FINAL REPORT ON
SERIOUS RAILWAY ACCIDENT NO 0054/2013
OF 24.07.2013
NEAR SANTIAGO DE COMPOSTELA STATION (A CORUÑA)

The purpose of investigating railway accidents is to establish their causes and the circumstances in which they occurred, with a view to preventing recurrence in the future, and to draw up suitable recommendations for reducing the risks of railway accidents. In any event, this investigation is not concerned with apportioning blame or responsibility and is independent of any judicial inquiry.
(Royal Decree 810/2007, of 22 June 2007, Title III, Article 21)

1. SUMMARY

A serious accident occurred at 20:41 hours on 24 July 2013, at PK 84+413 of line 082 from Coto da Torre branch (Ourense) to A Grandeira branch (A Coruña), kilometre point 85.0, near Santiago de Compostela station (A Coruña). This was due to derailment of all vehicles of long-distance passenger train 150/151, belonging to Renfe Operadora. This had come from Madrid-Chamartín and was bound for Ferrol.

The entire trainset was derailed causing catastrophic personal injuries and material damage. There were 80 fatalities and many seriously injured.

Conclusion: The cause of the accident was excessive speed of the train (travelling at 179 km/h) on the curve leading in to A Grandeira branch (the Angrois curve, speed limit 80 km/h). The driver was in breach of the requirements of the timetable of train 150/151 and of the Table of Maximum Speeds for line 082.

As a contributory cause, it is noted that that the driver's attention was reduced when he answered a service telephone call on the train from the train manager, which caused him not to brake sufficiently to reduce speed before entering that curve.

Recommendations:

Final addressee	Number	Recommendation
Adif	54/13-1	Make it a rule that all speed reductions, from a certain deceleration onwards, must be marked at the trackside by fixed speed limit signs.
Adif	54/13-2	For these situations (significant speed reductions), arrange to set up balises progressively which may help to control the speed of trains, so that they brake in case the speed limit for entry into the block section is lowered. Therefore, implement the necessary ASFA Digital (Automatic Braking and Announcement of Signals) systems.
Renfe Operadora	54/13-3.1	Reinforce the procedures set in the Renfe Operadora SMS so that safety-related defects detected at any level are referred to the departments with the prescribed function of analysing and considering them, thereby assuring effective preventive management.

Dirección General de Ferrocarriles (National Directorate-General of Railways DGF)	54/13-3.2	The national railway safety authority will ensure that Recommendation 54/13-3.1 is extended to the other railway undertakings.
DGF	54/13-4	The national railway safety authority should consider whether to reconvene the joint traffic safety committees, including active input from representatives from Adif and the railway undertakings, and under the authority's supervision. These committees can analyse risk situations that can derive from the interaction between driving, vehicle and track.
DGF	54/13-5	The process of commissioning new railway lines and alternative stretches should include a specific risk assessment. This should include identification and management of possible hazards driving from the interaction between subsystems, in normal and degraded operating conditions, and their links with the driving and traffic staff involved when a train is travelling from beginning to end of the line or alternative stretch, and its connection to the existing network. Also analyse the viability of the layout at the various construction stages. In justified cases, promote the application of such assessments to lines which are in service.
DGF	54/13-6	Make the necessary arrangements for communications with driving staff in the cab to take place safely and avoid possible distractions. Make these arrangements part of the general regulations and pass them on to the railway undertakings for inclusion in their safety management systems.
Renfe Operadora	54/13-7.1	Promote the progressive implementation of an audio recording system in drivers' cabs. Assess the feasibility of adding a video recording system as well.
DGF	54/13-7.2	The national railway safety authority will ensure that Recommendation 54/13-7.1 is extended to the other railway undertakings.

2. BASIC SEQUENCE OF EVENTS

2.1. SEQUENCE OF EVENTS

2.1.1. Details

Date/time: 24.07.2013/20:41

Place: PK 84+413, 3.6 km from Santiago de Compostela station

Line: 082 Coto da Torre Branch - A Grandeira Branch, km point 85.0

Municipality: Santiago de Compostela (Angrois District)

Province: A Coruña

Autonomous Community: Galicia

2.1.2. Description of events

The events occurred at 20:41 hours on 24 July 2013, at PK 84+413 of Line 082, Coto da Torre branch - A Grandeira branch, km point 85.0, near Santiago de Compostela station.

The Alvia Class 730 long-distance passenger train 150/151, run by Renfe Operadora, consisted of 13 vehicles. It was coming from Madrid-Chamartín and bound for Ferrol (A Coruña). After making a scheduled stop at Ourense station with changeover of driver, it continued on its route via line 082 (known as the Ourense – Santiago line). It departed from Ourense with a four minute delay.

The train covered the first 78 km of the line at an approximate speed of 200 km/h. The ASFA Digital system was working. All signals on its path indicated 'track clear'.

About 6000 m (PK 78+280) before the start of the curve leading to the A Grandeira branch (at PK 84+228, where speed of travel is restricted to 80 km/h), the driver answered a service call from the train manager (guard) on the corporate mobile telephone.

The trainset continued along track 1 and passed caution signal E´7 (PK 80+619) of the A Grandeira branch. After noting that the signal was indicating 'track clear' to proceed on the main track, and at a speed close to 200 km/h, the driver continued the telephone call with the train manager. This probably distracted his attention, and he did not start braking in time to adjust to the prescribed speed for the radius 402 m curve located from PK 84+228.

The last sound of the telephone conversation was recorded very close to signal E7 at the start of the branch (PK 84+176), which also indicated that the track was clear (100 seconds had passed since the start of the call). This is when the emergency brake was applied, as the signal was passed at 195 km/h.

Train 150/151 was already very near the start of the curve (PK 84+228). It derailed on the curve, 185 metres from the start, at PK 84+413, while travelling at 179 km/h.

Tren 150-151	Train 150-151

The three coaches of the trainset remained derailed and off line 1 on which they had been travelling.

The first three were separated from the next two coaches by about 10 m, while those two were about 30 m away from the rest. The rear generator car caught fire. One of the coaches of the rear rake (the eighth) was pushed over the containing wall on to a nearby road.

Both the main tracks of line 082 were blocked at the A Grandeira branch. A third track which passes next to the others at that point, but belongs to line 822 (Zamora - A Coruña), was also treated as out of service, to facilitate the work of rescue and repair, even though this track was unaffected by the accident.

There was substantial material damage, mainly to rolling stock. Track 2 was not reopened to traffic until 26 July, while track 1 remained closed until 29 July.

2.1.3. Decision to open the investigation

The Head of Accident Investigations of the Traffic Safety Directorate of Adif (the Spanish railway infrastructure administrative body) informed the secretary of the Railway Accident Investigation Commission (CIAF), by telephone call at 21:11 hours on 24 July 2013, that the accident now under investigation had occurred. He also sent SMS messages to the other CIAF staff at 21:18.

At the same time the Ministry of Development Sub-Secretariat also telephoned the CIAF Chairman and Secretary to inform them of the event and its gravity. They both immediately set out for Santiago de Compostela. The Secretary arrived at the accident scene the same night. The Commission's rail infrastructure expert joined him after midnight. They immediately began analysis of what had happened with Adif and Renfe Operadora staff. Early next morning, the CIAF Chairman and one of the technical investigators arrived at the scene of the accident and joined the team already at work.

Article 21 et seq. of the Regulation on Traffic Safety on the Public Rail Network, which was approved by Royal Decree 810/2007 of 22 June 2007 (BOE No 162, of 7 July 2007), assign competence for the investigation of railway accidents and incidents to the Railway Accident Investigation Commission.

In accordance with the provision of Article 21 of that Regulation, and as defined in Article 2, it is mandatory to investigate what has happened when the accident is serious.

Under Article 23.1 of that Regulation, and in view of the exceptional features of this accident, the CIAF Chairman passed a resolution on 26 July 2013 appointing the CIAF Secretary as Chief Investigator. The Secretary, who has signed this report, then worked with the two investigators belonging to this Commission.

The members of the investigating team were the Secretariat technician referred to, plus:

- the Traffic Safety Director of Adif, who delivered his personal report on 6 November 2013, signed, with due authority, by the Sub-Director of Rolling Stock and Traffic Safety Management and the head of accident investigation; and

- the Traffic Safety Director of Renfe Operadora, who delivered his personal report on 5 November 2013, signed jointly with the head of the accident technical investigation area.

INECO, S.A., a publicly owned company, acting within the framework of an agreement for the provision of support in investigating railway accidents signed with the Sub-Secretariat of the Ministry of Development, has carried out work in support of the accident investigation on behalf of the chief investigator.

