerned the Traffic Controller's duties.

On leaving, in the car park, the Morning Train Announcer met the Evening Traffic Controller. Each was in their car. The Morning Announcer waved but did not speak to him.

In the TAL, the Morning Train Announcer entered Train 45938 with an arrow pointing to the left. This indicates that the train is travelling on wrong-track working in relation to the normal direction of travel on this track. The header boxes show the normal direction of travel of this track.

If, in his capacity as Train Announcer, the latter hears the Traffic Controller give a "written order" to a driver to ignore the red stop signal without the train approaching in wrong-track working having arrived, he is obliged to intervene. He must remind him that there is a train on wrong-track working travelling on this track. The same applies to the Switch Tenders.

The arrival time of Train 45938 was not indicated in the TAL, it was therefore still en route.

Morning Switch Tender 1

He left his post at around 11h15. He reminded Morning Switch Tender 2 of the catenary protection arrangements and of the fact that the Thionville-Bettembourg track was closed (track 2).

Morning Switch Tender 2

On the arrival of Evening Switch Tender 1, he informed him, with regard to the Bettembourg-Thionville section of line:

- that the Thionville-Bettembourg track was closed;
- that there was catenary protection on the Thionville – Bettembourg track;
- that there was two-way working on the Bettembourg – Thionville track;
- that works were in progress on one of the track installations;
- that a freight train was waiting to depart for Luxembourg but that this station had not yet given its approval.

He did not provide information relating to Train 45938, since it had not yet been announced when he handed over. He had not heard the announcement of this train.

He came off duty at 11h30.

The Evening Traffic Controller

He arrived at the CCP at 11h35, a little late. In the car park he saw the car of the Morning CCP Traffic Controller leave.

He signed the duty roster. The Evening Announcer informed him of the various works in progress but did not inform him of the wrong-track working of Train 45938 from Thionville to Bettembourg. He also read the information written on a sheet of paper (see Annex 8) by the Morning Traffic Controller and saw no entry relating to Train 45938. He only read part of this document and did not cross out the 45938 entry. He then read the various time log documents.

Once at his console, he looked at the VCP and saw that RET 837617 had been announced

from Berchem and that its approach route had been plotted on track 2. At around 11h37, he heard the Evening Announcer announce the departure of this train to Thionville. Thereupon, Evening Switch Tender 1 informed him that the Dm MFS would not set to 'proceed' on a clear track. He saw on the VCP that the route was engaged and that the anti-repeater blue light was flashing (see 3.3.2). The track circuit (exit track towards Thionville) was white. He ordered Evening Switch Tender 1 to cancel the route and try again to establish and set the signal to 'track clear'. The signal would no longer set to 'free track'. He then said: "Leave the set route, we'll run on a written order". He thought that a random fault had occurred, as happened from time to time at Bettembourg. He did not think that Thionville could have sent a freight train at that time of day, a period that was usually reserved for passenger trains.

He then contacted GTR Headquarters in order to be put into contact with the driver of Train 837617. He reached him on the telephone and, at 11h41, dictated the written order to pass through the Dm MFS, an order that was correctly read back by the driver. During this conversation, he saw that the MCP Traffic Controller was calling him on his direct telephone line. He did not, however, hear this Traffic Controller's call over the public address system.

He then took a call from the MCP Traffic Controller who said to him: "What are you doing, the Thionville train hasn't come in yet[1]" and at the same time the Train Announcer asked him: "has the train come in?". The CCP Traffic Controller was taken aback. And after having realised the situation, he tried to contact the GTR Exchange which was engaged. He ordered Switch Tender 1 to press the GTR warning button and the Train Announcer to push the emergency button to cut off the power to the catenary. He then immediately contacted Headquarters on a direct line to report the event and at the same time asked whether the GTR warning had reached the Exchange. The answer was no. He then asked Headquarters to issue a warning: "We've made a mistake". About a quarter of an hour later, the CCP received the news from Thionville that two trains had collided.

He did not understand why the written order had been issued. He thought that he could have been misled by the signal showing that the exit track was unoccupied, as indicated on the VCP (white track circuit), and by the fact that the train departure announcement had been made by the Train Announcer. He had forgotten to look at the lights on the WWFE module and at the TAL.

The Evening Train Announcer

He came on duty at 11h28. The Morning Train Announcer informed him of all the train movements under way and all the announcements made by the neighbouring Control Posts. He was therefore aware that Goods Train 45938 was on wrong-track working on the Bettembourg-Thionville track, coming from Thionville and heading for Bettembourg.

Around 11h30, the Morning Traffic Controller handed over to him, adopting what he considered to be the correct procedure, informing him, as would any traffic controller, that Goods Train 45938 was on wrong-track working. He noted all the details relating to this handover on a piece of scrap paper (cf. Annex 8) which was in the middle of the CCP Traffic Controller's desk. The Evening Train Announcer took note of this.

The Evening Train Announcer then found out from the MCP about the trains that were ready to leave from the marshalling yard. This was the case as regards the 44943 bound for Thionville. He filled in the sheet of scrap paper.

The Evening Traffic Controller then arrived (two to three minutes after his morning colleague had left). The two operators (CCP Traffic Controller and Train Announcer) then handed over in proper and due form, including drawing attention to the presence of the sheet of paper on

[1] i.e., into "the marshalling yard".

the console and the fact that Train 45938 was on wrong-track working.

Around 11h35, the Train Announcer announced the RET 837617 to Thionville, giving its departure time as 11h39. The Thionville operator did not react and did not draw his attention to the fact that the regional train had to be held back because the freight train was still on wrong-track working on the Bettembourg-Thionville track.

He then became involved in checking his e-mails, the delays entered in the Excel file and ordering food, for his Traffic Controller and himself, from a pizzeria in Bettembourg. At one point, he heard his Traffic Controller order Switch Tender 1 to cancel and re-plot the "Dm" MFS route to Thionville. He then heard the Traffic Controller have a telephone conversation with someone (he did not know who it was). On finishing the previous telephone conversation, he heard the CCP Traffic Controller call his colleague at the MCP. Immediately afterwards, the CCP Traffic Controller gave the order to CCP Switch Tender 1 to press the "GTR warning" button. He thought that RET 837617 was still near the "Dm" MFS, either just before or just after it.

He then asked his Traffic Controller if Goods Train 45938 had arrived at the MCP. Receiving no reply, the Train Announcer realised that the CCP Traffic Controller had probably issued a written order to the driver of RET 837617 (conversation not heard by the Train Announcer). The CCP Traffic Controller had not asked him the arrival time of 45938 at the MCP or whether the arrival time of 45938 had been entered in the TAL.

The Train Announcer also said that:

- he had heard the MCP Traffic Controller inform the CCP Traffic Controller by telephone that Train 45938 was under way;
- he had heard his Traffic Controller calling Headquarters and asking if the GTR had worked and it had appeared not to have done;
- a second attempt had been made by Headquarters to trigger the GTR warning;
- CCP Switch Tender 2 had directly pressed the red button of the system to cut the electrical power supply to Bettembourg Station;
- he had directly telephoned the Thionville Traffic Controller to find out if it was in fact true that Goods Train 45938 was still travelling on wrong-track working and this was confirmed. During a second call, he asked him to contact Goods Train 45938 and to stop all trains travelling on the Bettembourg-Thionville section.

A few minutes later, he heard the tragic news from the Thionville Traffic Controller and passed it on to his Traffic Controller, taking over the latter's duties as he was no longer in a fit state to continue working.

He was later relieved from his duties as Train Announcer and CCP Traffic Controller by another employee.

Evening Switch Tender 1

He came on duty at 11h25. On handing over, Morning Switch Tender 2 informed him of the situation in the station. He heard the Morning and Evening Train Announcers handing over. He also noticed that the Morning Traffic Controller and the Evening Train Announcer were speaking to each other then, on his arrival, the Evening Traffic Controller spoke to the Evening Train Announcer. Evening Switch Tender 1 cannot say what was said during these three conversations. Nor did he familiarise himself with the Train Announcement Log or the note on scrap paper written by the Morning Traffic Controller.

Around 11h40, the Evening Train Announcer contacted his French colleague to announce

that Train 837617 was about to depart for Thionville. When Evening Switch Tender 1, who was unaware that Train 45938 was on wrong-track working, tried, on his own initiative, to plot the route for this train, the exit signal towards Thionville would not set at 'proceed'. He had beforehand looked at the VCP and noted that the section of track that leads up to the French border was white. The Evening Traffic Controller ordered him to try once more. As the signal would not set at 'proceed', Switch Tender 1 again consulted the VCP. The section of track was still white. He heard the Evening Traffic Controller give the order, by ground-train radio, to the driver of 837617 to pass through the signal. During this time, Switch Tender 1 was in the process of switching another train in the direction of Wasserbillig. The Train Announcer was sitting at his post. The gong announcing a train coming from France and the area warning lights passing from white to red when this train entered Luxembourg occurred after the order form was issued but while Train 837617 was still stationary at the Dm signal.

The MCP Traffic Controller then contacted the Evening CCP Traffic Controller to tell him that Goods Train 45938 coming from Thionville had not yet arrived at Bettembourg[1]. The latter asked the Evening Train Announcer if a train was travelling between Thionville and Bettembourg. The latter replied "Oh shit, I thought that the train had already come in". Evening Switch Tender 1 then immediately pressed the "GTR Alarm" button several times, holding it down for a few seconds. Evening Switch Tender 1 was certain that RET 837617 was still stationary at the Dm signal when he triggered the GTR alarm. Furthermore, the Evening Traffic Controller ordered Evening Switch Tender 2 to cut the power and immediately inform Headquarters so as to stop the train by GTR. He also contacted his French colleague to inform him that a mistake had been made and that he had to contact the drivers of the two trains.

We were informed of the collision of the two trains at about 12h05.

Evening Switch Tender 2

On arriving, he sensed that the atmosphere was extremely tense. As the Traffic Controller and Train Announcer were very busy, he asked Evening Switch Tender 1 what was happening. He was told that on plotting the Bettembourg border-Thionville route, the signal twice failed to set at 'proceed' and that he had been given the order to: "leave the route interlocked, I'm going to issue a written order". Switch Tender 1 told him that it appeared that a goods train from Thionville had not yet entered the marshalling yard.

Evening Switch Tender 2 saw from the VCP that the train that had received the written order had started to move along track 1 where, in this time band, trains had been travelling in both directions for 3 weeks. At that moment he heard the MCP Traffic Controller, who had tried to get in touch with the CCP Traffic Controller, ask "what are you doing, the freight train hasn't come in yet".

For the first time in his career of carrying out orders, he pushed the emergency button several times, without having received the order to do so, in order to cut off the electric traction power supply. At the same time, Switch Tender 1 pushed the GTR alarm button.

The Train Announcer immediately informed Thionville about what was happening. Evening Switch Tender 2 said to the Train Announcer: "They should be in radio contact with their depot, can't they do anything?"

The Evening Marshalling Post Traffic Controller

[1] Evening Switch Operator 1 does not remember whether the MCP Traffic Controller gave a warning via the direct link (public address system).

He came on duty at 11h30 and his predecessor informed him, among other things, that Train 45938 was expected from Thionville, on wrong-track working.

Around 11h35, he noticed on the MCP VCP that a CCP route had been set from the "Dm" MFS towards the Bettembourg-Thionville track. The Dm MFS did not therefore set at 'proceed' on a clear track since the "direction" was towards Thionville. At that point, he did not query the situation for the following reasons:

- he assumed that a test was being run on behalf of the "S" Department (a thing that sometimes occurred several times per shift);
- the CCP staff were experienced people who had been working at the CCP for several years.

He was busy with other tasks when he later realised (around 11h41) that the "Dm towards Thionville" route was still plotted but at that time the circuit of track upstream of the Dm MFS was red and therefore occupied. Since he found this strange, he wanted to warn the CCP Traffic Controller that Train 45938 that had left on wrong-track working from Thionville had not yet arrived at the Bettembourg goods depot. For this reason, he used the direct MCP-CCP telephone line (he had never used the intercom connection). No one picked up. Twenty to 30 seconds later, the CCP Controller called him back asking "Did you ring me?". He answered "Listen mate, you do realise that the freight train hasn't come in yet?!". It seemed to him that the CCP Traffic Controller was flabbergasted when he said this and he thought that he heard the words "Patrick… freight train". He then realized that the CCP Traffic Controller was unaware that 45938 was under way before he rang him. The conversation was finally cut off.

After picking up the phone, he saw on the VCP that the train stopped at the MFS had just left.

Thionville CCRP Staff

The Traffic Controller

In view of the delay of Train 91, the train timetable was changed and he decided to despatch Train 45938 when 837615 arrived, knowing that the Bettembourg train (RET 837617) would be made a few minutes late, but that this was not serious. The announcement was made as normal at Bettembourg.

The Sector 1 Traffic Operator accepted the RET announced by Bettembourg saying that it would be OK after Track 1 had been cleared of the freight train. At this precise moment, the Sector 1 Traffic Operator turned to him and said: "He hung up on me".

Around 11h50, Train 45232, travelling from Bouzonville to Thionville, announced a power cut on the line. Having called the East France Substation Unit, the Substation Controller gave him no explanation for this power cut.

A telephone call from the works site warned him that a head-on collision was about to happen between a passenger train and a goods train in the vicinity of Distance Marker 203km.

Sector 1 Traffic Operator

The 45938 arrived at about 10h30 on track 2M, about 10 minutes early. It stopped at square Sign 244 and its driver reported that the locomotive's radio was not working.

After the arrival of Trains RET 837683 and GL 91, TGV 2604 was announced at Bettembourg on wrong-track working.

An agreement was reached with Bettembourg to despatch 45938 on wrong-track working. Bettembourg wanted trains 750011 and 837615 to go first. The decision was taken to send 45938 on wrong-track working along Track 1 as soon as RET 837615 had arrived.

As soon as it had arrived, there was further discussion and it was decided to despatch it. The Sector 1 Traffic Operator announced it to Bettembourg, who read back the announcement. After checking that there was no reason not to, he despatched it.

Twelve minutes later, a different person at the Bettembourg Control Post announced RET 837617. It was clear to the Sector 1 Traffic Operator that this train would not be despatched until after the arrival of 45938, as the safety systems would not allow it to be despatched beforehand[1]. The BM-113 interval was occupied. Bettembourg called back about 4 minutes later and asked where 45938 was. The Sector 1 Traffic Operator replied that it was at the border or thereabouts, according to checks carried out on the interval. Bettembourg hung up immediately.

A few minutes later, the Luxembourg Controller tried to contact him on the telephone but when the Sector 1 Traffic Operator answered there was no-one on the line. He called him back and the person contacted said "It's not serious, Bettembourg has made a mistake. They've issued a written order". Just after this telephone conversation, the Traffic Controller was told by one of the works managers that an accident had just occurred at the border.

Sector 1 Switch Tender

His statement confirmed that of the Sector 1 Traffic Operator.

Traffic Operator 2

Goods train 45938 arrived from Uckange at around 10h30. It waited for about an hour at Square Sign 244. The Sector 1 Traffic Operator, after agreeing with Bettembourg, gave him the order to despatch this train.

Other CFL Staff

A representative and a GTR (Ground-Train Radio) operator came to "Network Management Headquarters" (NMH*).

Evening Representative at Network Management Headquarters (NMH)

He came on duty at 11h35.

At 11h43, the Bettembourg CCP Evening Traffic Controller immediately asked him if the GTR alarm had reached NMH. He replied that it had not. The Bettembourg CCP Controller then said that he had made a mistake. At the same time, the Evening Representative orders the Morning GTR Operator, still present at Headquarters, to transmit a general call telling the trains travelling between Bettembourg and Thionville to stop immediately. He then ordered the Bettembourg CCP Traffic Controller to cut off the electricity on the Bettembourg network.

As soon as he had hung up, he telephoned the Luxembourg "Substation Unit" Manager so as to cut off the power between Bettembourg and Thionville as well. Finally, he warned the Traffic Controller at Thionville Station that RET 837617 was en route for Thionville and that Goods Train 45938 travelling to Bettembourg had not yet arrived at the Bettembourg marshalling yard. He is not sure whether he asked the Manager at Thionville to cut the electricity or whether he asked the SU Manager to warn Thionville.

[1] Note: The GRO allow the departure or passage of a train to be announced before the arrival of a train on wrong-track working on the same track.

Operator at the Morning GTR Post at NMH

Around 11h43, he heard the Representative's telephone ring. He heard him speaking but did not know to whom he was speaking. The Representative then asked him if a "GTR alarm" had reached Headquarters. The GTR Operator replied that he had not heard any alarm and that the warning light had not come on.

The Representative therefore gave him the order to transmit a general call ordering all trains travelling between Bettembourg and Thionville to stop. He transmitted this call several times, in French and in Luxembourgish. During this time, he heard the Representative order the "Substations Unit" (SU) to cut off the electricity on the network.

The GTR operator then tried to contact Train 837617 on the direct line, without success.

The Representative told the Thionville Control Post to cut off the power on the network. He was told that this had already been done.

Operator at the Evening GTR Post at NMH

In the afternoon, an engineer from the Telephony Department, which is responsible for the GTR network, came to carry out tests on the GTR from NMH.

The Operator of the GTR post said that:

- the transmission of a radio warning issued by the Bettembourg Control Post and NMH was not working;
- the alarm did not therefore reach the trains in the Bettembourg sector;
- the radio warning transmissions and the Kleinbettingen and Luxembourg Control Posts did not work.

After repair, the system was restored to working order at around 17h30.

Telephony Department Engineer

He arrived at the Bettembourg CCP at around 13h to test whether the GTR alarm button was working. This alarm was in fact received at Headquarters, with an abnormally long delay, but it was not received by two train drivers at Bettembourg Station.

At around 13h45, he arrived at Luxembourg Headquarters (NMH) to discover the nature of the problem regarding the GTR alarm system. After investigations, he found that the 1520 Hz frequency output level was not enough to trigger the alarm buzzer in the traction units. He changed a frequency-generator module and the GTR alarm system was restored to working order.

No periodic maintenance is in place for the GTR alarm system and work is only carried out when a fault is reported.

Other SNCF Staff

The Driver of Train 45938 (driver from Bâle to Uckange)

On leaving Mulhouse North, the radio jammed when the driver tried to change channel, it then cleared of its own accord. This problem reoccurred at Colmar. The driver was able to get it to work after a few adjustments. Towards Sélestat, a new fault occurred with an MMI (Man Machine Interface) message being displayed. The driver was unable to get it working again.

He advised the Hausbergen Control Post of this fault saying that he had followed the instructions on page 470 of the locomotive's computerised troubleshooting guide. Five to ten minutes later, the control post called him back to tell him to proceed to his destination.

At Uckange, the train was received at the marshalling yard and he informed the control post at this station that the radio was faulty. On leaving his train, he met the driver who was relieving him. He told him verbally that the radio was out of order and that the Regulator had been informed.

The Strasbourg ROC Regulator

At 6h45, the Hausbergen Traffic Operator informed him that the GTR of the locomotive of Train 45938 was out of order. He immediately informed the COFRET (Freight Manager at the Regional Operations Centre) at Strasbourg verbally. The COFRET authorised him to continue to the first servicing station. He informed the Hausbergen Traffic Operator of this decision.

Around 7h30, he informed the Metz-Nancy Regulator of the GTR fault and issued an Equipment Incident Sheet (EIS) for the COFRET. This EIS was faxed by the COFRET at 8h20 to the traction unit operator *.

The Strasbourg COFRET

Around 6h45, the Strasbourg ROC* Regulator informed him that there was a problem with the GTR on Train 45938. The Regulator told him that the driver followed the instructions on page 470 of the locomotive's computerised troubleshooting guide.

He called the Equipment Manager of this train, SIBELIT[1] South Table Operator. As the latter did not reply immediately, he consulted the Traction Reference Manual "Using the Train in Degraded Mode". He noticed that, according to the instructions on page 470, the train could provide a limited service, meaning that it must be taken back to its home depot, Thionville in this case, within 24 hours. He shared this information with the SIBELIT South Table Operator who gave him the green light for the train to continue, without specifying up to what point.

He informed the Regulator and faxed SIBELIT an Equipment Incident Sheet (EIS).

The SIBELIT Operator

Train 45938 was travelling on a route dependent on the "South" Table of SIBELIT's Operational Centre located at Luxembourg.

At around 7h/7h30, the Manager of this Table was informed on the telephone by the Strasbourg COFRET of a radio problem on this train, but had no further details. At 8h16, an EIS stating that the GTR of 45938 was out of order was faxed to SIBELIT. The Manager did not receive it immediately. He only found out about it later (he was not sure of the time). He is authorised to cut off the locomotive at the servicing point, which in this case is Bettembourg[2]. Before deciding, he received a telephone call from the driver taking over at Uckange who wanted to keep his locomotive, particularly as the GTR was working in the other cabin that was to be used on leaving Bettembourg for the next train. The Manager concurred and agreed that the locomotive would be changed at Woippy.

Consequently, at 10h44, he faxed the Nancy COFRET to advise him of his decision and arrange for the Nancy ROC Chief Regulator, the Nancy ROC Regulator, the Thionville CCRP and the Thionville depot to be informed of it.

He was informed of the accident at about 12h10 by the Nancy COFRET.

---

1 The role of this company is explained in paragraph 5.4.1 below

2 A radio fault does not require the immediate stoppage of a locomotive.

Recordings of telephone conversations

The telephone conversations were recorded at the Bettembourg switch posts (CCP and MCP).

Exchanges between the CCP Train Announcer and the Thionville Sector 1 Traffic Operator

A Train Traffic Diagram is shown in 6.1. below.

Just before 11h, the Thionville Traffic Operator asked the Bettembourg Train Announcer if the 750011 had arrived at Bettembourg. He received the answer: "Ah, the HPV[1], it's here, we're waiting for the 2604 then we'll send it off".

The Thionville Traffic Operator then suggested that Train 45938 should travel behind Train 750011. As Train 837615 (which was to follow Train 750011 about ten minutes later) was on time, the CCP Train Announcer rejected this solution and the two operators agreed that:

- Train 45938 should run behind Train 837615;
- Train 45938 should only be announced after the arrival of Train 837615 at Thionville.

During this conversation, the CCP Train Announcer said at one point "I don't have the French number after 45938[2] has completed its run". Thionville gave it to him.

At 11h27, the Thionville Traffic Operator announced the departure of Train 45938 on wrong-track working to the CCP Train Announcer who approved it.

A conversation, probably dating from the day before, is included on the recording.

At 11h39, the Bettembourg Train Announcer announced Train 837617 to the Thionville Traffic Operator who approved it, without comment.

At around11h42/43, the Bettembourg Train Announcer asked the Thionville Traffic Operator at Thionville where the 45938 was. He replied that it must be at the border, which surprised the Train Announcer. The Traffic Operator then informed him that the train had cleared the first block.

Shortly afterwards, the Train Announcer called the Traffic Operator back to ask him whether the 45938 had arrived yet. He was told that it had not. The Train Announcer concluded that it was en route between Thionville and Bettembourg, which the Traffic Operator confirmed.

The Train Announcer then reminded the Traffic Operator that he had announced the 837617 at 11h39 (the Thionville Traffic Operator confirmed this), that this train was en route and that the trains would therefore meet head on. The Thionville Traffic Operator asked him if the power had been cut and the Train Announcer assured him that it had.

In order to find out where these two trains were, the Train Announcer asked the Traffic Operator to contact one of the work sites. The Traffic Operator agreed to this explaining that the CCRP was going to try and contact them by radio.

The Train Announcer called the Traffic Operator back to find out if anyone had found out what was happening. The Traffic Operator replied that they were not sure but it would appear that Train 837617 may have hit a car and asked him if the 837617 had been dispatched on wrong-track working. The Train Announcer replied that it had been sent in the normal direction.

---

1 Empty-run Passenger Train: a train made up of passenger cars but running empty.

2 This train changes number at the border between Luxembourg and France.

The Train Announcer called yet again but was told that there was still no information. Around 11h44, the Thionville Traffic Operator called Bettembourg to say that the two trains had collided.

Exchanges between the MCP and CCP Traffic Controllers

The MCP Traffic Controller tried to get back in touch with the CCP Traffic Controller by the direct telephone line. Having failed to do so, because the line was engaged, he hung up. The CCP Traffic Controller then called his opposite number at the MCP to find out why he had called him. The latter told him that he had seen that the CCP had set a route. The CCP Traffic Controller confirmed this and said that this train had been given an order to pass through the signal. The MCP Traffic Operator drew his attention to the fact that another train, the 45938, had been en route since 11h27. The CCP Traffic Operator was surprised ("You're kidding me"). The MCP Traffic Controller told him that this train had not yet arrived at the marshalling yard. The CCP Traffic Controller reacted by ordering the Control Post to "stop, stop".

Issuing the order to pass through the Dm signal to the driver of Train 837617

The Traffic Controller informed the driver of Train 837617 that there was a slight technical problem and that he had to give him a written order to enable him to pass through the Dm Signal.

He then sent him this written order.

General alarm raised by the GTR Exchange Operator

Around 11h44, the GTR operator broadcast the following messages:

in Luxembourgish:

"Attention, attention: all trains on the Bettembourg-Luxembourg line must stop",

"Bettembourg-Thionville all trains must stop"

then in French:

"Attention, all trains in the Thionville direction and the Bettembourg direction on the Bettembourg-Thionville track must stop".

Emergency cut-out of traction power at Bettembourg

Around 11h44'30", the Luxembourg Representative gave the order to the Luxembourg Substation Regulator to cut the power on the Bettembourg-Thionville line, explaining that two trains were travelling on the same track.

Operation of the GTR

Recording the use of the pushbuttons

Recording the use of the pushbuttons for the Luxembourg area

Note that the Bettembourg-French border section of line forms part of this area.

After the accident, the counter recording the use of the GTR alarm buttons for this area displayed the number 436.

The last entry in the Fault Book dates back to 14 September 2005 and bears the number 435. Consequently, one of the alarm buttons for this area had been used only once between 14 September 2005 and 11 October 2006.

This single use could have occurred on 11 October 2006 or before that.

All of the times that the alarm button is pressed are recorded, even if they last less than 0.6 of a second and are therefore ineffectual for transmitting the alarm.

Recording the use of the pushbutton for the Belval Factory area

On the afternoon of 11 October 2006, the GTR alarm-button-use recording counter for this area displayed the number 2756.

The last entry in the Fault Book dates back to 14 September 2005 and bears the number 2756. Consequently none of the alarm buttons for this area had been used between 14 September 2005 and 11 October 2006.