2.2. CIRCUMSTANCES OF THE ACCIDENT

2.2.1. Railway staff involved

The railway staff involved were mainly the train crew, belonging to Renfe Operadora. They consisted of:

- the driver of train 150/151, whose registration number was 8945362; and
- the manager of train 150/151, with the duties of guard, registration number 9610643.

Off-duty staff also travelling were the driver who had driven the train on the Medina del Campo-Ourense route, one safety officer and two employees of the catering firm, who were working in the restaurant car.

2.2.2. Rolling stock

Train 150/151 leaves Madrid-Chamartín at 15:00 hours daily (it has another number at weekends). It is a double rake. It arrives at Ourense at 19:51 hours, where the two rakes are divided. One goes to Ferrol (with the same number), where it is scheduled to arrive at 22:36 hours. The other goes to Pontevedra (renumbered as a different train). Departure time from Ourense station is 20:01 hours; arrival at Santiago de Compostela according to the timetable is 20:41 hours.

On the day of the accident, train 150/151 was made up of number 730.012, i.e. rake 12, Class 730, manufactured by the Talgo-Bombardier Consortium and consisting of 13 vehicles: two power cars at either end, followed by two generator cars at either end, eight passenger coaches and a restaurant car. Both the power cars and the generator cars had bogies (two and one, respectively). The other coaches had simple independent wheelsets.

The train had 264 seats, divided into 48 club class (including one place for people of reduced mobility - PMR) and 216 in tourist class. The seats were in two coaches for club class and six for tourist class. As specified in the train logbook, it is 185 m long and weighs 382 tons. The total number of axles is 22.

Class 730 is a conversion of Class 130 (only suitable for travel on electrified lines). Class 130 is also manufactured by the Talgo-Bombardier Consortium. To convert it, they modified two end passenger coaches to accommodate one generator unit each. The electricity generated by these powered the electric motors of the power cars, allowing the class to travel on unelectrified lines.

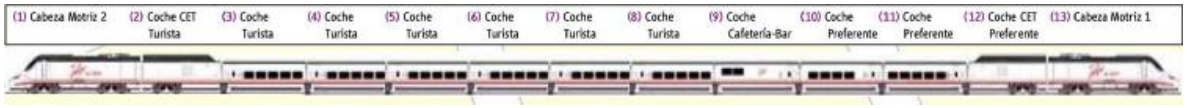
The main technical features of Class 730 are as follows:

- Wheels adjustable for travel on any tracks of standard or Iberian gauge.
- Power supply from an overhead power line at 25 kV AC or 3 kV DC. It can run on unelectrified lines, due to the presence of the generator cars described above.
- Equipped with ASFA Digital and ERTMS/ETCS, although shortly after commencement of commercial operation on line 082 (Ourense-Santiago), due to problems of reliability and

availability with the ERTMS configuration of this Class 730 on this line, the operator (Renfe Operadora) applied to operate under a trackside signal block (BSL) with the protection of ASFA Digital. It received authorisation to do this from Adif. The Madrid - Olmedo high-speed route operates with ERTMS.

- Where the route permits, Renfe Operadora is authorised to operate on lines of standard gauge (1 435 mm) with ERTMS switched on, at a maximum speed of 240 km/h. On lines of Iberian gauge (1 668 mm), its maximum speed is 220 km/h. Finally, irrespective of gauge, it operates with ASFA at a maximum speed of 200 km/h. If the line is not electrified (diesel power), the maximum speed is 180 km/h.

In the direction of travel, and from front to tail, the positions of the vehicles of train 150/151 in the accident were as follows:



Numeración UIC	Tipo de vehículo
96719 730 045-2	CABEZA MOTRIZ 2 (1º)
90717 730 132-8	COCHE EXTREMO TÉCNICO (2º)
90717 730 131-0	COCHE TURISTA (3º)
90717 730 130-2	COCHE TURISTA (4º)
90717 730 129-4	COCHE TURISTA (5º)
90717 730 128-6	COCHE TURISTA (6º)
90717 730 127-8	COCHE TURISTA (7º)
90717 730 126-0	COCHE TURISTA (8º)
90717 730 125-2	COCHE CAFETERIA-BAR (9º)
90717 730 124-5	COCHE ACCESIBLE PREFERENTE (10º)
90717 730 123-7	COCHE PREFERENTE (11º)
90717 730 122-9	COCHE EXTREMO TÉCNICO (12º)
96719 730 046-0	CABEZA MOTRIZ 1 (13º)

LEGEND

Cabeza motriz	Power car
Coche CET Turista /coche extremo técnico	Generator car, tourist class

Coche turista	Passenger coach
Coche cafetería-bar	Restaurant car
Coche preferente	Club class coach
Coche CET preferente	Club class generator car
Coche accesible preferente	Club class coach with mobility access

2.2.3. Description of infrastructure and signalling

2.2.3.1. Madrid-Ferrol route

Train 150/151 runs between Madrid and Ferrol on lines with different features, detailed below:

Line 080 Madrid-Chamartín - Valladolid-Campo Grande

From Madrid-Chamartín (PK 0+800) to point at PK 133+900 in Olmedo, where it links with line 074.

This is a double high-speed track. It is electrified (25 kV) and has the standard gauge. It has BSL, ERTMS/ETCS level 1 and back-up ASFA, and a GSM-R communications system.

Olmedo high-speed line 074, point at PK 133+900 - Medina del Campo changeover

The point at PK 133+900 on line 080 is PK 0+000 of line 074. That line is 19.9 km long and links Olmedo with the gauge changeover at Medina del Campo. It leaves from there on the Iberian gauge to line 820.

It has BSL, ASFA and a GSM-R communications system. From the beginning (PK 0+000) to PK 3+312, the route runs in a double electrified track of standard gauge. From this point, it is a single track to Medina del Campo.

Line 820 Medina del Campo – Zamora

The train leaves the changeover on Iberian gauge at PK 0+000 on line 820. It goes along this line to Zamora, a distance of 89.5 kilometres of Iberian gauge single track. The track is not electrified. It has automatic clearance block for single track (BLAU) with central traffic control (CTC), local control (ML) and ASFA. There is no track-train radio telephony.

Line 822 Zamora - A Coruña

At Zamora, PK 89+500 of line 820 is PK 0+000 of line 822.

The train runs along this line to Ourense station, a distance of 248.9 kilometres. The route continues with a single track on the Iberian gauge. It is not electrified, but has CTC, local control and ASFA. There is no track-train radiotelephony. Between Zamora and Puebla de Sanabria (106.9 km), the track has BLAU. Between Puebla de Sanabria and Ourense, it has an automatic block for single track (BAU).

The train's two rakes are separated at Ourense station. The rake bound for Ferrol continues to transit line 822, now electrified (3 kV). After 1 km, it reaches the Coto da Torre branch, where it moves on to line 082.

Line 082 Coto da Torre branch - A Grandeira branch km point 85.0

As explained in greater detail in the sections below, this line is a component of the future Madrid - A Coruña high speed line. As such, it has the design features of high speed, a double track and 25 kV electrification. It has been temporarily laid to the Iberian gauge, although it has multi-purpose sleepers to allow a quick change to standard gauge when the circumstances warrant it. It has BSL, ERTMS/ETCS level 1, except at its beginning and end, and back-up ASFA. The communications system is GSM-R.

It ends at PK 85+000, at the A Grandeira branch, where it again connects to line 822. It leads to A Coruña via Santiago de Compostela station.

Line 822 Zamora - A Coruña

PK 85+000 of line 082 corresponds to PK 375+400 of line 822.

Santiago de Compostela station is at PK 378+500 (that is 3.1 km from A Grandeira branch, where line 082 finishes). It continues to A Coruña. The distance between the two towns is 60.7 kilometres. This is Iberian gauge, double track which is electrified (25 kV). It has two-way automatic block (BAB), CTC, local control, ASFA and track-train radiotelephony.

This section of line 822 (Santiago de Compostela - A Coruña) belongs to the section called Eje Atlántico. From A Coruña, it passes via line 800.

Line 800 A Coruña - León

At A Coruña, PK 439+200 of line 822 is also PK 550+600 of line 800. This line covers a distance of 26.1 km up to Betanzos-Infesta. It is a single track on the Iberian gauge, unelectrified but with CTC, local control, ASFA and track-train radiotelephony. It has BLAU except for the first 5.7 km, which are equipped with BAU.