Receipt at GTR Headquarters

GTR Headquarters did not receive the signal (warning light + buzzer) which should have reached it as a result of Switch Tender 1 having pressed the alarm button as he says that he did at around 11h42'30".

Hidden fault on the device for transmitting radio warnings to the trains and Headquarters

As explained in 3.4.3.1, the alarm is sent to the trains if the CCP warning button is pressed for more than 0.6 of a second. This alarm is transmitted by a device that has a card; due to a fault on the latter, this transmission failed on 11 October 2006.

However, this card was not involved in transmitting the alarm to the GTR Exchange; if the pushbutton had been pressed effectively (held down for more than 0.6 of a second) on 11 October 2006, the alarm signal would have been transmitted[1] to the GTR Exchange, but this was not the case.

Conclusion

The record of pushbutton use shows that the statements made by Switch Tender 1 claiming that it was pushed several times are incorrect: it was only pressed once between 14 September 2005 and 11 October 2006.

This use may be assumed as probably having occurred before 11 October 2006; if the button has been pressed at the time of the accident on 11 October, it could not have been held down for more than 0.6 seconds because Headquarters did not receive the signal and the failure of the card did not prevent the alarm signal from being transmitted to Headquarters.

[1] The theory of a faulty transmission cannot be completely dismissed, however, because the maintenance engineer who inspected this system after the accident observed an abnormally long transmission time.

Train Traffic Department

Two switch stations are involved in the movement of trains between Bettembourg and Thionville:

- Thionville Control Post 1 (Computer-Controlled Relay Post or CCRP) ensures safety at Thionville;
- Bettembourg Central Control Post.

These two Control Posts work together to operate the Bettembourg-Thionville section of line.

They both keep traffic records.

Bettembourg CCP Train Announcement Log (TAL)

For a train travelling from Bettembourg to Thionville, the entry in the TAL comprises the train's number, the announced departure time and any delays regarding arrival at and departure from Bettembourg. An arrow is added above the train number when the latter is on wrong-track working (on Track 2) and the person making the entries signs the document, train by train, when making the first entry.

For a train travelling from Thionville to Bettembourg, the entries are the same, with the addition of the arrival time at Bettembourg, and an arrow is entered for trains on wrong-track working (on Track 1).

Train 45938 is entered in the log, with an announced departure time of 11h27, and the Bettembourg-delay and CCP-arrival boxes do not contain the time but the wrong-track working arrow is already entered. The person who signed for this train is the Morning Train Announcer.

Train 837617 is entered in the log with an announced departure time of 11h39, and the Bettembourg-delay boxes contain a dash indicating that the train is on time. The person who signed for this train is the Evening Train Announcer.

Traffic Record for Thionville trains

For each of Tracks 1 and 2, the Train Traffic Record has two separate sections: one for trains travelling in the normal direction and the other for trains travelling on work-track working. For Track 1 in the normal direction, the Bettembourg announcement time, train number and arrival or passing time are indicated, while for wrong-track working, the train number and departure or passing time are indicated.

Train 45938 is entered with a departure time of 11h27 in the wrong-track working section and Train 837617 is entered in the normal-direction section with an announcement time of 11h39.

These entries are consistent with those in the Bettembourg TAL.

Movement of Freight Train 45938 and fault on its ground-train radio

Activities and organisation of the SIBELIT Company

In order to improve the productivity and quality of rail freight trains that operate on the route between Muizen (marshalling yard located South of Antwerp) and Bâle, the SNCB, CFL, SNCF and CFF railway companies have created an organisation that makes up the trains: the SIBELIT Company. The purpose of this Company is not to become a railway company in its own right but to

provide services, under a subcontracting arrangement, to the above-mentioned railway companies; its work involves combining time slots, locomotives and driving services and monitoring them. It acts as a Traction Unit Manager* for end-to-end routing of trains along this line.

SIBELIT is located in Luxembourg and may be manned by staff from Belgium, France and Luxembourg.

It receives an order to make up a train, from one or more of the four railways companies. It relies on these companies to provide locomotives and drivers. It asks the relevant infrastructure managers for the required time slots (the railway companies may apply for these slots themselves and then hand them over to SIBELIT).

SIBELIT tries to optimise the facilities at its disposal mainly by:

- co-ordinating the number of driver handovers;
- achieving smoother management of the time slots in the various countries along the North-South line;
- implementing an efficient centralised system enabling trains to be monitored regardless of borders.

After having made up the train, SIBELIT ensures that it is monitored in real time. It is up to SIBELIT to decide the steps to be taken to handle train management and all of the problems that may occur during a train's journey. For this reason, the SIBELIT offices in Luxembourg are manned full-time by two members of staff.

For an SNCF freight train, the task of the COFRET* at a ROC involves being the interface between the ROC and the freight management organisations. On the Muizen-Bâle line, the SNCF has subcontracted this task of train management to SIBELIT. SIBELIT is therefore responsible for taking decisions in the event of an incident occurring on one of the train's component parts.

The subcontracting agreement for the services provided by SIBELIT on behalf of SNCF includes an annex which details the "safety" aspects. This document lists the SNCF documents available to SIBELIT:

- business documentation;
- technical documents for the trains used;
- Instructions IN 1787 (Reference Manual-Transport Assignments with Special Acceptance and Routing Requirements);
- Instructions FR 0687 (Procedure for incorporating an exceptional transport assignment in an interpenetration train under the SNCF/CFL/SNCB agreement).

The business documentation, in the case in question, comprised:

- the memorandum for use by the line driver (TT057);
- the reference manual for the line driver (TT0510 to TT 0516).

Measures to be adopted in the event of a fault on the GTR of a traction unit in France

Measures to be adopted by the driver of the locomotive

In the event of a fault on the ground-train radio after departure, Chapter "F" (TT 0516), Article 51.10, of the line driver's reference manual describes the measures to be adopted. The driver must first determine whether the fault originates from the "ground" or "onboard". The fault is deemed to be "onboard" if it persists after a distance of 50km (the average length of two

consecutive radio blocks) without adopting any measures.

If the fault does not persist beyond these two consecutive radio blocks, he should continue his journey normally. He should make a note of the malfunction in the onboard book and report the fault to the Regulator as soon as he can.

If the fault persists beyond these two consecutive radio blocks and communications with the other drivers in the zone, or with the station, are still not possible, he must stop his train at the first servicing station (or, if necessary, at a track telephone).

The driver will advise the Traffic Operator of the first servicing station (beyond 50km). The Operator will advise the Regulator who will send this information to the "Freight Manager" (COFRET) of the railway company operating the train. He will decide what should be done and his decision is then relayed back to the driver in the reverse order (COFRET, Regulator, Traffic Operator, driver).

The driver will consult the troubleshooting guide, possibly computerised, relating to his locomotive (page 470). This troubleshooting guide will refer him to the memorandum used by the line driver. Sheets 514 (ground-train radio connection operating fault) and 501 (locomotive fault) show him the measures to be adopted depending on the situation encountered. Sheet 490 (restarting after an incident) details the measures to be adopted to get back under way.

If a locomotive arrives at the end of its journey with a faulty portable set, it may only get back under way after the latter is replaced.

Measures to be adopted by the Regulator

After ensuring that the fault does not originate from the ground equipment, the Regulator will contact the manager of the train traction unit and, with his agreement, adopt one of the measures open to him.

On lines where red light fusees are compulsory (Thionville – Bettembourg comes under this category) and for trains with only one driver, he will limit the speed of the train to 70 km/h until the traction unit can be replaced, **or else** assign an authorised driver to accompany the train

The decision to replace the locomotive in one of the train's through-stations, appoint an accompanying driver or limit the train's speed lies with the train's traction unit manager. For Train 45938, SIBELIT was this traction unit manager.

For unregulated lines, the person informed (the Traffic Controller or Traffic Operator of a station control post) will inform his ROC who will then proceed as if it had been informed directly. At the end of the procedure, it will advise the Traffic Controller or Traffic Operator of the decision or decisions taken.

Appearance and management of the fault on the GTR of the freight train

Freight Train N°45938 left the Bâle marshalling yard at 3h45 on 11 October 2006 for the Bettembourg marshalling yard. SNCF and CFL appointed SIBELIT (see point 5.5.1) to make up this train.

On leaving the Mulhouse North marshalling yard, at around 4h29, the ground-train radio failed for the first time. It began to work again a few moments later. The radio jammed again at Colmar, at around 4h55. After adjusting its circuit-breaker (RAD CB), it began to work again. It failed again at Sélestat, around 5h10, when the MMI (Man Machine Interface) warning was displayed, then the screen went black and it was impossible to get it to work again.

Around 6h40, the driver informed Hausbergen Control Post 1 of this situation. He followed

the instructions on page 470 of the locomotive's computerised troubleshooting guide. The fault persisted. At 6h45, the Traffic Operator at the control post informed the ROC of this fault. The ROC informed the Strasbourg COFRET. The latter, in agreement with SIBELIT (unit manager), who did not know whether it was a ground fault or an onboard fault, gave the locomotive the order to continue[1], despite the radio fault. The ROC sent this instruction to the Hausbergen control post who gave the order to the driver to continue to his destination. The train left at around 6h50.

At 8h16, SIBELIT received the EIS* by fax stating that the GTR of Train 45938 was out of order. This fax was not read immediately but about an hour later.

The train arrived at Uckange at 9h35. The driver informed the Switch Tender of Control Post 2 that the radio was not working. He also verbally informed his relief driver that the radio was not working and that the Regulator had been informed.

At 10h34, the new driver of Train 45938, who had departed from Uckange, arrived at Thionville Station. He informed Thionville CCRP from Square Signal 244 that the radio was faulty and that Nancy ROC was aware. He telephoned, on his mobile phone, to tell SIBELIT that he did not want his locomotive to be changed, particularly as the radio at the other end of the train was working. It was decided that the locomotive would be changed at Woippy, the destination station of Train 48785 which was allocated to this locomotive after Train 45938. At 10h44 SIBELIT sent a fax to the COFRET at Nancy explaining the situation. SIBELIT also informed the Chief Regulator the Nancy ROC Regulator, Thionville CCRP and the Thionville depot.

Movement of the freight train from Thionville

Due to the traffic conditions on 11 October 2006, Train 45938 was kept at Thionville, on Track 2M, at the foot of Square Signal 244, until the arrival of RET 837615 from Bettembourg. It joined Track 1, on wrong-track working, travelling towards Bettembourg once the square signal came on at 11h27. This square signal showed a green light.

Organisation of work at the Bettembourg Central Control Post (CCP) and the Thionville Switch Post (Post 1)

Except during periods when there is less traffic[2], the staff in attendance at the posts are indicated below.

Bettembourg CCP

Four members of staff man the Bettembourg CCP:

- one Traffic Controller;
- one Train Announcer;
- one Switch Tender 1, who is in charge of plotting the train routes;
- one Switch Tender 2, who is in charge of plotting the shunting routes.

The Traffic Controller and Train Announcer alternate between the two posts each month, having the required double qualification. The same applies to the two Switch Tenders.

---

1 without saying how far he should go.

2 When there is less traffic, some staff cover all or part of several of the posts referred to in this paragraph.

Traffic Controller

The total responsibility for train traffic lies with the Control Post's Traffic Controller. Some of the tasks that he has to perform may be carried out, under his supervision and control, by other members of staff: Train Announcer, Switch Tenders, etc.

The Traffic Controller must, in accordance with various Articles of the GRO:

- when coming on duty, consult the incident book;
- regulate, under his own responsibility, the routing and sequencing of trains. He performs the duties of Traffic Controller on the open line and Traffic Controller for routing trains within the area covered by the CCP;
- give verbal orders to operate the track equipment and work the signals to control train traffic;
- give the order to Switch Tender 1 to set the MFSs to 'track clear' in each particular case, an order whose fulfilment must not be associated with a prior condition or a deadline, nor be restricted in any other way. The Traffic Controller must ensure that the order has been carried out;
- give the order to pass through an MFS that cannot be set to 'track clear';
- transmit and receive train announcements himself. He cannot appoint another person to do this unless the latter is expressly appointed to assist in the Train Announcement Department (Train Announcer). The Traffic Controller must instruct the Announcer for each specific case and not in advance in a general manner. Performance of the order must not be linked to conditions. The Traffic Controller must listen to the train announcements received from other posts by the Train Announcer who must repeat them to him out loud;
- monitor the entries made by the Train Announcer in the Train Announcement Log;
- suggest changes to the order of priority of train traffic to Headquarters if these changes will speed up the running of the service;
- inform the staff, if affected, about changes to the sequencing order of trains on the open line resulting in changes to the Train Sequence Table (TST), about exceptional changeovers and avoiding and overtaking actions or about measures that are specific to a particular train announcement post;
- check, if necessary, an entire route if the Station Instructions do not anticipate the co-operation of other staff to perform this check;
- .....

He is:

- the only person competent to decide if and when a Main Fixed Signal must be set to 'track clear';
- appointed according to the GRO (Articles 01.21.12 and 04.02.02) to regulate train traffic on the open line. He is the only person authorised and responsible for applying or having applied in his area the provisions contained in Section 4 of the GRO relating to the open-line train traffic service. For this purpose, he seeks the agreement of neighbouring Traffic Controllers. He also personally fulfils the obligations which, according to the provisions of Section 4 of the GRO, are expressly within his remit. If some obligations can be fulfilled by other staff, by order of the Traffic Controller, this order must be given

on a case by case basis and only if the conditions for executing the order are met.

Train Announcer

The Train Announcer must carry out his work within the remit described in point 4.1.3 above. For this purpose he must:

- make entries in the Train Announcement Log, under the supervision of the Traffic Controller;
- sign, in the allocated column, the Train Announcement Log for each train entered therein.

Switch Tender

The Switch Tender is responsible for setting the Main Fixed Signals to 'track clear' when instructed to do so, on a case by case basis and without being subject to any condition, by the Traffic Controller.

When coming on duty, he must consult the incident book. If the Traffic Controller orders him to set an Exit Fixed Signal to 'track clear' before a train enters on wrong-track working, without the change in the sequencing order having been brought to the Traffic Controller's attention, he must not carry out this order but remind the Traffic Controller of the changeover.

Thionville Switch Post

The responsibility for traffic safety lies with the two Traffic Operators, one of whom is assisted by a Switch Tender.

In view of the central role that the Thionville Post plays, a Traffic Controller co-ordinates the tasks to be performed there. A commercial operator and an operator specially appointed to be in charge of works from Monday to Friday, during daytime hours, completes the staff in attendance at this Post.

Traffic Controller

He is, amongst other things, responsible for:

- supervising the traffic on the unregulated lines of the Thionville star;
- applying the special provisions concerning the border section from Thionville to Bettembourg and in particular the management of traffic on the WWFE between Thionville and Bettembourg;
- coordinating traffic when problems occur and managing incidents on these same lines;
- dealing with VACMA alarms and radio warnings;
- managing works, with the assistance of staff members, when the Works Operator is not in attendance.

By contrast, the Traffic Controller of the Thionville CCRP should under no circumstances take over duties that fall to Traffic Operators within their own traffic sector.

Sector 1 Traffic Operator

He is, among other things, responsible for:

- performing the tasks of Traffic Operator in Sector 1;
- coordinating the traffic in Thionville Station;

- applying the special provisions concerning the border section from Thionville to Bettembourg;
- keeping the Train Traffic Record for his sector.

Sector 1 Switch Tender

He is, among other things, responsible for:

- plotting the routes on Sector 1;
- handling reception on the *Fret Luxembourg* network of tracks;
- implementing the protective measures connected with the works, as instructed by the Sector 1 Traffic Operator.

Sector 2 Traffic Operator

He is, among other things, responsible for:

- performing the tasks of Traffic Operator and Switch Tender/Operator on Sector 2;
- keeping the Train Traffic Record for his sector.

Works Operator

He is, among other things, responsible for relations with those responsible for carrying out works (implementing protective measures for personnel and electric traction, defining movement measures, monitoring the movements of the works train, etc.).

The Use of the Documentation provided for Bettembourg CCP Staff

Staff at the Bettembourg CCP are provided with the GRO, in particular its Section 4, which applies in the case of this accident. These Regulations do not have a particularly user-friendly layout and they set out the principles that the staff must adopt in the various situations that they are likely to encounter. They also describe the role of certain interlocks but without describing the way in which they are implemented nor how they should be used. The investigators found no documents that served this purpose.

Staff learn about these interlocks during their training, firstly in the classroom then in the control posts where they work.

Staff are obliged to apply the GRO rigorously and are expected to know them. They are not obliged to consult them. A copy of these regulations is provided for them at the Control Post. They may possibly consult these regulations but it would appear that they rarely do.

Among the technical documents provided for the staff, the Dependency Table describes the dependencies between the signals and the routes on which they are used. This Table is not used by the staff at the Post.

Generally speaking, the investigators found no documents that would assist in decision-making, particularly as regards managing problem situations.

Safety Management System at CFL

EC Directive 2004/49 on railway safety stipulates that all infrastructure managers and all railway companies must establish a safety management system (see Annex 9), guaranteeing that all the risks created by its railway activities are controlled. This system is aimed chiefly at ensuring that staff are fully aware and continuously assess the situation and changes in safety on the ground, so as to detect emerging risks and adopt the necessary preventive measures.

Staff management as regards safety is based on proximity management, training and skills maintenance.

Organisation of the Safety Management System

CFL has adopted the DUPONT Safety Principle since 1998.

All safety initiatives are coordinated by the "Quality, Safety & Environment Department[1] (QSE)" answerable to the Managing Director. Each management level has its own Safety Representative and on the ground Zone Managers and Team Managers are responsible for providing a safety service.

A "Safety Management Committee" meets 3 to 4 times a year, attended by the General Management, those responsible for managing operational services and the QSE Department. In the event of a significant statistical increase in the frequency of certain events, they examine the preventive and corrective measures to be adopted.

Risk Assessment and Management Process

An assessment of safety on the ground is made via risk analyses, safety audits, regular monitoring of safety indicators and investigations into serious incidents and accidents.

An initial risk assessment for the entire network was conducted by the consultants "*Emch et Berger*" in 1998. This assessment gave rise to improvements in safety. Since 1998, additional one-off risk assessments have been conducted and in 2007 a new risk assessment was carried out in accordance with the instructions given in Chapter II of European Directive 2004/49 for the CFL railway company. Another is to be conducted in 2008 for CFL's infrastructure manager.

The events database is updated on a daily basis and the statistics on safety indicators are regularly submitted to the Safety Steering Committee with a view to highlighting the strong and weak points of safety management.

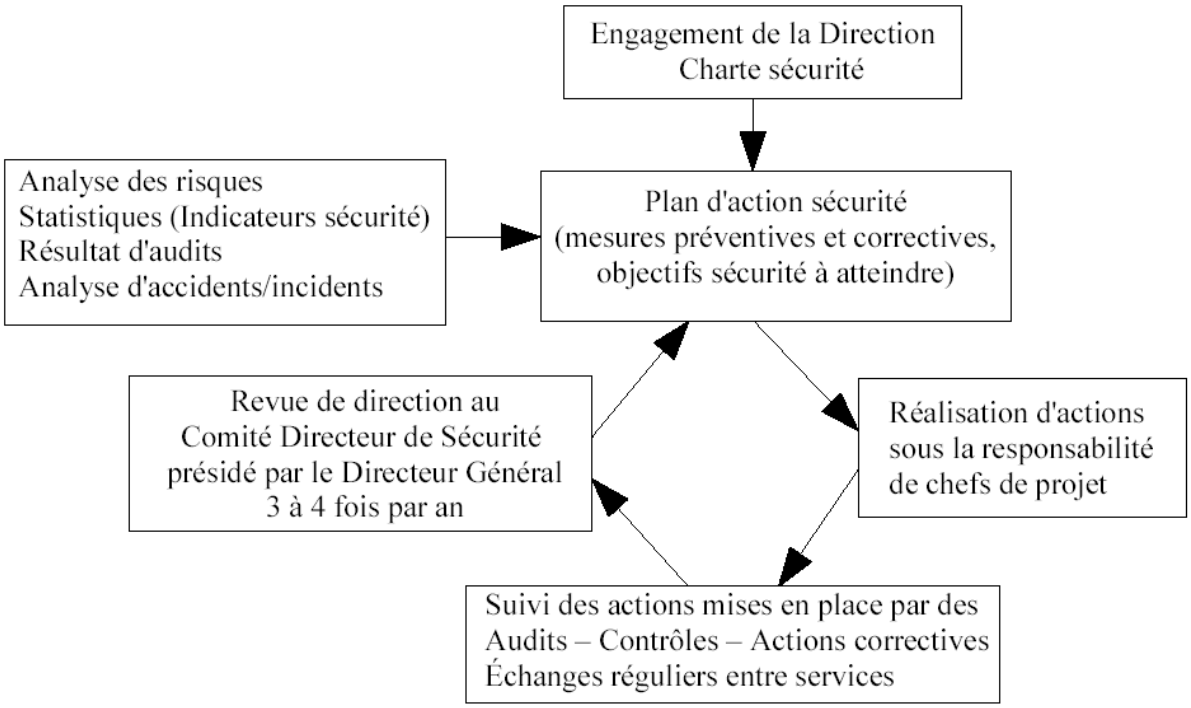
Investigations are systematically carried out on the incidents and accidents that have occurred in order to enable the weak points to be identified both in the technical systems and in the consistency or application of the regulations in force.

Audits enable the instances of compliance and non-compliance concerning safety to be identified. In 2006, the departments conducted 217 safety audits based on 257 statements. The QSE safety division provides training for auditors at the request of the departments. It was recently decided that the QSE Department should also monitor all of the audits.

The QSE Department issues instructions for the Head Offices and Departments, in accordance with the various recommendations (outcomes of audits, investigations, etc.) and checks that the instructions and procedures are applied. The responsibility for applying corrective measures, however, lies with the managers of the various departments. When the QSE Department encounters a difficulty, it informs the Director or operational manager of the Department concerned.

[1] This Department has a staff of 5.

The following block diagram illustrates how this process is handled at CFL:



Key

FRENCH	**ENGLISH**
Engagement…	Involvement of the Safety Charter Management
Analyse…	Assessment of Statistical Risks (safety indicators) Result of audits Analysis of accidents/incidents
Plan…	Safety action plan (preventive and corrective measures, safety targets to be met)
Revue…	Management review by the Safety Steering Committee chaired by the Managing Director 3 to 4 times a year
Réalisation…	Actions taken under the responsibility of the project managers
Suivi…	Actions introduced as a result of the Audits are monitored – Checks - Corrective Actions and regular Exchanges between the Departments

Analysis of Problems by the Management

On 9 November 2006, the SOA* Managers compiled a report on the accident at Zoufftgen. Its conclusions indicate in the Chapter entitled “Primary Cause and Responsibility” that “the cause of the accident was due to an error on the part of Traffic Controller XX who acted precipitously and without thinking…” and that “Traffic Controller XX is furthermore solely and entirely responsible for the accident”. As secondary causes, the responsibilities of the staff were also examined in great detail. Technical shortcomings were also indicated but only superficially. The management aspect was not dealt with.

These conclusions, very centred on the responsibility of the staff, with the blame being laid almost exclusively at their door, offer an insufficient risk assessment of the reasons behind the mistakes made with regard to the context in which the staff works. Furthermore, this approach could give rise to an automatic censure of any feedback from the operators to their managers on the difficulties that they may encounter, and therefore creates the risk that these managers have a false impression of what the situation really is.

Proximity Management

General Organisation

The administrative organisation was changed in 2000 by creating two Operational Areas (Central and Southern). By splitting the Transport Department into a Network Management Department and a Rail Transport Department (separation of the infrastructure manager and the railway company dating back to 1998), CFL did away with the position of Stationmaster (previously, each station was the responsibility of one person) in order to create the framework for two Operational Areas: a Central Operational Area (COA) and a Southern Operational Area (SOA).

This division into two operational areas has led to a concentration and regrouping of the proximity management structure. The Southern Operational Area (SOA), responsible for Bettembourg Station, is managed locally by:

- an Area Manager who monitors work quality, manages staff training, compiles local instructions and produces assessments of incidents and accidents within the SOA;
- three Assistant Area Managers responsible for the daily management of the stations (Bettembourg, Esch-sur-Alzette and Pétange). In addition to this duty, the SOA Manager also acts as Assistant Area Manager responsible for Esch-sur-Alzette.

These developments led to several employees finding that their roles had become unclear and their working practices unchecked as a result of the disappearance of Stationmasters whose job description meant that they spent more time in the Control Posts.

The aim of the new organisation is to encourage uniformity in points of view and decisions: the SOA is governed on the basis of team management, decisions being taken jointly between the three Assistant Area Managers. By contrast, within the stations, the Assistant Area Managers work independently. Note that the regulations defining the roles and missions of the old “Stationmasters” now “Area Managers”, have been done away with and not replaced.

The consolidation of proximity management staff has reduced their direct contacts with the teams on the ground and the time available to fulfil their supervisory role in the stations.

Since his appointment, the Assistant Manager responsible for Bettembourg Station has been heavily involved in numerous projects concerning stations or CFL:

- installing WWFE in 2003;
- redeveloping Dudelange Station;
- repairing the tracks to Berchem, Noertzange (including installing wrong-track working systems), Thionville and in Bettembourg Station;
- repairing electric traction systems;
- replacing switch gear;

- reorganizing, with the CFL Cargo Department, those aspects that concern CFL.

To this are added his duties as manager of the SOA:

- drawing up safety instructions for works;
- numerous enquiries and dealing with incidents and accidents in the marshalling zone (frequent derailments and minor collisions).

Under these circumstances, he feels that he had neither the time nor the means to intervene effectively as regards the Control Post teams, in order to monitor and improve their working practices.

Monitoring and checking working practices in the post

During interviews, the Area Manager and his Assistant said that they were surprised at the extent of non-compliant behaviour at shift handovers. As regards monitoring and checking working practices in the post, the local staff interviewed explained that they limited their presence in the posts so as not to undermine the Traffic Controllers in performing their missions and roles. The idea is to leave the Traffic Controller fulfil his responsibilities on a daily basis. Their feelings must also be considered.

The closeness or geographical distance of the Assistant Area Manager in relation to the Control Post also has an influence on his attendance at the Post. The attendance of the Assistant Area Manager of Esch-sur-Alzette is therefore very high which, we are told, enables him to have a closer relationship with personnel and better monitoring/control of the operators, enabling rapid restructuring. Conversely, the distance of the Bettembourg Assistant Area Manager's office from the CCP and MCP has an adverse effect on his frequent attendance at the CCP. Note, however, that the Assistant Area Manager had to attend the Bettembourg CCP more frequently during the weeks preceding the accident in order to supervise the teams during intensive works on the open track section and in the station. He noticed no major instances of non-compliant behaviour during the times that he was in attendance at the Post, particularly when staff came on and off duty.