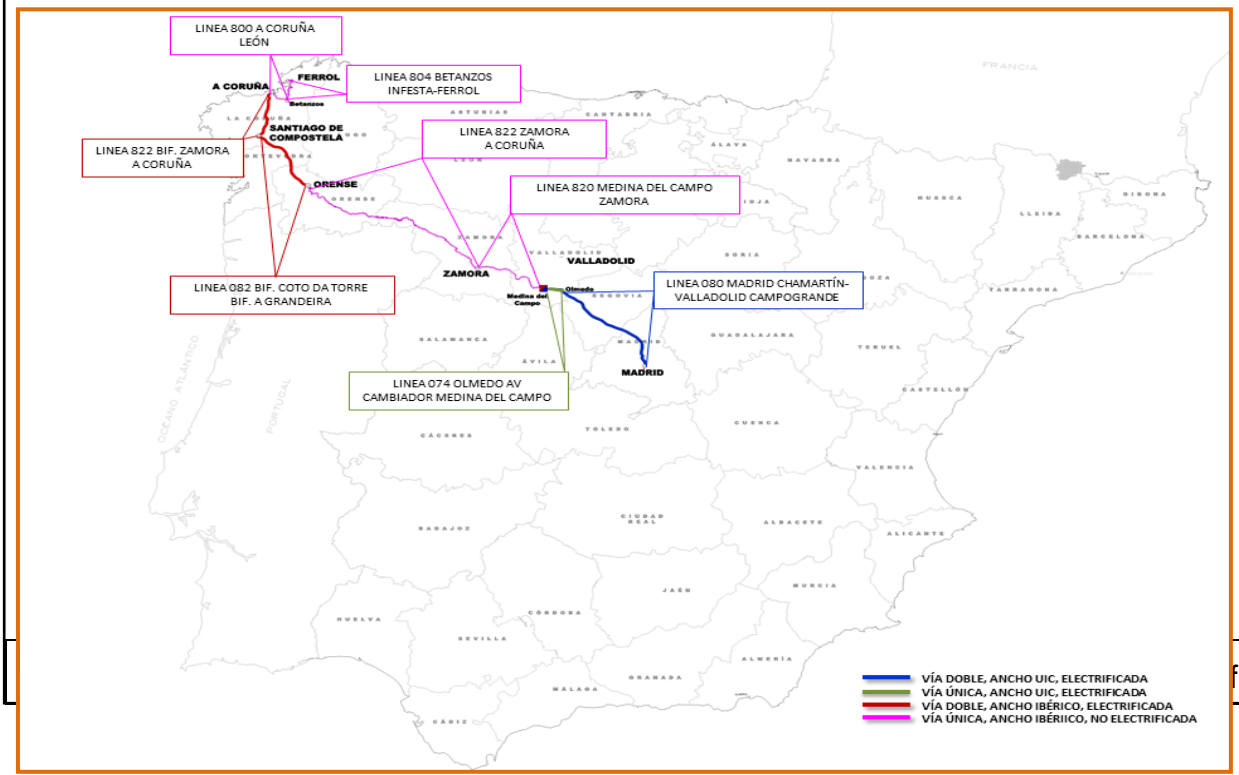
After Betanzos, the route is via line 804.

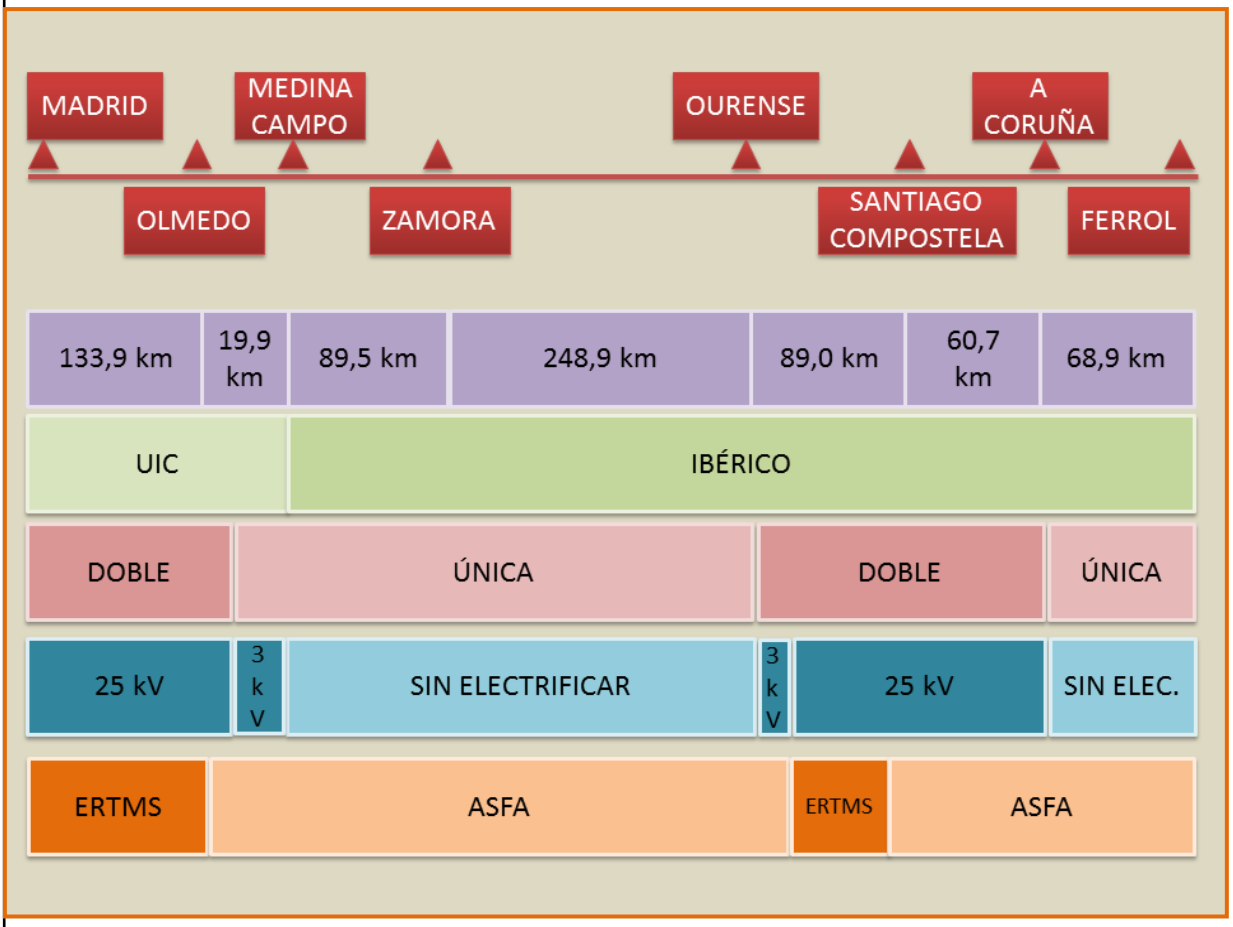
Line 804 Betanzos Infesta – Ferrol

At Betanzos, PK 524+500 of line 800 is also PK 0+000 of line 804.

The route passes via this line as far as Ferrol (terminus). Distance is 42.8 kilometres; the gauge Iberian. The single-track line is not electrified but has CTC, local control, ASFA, BLAU and track-train radiotelephony.

The two diagrams which follow summarise the description given.





Ibérico	Iberian
Doble	Double (track)
Única	Single (track)
Sin elec(trificar)/No electrificada	Unelectrified

2.2.3.2. Line 082 Coto da Torre branch - A Grandeira branch km point 85.0

2.2.3.2.1. Infrastructure and track

As described, the line consists of double track on the Iberian gauge, laid on multi-purpose concrete sleepers, grade PR-01. The track is type 60E1 and the catenary voltage 25 kV. Maximum slope is 25‰ and there are 31 tunnels and 35 viaducts, the joint length of which accounts for nearly 60% of the route.

The point of derailment (PK 84+413) is on the final stretch of line 082, before the sidings at the A Grandeira branch (PK 85+041), which are 3.1 km outside Santiago de Compostela station. The A Grandeira branch is a bypass which links the Ourense – Santiago line (082) to the conventional line (822) which runs on to Santiago and then, via the Río Sar branch (line 842), uses the twin-track Eje Atlántico from Santiago de Compostela to Redondela (line 824 via line 842). An aerial photograph of this area appears below.

Bif.	Branch
Línea	Line
Accidente	Accident
Estación	Station

At the derailment point, the old Ourense - Santiago line 822 (conventional single track) runs alongside the newly laid line 082.