The local personnel we interviewed also highlighted the fact that the shortage of staff meant that they could not gather the operators together in one room for briefings or debriefings. It is not possible to release them from their operational tasks to attend the training centre and refresher courses.

Training and Skills Management

At CFL, training takes the form of a long theoretical training course on the regulations, followed by a practical apprenticeship in the Control Post to become familiar with local working practices. Successful candidates gain a qualification.

Training for using WWFE was provided by SNCF. It took the form of a three-day sandwich course outside the Control Post, focusing on case studies and culminating in a self-assessment test. This training was limited to Traffic Controllers. The CFL staff criticised this course, its contents and its form, considering it to be ill-suited to the practices and mentalities of CFL personnel.

As regards skills management, CFL regulations state that all staff must attend one refresher course every two years.

Lastly, the assignment of employees to work in an operational area is handled by the HR Department, without involving local management, whose role is limited to submitting requests for staff. Furthermore, the rules regarding assignment to a post are set out in the contract of employment: all posts are assigned to the most senior person in the department.

Background information on commanding a route in the CCP

In order to command a main track route, the Switch Tender types in a code for its point of origin and a code for its destination. The route is thus formed and then, when all the conditions are met, the route is said to be set and the origin signal sets at 'proceed'.

At the CCP it is often the case that, at the first attempt to set a route, the origin signal does not set at 'proceed'. The Traffic Controller then gives the order to repeat the command. Usually, the signal will then set at 'proceed'.

If, despite repeating the command, the sign fails to set at 'proceed', the Traffic Controller must arrange to issue a pass-through order to the train driver waiting at the signal in question.

On the entire CFL network, 843 written pass-through orders were issued in the three months prior to the accident, 486 of which (i.e. an average of just over five per day) are solely for MFSs.

The breakdown for the 843 written orders is as follows:

- 129 in connection with level crossing problems;
- 88 in connection with work sites;
- 130 in connection with track circuit problems;
- 196 for other miscellaneous identified reasons;
- 300 for which no reason can be found, either because the cause could not be determined by the competent departments or because these operators had failed to make a note in the incident book.

At Bettembourg, 107 written orders to pass through an MFS were issued over this same three-month period, 90 of which at the Bettembourg CCP. These 90 orders were issued as a result of 42 problems, 25 of which had an indeterminate cause. The number of faults for which the cause was unknown is in the order of 60%. Note also that these 25 problems with indeterminate causes lasted for a short time: they concerned only one train out of 21 of them and two trains out of the other four. Questions may therefore be raised about the source of these problems which may be connected with fleeting problem situations.

Such a high proportion of problems without a clearly identified cause can only increase doubts as to the reliability of the system and reduce the attention paid to the checks to be conducted systematically before a pass-through order is issued.

Passive Safety

A head-on train crash is not covered by the rules of the "passive strength" concept, due to the excessive collision energy to be absorbed and taking into account the very small number of crashes of this type; active safety should cover this type of risk. Only cases of take-up and impact during shunting (or against a buffer stop) are covered by the scenarios referred to in SNCF regulations and specifications.

Observations

The front car of RET 2N NG and the locomotive of Freight Train BB 37 007 were entangled. The length of the front car of the RET was reduced by about twenty metres (27.35 before the crash, 7.60 metres after it); the locomotive mounted the front car of the RET, with the cab

crushed against the fairing of the cab of the RET.

The three passengers who died were found in the top level of the front car of the train. The drivers, of the train and the locomotive, were killed in the accident.

The initial contact of the two front vehicles occurred at the buffers of the locomotive and the anti-overrun absorbers of the frame at the front of the driver's cab of RET 2N NG.

The front frame absorbers of both leading vehicles were completely compressed. The anti-overrun absorbers of the RET frame were compressed and prevented the boxes from being uncoupled one from the other.

The front structures of the vehicles were then compressed and deformed.

Energy levels involved

The Technical Specifications of the Interoperability of High-speed Rolling Stock[1], define the energy of a crash (approx. 6MJ) that the structures of the leading vehicle or vehicles of a train or trains must be capable of absorbing. The energy involved at the time of the collision of the two trains at Zoufftgen was in the order of 120 mega joules (MJ) – (227-tonne train at 78km/h against a front part of the 272-tonne freight train at 79km/h). Such energy cannot be absorbed by train structures. It would appear that the impact was made more intense by the energy involved than any other crash that had previously occurred on the *Réseau Ferré National* (RFN – National Rail Network) (Lyon Station-June 1988, Voiron-September 1988 and Melun-October 1991).

Note that in France, the Rolling Stock Order of 1st July 2004 does not stipulate the energy that must be absorbed in the event of impact in order for a train to be admitted onto the RFN.

Assessment

This is the first major collision involving two recently-built trains that have in-built passive safety features for railway crashes limited to 36km/h.

Despite the high speed and the extent of the distortion observed after the collision, this accident has shown that:

- the energy absorption devices worked well despite the impact occurring on a bend and the poor compatibility at the interface between the two leading vehicles;
- for RET 2N NG, the alignment of the frames of the three carriage bodies was maintained (without overrunning or derailment);
- the distortion of the bodies was gradual.

Accidents and incidents of the same type

In Luxembourg, between 2005 and 2006, a Written Order A to pass through an MFS at 'stop' was issued unnecessarily and two shunting operations passed through a stop signal in the 'danger' position before the accident of 11 October 2006.

Between 1 September 2006 to the end of February 2008, 28 cases of incorrectly issuing an order to pass through a square signal occurred in France. Out of these 28 cases, 3 orders were unnecessarily issued, that is, issued in cases for which there was no justification for doing so (error of judgement).

[1] The conventional Rail Rolling Stock ITS is in the process of being written.

The causes for which they were incorrectly issued were in 15 cases, a procedural error, in 10 other cases a procedure that was incompletely carried out and in the last 3 cases errors in assessing the situation.

These last three errors relate to:

- an on-site inspection of a track device performed on a device other than the one whose controls had been switched off at the Control Post;
- an incorrect reading of the warning lights on a VCP;
- using a sheet from one job document instead of another.

Immediate measures adopted as a result of the accident

Since the accident, CFL has adopted the following measures:

- the presence for a temporary period of a qualified person, responsible for supervising the proper application, by an operator, of the procedures for passing through the automatic devices that exist on the border section;
- the SOA Manager (possibly on call) being informed in advance, by the CCP Traffic Controller, before any movement based on a Written Order A, Box 1, occurs towards Thionville (this measure shall apply until 30 April 2007).

Sequence and reconstruction of the accident

The movements of RETs 837617 and 45938 are detailed in Annexes 5 and 6 respectively.

Organisation of movements until the departure of Freight Train 45938 from Thionville

The movement of the trains between 10h40 and 12h on 11 October 2006 is as shown in the diagram in Figure 7 below.

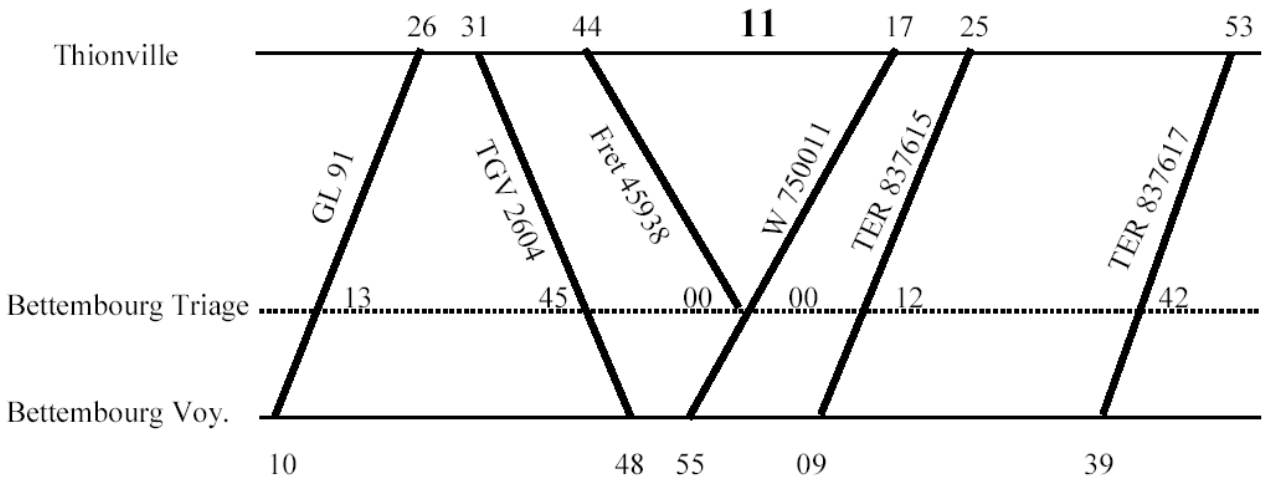


Figure 7

Thionville-Bettembourg: Theoretical diagram of movements on 11 October 2006

Key

FRENCH	ENGLISH
TGV	High-speed Train
Fret	Freight Train
RET	Regional Express Train
Bettembourg Triage	Bettembourg Marshalling Yard
Bettembourg Voy.	Bettembourg Passenger Station

Train GL 91 was announced with about a ten minute delay. Consequently, TGV 2604 would be about ten minutes late and Freight Train 45938 could not travel in its slot without delaying Train W750011 and RET 837615.

Around 10h30, Thionville Traffic Operator 1 suggested to the Bettembourg Morning Train Announcer to run 45938 behind Train 750011. He refused, due to the delay that this would cause for RET 837615 (about 15 minutes) announced from Luxembourg on time. They agreed to run 45938 between RETs 837615 and 837617.

Train 45938 arrived at Thionville at 10h41. It was stopped at Square Signal 244, so parked on Track 2M.

Trains 2604, 750011 and 837615 were delayed but within the usual regulatory conditions. RET 837615 arrived at Thionville at 11h26 (3 min. late).

On the arrival of this train, the Thionville Sector 1 Traffic Operator and the Bettembourg Morning Train Announcer confirmed their agreement to dispatch the 45938 that Thionville had announced on wrong-track working at 11h27.

When this agreement was concluded over the telephone, the Tenders in the two switch posts were aware that the movement of the freight train was likely to disrupt that of RET 837617.

For their part, the staff at the Thionville CCRP estimated that the RET would be about five minutes late but this could be made up before the train arrived at Nancy, its terminus. The Sector 1 Traffic Operator of the Thionville CCRP did not raise this issue of the delay with the CCP for various reasons:

- the regulations do not require him to do so;
- in France, the rule is for staff not to interfere in the work of another Control Post in the matter of safety except in cases where the regulations explicitly require them to do so;
- the Thionville CCRP had despatched this train, 45938, the day before without having obtained the formal approval of the CCP, who remarked upon it. The Thionville Traffic Operator did not want to attract further remarks on the fact that he was interfering in the work of the CCP.

Relief of staff at the Bettembourg CCP

At the Bettembourg CCP, the usual relief time between the morning and evening team is 11h30. This time is somewhat earlier than the usual time of 12h but has been approved by the station management.

Relief of Switch Tenders between 11h15 and 11h27

Morning Switch Tender 1 left his post at 11h15 (relieved by Morning Switch Tender 2) and the Evening Switch Tender arrived at 11h25. He relieved Morning Switch Tender 2 and assumed both switch tender posts, as Evening Switch Tender 2 had not yet arrived. Morning Switch Tender 2 left the CCP at 11h26.

At 11h27, just after the announcement of Train 45938, three staff were in attendance at the Bettembourg CCP:

- the Morning Traffic Controller;
- the Morning Train Announcer;
- the Evening Switch Tender.

The Morning Traffic Controller and the Morning Train Announcer were aware of the movement of Train 45938 on wrong-track working whereas Evening Switch Tender 1 was probably not because Switch Tender 2 had not informed him. In fact, the switch tenders only become involved with a train when it is announced, because it is then that they then need to plot the route.

Relief of the Evening Train Announcer between 11h28 and 11h35

At 11h28 the Evening Train Announcer arrived at the Control Post and relieved the Morning Train Announcer who, among other things, told him that 45938 was on wrong-track working between Thionville and Bettembourg on Track 1.

At 11h30, the Morning Traffic Controller wanted to leave but the Evening Traffic Controller had not yet arrived. According to a practice contrary to the regulations but apparently quite

common, the Evening Train Announcer, accredited as a Traffic Controller, briefly acted as Evening Traffic Controller in the interim, until the latter arrived.

The Evening Train Announcer then relieved another person, but this time it was the Morning Traffic Controller, to make up for the absence of the Evening Traffic Controller. The Morning Traffic Controller again mentioned that 45938 was on wrong-track working. In addition to this oral handover, the Morning Traffic Controller gave a sheet of "scrap paper" to the Evening Train Announcer.

It is common practice at the Bettembourg CCP to use a sheet of "scrap paper". Two main methods of use co-exist. In the first case, the Traffic Controller writes down what he thinks is important throughout his entire shift and crosses out the entries as and when the information is no longer of interest. In the second case, he fills in this sheet to pass on information to his successor.

This sheet referred to the fact that Train 45938 was on wrong-track working from Thionville, this reference being crossed out (cf. Annex 8). It has not been possible to find out who crossed out the words "45938 on wtw" nor whether it had already been crossed out when the Evening Train Announcer came on duty.

Shortly after 11h30, the Morning Train Announcer and then the Morning Traffic Controller left the CCP where only the Evening Train Announcer and Evening Switch Tender 1 remained.

Evening Traffic Controller coming on duty at 11h35

The Evening Traffic Controller arrived at the CCP at around 11h35, five minutes late. He relieved the Evening Train Announcer. It has not been possible to establish whether, at the time of this handover, the wrong-track arrival of Freight Train 45938 was mentioned; the statement of the Train Announcer (who says that he mentioned it) and that of the Traffic Controller (who says that he was not informed about it) are contradictory on this point.

The Evening Train Announcer informed the Traffic Controller of the sheet of "scrap paper" written by the Morning Traffic Controller; it was not possible to find out whether the words "45938 on wtw" had been crossed out by the Train Announcer during the period when he was acting as both Traffic Controller and Train Announcer.

Around 11h37, the Traffic Controller signed the Duty Log which contained no note. He had a look at the VCP and noticed the arrival of the usual RET. He then looked through the day's telegrams and orders as well as his e-mails.

Situation at the Bettembourg CCP at 11h37

At 11h37, three staff were in attendance at the Bettembourg CCP, all on evening duty:

- the Traffic Controller;
- the Train Announcer;
- Switch Tender 1.

Switch Tender 1 was at his post. He saw the various lights on the line of the tracks or alongside this line on the VCP. He did not expect any trains as he was not informed of any when he relieved the Morning Switch Tender 2.

The Train Announcer *was* aware that the freight train was on wrong-track working, but appeared to consider that this was no longer his problem since the Traffic Controller was present and he said that he had informed him of it.

The Traffic Controller completed his handover, a handover that was somewhat stressful due

to his late arrival. He was in possession of the sheet of "scrap paper" that referred to the wrong-track working of Freight Train 45938. We were unable to discover whether the entry was crossed out or not. In any event, it is clear that he was unaware of the arrival of the freight train, either because he had not been informed about it when he came on duty, or because he did not make a mental note of this information.

The fourth member of the evening shift, Switch Tender 2 had not yet arrived (he arrived at his post at around 11h43).

None of the VCP lights at the top of the VCP, where the tracks to Thionville are indicated, showed that the freight train was travelling along Track 1 on wrong-track working from Thionville to Bettembourg. Only the lights on the WWFE module could have indicated that a train was likely to be travelling along Track 1 on wrong-track working between Thionville and Bettembourg, since light INT BM-113 was red[1].

The TAL contains the reference to the fact that the freight train was on wrong-track working.

Attempt to set the route of RET 837617 to Thionville

On the announcement of RET 837617 from the Luxembourg side (just before 11h37), Evening Switch Tender 1 plotted the route between the entrance of Bettembourg Station and the Dm signal.

At 11h37, the Evening Train Announcer announced RET 837617 to the Thionville Sector 1 Traffic Operator who recorded this announcement without comment. The Train Announcer then went behind the VCP to find the menu of a local pizzeria to order some food.

During this time, Switch Tender 1 plotted the "Dm origin signal to French border" route. The route was formed on the VCP but the Dm signal did not set at 'proceed'.

It is not unusual for a MFS not to set at 'proceed' when a route command is made, but when this command is repeated the signal sets at 'proceed', which avoids the need to issue a pass-through order. The Evening Traffic Controller therefore asked the Evening Switch Tender to abort the route and perform the command again.

Back at his post, the Train Announcer asked his colleagues who wanted to order food for lunch. The Traffic Controller asked him to order lasagne. The Train Announcer ordered two, one for the Traffic Controller and one for himself. It was about 11h38.

Switch Tender 1 informed the Evening Traffic Controller that the Dm signal would still not set at 'proceed', despite the second attempt to command the route.

Issuing the order to pass through

Status of the VCP at 11h40

At 11h38, the track occupation lights for the areas around the passenger station (PS) were red, due to the presence of the RET. The lights upstream of the Dm signal were white, because the PS to the Dm signal route was set but these areas were not yet occupied. They went red at about

[1] This light may be red because a train travelling in the normal Bettembourg to Thionville direction has not yet arrived at Thionville, or because a train is on wrong-track working from Thionville or there is a system fault; in the present case, it was red because the freight train was on wrong-track working.

11h39.

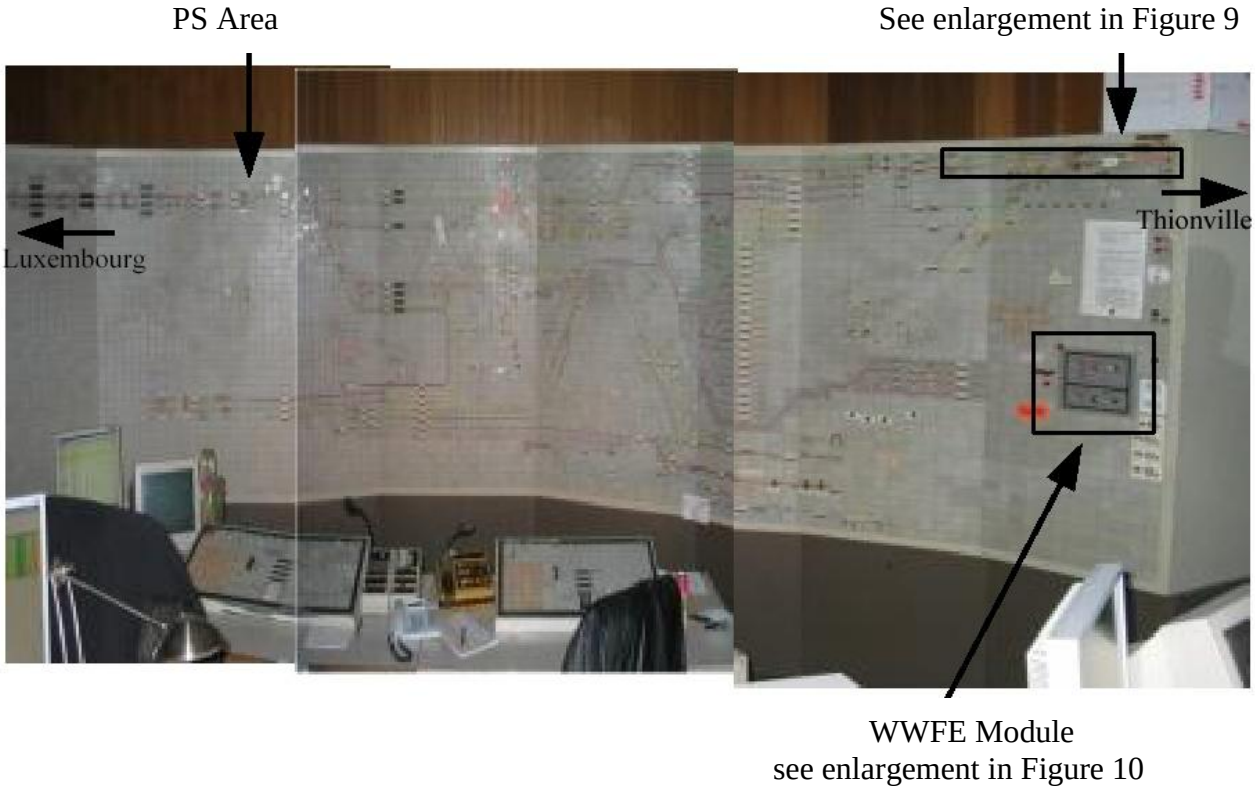


Figure 8: VCP at the Bettembourg CCP

At 11h40, the RET approached the Dm signal at 'danger' and braked to stop in front of it. At this time:

- the track occupation lights for the areas located upstream of this signal were red because they were occupied by the RET;
- the track occupation lights for the areas located between the Dm signal and the Bm signal on Track 1 were white, because the route had been commanded and all the conditions relating to these areas had been fulfilled;
- the blue anti-repeater light was flashing, because the conditions relating to the Bm-113 interval had not been fulfilled;
- the track occupation lights for the areas located between the Bm signal and the border were also white, because no train was travelling along this section (note that, as explained in 3.3.2 above, the "white" status of these lights does not have the same meaning as on the rest of the VCP, and does not denote that a route has been set);
- the Dm signal check light was red;
- the Bm signal check light was red, because the freight train return to marshalling yard route had not been commanded.

Figure 9 below shows the information displayed on the VCP in this area at 11h40.

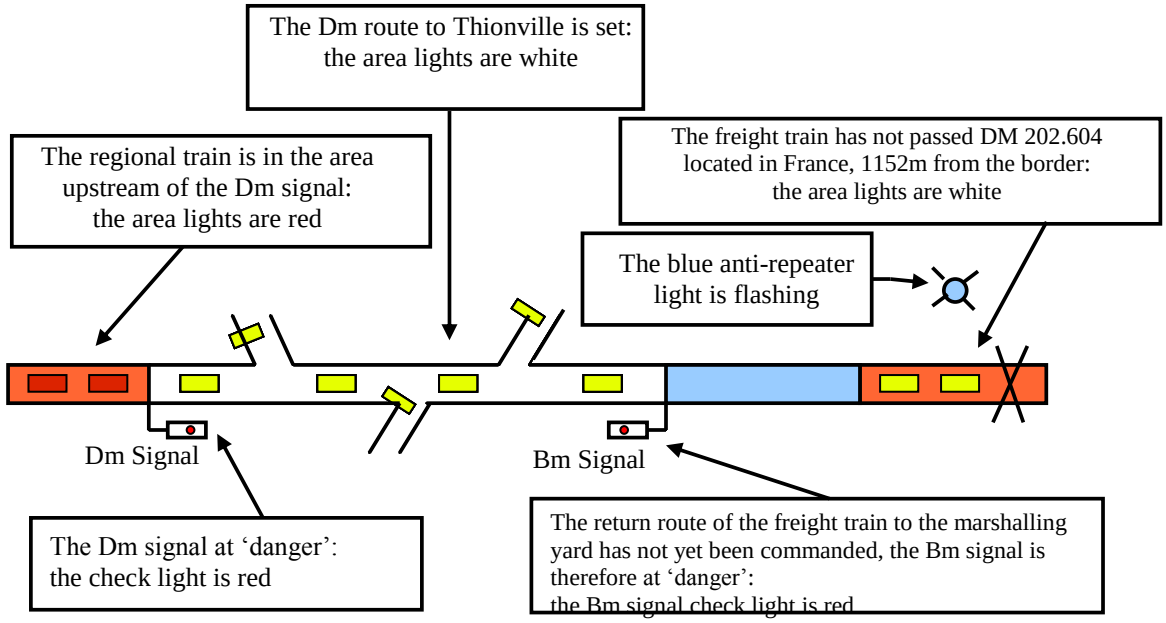


Figure 9: VCP of Bettembourg end on French side
Schematic Reconstruction of the Information Displayed for Track 1 at 11h40

The Track 1 lights on the WWFE module, for their part, show the following information:

- light INT BM-113 is red, because a train (the freight train) is travelling on this portion of the track;
- light SN BM-113 is off, because Thionville has taken the direction (wrong-track working set);
- emergency-direction switch off, because it had not been activated;
- wrong-track working light is off.

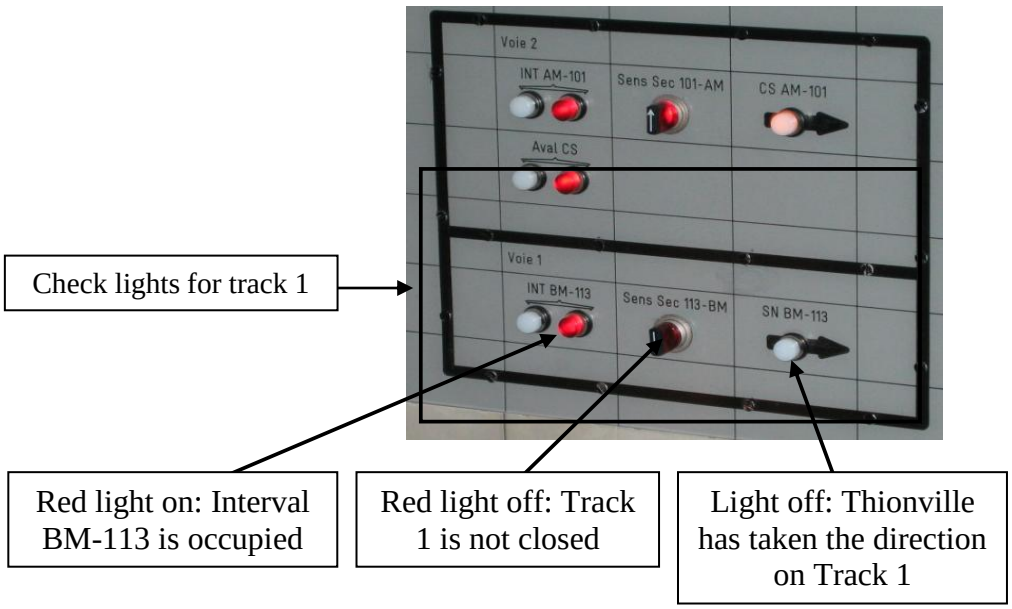


Figure 10: The WWFE Module at 11h40

Interpretation of the situation by the Bettembourg Traffic Controller

The Traffic Controller thought that the traffic on track 1 was running in the normal direction, namely towards Thionville; the information that he could actually obtain combines to create this impression and the world around him behaved as if this was really the case:

- all the trains scheduled in the 11h30 – 13h30 time slot were ordinary trains travelling in the normal direction (Track 1 towards Thionville), which was the case of the incoming RET;
- the RET was on time and announced at Thionville with no special comment;
- Switch Tender 1 tried to plot the route to Thionville, which was actually forming but the Dm signal did set at 'proceed';
- when he came on duty, he found no mention of the freight train being en route.