The plane layout around the accident site consists of a very long straight (4377 m) starting around PK 79+916 and ending at PK 84+228. That marks the start of the bend where the derailment occurred. The curve has a (design) radius of 402 m and a total length of 666 m, ending at PK 84+894. That total breaks down into an initial transition of 202 m, 264 m of round curve and the final transition stretch of

more than 200 m. The derailment began (point 0) at the end of the first transition. The cant on the curve is 130 mm. Maximum permitted speed is 80 km/h according to the current Maximum Speed Table.

The elevated stretch from PK 79+630 to PK 84+261 has a 12.5‰ incline (4631 m). Then a 364 m length of ramp begins, with an incline of 8.6‰, with the appropriate vertical transition, and this is where the derailment occurred. The ramp ends at PK 84+625.

Some special features of the area are as follows:

- the Marrozos tunnel (no 30), 1285 m long, which begins at PK 80+671 and ends at PK 81+956;
- the O Eixo viaduct (no 35), 1225 m long, which begins at PK 82+112 and ends at PK 83+337;
- the Santiago tunnel (no 31), 641 m long, which begins at PK 83+465 and ends at PK 84+106; and
- a viaduct (E-01), 80 m long, which begins at PK 84+245 and ends at PK 84+325. This therefore comes within the transition zone of the above-mentioned curve, which extends across the two tracks of line 082 and the single track of line 822 (conventional to Ourense).

2.2.3.2.2. Control and signalling systems

Line 082, Coto da Torre branch - A Grandeira branch, km point 85.0, has a block via trackside signal (BSL). The central traffic control (CTC), managed from the Adif Regulation and Control Centre (CRC) at the high-speed control post of Madrid's Atocha station does not cover either branches (Coto da Torre or A Grandeira). These, with the adjacent Ourense and Santiago de Compostela stations, are managed from the Ourense control post when they are under central control. Nevertheless, both are operable under local control, when operations are carried out from Ourense and Santiago de Compostela stations respectively.

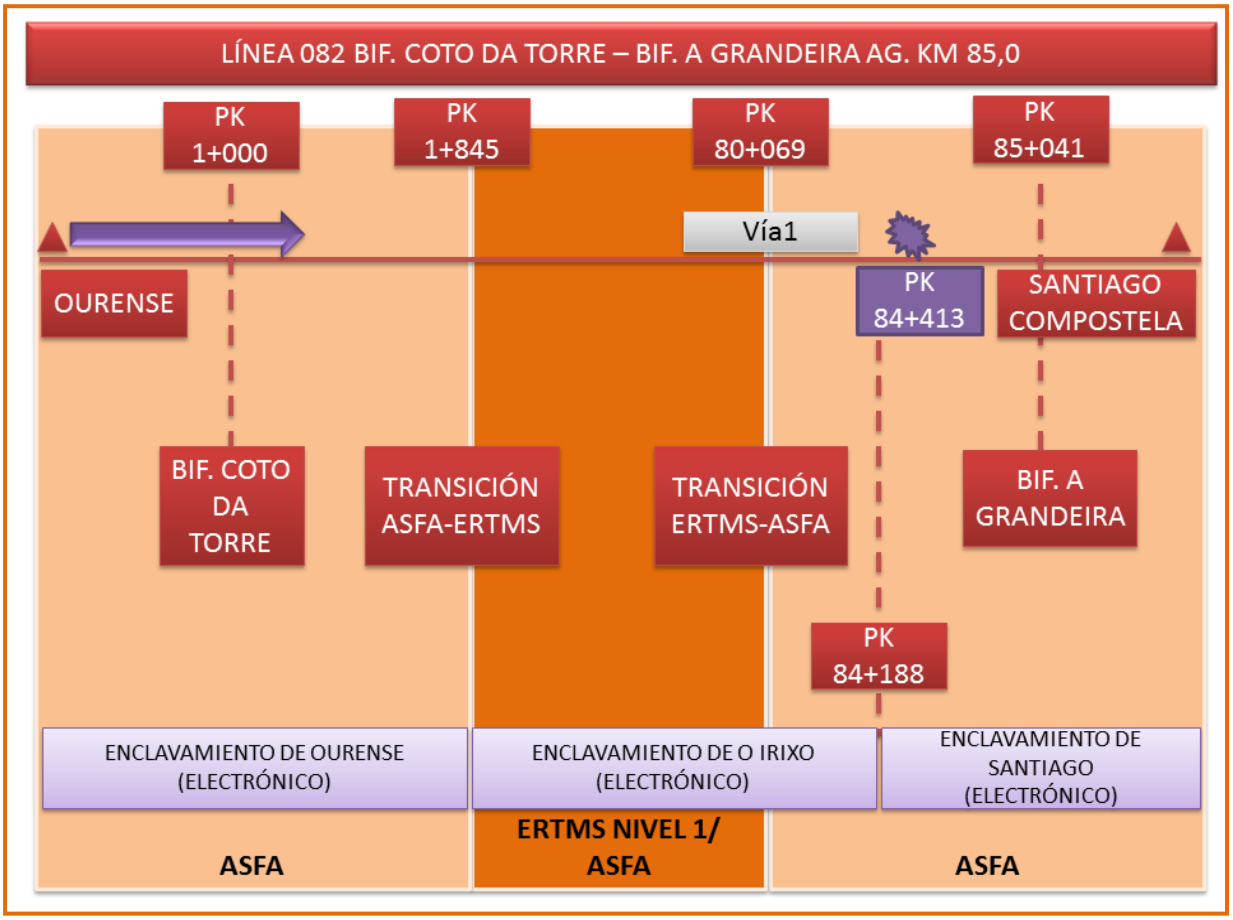
The line has level 1 ERTMS/ETCS. In the direction of travel of the train (from Ourense to Santiago), this covers from PK 1+845 to PK 80+069. In the opposite direction, ERTMS is established from PK 84+200 to PK 7+206. As a back-up, ASFA is installed throughout the route.

The point of the derailment (PK 84+413) is near the end of the line, at the A Grandeira branch. This is already beyond the stretch fitted with ERTMS. Hence at this point traffic is managed from the central control post at Ourense or, failing this, from Santiago de Compostela station when under local control.

So there are three electronic interlocking limits laid out on the Ourense-Santiago section, which govern operations on this line. In the train's direction of travel, the Ourense electronic interlocking system applies from the start of that station to PK 1+845 (the point where the ERTMS towards Santiago commences). The O Irixo interlocking system (with ERTMS) covers from the previous point to

PK 84+188 (although the ERTMS towards Santiago ends at PK 80+069). The Santiago electronic interlocking system runs from PK 84+188 to Santiago de Compostela station.

The diagram below summarises the system installed on each stretch.



Bif.	Branch
Enclavamiento (electronico)	(electronic) interlocking system
Nivel 1	Level 1
Transición	Transition

The beginning of the derailment (PK 84+413) is located within the zone managed by the Santiago de Compostela electronic interlocking system. This interlocking system covers the A Grandeira and Río Sar branches and Santiago station itself, all of which, as commented, are controlled from Ourense control post, when in central control mode, or from Santiago de Compostela station when in local control mode.

More specifically, the derailment occurred in the A Grandeira branch, a subsection controlled by the Santiago de Compostela interlocking system. Access to the branch via track 1 of line 082, in the direction of the derailment (from Ourense to Santiago) is protected by entry signal E7 (PK 84+176) which, in turn, is announced by caution signal E´7 (PK 80+619).

E7 is a tall signal with three lights (green, yellow and red). It is on the right side in the direction of travel. It has a fixed board showing 50 (50 km/h for a diverging line, which is not the case) and a luminous direction display. It has balises beforehand (PK 83+876) and at the signal (PK 84+171). Its position is at the exit from the Santiago tunnel (no 31) and it is clearly visible.

E´7 is a tall signal with three lights (of which only two are operative: green and yellow). It is on the right-hand side in the direction of travel. It has a fixed board showing 60 (60 km/h for a diverging line, which is not the case) and a luminous direction indicator. It has a balise beforehand (PK 80+319) but not at the signal (not necessary). It is located a little before the entrance to the Marrozos tunnel (no 30) and is clearly visible.

Associated with this signal (E´7), three boards have been set up nearby, at PKs 80+086, 80+278 and 80+398, located at catenary posts.

Other signs using existing boards in the area before the point of derailment, and in the direction of travel, are as follows:

- Board indicating change of ASFA mode (PK 80+803). This is on the right, inside tunnel no 30 (Marrozos). It marks the point where it is necessary to change from *ASFA - high speed* to *ASFA – conventional* mode.
- Board marking the start of the RGC area (PK 84+176), located at the same post as signal E7. It shows that near here falls within the scope of RGC (the General Traffic Regulation).
- Fixed speed reduction sign (PK 84+273), on the right-hand side at a catenary post, and close to the point of derailment (402 m curve). It marks the 100 metres where the maximum speed permissible for the infrastructure changes, as prescribed by the Maximum Speed Table. Below there is another board showing the depressurisation of the train, for the comfort of the passengers.
- Entries to tunnels and viaducts are also marked with boards, showing the name and length.