The two warnings on the VCP that indicated that the real situation was more complicated were:

- the flashing of the anti-repeater, which the Traffic Controller noticed but ignored;
- the fact that the direction light for the WWFE on Track 1 went out, of which he was unaware since he had not consulted the WWFE module on the VCP.

The fact that the freight train was on wrong-track working was also entered in the TAL, but the Traffic Controller did not refer to it.

Issuing the Pass-through Order

Since he believed that the direction of travel was set as being towards Thionville, the CCP Traffic Controller did not carry out all the prescribed preliminary checks before issuing a pass-through order.

He looked at the top right-hand part of the VCP; he saw that all the lights downstream of the Dm signal were white which meant that the route was formed for the part of track concerned at Bettembourg Station, before the Bm signal, and that there was no train travelling towards the French border, Luxembourg side.

Although the blue light of the anti-repeater was flashing, indicating that all the conditions were not met for setting the route downstream of the Dm, he did not look at the WWFE module, an omission that seemed to occur fairly often at the Bettembourg CCP[1]. He did not notice therefore that the check light for Interval BM-113 was red (interval occupied or experiencing a fault) and that the direction check light SN BM-113 was off (wrong-track working set or a fault), which would have informed him of the real situation.

Neither did he call the Thionville CCRP, a compulsory requirement under the Border Operation Instructions, which he usually did before issuing a pass-through order, perhaps because of his late arrival on duty and his wish to return as quickly as possible to the status quo; he did not want to delay the RET.

He therefore concluded that the Dm signal was faulty, failing to perform some regulatory checks, namely those that concern the condition of the WWFE on setting the Dm signal at 'proceed' (the signal cannot set at 'proceed' if wrong-track working is set).

At 11h39, the Evening Traffic Controller decided to dictate over the radio an order to pass

[1] Note that an examination of this module requires a voluntary action because it is not in the Traffic Controller's field of view when he is looking at the check lights for the tracks towards France.

through the Dm signal to the driver of the RET. At this point, the front end of Freight Train 45938 was near DM 197, i.e. about 4'30" away from the point where this train is announced by a gong and where the area lights on the right hand side of the VCP change to red.

He asked the GTR Exchange to put him in touch with the driver. At 11h40, the Evening Traffic Controller began to dictate the order to pass through the Dm MFS (Order on Form A1) to the driver, as the RET was waiting at the signal.

At 11h42, the pass-through order was dictated and RET 837617 resumed its journey to Thionville at 11h42'10".

Attitude of the other CCP staff

It has not been possible to establish precisely why none of the staff at the Bettembourg CCP tried to dissuade the Traffic Controller from issuing this order. From the records and information gleaned about this shift it appears that:

- the Evening Train Announcer knew that the freight train was on wrong-track working. When the Traffic Controller was dictating the pass-through order, and for part of the time that it was being dictated, he was not at his post but busy ordering a meal using a telephone located behind the VCP.

  He did notice that the Traffic Controller was having a telephone conversation, but he could not hear it and did not think he was involved.

  This lack of attention may have been as a result of forgetting that the freight train was en route, or to a generally passive attitude regarding the actions of the Traffic Controller, in sole charge of the decisions to be taken.

- Evening Switch Tender 1 probably did not know about this train for which he was involved only as regards its announcement, an announcement that he had not yet received, and moreover Switch Tenders do not, on principle, interfere with the decisions made by the Traffic Controller[1].

Attempts to rectify the situation

Realisation of the mistake by the CCP Traffic Controller

At 11h37, the MCP Traffic Controller noticed that a Dm route was being set towards the Bettembourg-Thionville track without the signal setting at 'proceed'; this was the first attempt of Switch Tender 1. He assumed that the "Infrastructure" Department was conducting a test. He was aware that Freight Train 45938 was travelling on Track 1 on wrong-track working (his predecessor had passed on this information to him and the train was entered in the MCP's TAL) and that it had not yet returned to the marshalling yard.

At 11h41 he noticed that this route was still plotted but the area located upstream of the Dm signal was red due to the arrival of the RET. Surprised by this situation, he tried to warn the CCP Traffic Controller that Freight Train 45938 had not yet arrived at the marshalling yard. He tried to call him on the telephone but the line was engaged (the CCP Traffic Controller was dictating the pass-through order).

At 11h42, the CCP Traffic Controller, who noticed that his MCP colleague had been trying

[1] This non-interference does not mean that they would allow a mistake that would jeopardise safety to be made, but that they have little involvement with what the Traffic Controller does.

to contact him, 'phoned him back. The CCP controller then realised, as a result of the information given by the MCP Traffic Controller, that the RET and the freight train were on a collision course.

At 11h42'30", the CCP staff therefore became aware of the risk of the imminent collision of the two trains. At this moment, i.e. two minutes before they crashed, the two trains were about 3km apart.

Various attempts to rectify the situation were then attempted, but none could be completed in time.

Radio warning

At 11h42'30", the CCP Traffic Controller tried to contact the Luxembourg GTR Exchange to re-establish contact with the driver of the RET. He could not reach the GTR operator who was busy putting the driver of another train in contact with the Luxembourg Control Post. He said that he had ordered Switch Tender 1 to raise a GTR alarm (between 11h42 and 11h43). The latter did not press the "GTR warning" button or hold it down for less than 0.6 of a second. If he had held it down for more than 0.6 of a second, the signal to raise the alarm would have been received at GTR headquarters (a light and a buzzer would have come on), but the radio warning would not in any case have reached the driver of the RET because of a hidden fault on the device (an electronic card malfunction).

As they had no way of checking that the alarm had been sent, the staff at the Bettembourg Control Post thought that it had been raised but were not certain.

The Traffic Controller then tried to telephone the GTR Exchange again, but without success as the line was still engaged.

He then contacted Headquarters (at 11h43) to report the incident and requested confirmation that the GTR warning had in fact worked. He was told that no alarm had reached the GTR Exchange or the locomotives on the line.

At 11h 44' 10", the operator at Headquarters sounded a GTR alarm (general call) to stop all the trains travelling within radio range.

Regional Train RET 837617 was still in Luxembourg at about 200 metres from the French border but its driver did not hear this alarm because he had probably already tuned his ground-train radio to the SNCF channel; nor could the freight train driver hear it because he was till in France and, in any event, his radio was faulty. Note that the CFL GTR is usually heard in France up to DM 202.2 and the SNCF GTR is usually heard up to Bettembourg. But this coverage is not guaranteed[1].

If a radio warning issued at 11h42'30" had worked, it is highly likely that the crash could have been avoided (see point 6.8.2 below).

Traction power cut requested by the Bettembourg CCP

Also around 11h 44', Switch Tender 2 tried to cut the power on the Bettembourg track at the border by pressing a button on his console. This action had no effect because neither Switch Tender 2 nor any of the CCP staff knew that this button only operates on the marshalling yard track and has no effect on the main tracks.

After having issued the radio warning at 11h44'10", the operator at Luxembourg Headquarters asked the Luxembourg Substation Regulator to cut the power on the Bettembourg

[1] Neither the Joint Instruction nor the French and Luxembourgish Instructions regarding GTR covers the radio blocks (or areas) on either side of the border.

tracks at the border, which he did at 11h 44' 30".

Contacting the Thionville CCRP

Around 11h44, the CCP Train Announcer asked the Thionville CCRP Sector 1 Traffic Operator where Train 45938 was. The Thionville Traffic Operator told him that it should be at the border. The Train Announcer hung up without comment.

The Thionville CCRP had therefore not been informed before the accident of the risk of collision between the two trains.

Around 11h45, the Train Announcer called the Thionville Sector 1 Traffic Operator back to get an update on the situation and asked him to get information from one of the "works" sites to find out where the trains were. He told him that the power had been cut on the Luxembourg side.

At 12h05, Thionville advised the Bettembourg CCP of the collision.

The collision of the two trains

Reconstruction of the actual collision

At 11h42, Train 45938 was travelling at about 90 km/h. At 11h44, its driver noticed that the Abm Signal (remote announcement signal of the Bm signal) was set at 'danger'. He began to brake when he saw a wrong-track working train coming towards him on the same track. He pressed the emergency brake button and less than 5 seconds later, the two trains collided at 11h44'27". Train 45938 was still travelling at a speed of 79 km/h.

About ten seconds before 11h44, the driver of RET 837617 noticed the warning signal (a yellow light at DM 204.246) of the semaphore of DM 202.60 set at 'danger'. He applied the brakes but this signal went green before he passed through it. He stopped braking. A little after DM 203.750 (an area where he was travelling at 82 km/h), he saw a train coming towards him in the opposite direction on the same track. He pressed the emergency brake button and less than 5 seconds later, the two trains collided. RET 837617 was still travelling at a speed of 78 km/h.

At 11h44'27" (the time of the daily report from the East-France Substation Unit) the substation supplying the Thionville North sector cut out. After finding the fault, the Unit isolated the section of line in the direction of Luxembourg. It was then possible to switch the power back on on the rest of the Thionville North sector.

The collision therefore occurred at 11h44'27", the time that the power cut out.

Observations after the collision

The Regional Express Train (RET)

The RET was not derailed, but the first car was totally destroyed. It was no more than a mass of metal measuring 7.60 metres long whereas originally it was 27.35metres. The other two cars were slightly damaged (chiefly broken glass) and remained on the line along the centre of the track.

The Freight Train

The locomotive (BB 37007) was totally destroyed and the first 8 wagons were destroyed or seriously damaged. The other 14 remained on the rails. The locomotive mounted the train and the first 8 wagons were either entangled with the locomotive and the train or had surmounted the train, or else overturned into the ditch. Among the first wagons, there was an empty tanker used to transport hazardous substances.

Emergency Services

First Aid

At around 11h50, passenger safety and first aid were provided by the people at the scene of the accident (SNCF infrastructure employees and SECORAIL personnel) using emergency first aid kits available at the track repair work site.

Intervention of the Emergency Services

The Moselle DFES* *[Departmental Fire and Emergency Service]* received three calls between 11h45 and noon from calm people, saying that the accident was serious and that they were having difficulty in pinpointing their location. They thought that they were still in Luxembourg.

A site worker gave a clear indication: we are at PR1. This indication was clear for the fire brigade since the emergency plan for the track repair site had been devised the week before.

Furthermore, the (injured) guard on board the RET informed the Nancy Regional Operations Centre of the accident at 12h03. He informed the CODIS *[Departmental Fire and Emergency Operations Centre]* to activate the Intervention and Emergency Plan (IEP).

The first firemen arrived at the scene of the accident around 12h10.

Heavy equipment was brought in: 84 French and 15 Luxembourgish engines.

The following were set up:

- a medical area comprising front-line medical posts, ambulances and a helipad;
- co-ordinated French and Luxembourgish command posts.

None of the injured was trapped and operations to recover the dead were completed by early morning on 12 October. Lifting operations were then begun, under the supervision of railway engineers.

Analysis of the various scenarios of corrective actions

Actions that could have been undertaken by the Bettembourg CCP

When the Bettembourg CCP staff became aware of the risk of collision of the train, at 11h42'30", they could have taken three actions in parallel to rectify the situation:

- issue a radio warning to the RET, on the Luxembourg side;
- order the power to the Luxembourg SU* catenary to be cut by using the alarm telephone;
- telephone the Thionville CCRP to raise the alarm so that the same actions could be carried out on the French side (radio warning and cutting the power to the catenary).

This section analyses the possible scenarios that could have resulted from these actions, in a favourable situation (normal operation of equipment) as well as in different situations involving partial actions or equipment failure.

Potential effect of corrective actions on the Bettembourg side

The effect of the possible corrective actions at Bettembourg is shown in the following movement diagram (Figure 11).

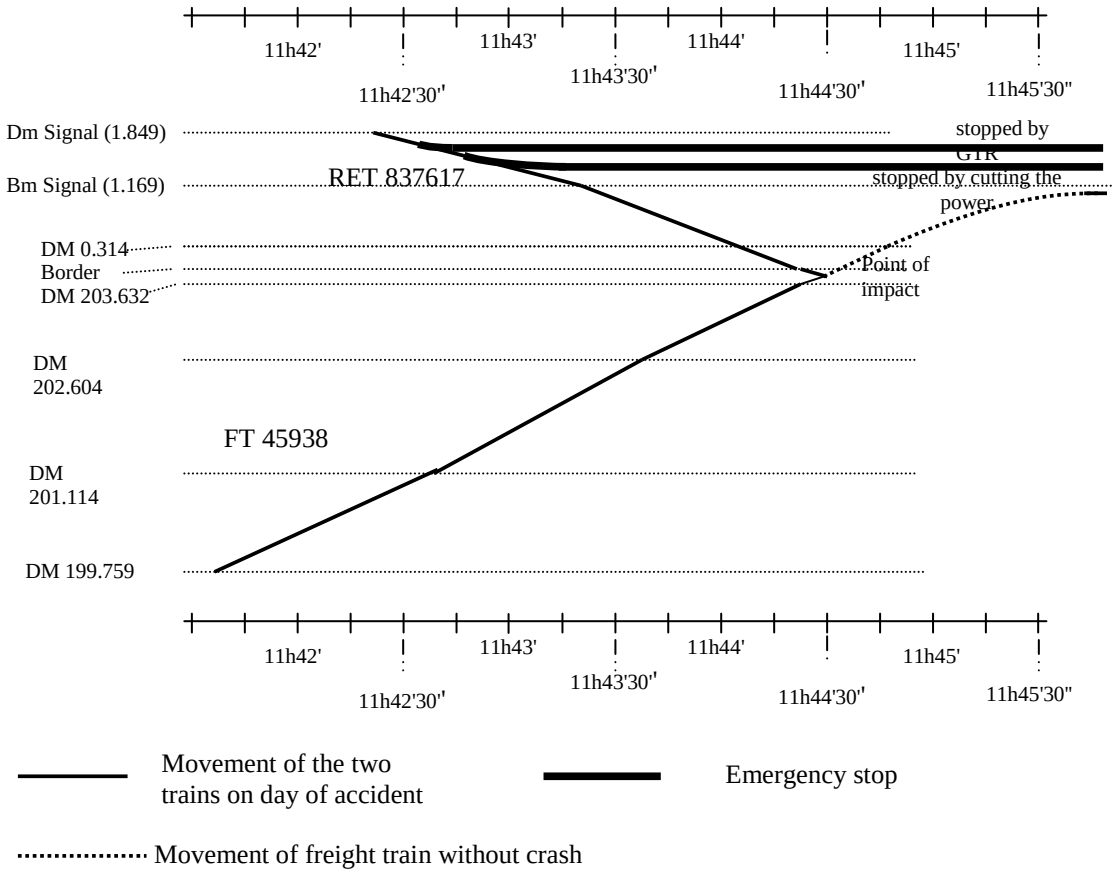


Figure 11: Movement Diagram 1
Potential effect of corrective actions at Bettembourg

Radio warning on Luxembourg side at 11h42'30".

Taking into account the times indicated in Annex 5, when the radio warning was issued the RET was near DM 1.7 located within the territory of Bettembourg Station. It is highly likely that the driver had not yet changed his radio frequency and was travelling at low speed (in the order of 20km/h). He was about 600m away from the Bm signal where the freight train had just stopped. As its emergency braking distance at this speed is in the order of about twenty metres, the RET would probably have stopped before the Bm signal, a signal where the freight train would have stopped about ten minutes later (see Figure 11 below).

Cutting the power to the catenary in Luxembourg at 11h42'45"

The power to the catenary is assumed to have been cut at 11h42'45", allowing 15" for the request to have been made by the Bettembourg CCP to the Luxembourg SU.

In the absence of a warning from the GTR, the driver of the RET, in accordance with the instructions applicable to such a case, would have immediately applied the emergency brake around DM 1.3, where he was travelling at about 50km/h. As the emergency braking distance at this speed is about a hundred metres, the RET would probably have stopped at around DM 1.2 just before or just after the Bm signal located at DM 1.169. The crash would very probably have been avoided as the freight train would have stopped at the Bm signal (see Figure 11 above).

Potential effect of the corrective actions on the Thionville side

Furthermore, assuming that the Thionville CCRP would have been alerted at around 11h42'45" by the Bettembourg CCP, it could have carried out the same corrective actions on its own territory (see diagram below, Figure 12).

The following analysis is made on the hypothesis that no GTR warning or power cut is activated from the Luxembourg side.

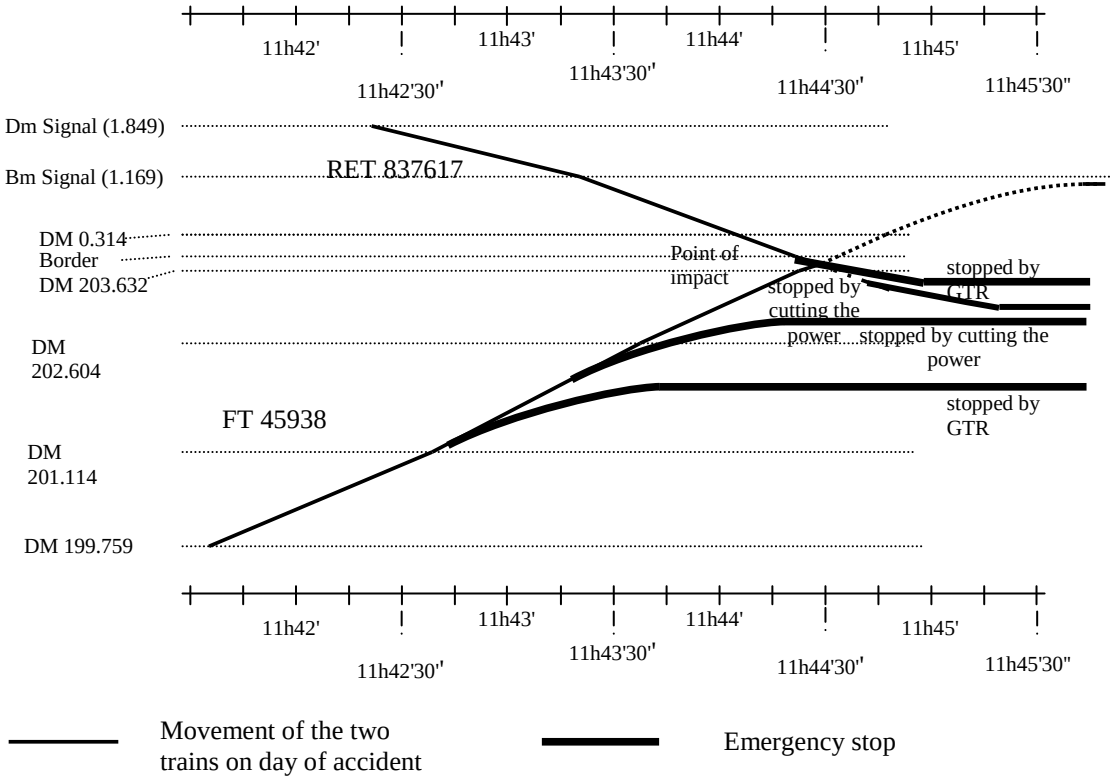


Figure 12: Movement Diagram 2
Potential effect of corrective actions at Thionville

Radio warning on French side at 11h42'45"

If the ground-train radio had worked, the driver of the freight train, on being warned when he was near DM 201.200, would have applied the emergency brake which would have brought him to a halt just before DM 202.

The RET would have received the radio warning as soon as it passed the border where it was travelling at 78 km/h. The driver would have applied the emergency brake and would have stopped after about 240m, i.e. near DM 203.5. No collision would have occurred.

Power cut on the SNCF side, at around 11h43 (taking into account the time required to contact the various parties)

If the CCRP had cut the power to the catenary, and in the absence of a warning via the GTR, the driver of the freight train would have continued under way for 20 seconds before applying the emergency brake. At this point he would have been near DM 202.1 which would have resulted in the freight train stopping near DM 202.8. Moreover, the RET would have been without power as soon as it passed through the separation section (Luxembourg DM 0.314, French DM 204.07). It

would have travelled for a further 20 seconds, which would have brought it to DM 203.6 and it would have stopped, after emergency braking, near DM 203.3. The collision would not have taken place or it would have occurred at very low speed.

Conclusion on the consequences of the various scenarios of corrective actions

We can conclude from the above analyses that, when the Bettembourg CCP team became aware (at 11h42'30") of the imminent collision situation, the three corrective actions available to them could have been effective, each of them being capable on its own of preventing the collision:

- issuing the radio warning would normally (had there been no fault) have stopped the RET before the Bm stop signal where the freight train was to have stopped: the collision would have therefore been avoided;
- the request to cut the power to the catenary, made to the Luxembourg SU, would probably have stopped the RET before the Bm signal where the freight train should have stopped;
- the warning given to the Thionville CCRP at 11h42'45" would have resulted in the CCRP issuing the same warning procedures to the trains via the ground-train radio and cutting the power to the catenary in France. The freight train could not have been warned by ground-train radio due to the fault on its onboard system but cutting the power to the catenary could have stopped it before it reached the border; the RET could have also been stopped (initially by the warning issued over the ground-train radio) in time to avoid or very considerably reduce the seriousness of the collision.

Analyses and preventive recommendations

The investigation into the sequence of events that led up to the accident has prompted a search for the required preventive measures in the following areas:

- Conditions for issuing an order to pass through a signal set at 'danger';
- Frequency of signal faults at the Bettembourg CCP;
- Supporting documents for dealing with fault situations;
- Ergonomics of the Bettembourg VCP;
- Consistency and ease of application of operating procedures;
- Telephone systems and their use;
- GTR systems and their use;
- Electric traction systems and their operation;
- Organisation of work at the Bettembourg CCP;
- Dealing with emergency situations;
- Safety Management System (SMS).

A summary of the main measures adopted since the accident is given elsewhere.

Conditions for issuing an order to pass through a signal set at 'danger'

Before issuing an order to pass through a route origin signal that does not set to 'proceed', the CCP Traffic Controller must ensure that there is no reason for its remaining at 'danger' and that the situation is really due to a fault.

To do this, he must follow the procedure described in paragraph 4.1.3.3 and be certain that:

- no train travelling in the opposite direction is present on the section of track downstream of the signal and up to the next protection signal;
- no mechanism is keeping the signal in the danger position.

At CFL, the process of obtaining this assurance is achieved by checking that no trains are present in the section of track protected by the signal. This assurance is given by looking at the track occupation check-lights on the VCP and examining the various regulatory paper records (duty rosters, Train Announcement Log, Joint Railway Operation Instructions for the Bettembourg-Thionville section of line, etc.).

Once certain, he must check that no mechanism is keeping the signal set at 'danger'. To do this he checks the VCP lights.

Lastly, when all these checks convince him that there is a fault on the WWFE, he must perform an additional check, by telephoning Thionville.

Only then can he regard the signal as being faulty or being kept at 'danger' by a faulty signal.

In the case of the accident of 11 October 2006, the Traffic Controller did not consult the information on the WWFE module, where he would have seen that he did not have the right of way and that the track on which the RET was supposed to travel was occupied. He did not consult the

TAL and did not get in touch with the CCRP at Thionville which would have enabled him to realise that the last train despatched by Thionville (Train 45938) had not yet arrived at Bettembourg.

The discovery of this human error, directly linked to the accident, emphasizes the importance of complying with the applicable regulations.

Recommendation R1 (CFL): remind all staff at the Switch Posts that they must be certain, before issuing an order to pass through a signal that has remained set at 'danger' after commandeering the route for which it is the origin signal, that the reason that it stays in the danger position is in fact due to a system fault.

This reminder, although certainly necessary, will never be sufficient. As part of the preventive guidelines to be implemented as a result of this accident, it must be strictly linked to the preventive recommendations detailed below which cover other factors that may have played a determining role in making this mistake.

Frequency of signal faults at the Bettembourg CCP

The number of pass-through orders issued at CFL is very high (see paragraph 5.9). Nearly 54% of these orders are connected with level-crossing or track circuit faults or other known reasons and almost 36% are for unidentified reasons (reason not given or not identified by the technical departments).

For Bettembourg Station, there were 42 faults in 3 months that justified an order being issued. An average of 800 train routes is set over 24 hours. It would therefore seem that there are about 0.00058 faults per train route. In one quarter, 72 800 train routes are set which means, given that five employees work to ensure that the Traffic Controller's post is constantly filled, there are 14 560 train routes per employee per quarter. One employee is therefore confronted with 8.45 fault situations per quarter, i.e. one every ten to eleven days. At Thionville, there were 80 faults of the same type for the whole of 2006 and for the three posts capable of issuing pass-through orders. The same reasoning shows that an employee finds himself in a situation to issue an order about every 64 days.

This repeated issuing of orders, for whatever reason, turns an act that requires very special attention into a commonplace event because, under these circumstances, no safety mechanism will be activated. Everything relies on the man who, before issuing this order, should have assured himself that there was no reason not to issue such an order.

This trivialisation leads to the risk of gradually establishing an imperfect and simplified method of dealing with the measures to be adopted.

Employees can even be led to reversing their method of reasoning. They should normally investigate the reason why the signal is set in the danger position and, if they do not find one, assume that the signal is faulty. If experience teaches them that in the vast majority of cases where MFSs do not change to 'proceed' it is because the signal itself or one of the mechanisms that keeps it at 'danger' is faulty, the employees' logical thought process assumes: "the signal is still faulty, unless there is evidence to the contrary", with the result that insufficient effort goes into properly determining the reason.

Recommendation R2 (CFL): based on feedback on the causes of faults at the Bettembourg CCP leading to a pass-through order being issued following an MFS failing to set at 'proceed', define and implement a list of measures that will reduce the frequency of these events.

In paragraph 5.9, we said that at the Bettembourg CCP the signal protecting a route often did

not change to 'proceed' on the first attempt at setting the route but would open on the second attempt.

This situation leads to the same risks of trivialisation referred to above. A safety system must work on the first attempt, except under exceptional circumstances, so that any malfunction is considered by the employees as an exceptional situation requiring their full attention.

Although the investigators have not sought the exact reasons for this malfunction, the cause may lie in the design of the Control Post or its maintenance.

Recommendation R3 (CFL): find the causes of the failure to set at 'proceed' of the MFSs at the Bettembourg CCP encountered on the first attempt at route setting and adopt measures to eradicate them.

Supporting documents for dealing with faults

Support documents are available to staff at the Bettembourg CCP (Dependency Table, Technical Notice) but there is no kind of 'checklist', except for the sheets in Annex 6 of the Joint Operation Instructions regarding the safety systems connected with the WWFE.

If a fault is presumed to exist, the Traffic Controller consults the VCP but he has no single document that details, route by route, the list of checks to be performed before concluding that a fault exists. The approach adopted by CFL is to memorise this information.

As stated in point 5.7 above, the support documents are not used by the employees working at the post.

This is a cultural choice of CFLs which puts the individual at the centre of the safety procedures, but makes safety dependent on the reliability of the employees' memory. It does not appear that the bases for this choice are very solid.

Firstly, attending a refresher course every two years may seem insufficient in view of the importance and complexity of the GRO. But even if these courses were held more frequently, the difficulty would not necessarily be resolved. In fact, it must be admitted that, in its current form, the GRO are highly impractical in an actual operational situation. The information required to handle a situation such as a presumed signal fault is spread throughout the document. Confronted with a situation such as that of 11 October 2006, the Traffic Controller who would have wanted to refer to the document would have had to follow several cross references in order to work out the procedure that would have enabled him to make a diagnosis, localise the source of the problem and take the appropriate action to deal with it.

This great difficulty in using the GRO in an operational situation clearly does not encourage staff to make use of it, even when in doubt. Furthermore, it would not provide an easy-to-remember structure suited to the various situations encountered. Traffic Controllers are forced to rely more on collective memory and to find other mnemonic means to carry out their work, which results in the VCP playing an almost exclusive role.

Among other things, the staff at the Bettembourg CCP have no documents available to them at the Post that describe:

- the object, operation and measures to be adopted (in a general manner) as regards the mechanisms that exist at the Post;

- the mechanisms involved in changing a signal to 'proceed'[1];
- an organised list (such as a check-list) of the things to be checked in the event of a signal not changing to 'proceed' before concluding that a fault exists.

Such documents could be used to help employees when they are required to deal with a signal that will not change to 'proceed', or a fault on a safety system.

The absence of such a document to aid decision-making in real time forces the employee to rely solely on his memory of the training received, which may be inaccurate or incorrect. It thus presents the risk of an oversight, leading to a pass-through order being issued improperly.

Recommendation R4 (CFL): examine the possibility of creating documents to aid decision-making of Traffic Controllers so as to guide them through the process of issuing a pass-through order.

These documents could indicate all the stages that must be gone through before issuing a pass-through order.

Ergonomics of the Bettembourg VCP

The VCP is the basic tool used for applying safety rules at the CCP. It appears that the design of this VCP could create the risk of errors being made.

Risk of confusion associated with the area warning lights

Two types of lights of identical appearance (see paragraph 3.3.2) give different information.

When a light is white this means, on almost the entire VCP, that the portion of track being checked is clear of all trains and that the route that these lights are indicating has been set. It also gives the assurance that no train can travel along this portion of track except for a train passing through the route origin signal.

By contrast, when the four lights (two per track) located at the right-hand end of the VCP (see Figure 4 of paragraph 3.3.2) on the tracks towards Thionville are white, this means that the portion of track being checked is clear of all trains but indicates nothing else. These lights are white, as well as others, even when a train is travelling on wrong-track working from Thionville until it passes DM 202.604.

On the day of the accident, when the Bettembourg CCP Traffic Controller looked at the VCP, Train 45938 had not yet reached DM 202.604. The lights were therefore white. He might have thought, by confusing the meaning of the lights, that all the conditions, including those relating to the WWFE, had been met to despatch the RET from the Dm signal towards Thionville. He was not therefore prompted to ask himself whether there was a train on Track 1.

Recommendation R5 (CFL): examine the possibility of eliminating the risk of confusion associated with the differences in meaning of the VCP area lights, between the tracks on the French side and the other tracks involved.

This could be achieved by changing the lights on the French side:

- either by giving the colours of these lights the same meaning as those of the other area lights;

[1] A document called the "Dependency Table" exists which might support this purpose. It is virtually never consulted by the employees.

- or by positioning them so as to eliminate any confusion.

The WWFE Module

The WWFE module is positioned on the right-hand side of the VCP (French side) but on a part of it that is located far from the information written on and near the tracks to Thionville (see Figure 13). It cannot be read by the Traffic Controller at a glance at the same time as the information displayed on these tracks. The Controller must consciously move his head to see both parts of the VCP one after the other. In the other directions, all the information concerning the tracks in the same direction (Luxembourg for example) can be read at a glance.

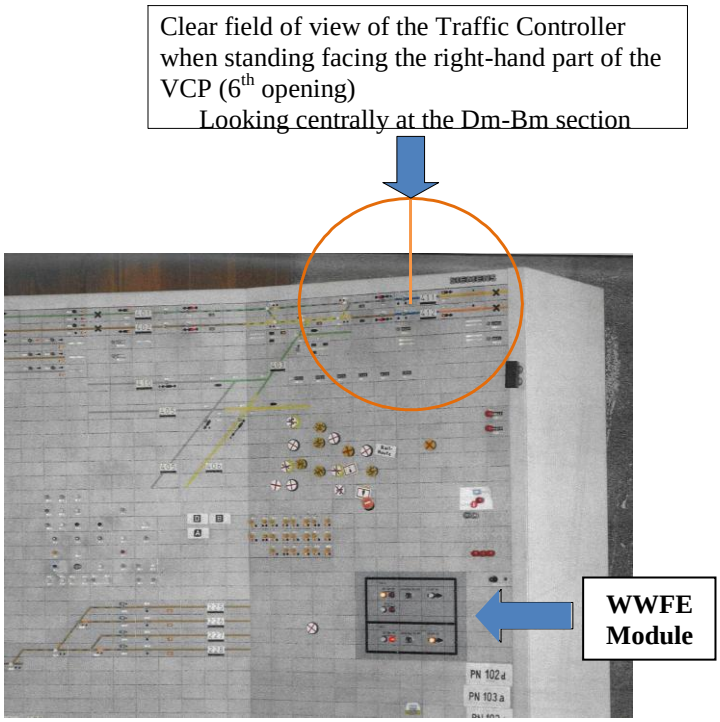


Figure 13: Visibility of the WWFE Module

Moreover, the ways of displaying some of the lights on this module are different from those on the rest of the VCP giving equivalent information (occupation of portions of track and direction interlocking status). For example: taking the direction of travel in all directions except towards Thionville is shown on the VCP by a small arrow that lights up white when this direction is taken whereas, on the WWFE module, the direction arrow is painted grey and a light located on this arrow lights when the direction has been taken.

This difference of presentation may reinforce the impression of an incongruous add-on that this WWFE module may give and contribute to the reason why, generally, the Traffic Controllers do not consult it.

Recommendation R6 (CFL): explore how to make the VCP more uniform by bringing all the information shown on the WWFE module into the area of the VCP where the tracks to Thionville appear, by using the same symbols as those that exist elsewhere on the VCP (two-position arrows along the path of the tracks).

The training on how to use WWFE modules is limited to Traffic Controllers and is conducted according to the principles adopted at SNCF, namely a three-day course away from the

Control Post, centred on case studies. This content and form do not match the practices and expectations of CFL personnel towards training. They are used to a long theoretical training programme, followed by a practical on-the-job apprenticeship enabling them to learn local specific details, rather than the case studies with which they have been presented.

<u>Recommendation R7 (CFL)</u>: re-train Bettembourg CCP employees in the use of WWFE modules by adapting this training to suit the current practices at CFL and to ensure that their knowledge is regularly updated.

Consistency and ease of application of operating procedures

Train announcement information on the Bettembourg VCP

For the vast majority of trains passing through Bettembourg or leaving from Bettembourg, a visual announcement system displays the train number on the VCP; after which there is no verbal announcement or record made in the TAL. This system of visual announcement is not used for trains coming from or going to Thionville.

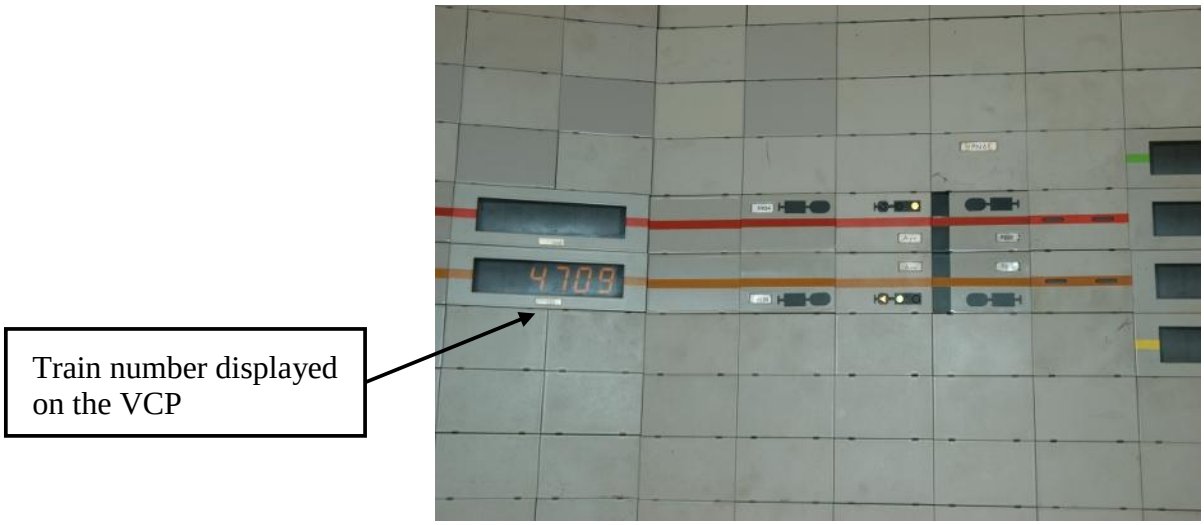


Figure 14: Visual Announcement System

The setting of an MFS at 'proceed' and the visual train announcement system are not interlocked with each other. If an MFS fails to set at 'proceed' (apart from those heading for Thionville) the Bettembourg Traffic Controller, in order to know whether a train is occupying the portion of track downstream of the signal in question, first looks to see whether a train number is displayed in the window of the visual announcement system of the section of track concerned. This window is positioned in the middle of the track line.

On the Thionville side, the Bettembourg CCP VCP does not give this information and the Traffic Controller must consult the Train Announcement Log, a Log which is not on his desk but on that of the Train Announcer. This absence of announcement information on the VCP may result in forgetting to check whether a train is present. Making the procedure more uniform on the Thionville side would reduce the risk of error.

At Thionville, announcements are made by the ATAS (Automatic Train Announcement System). It enables several trains to be recorded and displayed on a screen in advance, which the Luxembourg system is incapable of doing. An effective solution, so as to have only one method of work for the CCP Traffic Controller, would be to extend the ATAS* to Bettembourg and display just one train number in a window positioned in the same way as in the other directions.

On the day of the accident, if a train number (45938) had been displayed on the VCP, in the top part, the Traffic Controller would not have forgotten the freight train.

Recommendation R8 (CFL, SNCF, RFF): examine the feasibility of extending the ATAS to Bettembourg, by displaying the first train announced on the VCP.

It is not proposed to extend the Luxembourg system to Thionville. If this were done,

Thionville, in this direction only, would have a train announcement system incapable of displaying several trains at the same time. A double train announcement management system could be created for the CCRP staff.

Telephone systems and their use

The telephone lines available to the CCP Traffic Controller and Train Announcer and the Bettembourg MCP Traffic Controller have been described in paragraph 3.2.4.1.

The MCP Traffic Controller is connected to the CCP by just one direct line to the Traffic Controller. Neither of the two CCP staff can therefore take the calls of the other when one of them is busy. On the day of the accident, the Train Announcer was unable to reply on behalf of his Traffic Controller, who was then busy dictating the pass-through order.

Moreover, the Bettembourg CCP Traffic Controller was unable to contact Headquarters because the line was engaged by another conversation, although it was vital that he should contact Headquarters immediately.

Recommendation R9 (CFL): review the wiring of the direct telephone connections to the Bettembourg CCP and ensure that emergency lines run simultaneously to the consoles of the Traffic Controller and the Announcer; also provide a means of immediately contacting Headquarters, under any circumstances, in the event of an emergency.

GTR systems and their operation

Prevention of hidden radio warning faults at CFL

As soon as the Bettembourg CCP Traffic Controller became aware of the risk of collision, he ordered Switch Tender 1 (shortly after 11h42) to press the button to issue a radio warning. This action should normally have enabled the RET to stop in time (6.5.2).

The radio warning was not received because the button had not been effectively pressed or pressed for less than 0.6s.

If the button had been pressed, the warning would still not have reached the train, due to the device's hidden fault. This fault was all the more serious considering that no checking device was capable of detecting it beforehand.

Recommendation R10 (CFL): carry out maintenance procedures and check the operation of the radio warning system to ensure that it works properly.

Border systems and procedures

The Bettembourg to Thionville section of line is equipped with ground-train radio from beginning to end. The Luxembourg section is covered by Luxembourgish systems and instructions while the French section is covered by French systems and instructions. There is no continuous warning transfer before or after the border, which means that there is no guaranteed coverage area between the French and Luxembourgish broadcast reception areas. Moreover, the frequency re-tuning operation that a driver passing across the border must perform may make him momentarily unreachable if the tuning is not done exactly at the point where the two radio blocks meet.

Under these circumstances, radiotelephony connections and the radio warnings issued from one side of the border cannot be heard on the systems of the other network by the driver of a train coming from the other network and heading towards this border. It is therefore not possible to contact this driver or issue a radio warning that can be heard by him, however urgent it may be.

Recommendation R11 (CFL, SNCF, RFF): change the ground-train radio systems so that radio warnings and radiotelephonic communications sent by the Bettembourg or Thionville Control Posts may be received on the systems of the radio blocks located on the other side of the border.

The area where the ground-train radio of one of the networks (CFL or SNCF) is extended by trains travelling in the other country should be designed so that a train receiving the radio warning at the beginning of the listening area can stop before reaching the border.

Management of the conditions of movement of a train in the event of a ground-train radio fault on the French network

The fault on the radio in the traction unit of Train 45938 was detected just after Mulhouse. The driver then complied with the regulations (see paragraph 5.5.2.1) by reporting the fault to Hausbergen Post 1. The instructions that were transmitted to him resulted in this train being left to travel for about 300 kilometres without a radio.

As indicated in point 5.5.2, the regulations state that restrictive measures should be applied, as laid down by SNCF regulations (limiting the speed to 70 km/h or taking on a second employee) until the traction unit is replaced; this replacement must be made, at the latest, at the end of the journey of the locomotive pulling this train (Bettembourg in this case).

These regulations were not applied because the restrictive travel measures were not actually adopted.

Furthermore, these regulations seem somewhat lenient in that they allow a train to travel without ground-train radio until the locomotive reaches its terminus, even though this terminus is still far away when the fault is detected.

The fault on the radio in the locomotive of Train 49538 had no practical consequence as regards the accident because the Bettembourg CCP did not inform the Thionville CCRP of the head-on situation of the two trains. The situation would have been different had the CCRP Controller been warned: he would have then tried to warn the driver of the freight train by radio but could not have done so due to this fault.

Recommendation R12 (SNCF, RFF, EPSF): examine tightening up the regulations in the event of a radio fault, by stipulating that the fault must be remedied (by changing the traction unit, providing a portable radio set, etc.) according to stricter criteria.

Electric traction systems and their operation

The Bettembourg to Thionville section of line is electrified from end to end. Each of the two networks has full control over the systems connected on their own territory, both on the technical and organisational level. At CFL and SNCF, the power is cut on the main tracks by the Substation Unit.

In the event of an incident requiring a train travelling on the other network to be stopped in an emergency, no direct means is available to the Switch Tenders to access the Substation Unit of the other company.

Applying the emergency cut-off procedures at the Bettembourg CCP

When the Bettembourg CCP Traffic Controller realised his mistake, he could have asked the Luxembourg SU to cut the power via the alarm telephone. This was not done, whereas it would have enabled the RET to have been stopped or, at least, led to a reduction in its speed. By contrast, Switch Tender 2 tried to cut the power by pressing a button at his post but whose purpose was not to cut off the power on the tracks leading to the French border.

The power was only cut (at 11h43'30") after the Traffic Controller had informed Headquarters in Luxembourg that the RET had been despatched in error and after HQ had asked the Luxembourg Substation Unit to cut the power.

It appeared that the Bettembourg CCP staff wanted to cut the power to the CFL tracks leading to the border by adopting inappropriate measures rather than making use of the alarm telephone between the CCP and the Luxembourg SU.

Recommendation R13 (CFL): provide Bettembourg CCP staff (and if necessary staff elsewhere using similar systems) with further training on electric traction and ensure that their skills are kept up to date.

Cross-border procedures for requesting an emergency power-cut

If the CCP had been able to request an emergency power-cut from the SNCF Substation Unit as soon as it had realised the mistake made (around 11h42'30"), the collision could have probably been avoided.

In fact, the driver of the freight train would have realised the lack of power at around 11h43 and would have continued under way for 20 seconds, as the regulations dictate that he should, before applying the emergency brake. At 11h43, the front end of the freight train was near DM 201.600 (see Annex 6). The emergency braking distance of the 45938 may be estimated to be around 1 000 metres. It would have stopped near DM 202.600 i.e. about 1 400 metres from the point (separation section) where the RET would have noticed the lack of power on the SNCF network; the RET driver would probably have stopped of his own accord before DM 202.600.

The procedures effective on the day of the accident to cut the power on the SNCF network at the request of the Bettembourg CCP were not very rapid (see paragraph 3.5), since there were no direct telephone connections between the Bettembourg CCP and the East-France SNCF Substation Unit.

Recommendation R14 (CFL, SNCF, RFF): install the telephone links required to cut off the power quickly on request from the Bettembourg CCP in the event of an emergency on the French border-Thionville section of line .

In fact, such a telephone connection was in existence at Thionville; the CCRP has a direct ‘de-facto’ connection with Luxembourg Headquarters, which shares the same region as the SU; but it would be better if the connection were guaranteed from console to console.

Organisation of work at the Bettembourg CCP

Role of Traffic Controller

The CCP Traffic Controller is responsible for train and shunting movements in the area covered by his Control Post. He receives all the information relating to traffic movements, takes all

the decisions, orders the Train Announcer and Switch Tenders to perform all the actions required to manage traffic movements and checks that his orders are carried out properly. He is not authorized to give orders that include a condition that stipulates that he shall not order several successive actions in one go. In some cases covered by the GRO, he is authorised to delegate certain tasks, but he must still continue to monitor them.

In a post as large as the CCP, it is unrealistic to be able to work like this. In practice, the other staff performs routine tasks as a matter of course despite the fact that this is forbidden by the regulations: there is an implicit delegation of tasks. Furthermore, the staff give off a strong feeling of dissatisfaction and tend to consider that it is neither their job to reflect upon nor monitor situations. Such an approach to the job results in possibilities for corrective mistakes being lost and encourages a passive attitude.

Recommendation R15 (CFL): based on an analysis of staff activity, examine the safety regulations so that the division of the safety tasks to be performed in a Switch Post like the one at the Bettembourg CCP, by the different employees at the post (Traffic Controller, Train Announcer and Switch Tender), corresponds both to the employee responsibilities and to the operational constraints.

Handover

Relieving staff

The GRO state that an employee must not leave his post until he has personally handed over to the person relieving him.

It appears that this rule was not observed at the CCP and that it was not unusual for a handover to be done through a third person, a third person who is in principle qualified to fill the post for which he is serving as an intermediary[1].

Local management knew that handovers were not carried out strictly as stated in the regulations but was unaware of just how widespread the practice was.

Each time information is passed on, the risk of loss exists. The practice of passing on information under this "cascade" arrangement increases this possibility. It also prevents the person coming on duty from having direct contact with the person coming off duty and asking him for explanations about things that may not seem clear to him.

Recommendation R16 (CFL): implement the relief protocol, ensuring in particular that handover is done directly between the two employees that occupy the position concerned, as the regulations require.

This protocol could be adapted by adopting the practices applied in other rail networks or in other sectors such as in aviation or the nuclear industry.

Documents used on handover

At the Bettembourg CCP, the Traffic Controller who is handing over must make a brief note in the "Duty Roster" of the subject of the documents, order and notice that concern the shift of the person relieving him, unless these details are mentioned in the Train Announcement Log.

It was found that this method of passing on information is rarely used and has been replaced by oral communications and a loose sheet of (scrap) paper. The various employees do not treat this sheet in the same way. Some fill it up in order to inform their successor, others pick it up as soon as they come on duty and use it as a rough log. In this case, it is common practice to cross out an item

[1] It is sometimes the case that no handover will even occur.

when it is no longer useful to the person who entered it. However, this person may fail to realise that a crossed-out item may be of use to his successor, or the fact that this information is still present on the scrap paper, but crossed out, may be misleading.

On the day of the accident, Train 45938 on wrong-track working was entered on this sheet of scrap paper. On the sheet found after the accident, this entry is crossed out. It has not been possible to find out who crossed out this train. If the evening Traffic Controller had found this train crossed out, he might have concluded that "this train has arrived", although he might just as well have concluded "my predecessor has done his job as regards this train, but this doesn't give me any information about this train's whereabouts".

The information passed on to the successor should only include that which is essential to him but must be unambiguous.

Moreover, staff have pointed out that the list of information to be entered in the duty roster was restrictive and did not cover all requirements, hence the use of other means such as the sheet of scrap paper.

Recommendation R17 (CFL): examine the possibility, when passing on safety information at handover, of using standardised documents (on national or local level), ensuring that this information can be traced and provides comprehensive coverage of all the information (and only that information) required by the person taking over.

Dealing with emergency situations

At 11h42'30", at the time of his telephone call to the Traffic Controller at the marshalling yard, the Bettembourg Traffic Controller realised that a collision between the freight train and the RET was imminent. He did not know how much time he had to react (it was in fact about two minutes).

Two measures were in fact attempted during this time: issuing a radio warning and cutting the power to the main tracks.

The radio warning should have succeeded under normal conditions, but the failure of the radio warning to arrive at the Headquarters shows that the pushbutton had been pressed ineffectually (less than 0.6 of a second) or had not been pressed at all. Furthermore, even if the procedure had been carried out properly, the system's hidden fault would have prevented the warning from being transmitted to the trains.

The request for confirmation of receipt of the radio warning at the GTR Exchange was also a good reaction but, because the telephone was engaged, the information concerning the failure of the first attempt was only obtained later at Headquarters; the warning repeated at that time was too late to be effective. It therefore finally failed due to a combination of a handling error and a random circumstance delaying an urgent telephone call.

Neither was the attempt to cut the power successful. Evening Switch Tender 2 pressed the corresponding button but did not know – and neither did the rest of the staff on duty – that this button had no effect on the main tracks. The existence of the direct telephone connection with the Substation Unit was unknown to the Bettembourg CCP staff; it was finally Headquarters who warned – too late – the substation exchange. Unfamiliarity with the system's operation therefore played a major role in the failure to cut the power (see paragraph 7.8 above).

Other actions could have been taken: the chief one should have been to warn the Thionville CCRP, which could have prevented the collision if this information had been given to it

immediately (see paragraph 6.8.3). No attempt to do this had been made, however, perhaps through a lack of sufficient human reflexes to pass on information, or perhaps through excessive reliance on the radio warning.

Generally speaking, other possible actions also spring to mind under such circumstances (closing signals, diversion using the Switch Tenders, warning the trains via personnel on the tracks, etc.) which in this case may not have been of any use.

This list of reasons for the possible failure of corrective actions confirm that:

- in an emergency situation, the required actions have more chance of success if they have been prepared in scenarios established beforehand and have been properly assimilated by the staff concerned so as to become reflex actions;
- backup corrective actions must be found to tackle any random adverse circumstances;
- staff preparation must include not only a good knowledge of systems and procedures, but also involve practical training in alerting practices.

The investigators felt that, both at CFL and SNCF, there is almost no staff preparation in corrective emergency situations or practical training in alerting practices.

In the aeronautics industry, for example, it has been proved that training in emergency situations can considerably improve the chance of correcting such situations when they occur.

Recommendation R18 (CFL, SNCF and RFF): prepare staff responsible for safety to deal with the emergency situations that are most likely to occur, including in particular:

- **identifying the risks to be dealt with;**
- **formalising reaction scenarios;**
- **training and staged exercises.**

The use of simulators may be worth investigating, in view of the practical difficulty of staging emergency situations while trains are actually in motion.

Safety Management System (SMS)

Several aspects of the SMS are involved, or even called into question, by the analysis of the Zoufftgen accident. These are:

- safety and operating standards;
- feedback procedure;
- staff training;
- proximity management.

Safety Standards

It is generally agreed that safety and operating standards must meet particularly the function of documentary reference, enabling staff to find in the documents answers to any question concerning the operation of the systems and equipment and the procedures to follow during normal operations and in the event of a fault.

In particular, they must assist in decision-making when faced with certain situations that

require rapid and decisive reactions and include clear operational guides that can be used in real time.

However, these functions do not appear to be met effectively by the two basic documents currently available to the Bettembourg CCP staff: the GRO and the Station Instructions. During the investigation, it was patently clear that the staff does not use these documents in real time and that these documents are not suitable for such use in any case.

The GRO

The GRO cover all the topics relating to train movements but are limited to general aspects and are difficult to read. They reflect the current philosophy at CFL which is based on acquiring a thorough knowledge of safety systems and procedures, without the need to refer back to basic regulatory texts.

At CFL, employees are obliged to apply the GRO to the letter without being required to consult the document, except for the Electric Traction Instructions. They are supposed to be trained and qualified to master the GRO perfectly and to apply them from memory. They attend refresher courses on the GRO every two years.

Should a Traffic Controller wish to refer to this document to handle an abnormal situation, he would, in many cases, need to follow several cross-references to reconstruct the procedure that would enable him to diagnose the situation, pinpoint the source of the problem and take the appropriate action to deal with it.

Furthermore, the contents of the GRO are not always applicable. The GRO have not been updated to include changes brought about by new technologies or reorganisation initiatives in traffic control. Some sections have been partially revised but all the obsolete information has not been removed from the original document (for example, GRO 04 still contains procedures concerning the controls of lever signals or equipment, whereas this technique is no longer used at CFL). They also appear to contain unrealistic requirements in certain areas such as defining the roles of the various staff members within the CCP (cf. 7.9 above).