Annex 2.2.3.2.2. a shows the sequence of signals and markers in the direction of travel from PK 80+086, first board near caution signal E´7 and up to the point of derailment.

At a distance of 479 m from the point of derailment, there is a crossover between main tracks consisting of points B1 and B3 (respectively at PK 84+892 and PK 84+983). This makes it possible to switch from track 1 to track 2. Next, bypass B5 is located on track 2 (PK 85+011). This is the end-point of line 082 and allows this track 2 to join the single track of the conventional line at Ourense (line 822 Zamora - A Coruña). From this point, the two tracks continue to Santiago de Compostela, but now as line 822.

Point B5 is exactly the start of the Santiago cut-and-cover tunnel, 610 m long. At the tunnel exit on track 2, point B7 allows access to line 824 (Redondela – Santiago de Compostela, on the Eje Atlántico) via line 842 (A Grandeira branch, km point 376.1 - Río Sar branch).

Continuing along line 822, somewhat further on, there are caution signal E´8 and station entry signal E8 at Santiago de Compostela station. These are located respectively 1065 m and 2442 m from bypass B5.

Annex 2.2.3.2.2. b contains the track diagram from Instruction A 2993, version 4, dated 16 July 2012, governed by CTC LAV Ourense-Santiago de Compostela.

2.2.3.3. Railway traffic data

According to the CIRTRA 2012 information system (Traffic per Track Section), Volume II, of Adif's Traffic Department, the average weekly traffic transiting line 082 in 2012 was 90 trains: 26 long-distance, 63 medium-distance and 1 service train.

The long-distance services (trade name *Alvia*) serve the Madrid-Ferrol link. They are hauled by Class 730 locomotives, the same as the train involved in the accident. Two daily services run each way on working days, and one at weekends (two on Sundays between Santiago de Compostela and Madrid).

The medium-distance services (trade name *Avant*) serve the A Coruña-Santiago-Ourense link and are hauled by Class 121s. In November 2013 seven daily Avant services were scheduled each way on working days. This was reduced to five at weekends.

Class 121 locomotives are manufactured by the CAF-ALSTOM Consortium. They have adjustable wheels (for Iberian and standard gauges), although in this zone all trains always run on the Iberian gauge. The maximum speed of travel is 250 km/h, and they have ERTMS and ASFA.

2.2.4. Communication systems

Two different contexts can be identified: communication between train and control post (outside the train) and communications within the train itself.

To communicate outside the train on line 082, Coto da Torre branch - A Grandeira branch, km point 85.0, GSM-R is available (mobile telephony with a band reserved for the railway). This operates between the train and the Madrid-Atocha control post.

On the ways in to Ourense and Santiago de Compostela, from line 082, there is the track-train radiotelephony system, which links the train with the Ourense control post.

To communicate inside the train, there is internal telephony for the driver to communicate with the crew. The personnel on duty on the train (train manager and driver) can also use the corporate mobile telephone. This enables them to communicate with each other and also outside, in limited form, and if necessary.

2.2.5. Activation of the railway contingency plan

According to the information supplied by the Ministry of Development's Emergencies and Crisis Coordination and Management Unit, by Renfe Operadora and by Adif, the sequence of actions was as follows:

24 July 2013

After the accident, at 20:42 hours, the driver of train 150/151 reported what had happened via GSM-R from the driving desk (in the head power car) to CRC Atocha. From this time on, the emergency protocols of Renfe Operadora and Adif, and the coordination procedures between them, came into action in order to implement the measures envisaged as necessary in support of the emergency. Pursuant to these, CRC Atocha reported what had happened to 112, to the 24h Network Management Centre (CGR24) and to the Adif control post at Ourense.

At 20:45 hours Adif CGR24 informed the Adif control post in León and the Renfe Operadora Operations and Civil Defence Centre (CECON). After a chain of communications, Renfe Operadora convened its crisis cell and activated the emergency protocol. The cell for assistance with communication media was set up for 24 hours. Adif, in turn, launched its contingency plan.

In addition to tracks 1 and 2 of line 082 (Ourense-Santiago), which the accident blocked, the Ourense control post decided to suspend traffic on the tracks of the conventional network in the area, to allow risk-free action by people and equipment.

At 21:20 hours Renfe Operadora and Adif began to establish an alternative transport plan to minimise, as far as possible, the consequences of the severing of lines for trains which were already travelling on them, or were scheduled to do so.

Adif deployed major human and material resources. It mobilised three workshop trains and heavy track machinery in order to start work to repair the line, in so far as it was authorised to do so.

Renfe Operadora also activated the major accidents protocol with reference to the compulsory passenger insurance taken out with the insurance company, Allianz. It activated the protocol for looking after casualties and family members, by opening a helpline to attend to family members, manage the information, requests for removals and psychological support. Later, on 29 July, an office was set up in Madrid to look after the families of those injured in the accident, with a procedure for assisting family members with travel, with the cooperation of the airline, Iberia.

25 July 2013

At 03:10 hours the judge authorised access to the accident zone for personnel not belonging to the emergency services (Adif, Renfe Operadora, CIAF, etc.). Renfe Operadora used large cranes to start to clear damaged rolling stock from the track. It removed the first coach of the trainset at 07:25 hours. At 12:52 hours, removal of that rolling stock began by road to a field at A Escravitude (a locality near Santiago de Compostela), where it remained in judicial custody.

At 15:45 hours, after preliminary investigation work in situ, Adif began to repair track 1.

26 July 2013

At 05:00 hours, traffic was restored on the adjacent conventional track with 'proceed with caution' in force at the place of the accident. Trains were authorised to pass at ordinary speed at 07:30 hours. At the same time, traffic was restored on track 2 of line 082 involved in the accident. A speed limit of 30 km/h applied to pass through the accident zone.

28 July 2013

At 06:45 hours Renfe Operadora removed the last rolling stock from track 1. This was the head power car. This left the track unobstructed. Adif proceeded with the repair works.

29 July 2013

At 06:15 hours, the speed limit on track 2 was lifted. At 07:25 hours, traffic was restored to track 1, with a 30 km/h speed limit through the accident zone. That limit remains in force on the date of this report.

2.2.6. Activation of emergency plan by the public services

On 24 July 2013, after the accident, Adif alerted the Galicia Emergency Centre (112) to mobilise the National Police, Guardia Civil, Local Police, Civil Defence, Red Cross, Fire Brigade and other healthcare services to go to the scene of the accident.

As it happened, the main police headquarters, Guardia Civil and Local Police of Santiago de Compostela, had drawn up safety arrangements for that night. The main purpose of this was to guarantee normal progress of all the activities planned for the celebration of Galicia Day and the festival of St. James the Apostle. This plan made it possible to move over 140 police personnel to the zone of the accident by 21:15 hours. Parallel to the police deployment, the Fire Brigade and Civil Defence were involved.

On the other hand, the Xunta (Government) of Galicia activated its emergency plan entitled Territorial Civil Defence Plan of the Autonomous Community of Galicia 'PLATERGA.' Level 2 of this plan mobilised all the resources required for this eventuality.

Therefore, according to Galician Government figures, more than 3000 personnel took part in the operation launched in response to the accident: national police; members of the Guardia Civil, local police; firefighters from seven different fire stations in Galicia; members of 26 Civil Defence groups; psychologists and healthcare professionals from six hospitals, professionals from the Judicial Authority, professionals from the Emergency Centre, and members of the Red Cross (staff and volunteers).

The Local Brigade of Scientific Police of Santiago de Compostela carried out the tasks of identifying the victims. They received reinforcements from major disaster action specialists from Scientific Police General Headquarters, who had travelled from Madrid.

2.2.7. Structures at the accident location

At the time of the accident, no construction work was in progress on or near the track. There were no temporary speed limits in the zone.

2.3. CASUALTIES (DEAD AND INJURED) AND MATERIAL DAMAGE

2.3.1. Casualties (dead and injured)

According to the information supplied by Renfe Operadora, 221 tickets for Santiago de Compostela, or stations beyond, were sold for train 150/151. These tickets were for persons older than four years old since no ticket is required for children up to the age of four.