It is now accepted and admitted at CFL that the existing GRO do not take into account:

- recent technological advances;
- developments in operational methods;
- the increase in the volume of traffic;
- the increase in the volume of work, particularly for the Traffic Controller.

Most of the staff interviewed found it almost impossible to comply with the GRO while meeting the demands of day-to-day work within the CCP. Since it fails to meet staff requirements, the GRO document is practically never consulted by them. In fact, during a visit made to the Bettembourg CCP, we noticed that the GRO were kept at the bottom of a drawer.

Station Instructions

Two chapters out of the seven of the Bettembourg Station Instructions deal with traffic safety. They do not provide a description of the details of the station's operation and often merely refer back to an article of the GRO. They are grouped in the Station Instructions with 5 other chapters dealing with very diverse subjects that generally have no relation to operation (cf. 4.1.1).

Difficulty in using these documents

This lack of a reference document suited to the actual working conditions makes it easy to deviate from practices and "normalise the deviation", because without regular recourse to a

consistent, explicit and applicable written text, deviations that have become common practice, whether justified or not, replace the real reference document in the collective (and often the staff's) memory. Such a situation becomes riskier the more complicated the contexts, systems and situations that the staff are required to handle. In fact, the greater this complexity, the more likely it is that in their short cuts and adaptations, employees forget a text book situation, or interaction, or misunderstand the implications, and they themselves set the trap into which they will fall when the neglected conditions come to pass.

It is therefore necessary that steps should be taken to revise the frame of reference represented chiefly by these documents since they have become unsuited to real working conditions and fail to meet safety management requirements.

This restructuring will have the advantage of updating the regulations as regards the existing rail traffic control situation and improving the ergonomics of the documentary support that can be used in a real-life situation.

Recommendation R19 (CFL): revise the General Regulations on Technical Operations and the Station Instructions, with a view to adapting the frame of reference to the actual rail traffic control conditions and to providing staff with operational documents that guide their actions in real time.

This initiative could be based on an audit of the practices and operational requirements of staff in the Control Posts and their encounters with the existing reference material. It might be necessary to create a temporary situation linking the existing GRO to the use of certain operational reference documents, such as the one referred to in Recommendation 4. This situation, which would require a change in the principles currently adopted at CFL, will have to be clearly explained.

Feedback Procedure

Safety management requires a knowledge of the difficulties and near-misses in connection with safety, recorded at the various management levels. This knowledge enables safety management to be taken into account chiefly when considering investments and staff training.

This knowledge can only be obtained by rigorous record-keeping in the documents relating to system faults, and by the operators themselves passing on information in a "non punitive" process. It is then possible to build up reliable feedback and identify the measures to be taken.

Passing on information on incidents and near misses

The main source of feedback that the investigators identified refers to the regulatory documents that must be completed in the event of a fault and the audit reports. They found no organisational structure that would encourage employees voluntarily to divulge information on near misses from which lessons could be learned in order to improve safety. The regulatory documents themselves are difficult to use because they are not correctly filled in: 35% of orders to pass through a signal at Luxembourg have no justification, and this figure rises to as much as 47% at the Bettembourg CCP.

The investigators did not receive a report enabling them to assess the effectiveness of passing on information about safety via the "trusted person" appointed in 1998.

In practice, feedback reports are fairly limited, which results in the risk that the knowledge of any problems encountered remains fairly patchy.

Analysis of the Zoufftgen accident by the local management

Examination of the SOA report (see point 5.8.3) shows that, as regards the human factor, its authors lay the blame exclusively at the door of the staff on duty at the post and do not appear to ask

questions about the organisation of the work and the overall system on which it is based. This report also states that proposed disciplinary measures regarding these employees are detailed in a separate document.

The proposals for change deal with regulatory aspects and the make-up of the systems. The only proposal from the "human factors" point of view is limited to an awareness campaign to ensure that regulations are strictly followed. The frequency of safety audits and tours of inspection will also be increased.

The question of staff working conditions is tackled neither in the analysis of the causes of the accident nor in the proposals for change.

This approach appears to be too narrow and too focused on defining staff responsibilities to enable the causes of human error to be thoroughly analysed and the necessary preventive measures to be adopted.

Generally speaking, once the mistakes made by the operators have been identified, it must be determined whether their environment explains, at least in part, why the mistakes were made. This environment particularly refers to the technical work tools and regulations available to staff, the actual environment in which they work, the training that they have received and the extent to which their skills are maintained.

Recommendation R20 (CFL): examine changing the arrangement for operators to submit feedback reports and build into the Safety Management System procedures that provide reliable feedback reports, in a non-punitive context. Take into account, when analysing accidents and near misses, aspects connected with the work context and organisation.

Staff skills and training

The investigation report highlighted several areas, involved in the sequence of the accident, in which staff skills appeared deficient or inappropriate and where their training should be refreshed or reinforced.

Namely:

- using WWFE (Recommendation R6);
- the operation of electric traction systems (Recommendation R13);
- dealing with emergency situations (Recommendation R18).

Beyond these particular topics, most of the recommendations made in this report, when they are implemented, will call for actions to provide the appropriate training.

An extensive training programme must therefore be embarked upon and carefully implemented. Since the recommendations made are not limited to the Bettembourg CCP, it may involve all staff at the CFL switching posts.

Proximity Management

Local managers discovered that the deviations of behaviour at the CCP compared with the frame of reference were much greater than expected. They were particularly surprised at the situation as regards:

- the information relating to signal faults: far too little information to repair the phenomenon;
- the handover conditions.

A major reform of the tasks carried out by local managers was introduced, splitting the organisational structure into two operational areas. The position of Stationmaster was removed.

As seen in point 5.8.4, the Area Managers were unable to fulfil their on-the-spot role. Now, the first channel through which the management is normally made aware of the situation on the ground is via the hierarchical route, with the staff playing a pivotal role. It is he who is in touch with reality, and the clearness of his instructions depends totally on his ability to know what is happening in the post and to pass on information.

Recommendation R21 (CFL): enable local managers to be on the spot and have the necessary means to check and monitor the staff on the ground.

Measures adopted since the accident

Since the accident, measures have been adopted by CFL and SNCF. The main ones are described below.

Some measures relate to investments or tasks carried out jointly by CFL and SNCF such as:

- providing direct telephone lines between the Bettembourg CCP and the East-France SU and between the Thionville CCRP and the Luxembourg SU with regular connection test procedures;
- installing a mobile SNCF GTR system at the Bettembourg CCP enabling a warning to be issued on the SNCF border channel;
- training for all operators at the Thionville and Bettembourg Switch Posts by the companies concerned (SNCF and CFL) in order to ensure that the procedures referred to in the Border Operation Instructions are properly applied and that the record of these training courses can be traced. They would include joint practical training in rare or reduced-efficiency situations and must be carried out periodically, with the dates of the training being on general display;
- additional training by SNCF covering the special features of WWFE, aimed at the Bettembourg Traffic Controllers;
- annual performance of a cross-border multifunctional exercise regarding WWFE between SNCF and CFL in the context of a reduced-efficiency situation;
- planning joint safety meetings with SNCF;
- revising the Border Operation Instructions.

Others are specific to CFL, such as:

- introducing a Reflex Sheet to be completed by the Traffic Controller before issuing a Written Order A for all faults on systems requiring a written order to be issued;
- beefing up the checks and controls at the Control Posts, particularly as regards the staff handover arrangements and keeping accurate duty documents;
- analysing Written Orders A so as to be able best to determine the causes of faults in order to be able to remedy them;
- preparing a procedure to perform a monthly check to ensure that the GTR warning buttons are working properly;
- re-organising the Bettembourg CCP into two traffic sectors, with two Traffic Controllers;

- reorganising the QSE Department by appointing "safety officers" within the various departments and adding to each Control Post a "safety manager" so as to have better on-the-ground feedback;
- reorganising the Operational Areas and setting up a team to assist with rail safety and, more particularly, the supervision and management of Control Posts from the safety point of view;
- an effort to restructure the GRO was made in 2005 and, in June 2008, CFL are to submit Sections 01, 02, 07, 08 and 09 to the Ministry of Transport for approval. Sections 04, 10 and 11 are to follow at the end of 2008;
- Since the end of 2006, CFL has had a Computerised Control Post simulator for use by Control Post operators so as to include in their refresher courses the measures to be adopted during reduced-efficiency operating situations. According to the feedback received by the operators and trainers, using this simulator considerably improves the quality of continuous training;
- In the "DuPont Safety Plan", introduced towards the end of 2007, continuous updating of the training received by Traffic Controllers, Train Announcers and Switch Tenders is provided for via a working group which is also attended by Traffic Controller representatives.

Conclusions

Identifying the causes and associated factors that contributed to the accident

In addition to the direct and immediate cause of the accident, the investigation highlighted the causes and factors that contributed or could have contributed directly to mistakenly issuing the pass-through order or to the failure of the attempts to rectify the situation, as well as the underlying causes associated with skills and, lastly, the organisational causes.

Direct and immediate cause

The direct and immediate cause of the accident was human error: the Bettembourg CCP Traffic Controller mistakenly issued, to the driver of the RET, an order to pass through a signal set at 'danger' protecting the section of track on which the freight train was travelling.

Causal factors relating to mistakenly issuing the pass-through order

Four causal factors contributed or could have contributed directly to mistakenly issuing the pass-through order:

- the defective handover procedure at the Bettembourg CCP carried out just before the accident, which compromised the Traffic Controller's ability to obtain the information that the freight train was travelling on wrong-track working on Track 1 using WWFE;
- frequent signal faults and habitual malfunctions at the Bettembourg CCP Switch Post, which may have led to less attention being paid to the assurances that must be obtained before a pass-through order is issued;
- the poor ergonomics of the documentation available at the Bettembourg CCP, particularly the lack of documentary decision-making tools which could have been used to support the Traffic Controller and help him perform all the checks required before a pass-through order can be issued;
- the improveable ergonomics of the VCP at the Bettembourg CCP, which may have contributed to the omission to check the status of the track along which the RET should have been travelling.

Causal factors relating to the failure of attempts to rectify the situation

Four causal factors contributed or could have contributed directly to the failure of attempts to rectify the situation:

- pressing the radio warning button ineffectually, or failing to press this button at all, which prevented the GTR Exchange from receiving the warning (this receipt by the GTR Exchange was not affected by the hidden fault on the radio warning device);
- the delay in cutting off the traction power, which led to it being cut off too late to be effective on the Luxembourg side;
- failing to transmit the warning to the Thionville CCRP, which would have enabled the latter to take corrective action on the French side to try and stop the freight train;
- the limited functionality of the telephone systems at the Bettembourg CCP, which did not allow two urgent calls through because the lines were busy (the call from the MCP and above all the call to the GTR Exchange).

Underlying Causes

Two underlying causes associated with staff skills played a role in this accident:

- insufficient knowledge of the procedures to be applied by staff at the Bettembourg CCP in various important areas (WWFE, electrical power, issuing pass-though orders, radio warning, emergency situations) which led to the wrong or ineffectual actions being taken;
- the lack of practical training in emergency procedures, which prevented staff from being prepared in their use.

Organisational causes: Safety Management System and regulatory framework at CFL

Three organisational causes may have contributed to this accident:

- the unrealistic distribution of tasks between the various employees at the Bettembourg CCP, which gives all the responsibilities to the Traffic Controller, the other employees not being allowed to intervene unless first ordered to do so by him. In the event of a problem situation, this distribution of roles may mentally overload the Traffic Controller and encourage a passive attitude among the other employees;
- the un-encouraging feedback arrangements at CFL, which prevent the latter from playing a full role in detecting potentially dangerous situations;
- the lack of rigour in supervising employees and in hierarchical control, which made it easy for lax practices to take hold.

Potential causal factors

Four factors, which did not in fact play a part in the sequence of the accident, would have compromised the effectiveness of the corrective actions that should normally have been performed:

- the hidden fault on the ground-train radio at Bettembourg which had not been detected during maintenance procedures; if the button had been pressed correctly, the radio warning would still not have reached the RET because of the faulty operation of the radio signal transmission electronic card;
- the fault on the ground-train radio of the freight train locomotive; if the Bettembourg CCP had notified the Thionville CCRP of the mistaken despatch of the RET, the CCRP could not have stopped the freight train by means of a radio warning;
- the absence of a continuous radio warning transfer near the border which, if the warning had been issued by radio, could have prevented it from being received by the trains to which it was sent;
- the absence of a direct connection between the Bettembourg CCP and the East-France Substation Unit, which would have given more time to cut off the traction power in France from the Bettembourg CCP, if this had been requested.

Recommendation R1 (CFL): remind all staff at the Switch Posts that they must be certain, before issuing an order to pass through a signal that has remained set at 'danger' after commandeering the route for which it is the origin signal, that the reason that it stays in the danger position is in fact due to a system.

Recommendation R2 (CFL): based on feedback on the causes of faults at the Bettembourg CCP leading to a pass-through order being issued following an MFS failing to set at 'proceed', define and implement a list of measures that will reduce the frequency of these events..

Recommendation R3 (CFL): find the causes of the failure to set at 'proceed' of the MFSs at the Bettembourg CCP encountered on the first attempt at route setting and adopt measures to eradicate them.

Recommendation R4 (CFL): examine the possibility of creating documents to aid decision-making of Traffic Controllers so as to guide them through the process of issuing a pass-through order.

Recommendation R5 (CFL): examine the possibility of eliminating the risk of confusion, associated with the differences in meaning of the VCP area lights, between the tracks on the French side and the other tracks involved.

Recommendation R6 (CFL): explore how to make the VCP more uniform by bringing all the information shown on the WWFE module into the area of the VCP where the tracks to Thionville appear and by using the same symbols as those that exist elsewhere on the VCP (two-position arrows along the path of the tracks).

Recommendation R7 (CFL): re-train Bettembourg CCP employees on the use of WWFE modules by adapting this training to suit the current practices at CFL and to ensure that their knowledge is regularly updated.

Recommendation R8 (CFL, SNCF, RFF): examine the feasibility of extending the ATAS to Bettembourg, by displaying the first train announced on the VCP.

Recommendation R9 (CFL): review the wiring of the direct telephone connections to the Bettembourg CCP and ensure that emergency lines run simultaneously to the consoles of the Traffic Controller and the Announcer; also provide a means of immediately contacting Headquarters, under any circumstances, in the event of an emergency.

Recommendation R10 (CFL): carry out maintenance procedures and check the operation of the radio warning system to ensure that it works properly.

Recommendation R11 (CFL, SNCF, RFF): change the ground-train radio systems so that radio warnings and radiotelephonic communications sent by the Bettembourg or Thionville Control Posts may be received on the systems of the radio blocks located on the other side of the border.

Recommendation R12 (SNCF, RFF, EPSF): examine tightening up the regulations in the event of a radio fault, by stipulating that the fault must be remedied (by changing the traction unit, providing a portable radio set, etc.) according to stricter criteria.

Recommendation R13 (CFL): provide Bettembourg CCP staff (and if necessary staff elsewhere using similar systems) with further training on electric traction and ensure that their skills are kept up to date.

Recommendation R14 (CFL, SNCF, RFF): install the telephone links required to cut off the power quickly on request from the Bettembourg CCP in the event of an emergency on the

<u>Recommendation R15 (CFL)</u>: based on an analysis of staff activity, examine the safety regulations so that the division of the safety tasks to be performed in a Switch Post like the one at the Bettembourg CCP, by the different employees at the post (Traffic Controller, Train Announcer and Switch Tender), corresponds both to the employee responsibilities and to the operational constraints.

<u>Recommendation R16 (CFL)</u>: implement the relief protocol, ensuring in particular that handover is done directly between the two employees that occupy the position concerned, as the regulations require.

<u>Recommendation R17 (CFL)</u>: examine the possibility, when passing on safety information at handover, of using standardised documents (on national or local level), ensuring that this information can be traced and provides comprehensive coverage of all the information (and only that information) required by the person taking over.

<u>Recommendation R18 (CFL, SNCF and RFF)</u>: prepare staff responsible for safety to deal with the emergency situations that are most likely to occur, including in particular:

- **identifying the risks to be dealt with;**
- **formalising reaction scenarios;**
- **training and staged exercises.**

<u>Recommendation R19 (CFL)</u>: revise the General Regulations on Technical Operations and the Station Instructions, with a view to adapting the frame of reference to the actual rail traffic control conditions and to providing staff with operational documents that guide their actions in real time.

<u>Recommendation R20 (CFL)</u>: examine changing the arrangement for operators to submit feedback reports and build into the Safety Management System procedures that provide reliable feedback reports, in a non-punitive context. Take into account, when analysing accidents and near misses, aspects connected with the work context and organisation.

<u>Recommendation R21 (CFL)</u>: enable local managers to be on the spot and have the necessary means to check and monitor the staff on the ground.

ANNEXES

Annex 1: Opening the Investigation

Annex 1a: Decision to open the investigation in France

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

Minister of Transport, Infrastructure,
Tourism and the Sea

2006-013

DECISION

The Minister of Transport, Infrastructure, Tourism and the Sea;

Having regard to Law 2002-3 of 3 January 2002 relating to the safety of infrastructures and transport systems and notably its Section III on technical investigations;
Having regard to Decree 2004-85 of 26 January 2004 relating to technical investigations after a land transport accident or incident;

HEREBY DECIDES

Article 1: A technical investigation, conducted in accordance with Section III of the above-mentioned Law 2002-3 of 3 January, has been opened into the railway accident at the border point of Zoufftgen (57) which occurred on Wednesday 11 October 2006.

Article 2: The Director of the Bureau of Investigation into Land Transport Accidents is hereby appointed to execute the present Decision.

Made at Paris on 11 OCT 2006

The Minister of Transport, Infrastructure,
Tourism and the Sea

Dominique PERBEN

Annex 1b: Certificate of Legitimisation of the Investigator in Luxembourg

THE GOVERNMENT
OF THE GRAND DUCHY OF LUXEMBOURG
Ministry of Transport

CERTIFICATE OF LEGITIMISATION

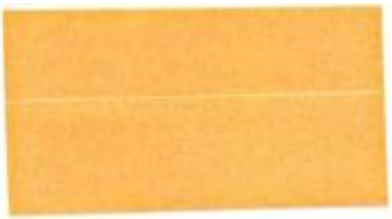
issued by the Minister of Transport on the basis of

- **Article 5 of the Law of 8 March 2002 on technical investigations relating to serious accidents and incidents that have occurred in the civil aviation, maritime and railway transport sectors and**
- **Grand Ducal Ruling of 31 July 2006 defining the terms and conditions of issuing, using and withdrawing the Certificates of Legitimisation of designated investigators and experts involved in technical investigations relating to serious accidents and incidents that have occurred in the civil aviation, maritime and railway transport sectors**

On the basis of the Law of 8 March 2002 on technical investigations relating to serious accidents and incidents that have occurred in the civil aviation, maritime and railway transport sectors,

the investigator appointed by the investigation authority

Surname:
First Name:
Profession:
Born on:
Residing at:



is hereby authorised to conduct the technical investigations relating to the serious accident that occurred on 11 October 2006 between a passenger train and a freight train at the border between Luxembourg and France near Zoufftgen. For this purpose, he benefits from the legal prerogatives listed in Article 5 and assumes the responsibilities referred to in Article 7 of the above-mentioned Law of 8 March 2002.

This Certificate of Legitimisation expires on 31 December 2007. It must be presented with a valid form of identification.

The Minister of Transport may at any time check whether the conditions of issue have been met. He may suspend or withdraw the Certificate of Legitimisation under the conditions referred to in the Grand Ducal Ruling of 31 July 2006 defining the terms and conditions of issuing, using and withdrawing the Certificates of Legitimisation of designated investigators and experts involved in technical investigations relating to serious accidents and incidents that have occurred in the civil aviation, maritime and railway transport sectors, undertaken in pursuance of Article 5 of the Law of 8 March 2002 on technical investigations relating to serious accidents and incidents that have occurred in the civil aviation, maritime and railway transport sectors.

The Certificate of Legitimisation is personal and non-transferable.

Certified copies of this document are addressed to the members of the investigating authority and to the Public Prosecutor in Luxembourg for information.

Luxembourg, 4 December 2006

Lucien LUX
Minister of Transport

INVESTIGATION INTO THE RAILWAY ACCIDENT THAT OCCURRED ON THE BORDER BETWEEN LUXEMBOURG AND FRANCE ON 11 OCTOBER 2006

BEA-TT/EEAI COOPERATION PROTOCOL

approved on 25 October 2006

1. AIM OF THE PROTOCOL

The "Land Transport Accident Investigation Bureau" (BEA-TT) and the "Accident and Incident Investigation Body" (EEAI) are the permanent investigation organisations for railway accidents and incidents that comply with Directive 2004/49/EC of 29 April 2004, in France and Luxembourg respectively.

The aim of this Protocol is to establish cooperation between these two organisations with regard to the accident that occurred on 11 October 2006 on the French/Luxembourg border, at Zoufftgen (France), on the Thionville (France) to Bettembourg (Luxembourg) section of line.

This investigation is conducted under the conditions stipulated in the said Directive and in its Article 22.1 in particular.

2. OPENING THE INVESTIGATION

The two investigating organisations have notified the European Railway Agency that an investigation will open on 16 October 2006.

3. CO-OPERATION BETWEEN BEA-TT AND EEAI

The two investigating organisations shall cooperate in order to produce a joint report.

The two organisations shall together determine:

- the scope of the investigation;
- the terms and conditions to guarantee the consistency and synergy of the investigations;
- the division of tasks and the organisation of work.

As the point of impact between the two trains occurred on French soil, BEA-TT shall provide a summary of the information produced by the investigations conducted in both countries. It will compile a draft report (or reports) that will be submitted to EEAI for approval under the conditions stipulated in Article 9 below.

During the investigation and within the scope of the applicable national regulations, BEA-TT and EEAI shall regularly exchange information, provide access to all the records and documents in their possession, insofar as this is possible, coordinate their work schedules and co-operate to produce the published documents (communications with the parties concerned, compiling the investigation report).

4. MAIN AREAS TO BE EXAMINED

Without waiting for the outcome of the investigation, it would appear that the following areas must be examined in depth:

- safety of the systems: WWFE, ground-train radio;
- conditions for staff intervention: recovery loops, means available to stop a train despatched in error;
- working conditions: ergonomics of Control Posts, staff training, available documentation;
- safety management;
- previous incidents of the same type.

This list is not restrictive. It will change as the investigation progresses.

5. EXPENSES INCURRED AS A RESULT OF THE INVESTIGATION

BEA-TT and EEAI shall pay their own expenses (mainly the cost of the investigators and their travel expenses).

The cost of outside services shall be met by the organisation requesting such services. It may, however, be split between the two organisations, on the basis of a formula to be devised by the two organisations, on a service by service basis, if both organisations should request a service.

6. INTERFACE WITH NATIONAL AUTHORITIES AND OTHER PARTICIPANTS

BEA-TT and EEAI shall seek to facilitate effective working relations with the national police forces, judicial authorities and other national authorities during the investigation. In particular, each organisation shall make every effort to facilitate contact with those responsible for the investigations of the other national investigation organisation should this prove necessary for conducting the investigation.

Similarly, the two investigation organisations shall seek to facilitate relations with other organisations (railway companies for example) for the investigation organisation in the other country.

7. PREROGATIVES OF THE INVESTIGATORS AND CONFIDENTIALITY

The BEA-TT and EEAI investigators shall operate in their own countries with the prerogatives granted to them under the national plan, in compliance with national regulations, particularly as regards confidentiality.

Clearly, therefore, this Protocol shall confer no power upon the investigators outside their own national territory. Each organisation shall facilitate the participation of their partner's investigators in the investigations that it conducts in its own country in accordance with national law.

The limit of territorial jurisdiction of each investigation organisation lies at the border between the two countries, i.e. DM 203.756 from Thionville and DM 0 in the direction of

Bettembourg.

8. MANAGING COMMUNICATIONS AND RELATIONS BETWEEN THE PARTIES CONCERNED

The communications (such as press releases or reports to the Government) produced by one organisation must be submitted to the other organisation for approval before their use or distribution. In the event of difficulty, BEA-TT and EEAI shall together compile a joint formulation.

9. INVESTIGATION REPORTS AND RECOMMENDATIONS

The following provisions shall apply to:

- final reports;
- interim reports;
- emergency recommendations[1].

The joint investigation report shall be compiled jointly and must be approved by both organisations. In the event of a difference of opinion between the two investigation organisations, the matter shall be brought before the BEA-TT Director and the EEAI Chairman who will try to find a common solution. If it cannot be found:

- the text of the report relating to the contested point shall be drawn up by BEA-TT and EEAI's point of view shall be summarised in an annex;
- the existence of this disagreement shall be mentioned in the introduction and in the conclusions.

The structure and presentation of the report shall be agreed upon by the parties.

BEA-TT and EEAI shall jointly sign the copy of the report to the recipients referred to in Art. 23.2 of Directive 2004/49/EC.

BEA-TT and EEAI, for their part, shall each distribute the report to the recipients they consider appropriate in accordance with the national regulations in force.

Any information received by one organisation about following up recommendations shall be sent, for information, to the partner organisation.

BEA-TT and EEAI shall seek agreement on compiling the emergency recommendations that they consider must be published during the investigation.