Service personnel, who need no tickets, were also travelling on the train. Travellers on the Ourense-Santiago route included a safety officer, the off-duty driver who had driven the train on the Medina del Campo-Ourense route, two people working in the cafeteria, the train manager and the train driver. In total these were six people. Hence it is deduced that 227 people were travelling on the train (ticketed + service), plus an indeterminate number of children younger than four years old.

To establish the number of fatalities, the Traffic Safety Regulation for the Public Railway Network, as amended by Royal Decree 918/2010, of 16 July 2010, in line with the criterion of the European Safety Directive, defines a fatality as any person who dies as a result of an accident immediately or within 30 days. A seriously injured person is someone who spent more than 24 hours in hospital because of an accident.

No official list of victims is available. Nevertheless, as an indication, at the end of August, Santiago de Compostela Magistrates' Court 3 put the number of people affected by the accident at 226, of whom 79 were fatalities and 147 injured. Later Renfe Operadora notified the death of a person, which brought the number of fatalities to 80 (including two crew members) and 152 those otherwise affected by the accident.

2.3.2. Damage to rolling stock, infrastructure and the environment

2.3.2.1. Rolling stock

The 13 vehicles making up the train were derailed and off track 1, on which they had been running. An economic valuation by Renfe Operador of the damage caused is pending.

A first group formed by the head power car (position 1), the diesel generator car (CET, position 2) and the first tourist passenger coach (position 3), was separated from the rest, between PK 84+684 and

PK 84+637. All these were derailed, off the track, and tilted at a steep angle to the right-hand side in the direction of travel, except the power car, which was tilted somewhat to the left.

A second group of vehicles, formed by the (tourist) coaches in positions 4 and 5, were isolated 11 m away from the first group. Both were also derailed and tilted sharply to the right. They were located between PK 84+626 and PK 84+600.

A final group was formed by the rest of the vehicles. These were separated by about 33 m from the second group, between PK 84+567 and PK 84+505: the coach in position 6 was derailed and tilted to the left. The seventh was across the track. The eighth was apart from the group and off the embankment as far as an adjacent road. The ninth (restaurant car) was overturned, with one end on top of the seventh. The tenth and eleventh (both club class) were overturned to the right. The twelfth (generator car) caught fire and was crushed. The thirteenth (tail power car) was tilted to the right.

According to Renfe Operadora, the vehicles running in positions 1, 2, 3, 4, 7, 8, 10 and 11 were damaged, with serious damage to those in positions 5, 6, 9, 12 and 13.

Most of the vehicles were pushed into a drainage ditch which runs along the track. The concrete wall and the raised embankment in the area also prevented the total overturning and sideways displacement of the vehicles. **Annex 2.3.2.1** contains pictures of the final state of the trainset after the accident.

2.3.2.2. Infrastructure

According to the information furnished by Adif, damage was caused to the superstructure and catenary of track 1, and only to the catenary on track 2. This damage awaits assessment. On track 1, it consisted of total write-off of 32 m of track, 600 sleepers and 8 posts with brackets, and 1200 m of catenary cable. On track 2, 100 m of catenary had to be replaced. It was also necessary to restore the barrier on the right-hand side and the two video monitoring cameras.

2.3.2.3. Damage to third parties

Projectiles - pieces of track and train - caused damage to nearby buildings which awaits valuation.

2.3.3. Time lost through track blockage

At 05:00 hours on 26 July, traffic resumed on the conventional track (line 822) with 'proceed with caution' in force in the accident zone. Thus this track was blocked for around 32 hours. Authority was given to pass at normal speed at 07:30 hours on the same day. At the same time, traffic resumed on track 2 of line 082, on which the accident occurred. The speed limit was 30 km/h through the accident zone. Thus track 2 was blocked for around 35 hours.

At 06:15 hours on 29 July, the speed limit on track 2 was cancelled. At 07:25 hours, traffic resumed on track 1, limited to 30 km/h through the accident zone. Thus this track had been blocked for 4 days and 11 hours.

According to Adif, a total of 29 trains (27 passenger and 2 goods) were affected, either through diversion on to other lines or by transfer of their passengers by road for part of their journey. Total delay was 699 minutes. On 24 July, 7 trains were delayed 90 minutes; on 25 July, 18 trains (including 2 goods) were delayed 483 minutes; and on 26 July, 4 trains were delayed 126 minutes.

2.4. EXTERNAL CIRCUMSTANCES

The event occurred in daytime. Weather conditions were good.

The 24th of July is the eve of the feast of St. James the Apostle and Galicia National Day. It also marks annual festivals in the city of Santiago de Compostela, capital of the Autonomous Community of Galicia.

3. ACCOUNT OF THE INVESTIGATIONS AND INQUIRIES

3.1. SUMMARY OF WITNESS STATEMENTS

The statements made by the driver and train manager, at the offices of Magistrates' Court 3 in Santiago de Compostela, have been examined and made available to CIAF for this purpose.

This Commission asked to interview the driver, who refused.

The following are excerpts from the statement made by the driver of train 150/151 on 28 July 2013 (his first statement):

Answers to the judge's questions

- He was going calmly until he reached the curve.
- He followed the same route several times each week.
- At point 83+400 [*he really means 84+300*], where the speed change signal is, he should have been travelling at 80 km/h.
- The speed reduction is before [*is made before*] and everyone does it where he considers it appropriate. Personally, he takes the caution signal [*E´7*], about 4 km before, as the reference point for braking.
- He was going at around 180-190 km/h when the accident occurred.
- He cannot explain why he did not reduce speed.
- 4 km is covered very quickly at 200 km/h.
- The signal was at green.
- The train was running 2 or 3 minutes late.
- He has never received warnings or penalties.
- He had an incident in Madrid [*commuter rail*] where he failed to make a scheduled stop, and received no penalty for it.
- The company checks, carries out speed checking scans to detect speeding.
- He thinks that he took over the train [*the one in the accident*] at 20:00 hours.
- The handover [*between drivers*] includes a verbal or written report as appropriate.
- Each driver has a copy of the train timetable. These are documents which all the drivers have. He too, has an updated timetable which is his own.
- On the high-speed lines they are [*also*] issued with a 'train logbook' which shows precautions, restrictions, anomalies etc.
- The timetable is always the same, and is kept updated.

- The timetable is a written book, and he requested it and has it on an iPad. He keeps it on an iPad and also in paper form. The iPad is not approved, but it [*the timetable*] is downloaded from Renfe's official website. He had both with him.
- Before boarding the train, he had only consumed coffee.

Answers to the public prosecutor's questions

- He has never had any problem passing medical check-ups.
- It is OK to have the iPad in the cab.
- He keeps the iPad switched on permanently for ease of viewing.
- When he is going to work, he takes the iPad with him to work and does not retrieve other pages [*pages unrelated to driving tasks*].
- They undergo a vast quantity of training courses. He holds a licence to drive trains. He has to be authorised both for the track and for the vehicle.
- He holds authorisation for all the tracks on which the vehicles driven by him run.
- He does not know what he was thinking about before entering the tunnel.
- It was inevitable that he should apply the electric brake, the pneumatic brake and the emergency button. He applied them all [*he is referring to the moment when he realised the A Grandeira bend was approaching, and he used all the brakes*].
- They keep the dead man's pedal inactive, and do not even realise that they are following the sequence.
- When he saw the curve, he could see he was not going to make it.

The public prosecutor asked what he meant, in the track-train conversation, to which they had just listened, when he says '*this is inhuman.*' His answer was:

- *'Ummm… there's always room for improvement… er… proceeding in full compliance with the timetable … looking at it… at 80, there might be some reminder on the track, physically …'*

Asked by the public prosecutor if the signalling was not enough, he answered:

- For him, it was.
- There was nothing on the track or in the vehicle which hindered him and might have been the cause of this accident happening.
- He was running on ASFA in high-speed mode with BSL [*trackside signal blocking*].

The public prosecutor asked: *could this [referring to ASFA] rather than something else have influenced the course of the accident or its very occurrence?*. The driver replied:

- *'The thing is, it all depends on me having to know that, at this point, I must adjust to this speed. There's nothing else to it.'*

Answers to questions by the driver's defence counsel

- He has been working for Renfe since 1982.
- He started out as an unskilled workman, auxiliary, secondman, authorised secondman, driver and principal driver.
- He was in freight until 2008. In 2008 he moved to Madrid to drive commuter trains until 2011. In 2011 he took up long-distance trains in Galicia.
- He has driven high-speed trains since they [*high speed*] began in Galicia, since 2011.
- The photo published on Facebook was of a course he did on the gauge changeovers at Valladolid and Medina del Campo. He never drove at that speed.
- Every driver has his train timetable.
- The company [*Renfe Operadora*] updates it and issues it already up-to-date. If someone from safety [*an inspector of the Traffic Safety Directorate*] sees that we do not hold an up-to-date copy of the timetable, they proceed to penalise us.

Questioned by counsel: *At the tunnel exit, was there any speed limit sign?* he answered:

- No [*there was no*] fixed sign.
- The whole distance up to this point is covered at 200 km/h [*up to the A Grandeira bend*].
- You 'eat up' the kilometres in no time [*referring to driving at 200 km/h*].
- He uses glasses for reading. On the iPad he can increase the font size to see the train timetable better, better than the paper version.

The following are excerpts from the statement made by the driver of train 150/151 on 31 July 2013 (his second statement, once it was known that there had been a telephone call before the accident:

Answers to the judge's questions

- Using the company's telephone is part of his job.
- The train manager telephoned him.
- If a friend rings him, he does not take the call unless the caller is the train manager or the management centre, in which case he has to answer the phone.
- The train manager explains to him what is happening on board the train. There may be a fire. And the driver is in charge of the train.
- The train manager had called to ask if he could put the train on to the bypass track at Puentedeume, for the convenience of passengers alighting from the train because, if they are put on the main track, the platform is on the opposite side to the passenger building. Then they have to cross the tracks in front of or behind the train. As there were passengers alighting at

Puentedeume, he called to ask if he could enter on the bypass track at that station. His reply was affirmative: that the train could go on either track.

- He had not referred to written material to answer the train manager's question. The only written material he had in front of him was the train logbook, and he had not consulted any written material.
- He did not know when they had called him. It had been during the arrival at Santiago.
- He had no idea of the place where he had been on the route at the moment when the telephone call had been made.
- It was clear that he was going to crash and he realised this at a distance, on seeing the curve. He knew he applied both brakes: electric and pneumatic.
- The electric brake is the motor brake and the pneumatic brake is applied to the brake shoes.
- Normally, for smoother braking, you brake with the electric brake and, if you need to brake a bit more, you apply the pneumatic brake a little. But if you need to brake much more, you put both brakes full on.
- He has been on many journeys with this train manager, and he does the same routes that the train manager may go on. One day, he ends up with one, and another day, with somebody else.
- He believes the train manager has done this route as much as he has, and he does it very often.

Answers to the public prosecutor's questions

- He has both the ATO system [*a control for pre-setting speeds*], which is a button, and the electric brake/power handle. In mid-position, the handle is at zero. Move it backwards, that is the electric brake; move it forwards, that is the power regulator.

Asked by the public prosecutor if he had to keep both hands constantly occupied, he answered:

- No, he can keep his hands completely free. If he is driving on the pre-set speed system, he can keep both hands free. The only thing he cannot let go is the dead man.
- He positions the corporate telephone in front of him [*on the driving console*]. He leaves the train logbook on a clip which holds it, and the iPad on a kind of screen which is not working, and he keeps it '*enlarged* so he can see it better, without having to peer.

Questioned by the public prosecutor about the reason for the train manager's call, and whether entry on one track or another was up to him or to the control, he answered:

- The train manager was asking him [*the driver*] whether the train would fit on the tracks at the station, because he [*the driver*] was aware of this information. And then the train manager, given this information, would call the management centre [*at Renfe Operadora*] to ask them to switch to one track or another.

- After that, the operations centre [*Adif*] would call him to let him know which track to enter on, although there was no need to say this to him, as they could tell him via the signals, by switching them to green-yellow.

Asked by the public prosecutor if it was the train manager's job to speak to control to position the train on one track or another, he answered:

- What the train manager says is the number of passengers, whether there is any passenger with reduced mobility, who cannot cross via the platform. If so, he requests a change of track, etc.

Asked by the public prosecutor if the call to discuss this matter had to last nearly two minutes, and why the train manager did not make the call on arrival at Santiago, when the train was stopped, he replied that:

- He had told the train manager that the train would fit perfectly at either platform, and the train manager had insisted.
- He was bound to answer when the telephone rang, because the train might be on fire.
- At that moment, he did not see the danger. He did not realise the point of reference [*to start braking*], because he did not see it. He thought it was not near and that he was going quite relaxed, at the right speed which posed no danger. He did not know if the call had been an influence, or not.

The public prosecutor asked him: *'Did you hang up before seeing the signal?'* He answered:

- '*When I braked, I had already switched off the telephone.*'
- He had missed the location of the caution signal, because he oriented himself from the signal [*caution signal E'7*], from the caution sign boards.
- He never saw them [*the E'7 sign boards*]. He did not know why he had not seen them. [*The sign boards before caution signal E'7 were his point of reference to start braking and reduce speed from 200 km/h to 80 km/h*].

Answers to the judge's questions

- After the accident, he could not find the corporate telephone: He was able to find his personal one, because he carried it in his pocket.
- When he got off the train, he used his personal telephone.
- He had looked for the tablet, but could not find it.
- The corporate telephone was used within the company. They could call him, but he could not call out.

Answers to the defence counsel's questions

- On the corporate telephone, it is only possible to make calls within the company, all from Renfe.
- When he is driving, he does not pick up calls if they are from a friend.

- He does answer calls from the management centre and personnel on board the train, in this case the train manager.
- The telephone number is displayed on the mobile and it has them entered and identified by name.
- He does answer calls from the train manager on board. He does not know what is going on behind.
- He identified that it was the train manager of that train when he received the call.

The following are excerpts from the statement made by the train manager of train 150/151 on 2 August 2013:

Answers to the judge's questions

- He is not a friend of the driver. It is purely a working relationship.
- He is the train manager on the route. They used to be known as conductors.
- He works for Renfe Operadora.
- His job is to check passengers getting on and off the train. He checks the passengers' tickets.
- He considers it worth reporting all incidents occurring on the train to the driver, as the driver is in charge of the train.
- Communication with the driver [*on board the train*] can be face-to-face or by telephone. Face-to-face means in person. Otherwise, where coverage exists, communication is by mobile telephone. If there is an emergency and there is no mobile coverage, he walks to the cab, but always uses the telephone first, since this is the quicker system.
- He called the driver to tell him he was taking people to Puentedeume [*where there was a scheduled halt*] and wanted to know if the train would fit the track on the section next to the passenger building. The driver confirmed to him that it would fit perfectly.
- He had never ordered the driver to enter the track of that section, because this was impossible.
- The call must have been before the accident. When the accident happened, his telephone was already in his pocket.
- He could not remember at what point he had made the call. He had called because telephone coverage existed at the time. Between Ourense and Santiago, there was full coverage over the whole route, but coverage was poor from Santiago to A Coruña.

Answers to the public prosecutor's questions

When the public prosecutor commented to him: '*on the driver's telephone* [*according to Vodafone*], *three rather than two calls were received. One was at 20:04:34 hours and lasted 35 seconds. A second call was at 20:05:36 hours and lasted 15 seconds'* [*the third call was the one made moments before the accident*], he answered:

- The first call was to say hello and tell him that he was the train manager of that train, although there is a document in which he enters this: the train logbook.

- The second call was to confirm that he could lock the doors [*operations completed*].
- As for the reason why he had made the third call, he explained that he had made it to find out whether the train could be positioned on track 2, which is the closest track to the passenger building at Puentedeume station. Normally, at Puentedeume, they enter on the main track and, on that track, passengers alighting from the train have to go to the end or beginning of the platform and cross the tracks, because there are crossings between the platforms, and go to the passenger building to get out on to the road which leads to the village of Puentedeume.
- The family getting off at Puentedeume had not said anything to him. He had taken the initiative, in order to improve the service and convenience for the passengers.
- He had already made such a call several times.
- He always made calls of this type in similar situations. On some trains you can make them, on others you cannot [*he means technically*].
- He does this if there are passengers. He always does it for passenger convenience.

Asked by the public prosecutor: '*did this conversation* [*the third*], *to tell him about the track you wanted, have to last one minute 42 seconds?'* the train manager gave a confused account but implied that he did not know how long it had lasted, but that he had talked as necessary.