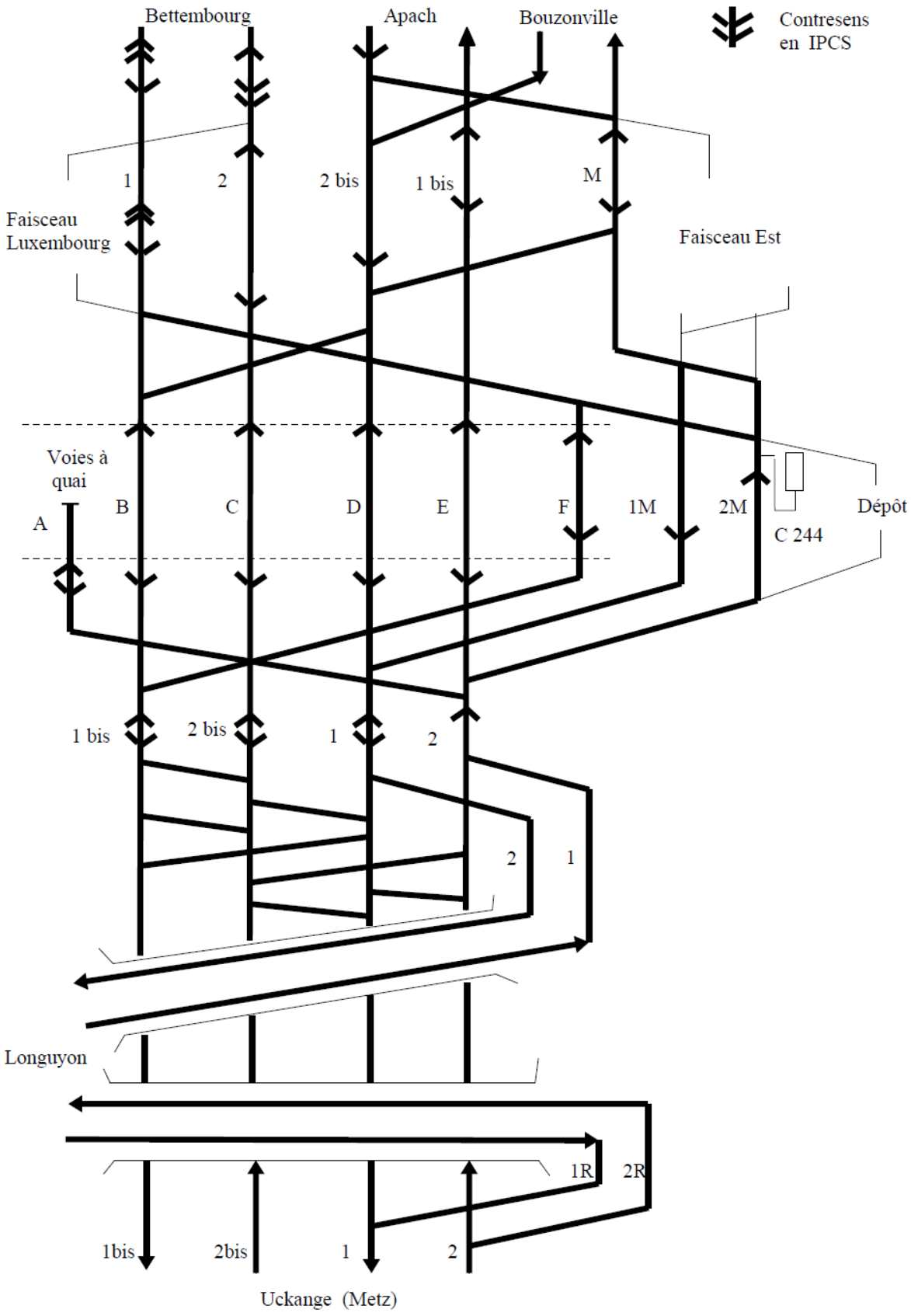
10. ANNUAL REPORTS

[1] During the investigation, it may prove essential for one or both of the investigation organisations to make one or more recommendations, without waiting for the publication of an interim report or the final report. This or these recommendations shall be called: emergency recommendations.

Under Directive 2004/49/EC and national legislation, BEA-TT and EEAI shall cover the investigation in their own annual reports[1], after having submitted the text regarding this investigation to the other investigation organisation for comment.

[1] Reports to the European Railway Agency and the National Safety Authorities.

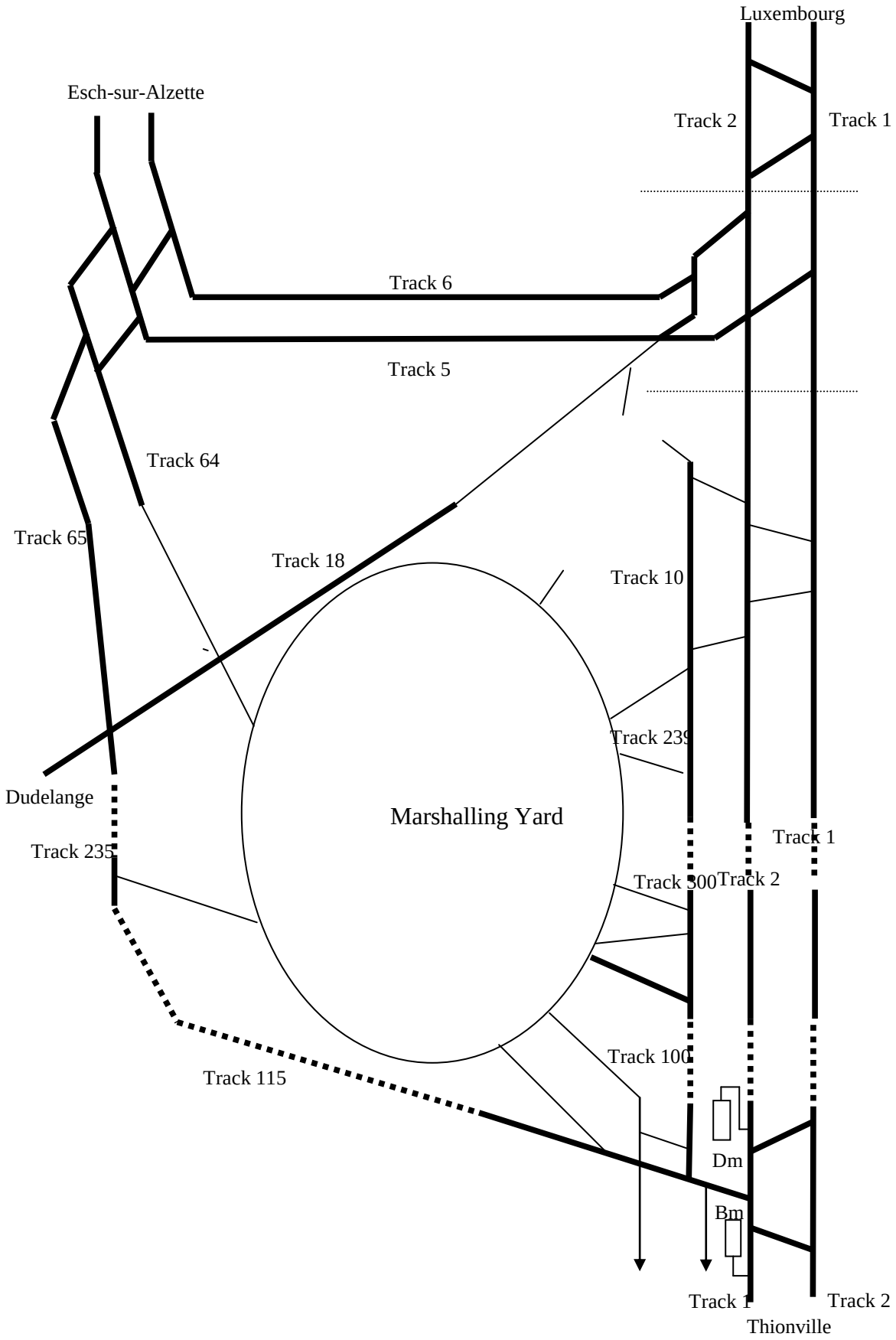
Annex 3a: Diagram of the Systems at Thionville Station



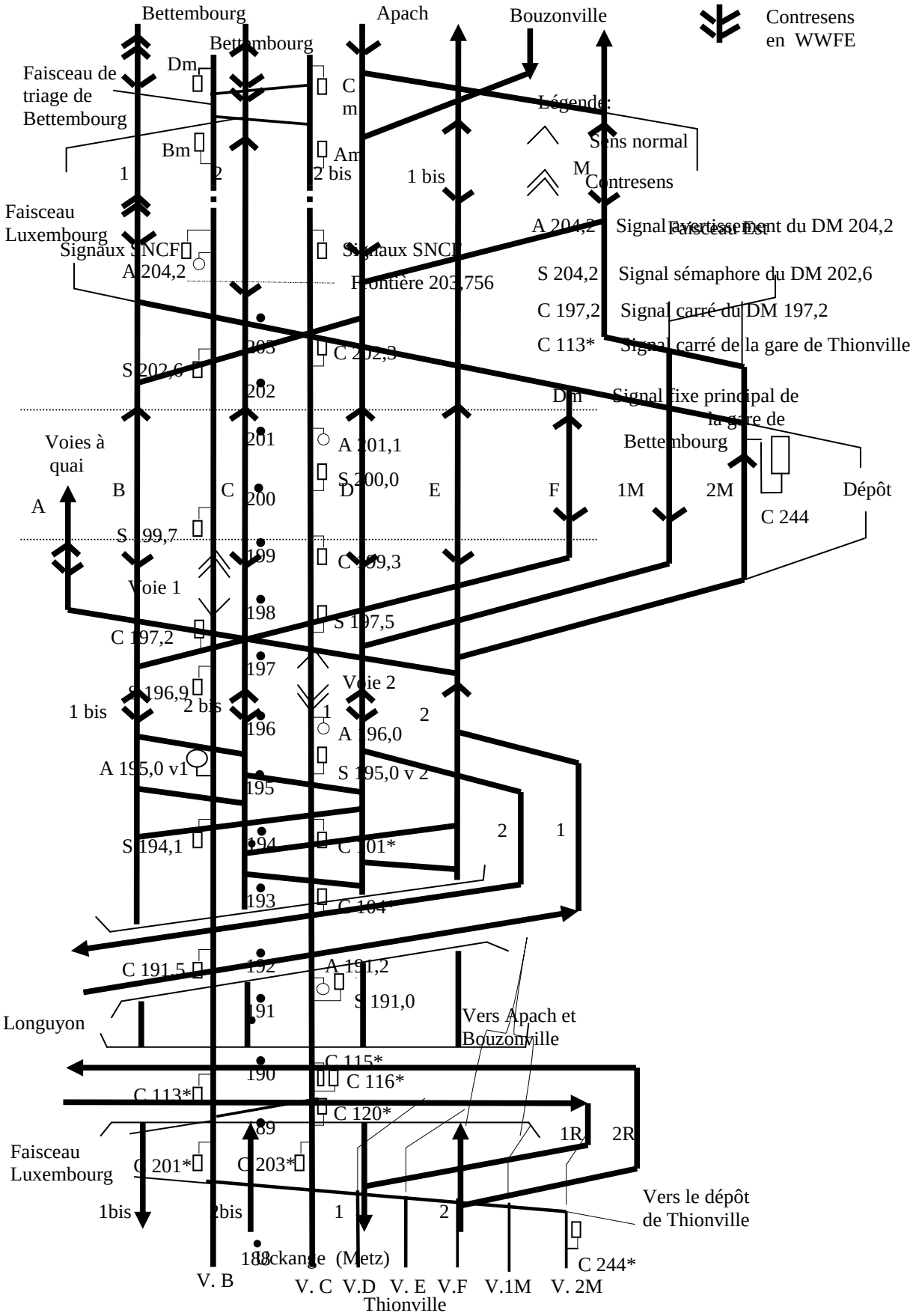
Key to Annex 3a

FRENCH	ENGLISH
Contresens…	WWFE wrong-track working
Faisceau Luxembourg	Luxembourg fan of tracks
Faisceau Est	East fan of tracks
Voies à quai	Platform tracks
Dépôt	Yard

Annex 3b: Diagram of the Systems at Bettembourg Station



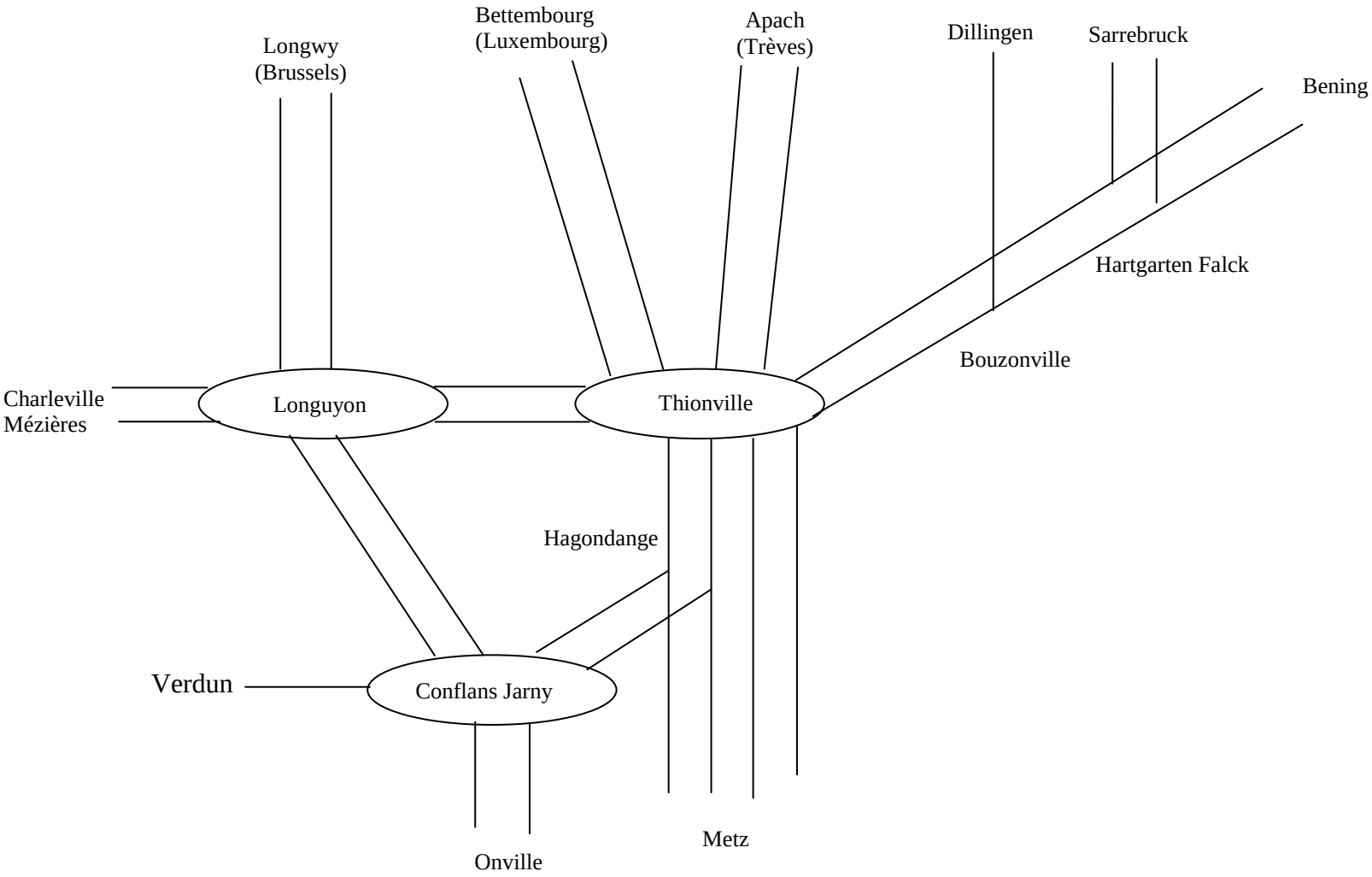
Annex 3c: Diagram of Systems on the Bettembourg-Thionville Section of Line



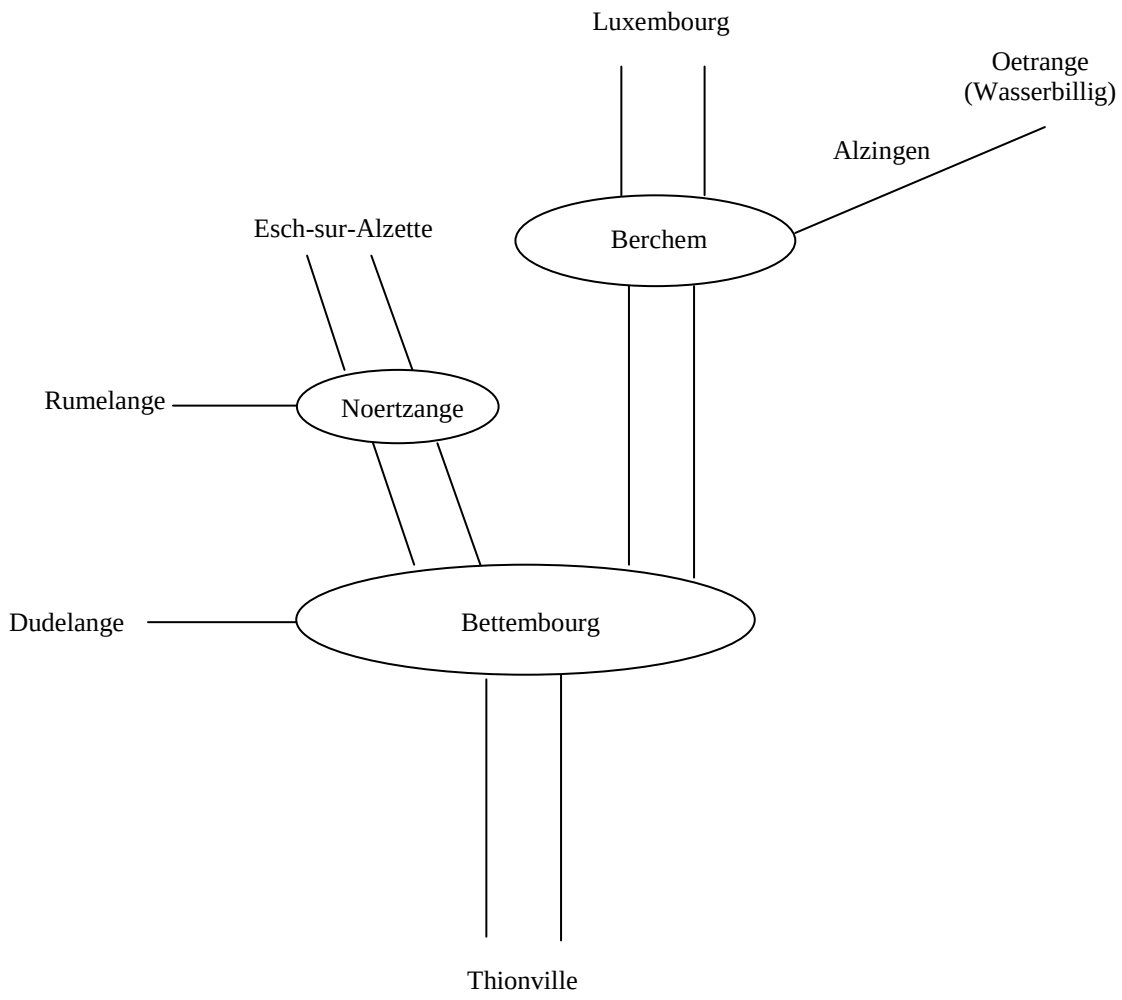
Key to Annex 3c

FRENCH	ENGLISH
Faisceau de triage de Bettembourg	Fan of tracks at the Bettembourg Marshalling Yard
Signaux SNCF	SNCF Signals
Frontière	Border
Voie	Track
Vers Apach et Bouzonville	Towards Apach and Bouzonville
Faisceau Luxembourg	Luxembourg fan of tracks
Vers le depot de Thionville	Towards Thionville Yard
Légende:	Key: Normal direction Wrong-track working A 204.2 Warning signal at DM 204.2 S 204.2 Semaphore signal at DM 202.6 C 197.2 Square signal at DM 197.2 C 113* Square signal at Thionville Station Dm Main Fixed Signal at Bettembourg Station

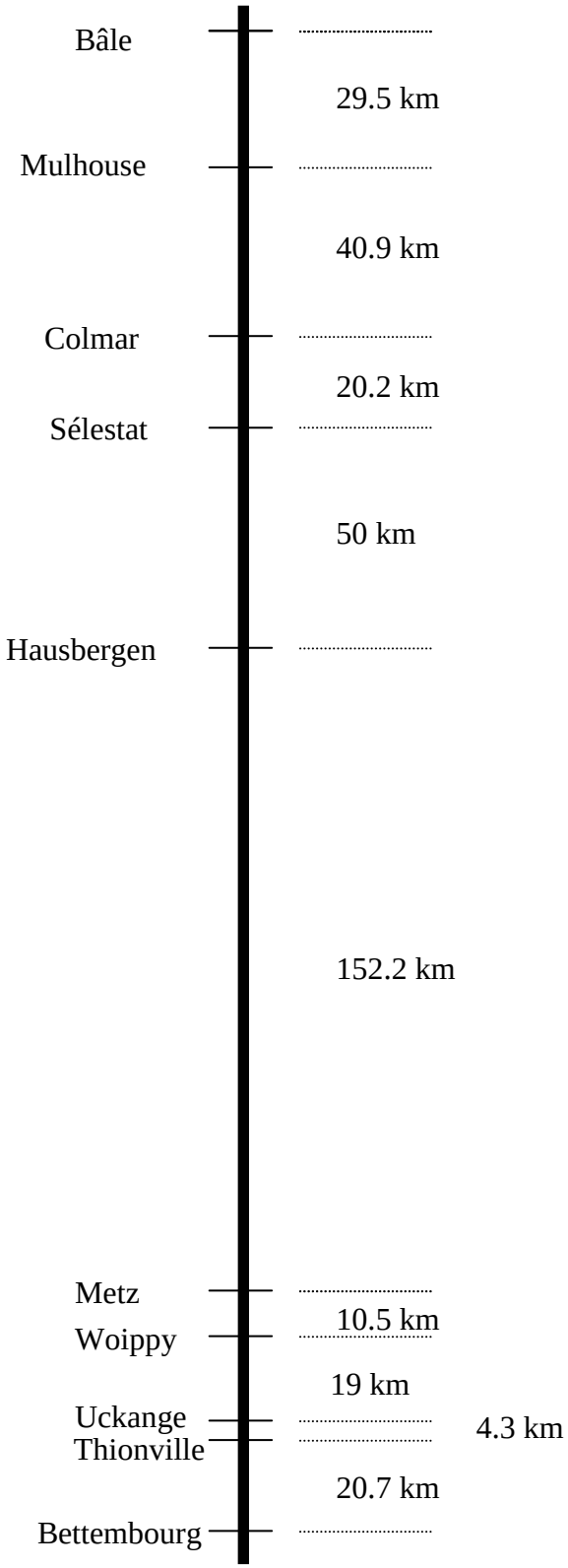
Annex 3d: Diagram of the Thionville Star



Annex 3e: Diagram of the Bettembourg Star



Annex 4: Section of Line from Bâle to Bettembourg



Movement of RET 837617
Length of train: 81.1 m.
Signals not intended for Train 837617 are shown in italics

Luxembourgish Distance Markers have been translated into French Distance Markers

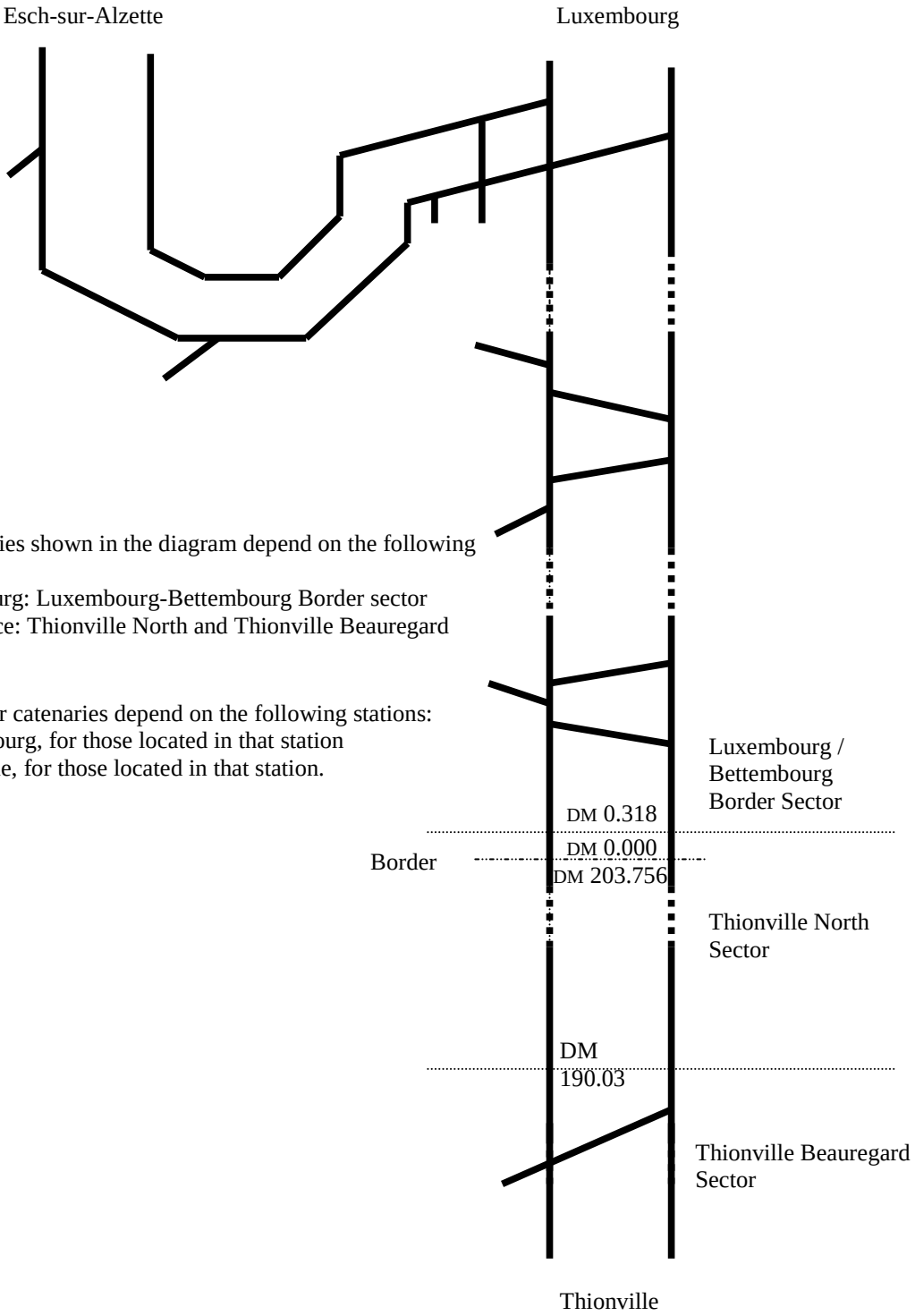
DM (Luxembourgish DM)	***System***	***Train Speed***	***Time that front end of train passed by***	***Time that back end of train passed by***
211.066 (7.310)	Axv Signal	127	11h37'09"	
209.821 (6.065)	Xv 1/2 Signal, Aqv	123	11h37'44"	
208.966 (5.210)	Passenger Station Line	121	11h38'10"	
208.528 (4.772)	Qv1/2 VB2 Signal	120	11h38'25"	
208.116 (4.360)	Signal at DM 4.360	118	11h38'36"	
207.943 (4.187)	Signal at DM 4.187	119	11h38'42"	
206.829 (3.073)	Adm Signal	116	11h39'16"	
205.625 (1.869)	Dm 1/2 (stop) Signal	0	11h40'57"	
205.625 (1.869)	Dm 1/2 (departure) Signal	0	11h42'11"	
205.605(1.849)	Dm1/2 (pass through) Signal	12	11h42'23"	
204.925 (1.169)	*Bm1/2 Signal*	70	*11h43'26"*	
204.246 (0.490)	A 204.2 Signal	76	11h44'01"	
203.756 (0.000)	Border		11h44'24"	
203.632	*Abm Signal*			
203.720	**Collision**	78	11h44'27"	
203.600		78		

Annex 6: Movement of Freight Train 45938 on 11 October 2006

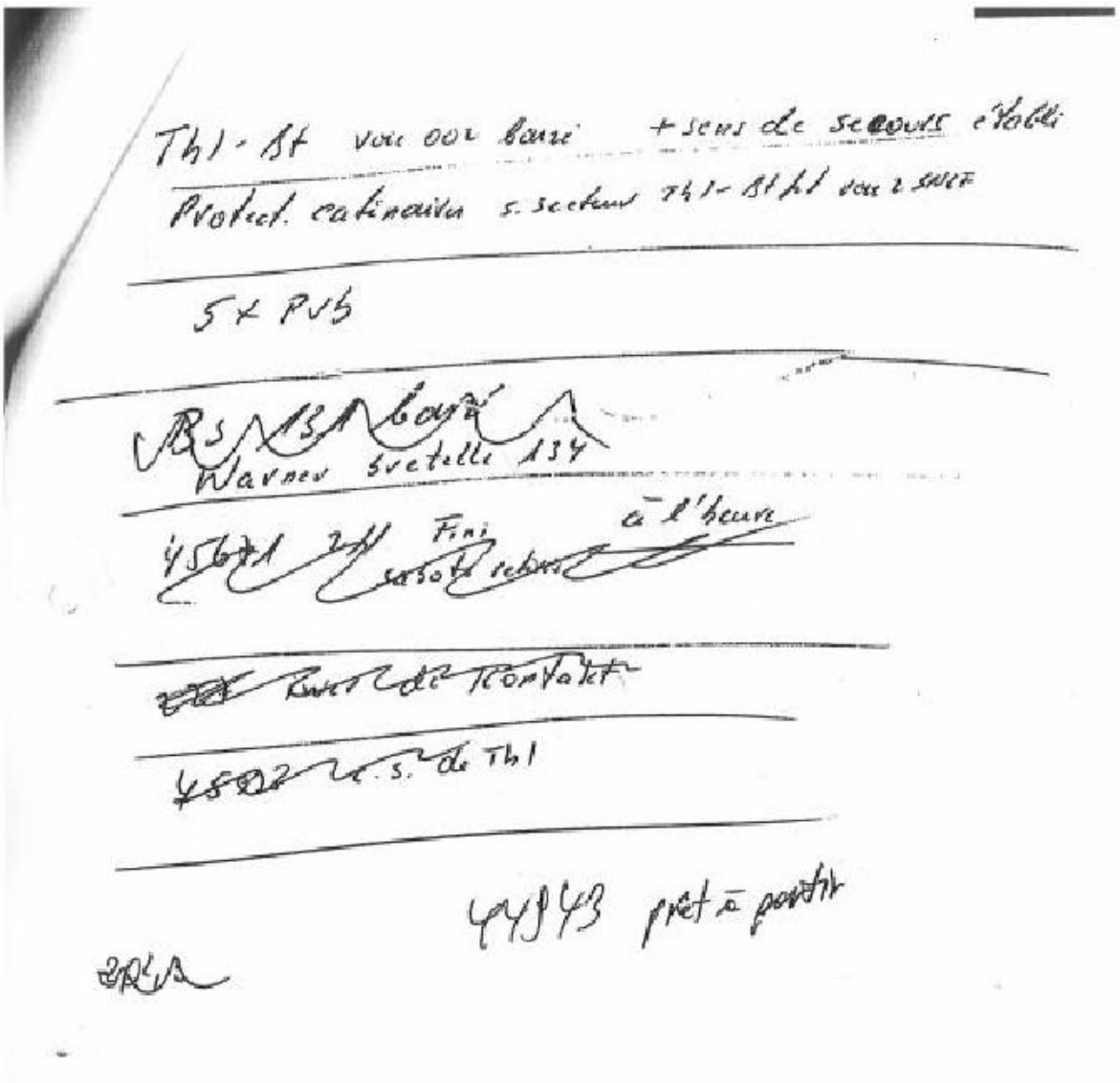
Movement of Freight Train 45938
Length of train, including locomotive: 363 m.
Signals not intended for Train 45938 are shown in italics

DM	***System***	***Train Speed***	***Time that front end of train passed by***	***Time that back end of train passed by***
188.00	C 244 Signal (departure)	0	11h28'31"	
189.638	*Signal C 113*	62	11h31'35"	11h31'46"
190.0	TIV 60 Announcement Signal (for works)	63	11h31'56"	
191.592	*Signal C 191.5*	58	11h33'33"	11h33'55"
191.600	TIV 60 Execution Signal (for works)			
194.187	*Signal S 194.1*	58	11h36'11"	11h36'33"
194.900	Hettange-Grande			
195.045	A 195.0 ^{V1} Signal		11h37'05"	
196.969	*Signal S 196.9*	58	11h39'01"	11h39'24"
197.200	C 197.2 Signal		11h39'16"	
198.4	R temp Signal	60	11h40'27"	
199.759	*Signal S 199.7*	87	11h41'36"	11h41'51"
201.114	Zoufftgen ex Passenger Station	88	11h42'40"	
202.604	*Signal S 202.6*	89	11h43'40"	11h43'55"
203.632	Abm Signal	83	11h44'23"	
203.720	**Collision**	79	11h44'27"	
203.756	Border			

Annex 7: Bettembourg – Thionville Diagram of electric traction systems



Annex 8: The A4 sheet of "scrap paper"



Key to Annex 8

FRENCH	ENGLISH
Thl-Bt...	Thionville-Bettembourg track 002 closed + emergency direction set
Protect…	Catenary protect. on Thionville-Bettembourg sector SNCF Track 2
5 (S?) x Pvb	
~~Bs 131...~~	~~Bs 131 closed~~ ~~Warner? brace? 134~~
~~45671...~~	~~45671 Zoufftgen? Finished on time~~ ~~caps? removed?~~
~~227...~~	~~227? Kontakt?~~
~~4518...~~	~~4518 on wrong-track working from Thionville~~
~~202.3~~	~~202.3~~ 44943 ready to go

SAFETY MANAGEMENT SYSTEM

Annex 3 to Directive 2004/49/EC

1. *Requirements applicable to the Safety Management System*

The Safety Management System must be documented in all its parts and describe in particular the division of responsibilities within the organisation of the infrastructure manager or railway company. It describes how the Management controls the various levels of the organisation, how the personnel and its representatives on all levels are involved and how the constant improvement of the safety management system is assured.

2. *Essential elements of the Safety Management System*

The essential elements of the Safety Management System are as follows:

a) a safety policy approved by the General Manager of the organisation and communicated to the entire staff;

b) the qualitative and quantitative objectives of the organisation as regards maintenance and safety improvement as well as the plans and procedures designed to achieve these objectives;

c) the procedures adopted to meet the existing, new and amended technical and operational standards or other provisions defined:

— in the TSIs *[Technical Specifications for Interoperability]*
or
— in the national regulations referred to in Article 8 and Annex II,
or
— in other pertinent regulations,
or
— in the decisions of the authority,

and the procedures adopted to ensure compliance with these standards and other provisions for the entire life cycle of the equipment and activities;

d) the procedures and methods regarding risk assessment and implementing measures to control risks whenever a change in operating conditions or the introduction of new equipment involves new risks for the infrastructure or operation;

e) staff training programmes and systems whereby the skills of these staff are kept up to date and the tasks are appropriately performed;

f) provisions providing sufficient information within the organisation and, if necessary, between organisations working on the same infrastructure;

g) procedures and formats for documentation that provides information on safety and determines the procedure for checking the layout of vital safety information;

h) procedures guaranteeing that accidents, incidents that have occurred or been near misses

and other dangerous events are reported, investigated and analysed, and that the necessary preventive measures are adopted;

i) plans for action, warning and providing information in the event of an emergency, adopted with the approval of the competent public authorities;

j) provisions enabling a regular internal audit of the Safety Management System.

Annex 10: Detailed chronology of the accident

As from 8h56, on 11 October 2006, the track in the Thionville to Bettembourg direction was closed to traffic, other than works trains, to enable track repair work to be carried out on French territory.

From that moment, traffic in both directions between the Bettembourg and Thionville Control Posts was made to run on the Bettembourg to Thionville track only, by using Wrong-track Working Fixed Equipment (WWFE).

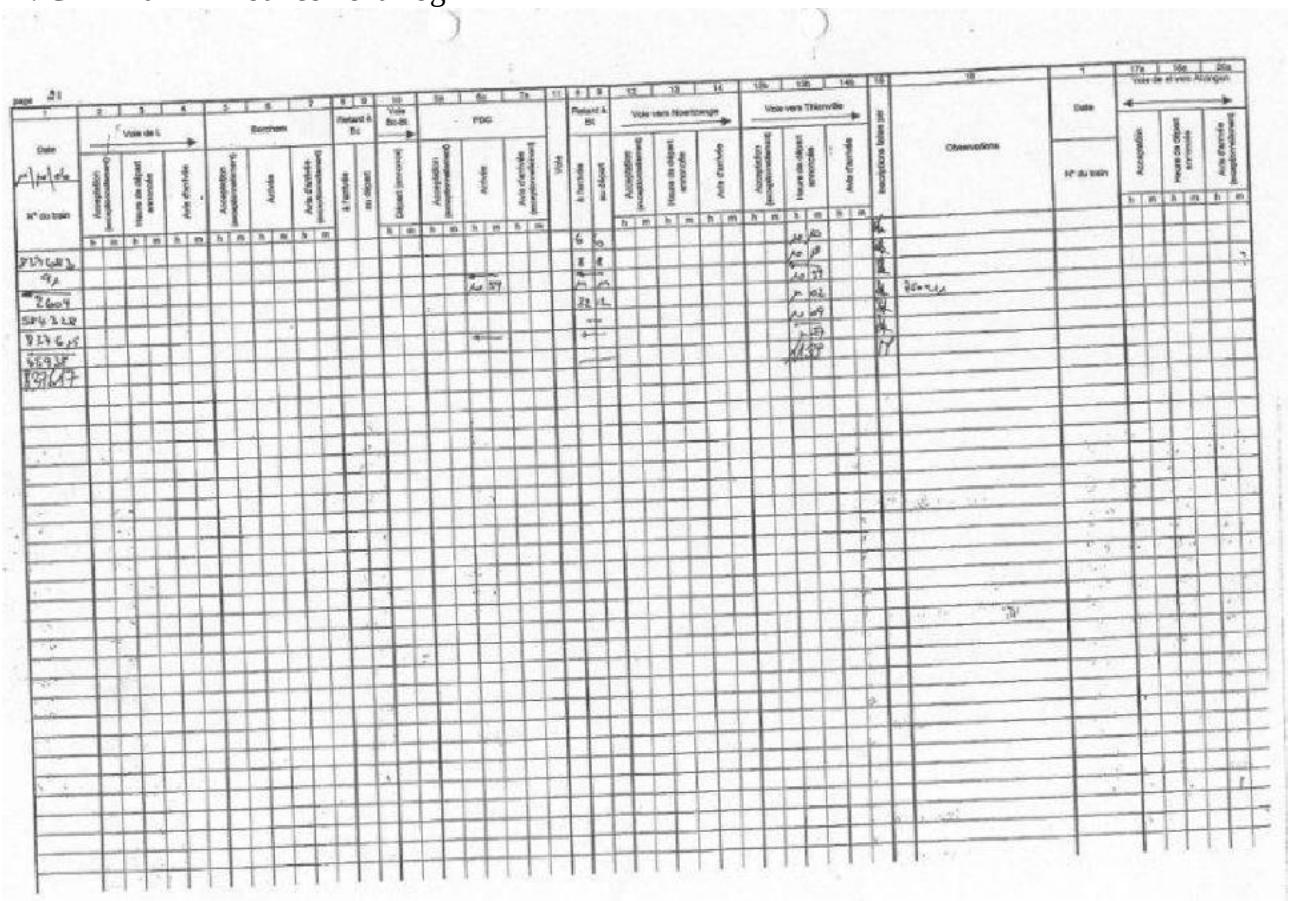
The table below describes the most likely chronology of the events that occurred that day, as far as the investigators were able to reconstruct it.

Time	Event
08h56	Track 2 closed and works begin
10h10	Train 837683 departs from Bettembourg to Thionville, 4 minutes late.
10h18	Train 91 departs from Bettembourg to Thionville, 6 minutes late.
Around 10h 30	Thionville Traffic Operator 1 agrees with the Bettembourg Morning Train Announcer to run: 1. High-Speed Train TGV 2604 from Thionville to Bettembourg (on wrong-track working) 2. Train 584328 (CFL No.)/750011 (SNCF No.) from Bettembourg to Thionville (in the normal direction) then to decide later about the departure from Thionville of the delayed Freight Train 45938.
10h33	Arrival of Train 837683 at Thionville, 15 minutes late.
10h36	Arrival of Train 91 at Thionville, 13 minutes late.
10h39	Departure of Train 2604 from Thionville on wrong-track working, 6 minutes late.
Around 10h41	**Arrival of Freight Train 45938 at Thionville Station about 5 minutes early**
10h59	Arrival of Train 2604 at Bettembourg, 14 minutes late.
11h00	The Morning Train Announcer announces 750011.
11h02	Train 750011 departs from Bettembourg, 1 minute early.
11h07	The Morning Train Announcer announces the departure of RET 837615 (normal direction). Departs at 11h09. Then agrees with Traffic Operator 1 to run Freight Train 45938 as soon as this RET arrives at Thionville.
11h09	RET 837615 departs from Bettembourg on time.
11h15	Morning Switch Tender 1 hands over to Morning Switch Tender 2 and leaves Bettembourg CCP without waiting for his relief.
11h17	Train750011 arrives at Thionville, 3 minutes late.
11h25	Evening Switch Tender 1 arrives at Bettembourg CCP and relieves Morning Switch Tender 2.
11h26	RET 837615 arrives at Thionville, 3 minutes late.
11h27	Traffic Operator 1 announces to the Morning Train Announcer the departure of the freight train on wrong-track working.

Time	Event
	Morning Switch Tender 2 leaves Bettembourg CCP
11h28	**The freight train from Thionville departs on wrong-track working after waiting approx. 45 minutes.**
	The Morning Train Announcer announces the departure of the freight train to the MCP Traffic Controller.
	The Evening Train Announcer arrives at the Bettembourg CCP
	The Evening Train Announcer relieves the Morning Train Announcer. During this handover, information concerning the freight train is passed on but we do not know what this information was ("train en route", "train announced", etc,) nor how it was passed on (verbally or by "showing the TAL").
11h30	The Evening Train Announcer relieves the Morning Traffic Controller. Sheet of scrap paper is passed on. The information passed on during this handover is not entered in the Duty Book. According to the statements, the freight train was mentioned but we do not know how. We do not know whether the entries on the sheet of scrap paper had been crossed out yet.
	RET 837617 departs from Luxembourg Station to Bettembourg on time.
11h34	The Evening Traffic Controller arrives at the Bettembourg CCP.
11h35	**The Evening Train Announcer relieves the Morning Traffic Controller and the Morning Train Announcer from the Evening Traffic Controller.** **The sheet of scrap paper is passed on.**
11h36	**RET 837617 passes through Berchem Station**
11h37	**Gong on VCP announcing the arrival of RET 837617 at Bettembourg**
	Evening Switch Tender 1 plots the route for RET 837617 to enter Bettembourg Station
	The Evening Train Announcer announces RET 837617 to Traffic Operator 1
	The Evening Train Announcer goes behind the VCP to find a menu
	Evening Switch Tender 1 tries to plot the route of RET 837617 to Thionville but the Dm MFS does not set to "track clear".
	The Evening Traffic Controller of the MCP notices an attempt to plot a route to Thionville on his VCP.
	The RET travels past the Bettembourg station building in the direction of Thionville without stopping.
	The Evening Train Announcer comes back with the menu and asks if anyone wants anything. He orders 2 lasagnes over the phone.
11h38	The Evening Switch Tender 1 informs the Evening Traffic Controller that he is unable to set the signal at 'proceed'.
	The Evening Traffic Controller looks at the VCP and notices that the route was interlocked, the last portion of checked track towards Thionville was "white" and the blue light was flashing.
	The Evening Traffic Controller asks the Evening Switch Tender to cancel the route then try again, but the signal still does not set at 'proceed' at the second attempt.
	The Evening Traffic Controller again looks at the portion of track towards Thionville on the VCP and concludes that there is a fault.
11h39	The Evening Traffic Controller asks to be put in touch with the driver of RET 837617 via the Ground-Train Radio (GTR).

Time	Event
11h40	**RET 837617 stops at the Dm MFS**
	The Evening Traffic Controller at the MCP sees that a route is still plotted towards Thionville on his VCP.
	Ground-train radio contact is established between the RET and the CCP.
	The Evening Traffic Controller begins to dictate a Written Order A1 authorising the driver of RET 837617 to pass through the Dm MFS.
	The MCP Traffic Controller tries to contact the CCP Evening Traffic Controller on the telephone but the line is engaged (call for the Written Order in progress).
11h42	Dictation of Written Order completed.
	RET 837617 resumes its journey towards Thionville
	The Evening Traffic Controller calls the MCP Traffic Controller back and is told that the freight train is still under way and has not yet arrived at the marshalling yard.
	The Evening Traffic Controller gets back in touch with the Ground-Train Radio Exchange to call the driver of the RET but the exchange is engaged.
	The Evening Traffic Controller asks Evening Switch Tender 1 to issue a GTR warning (by pressing the button).
11h43	Evening Switch Tender 2 arrives at the CCP and Evening Switch Tender 1 tells him what is happening.
	The Evening Traffic Controller calls the GTR Exchange again but the line is still engaged.
	The Evening Traffic Controller calls Headquarters on the direct line to find out whether the GTR has in fact worked. But Headquarters tells him that no GTR alarm has been received.
	The Evening Traffic Controller asks Headquarters to issue a radio warning.
	A gong on the VCP indicates that the freight train has entered the Bettembourg Station area.
11h44	The Evening Train Announcer asks Thionville Traffic Operator 1 where the freight train is. He replies that the train “must be at the border”.
	The operator at the GTR Exchange issues a general GTR call.
	Evening Switch Tender 2 tries to cut the catenary power by pressing the specific pushbutton.
11h44’27"	**Collision**
	Headquarters asks the Substation Unit Regulator (SUR) to cut the power to the main tracks.
	The power to the tracks is cut.
11h45	The primary “finishing” site supervisor reports on the site radio that an accident has happened.
	The Evening Train Announcer calls Traffic Operator 1 to explain the situation.
11h55	The Thionville Traffic Controller tries to contact the site supervisors working on this section of line.
12h05	The Bettembourg CCP is informed of the collision by the Thionville Control Post

Annex 11: CFL Train Announcement Log



Annex 12: Written Order A

Annexe 2
§ 07.02

CFL

ORDRE ECRIT
SCHRIFTLICHER BEFEHL **A** N° /Nr 001

pour/für
train/parcours en voie barrée
Zug/Sperrfahrt .....

peut franchir en position d'arrêt/fährt vorbei am Halt zeigenden

le SFP d'entrée
Einfahrsignal .....

le SFVb
Sperrsignal ...../...../.....

le SFP d'itinéraire
Zwischensignal .....

le SFVb
Sperrsignal ...../...../.....

1 le SFP de sortie
Ausfahrsignal .....

le SFVb
Sperrsignal ...../...../.....

de la gare/du secteur
des Bahnhofs/des Bahnhofsteils .....

le SFP intermédiaire
Blocksignal .....

du poste d'exploitation
der Betriebsstelle .....

2 partira de la gare/du secteur
fährt im Bahnhof/Bahnhofsteil .....
sans SFP
ohne Hauptsignal aus

3 entrera en gare/au secteur
fährt in den Bahnhof/Bahnhofsteil .....
sans SFP
ohne Hauptsignal ein

4 doit s'arrêter devant le PN ..... du PK ..... ; continuer, si la protection du PN est assurée
hält vor BU ..... in Km ..... ; weiterfahren, wenn BU gesichert ist

5 Manoeuvres autorisées au-delà du signal fixe « Halte pour manoeuvres » jusqu'à ..... h sur la voie d'entrée (normale/de la contre-voie/du contre-sens) de la direction de .....
Rangieren im Bahnhof ..... auf (richtigem/falschem/Gegen-) Einfahrgleis aus Richtung ..... über die Rangierhalttafel hinaus bis ..... Uhr erlaubt

6

le
....., den ..../..../19...
à h min
um ..... Uhr ..... Min
Le chef de circulation, - der Fahrdienstleiter
.....

REÇU / ERHALTEN
Nom/signature
Name/Unterschrift .....
Fonction
Dienststellung .....
N°/Nr .....

Marquer les cases utilisées en encadrant par un cercle les numéros correspondants. Biffer obliquement les mentions sans application dans les cases marquées.
Gültige Randnummern umrahmen! Nichtzutreffendes im umrahmten Teil schräg streichen!

017.74.001-0

Key to Annex 12

CFL	WRITTEN ORDER **A** **No. 001** for train/route on a closed track …..……	

permission is hereby granted to pass through the following signals set at 'stop':		
1	entry MFS……	Fixed Holding Signal (FHS) ..../...../.....
	route MFS……	FHS……./……../…….
	exit MFS……..	FHS……./……../…….
from the..... station/sector		
	interim MFS.....	from the.....operating post
2	the train shall leave from the…….station/sector, without an MFS	
3	the train shall enter the…….station/sector, without an MFS	
4	the train shall stop at LC……..at DM…….: continue if protection of the LC is assured	
5	Shunting permitted beyond the fixed "Stop for Shunting" signal until…….(time) on the entry (normal/counter-track/wrong track working) track from the direction of……	
6		

Date……/….19… at h min The Traffic Controller ……..	**RECEIVED** Name/signature…… Position…… No……

Mark the boxes used by circling the corresponding numbers. Cross out the inapplicable references in the marked boxes.

§12. OPERATING PROCEDURE FOR CUTTING OFF THE POWER

.....

A. CUTTING OFF THE POWER IN THE EVENT OF AN EMERGENCY

Employees' Duties

02. Any employee who witnesses an incident that requires an emergency power cut-off (06.38.02) of a contact line must, via the alarm circuit or by any other means that he considers the quickest, immediately order the Substation Unit Regulator (SUR) to cut off the power.

This rule may be waived in the following cases:

1) If the employee knows for certain that the section of contact line is powered by a 25 000 volt switch and if this switch can be reached more quickly than the closest telephone, then the power may be cut by the employee without the order of the SUR by manually throwing the switch.

2) If the employee knows for certain that the section of contact line is powered by a switch remotely controlled from the local service and if the authorised employee of the local service can be reached more rapidly than the SUR, then the emergency power cut-off may be ordered by the authorised employee of the local service.

3) If the employee knows for certain that the section of contact line is powered by an isolating switch that can be thrown without first turning off the power on the corresponding sub-sector (06.10.21) and if the conditions stipulated under (06.10.21) are met, then the employee may cut off the power by throwing the isolating switch without an order from the SUR.

If the power is cut off in an emergency as a result of one of the above 3 actions, the SUR must be informed as soon as possible. From that moment the SUR shall take control of operations.

Emergency cut-off order

03. The employee shall order an emergency cut-off by saying:

"emergency power cut-off ", indicating:
- if it involves a track on the open line, the distance marker and the nearby operating posts,
- if it involves a station track, the name of the station.

Furthermore, he shall give the name of the sector concerned, if he knows it.

After having given the emergency cut-off order, the employee must remain on the telephone

to receive confirmation that the power has been cut.

Cutting off the power

04. As soon as the order for an emergency power cut is received, the SUR must immediately cut off the power on the sector in question by opening and locking the circuit breaker switch.

Protection

05. The SUR shall then apply the protection measures referred to in the Blue Instructions.

.....

(§38) **MEASURES TO BE TAKEN IN THE EVENT OF INCIDENTS ON ELECTRIFIED LINES**

.....

Incidents requiring an emergency power cut-off

Paragraph 2g

02. An emergency power cut off must be performed in accordance with (06.12.02 to 08):

- .....

- **particularly**, when

.....

g) it is necessary, failing other means, to stop electric movements (trains and shunting operations) e.g.: unexpected obstacle, track fault, train travelling under dangerous conditions, runaway, unscheduled departure, etc.

List of sheets indicating an operating mode to be adopted

- Reversing, by its own means, a train that has stopped in Interval BM-113.
- Reversing, by its own means, a train that has stopped in Interval AM-101.
- The post for entering wrong-track working on Track 1 (Thionville) is unable to set wrong-track working.
- The post for entering wrong-track working on Track 2 (Bettembourg) is unable to set wrong-track working.
- Switching the Interval back to the normal direction (Track 1) cannot be achieved.
- Switching the Interval back to the normal direction (Track 2) cannot be achieved.
- Measures to be adopted to run trains when wrong-track running on Track 1 cannot be set.
- Measures to be adopted to run trains when wrong-track running on Track 2 cannot be set.
- Measures to be adopted to run trains when the normal direction on Track 1 cannot be set.
- Measures to be adopted to run trains when the normal direction on track 2 cannot be set.
- Accidentally switching off the EWTW or LWTW *[Entering/Leaving Wrong Track Working]* Panel on the Thionville side.
- Accidentally switching off the FWTW/NA *[Fixed Wrong-Track Working until Next Announcement Point]* Panel on the Bettembourg side.
- Shunting a train with the aid of a breakdown traction unit despatched from behind (train requiring assistance on Track 1).
- Shunting a train with the aid of a breakdown traction unit despatched from behind (train requiring assistance on Track 2).
- Breakdown assistance from the front (Track 1).
- Breakdown assistance from the front (Track 2).
- Reversing a train with the aid of a breakdown traction unit despatched from behind (Track 1).
- Reversing a train with the aid of a breakdown traction unit despatched from behind. (Track 2)