Answers to the public prosecutor's second set of questions

When asked by the public prosecutor: '*had you stopped with this type of train at Puentedeume in the past?'* he answered:

- *'Yes, but on the main track.'*

Asked by the public prosecutor: '*can you explain to me why you make a call three km from Santiago to manage something* [call the driver to see if he can stop on the bypass track at Puentedeume] *which you could have done once the train had stopped at the halt in Santiago?',* he answered:

- *'I'm thinking about it now, I'm remembering now. What I know is that, from Santiago, I have no communication until A Coruña.'*

Asked by the public prosecutor: '*but in Santiago you have it* [he means coverage] *to communicate all the matters which are considered essential once the train has stopped, don't you?*', he answered:

- *'At Santiago I have to control passenger access, boarding and alighting. When the train has stopped in Santiago, I have other duties to perform. Because, at this point, I have nothing to do, I call earlier'* [he is referring to the moment at which he made the call before the accident].
- *'According to the regulations, I can call the driver to consult him about any service-related matter. It is not specifically regulated. We have some autonomy to pick the moment and the person who can answer our question.'*
- *'I normally carry two telephones in case the battery runs out on me. You supply one.'*

3.2. SAFETY MANAGEMENT SYSTEMS

The European Directive on safety on the Community's railways (2004/49/EC) was transposed into Spanish law by Royal Decree 810/2007, of 22 June 2007, which approved the Traffic Safety Regulation of the National Public Rail Network. Annex V of the Directive prescribes the principal content of accident and incident investigation reports. Paragraph 3.2 of this refers specifically to the traffic Safety Management Systems (traffic SMS) of the companies involved in each accident.

The Safety Management Systems (SMS) in force at Adif and Renfe Operadora were analysed in accordance with this Directive. This analysis took place in three stages. The first two describe the contents of the traffic Safety Management Systems of both companies (Adif and Renfe Operadora). A third deals with their specific application to this accident.

3.2.1. SMS of the infrastructure manager: Adif

3.2.1.1. Structure and content

The company Chairman formally approved the SMS on 6 April 2010. It first states that Article 9 of Royal Decree 810/2007 requires that *'the Rail Infrastructure Manager (Adif) shall establish a Safety Management System which shall guarantee, within the scope of its duties, that the rail system at least meets the safety targets and standards and is adapted to the safety requirements prescribed in the technical specifications for interoperability (TSIs) and technical specifications for approval, and that the relevant parts of the safety methods (SM) are applied'.*

Based on this, it proved necessary to adapt the traffic SMS, in force at Adif since August 2006, to the new requirements specified in Royal Decree 810/2007.

The text quoted states the requirements and presentation format which Adif's traffic SMS must meet. It goes on to specify that it must guarantee control of all the risks posed by its own activity as manager of the infrastructure and of the railway undertakings which operate on it, including maintenance services, supply of equipment and deployment of contractors.

In order to adapt Adif's traffic SMS to the above requirements of the Royal Decree, the document with three titles listed below has been drawn up:

Title I: Requirements of the Safety Management System

This contains a description of the allocation of responsibilities within the Adif organisation. It explains how safety management is controlled at the various levels, how staff and their representatives participate in the various safety bodies, and how continuous improvement of the Safety Management System is assured.

It is structured into five chapters, the contents of which are as follows:

Chapter 1: Structure and assignment of responsibilities

1. General principles

2. Duties assigned to the Traffic Safety Directorate (DSC)
3. Duties assigned to the Executive Areas

Chapter 2: Evaluation of Traffic Safety Management

1. Safety methods
    - 1.1 Annual traffic safety plan (PASC)
    - 1.2 Inspection of railway services
    - 1.3 Safety visits
    - 1.4 Safety surveys
    - 1.5 Audits
2. Safety indicators
    - 2.1 Types and monitoring of indicators
    - 2.2 Traffic safety comparisons
    - 2.3 Early alert indicators

Chapter 3: Participation and cooperation bodies

Chapter 4: Continuous improvement of the Safety Management System

Chapter 5: Periodic internal audit of the traffic SMS

Title II: Basic elements of the Safety Management System

This describes the basics of the traffic SMS. It is fundamental to ensuring proper documentation of all processes with traffic safety implications.

It is structured into eight chapters, the contents of which are as follows:

Chapter 1: Safety policy

1. Fundamental declaration by Adif
2. Basics
3. Traffic SMS operating principles
4. Qualitative and quantitative objectives, and procedures to achieve them

Chapter 2: Publication and distribution of traffic safety documentation

Chapter 3: Procedures for ensuring compliance with technical and operational standards

1. Inclusion of railway rolling stock for service with Adif
2. Approval of rolling stock maintenance plans
3. Granting authorisations to run vehicles
4. Authorisation of maintenance centres
5. Certification of fulfilment of the required traffic safety conditions of the Control, Command and Signalling subsystem
6. Authorisations of change to certified traffic safety installations

7. Infrastructure inspection
8. Conventional rolling stock inspection
9. Inspection of maintenance centres
10. Inspection of train traffic
    - Inspection of loads
    - Inspection of the carriage of dangerous goods by rail
    - Inspection of conditions of travel during journeys in the cab
    - Inspection of speed recorders
11. Management of defect repair
    - Management of defect repair
    - Management of safety checks
12. Risk assessment and management procedure
13. Level crossing inspection procedure
14. Inspection of track works
15. Safety audits

Chapter 4: Contingency Plan

Chapter 5: Traffic safety requirements for suppliers and contractors

Chapter 6: Accident notification and investigation procedure

Chapter 7: Staff training programmes
- Obtaining traffic safety approvals
- Approval of authorisation programmes at approved training centres
- Replacement and withdrawal of driving authorisations and licences

Chapter 8: Procedures for the control of alcohol consumption and abuse of drugs and other psychoactive substances

Chapter 9: Issue of inspection records and handling of complaints

Chapter 10: Control of measuring instruments

Title III: Safety Management Systems of the Executive Boards

This gives a detailed description of each SMS specific to the Adif executive areas, and specifically those compiled for:

- Traffic
- Conventional network
- High-speed network
- Logistical services

3.2.1.2. Procedures

As supplementary information, the procedures which may be thought to be directly or indirectly relevant to this accident investigation are detailed below. They currently form part of the Adif traffic Safety Management System.

- Procedure of the traffic safety management participatory bodies -SGSC/OPG- (from Title I, Chapter 3)

  Approved in February 2009, it defines the bodies which facilitate active participation by all Adif staff in the traffic SMS, their membership and functions. It governs their functioning and establishes the necessary mechanisms to implement the measures they pass, in order to guarantee control of risk and continuous improvement of traffic safety.

- Procedure for drafting annual traffic safety plans -SGSC/PASC- (from Title II, Chapter 1, section 4)

  Approved in September 2010, this prescribes a set form for annual traffic safety plans, covering how they are drafted and the monitoring and correction of any non-conformities from it which may arise.

- Procedure for management of traffic documents –SGSC/GDC- (from Title II, Chapter 2)

  This was approved in February 2012. Its purpose is to ensure the availability and quality of the current regulations published by Adif, established in the General Traffic Regulation. It is the procedure for applying for them and publishing, distributing and handing them out in the necessary familiarisation time for the people who have to enforce them in pursuit of their duties.

- Procedure for certification of compliance with the traffic safety conditions applicable to the Control, Command and Signalling subsystem -SGSC/CCC- (from Title II, Chapter 3, section 5)

  Approved in January 2012, this describes the process at the Traffic Safety Directorate (DSC) for issuing the safety certificate of compliance of the Control, Command and Signalling subsystem with the applicable safety conditions, for lines, or routes thereon, belonging to the Public Rail Network (REFIG).

- Procedure for inspecting conditions of travel during journeys in the cab -SGSC/ICC- (from Title II, Chapter 3, section 10)

  Approved in October 2009, the procedure explains how to check, from the driver's cab, compliance by driving and traffic staff, preservation of the infrastructure and railway facilities necessary for operation, the safety devices and appliances in use, their fitness for circulation and the provision of the necessary staff.

- Procedure for inspecting speed recorders -SGSC/IRV- (from Title II, Chapter 3, section 10)

This procedure, approved in February 2011, is for the corroboration, by means of recorder samples, of compliance with the speed limits set in the timetables, execution of the required halts and the use and functioning of the signalling and braking systems (ASFA, ASFA Digital, ATP, LZB, ERTMS). In general, the procedure checks whether the actions of driving staff are appropriate in response to the successive information given by the safety devices. It also verifies the perfect working order of the other active signals from the static memory equipment.

- Procedure for managing defect repair – SGSC/GCA (from Title II, Chapter 3, section 11)

  The procedure, approved in August 2011, was devised for the creation of the rules of action after the detection of non-conformities to the requirements established and detected during inspections, visits, surveys, audits etc., which were discovered by any officer with power or authority to do so, in the course of his duties. These non-conformities may relate both to breaches of the regulations and to railway installations and rolling stock. The remedial action will be taken to solve real and/or potential defects at the source.

- Procedure for risk assessment and management –SGSC/EGR (from Title II, Chapter 3, section 12)

  Approved in October 2009, this establishes the procedure for assessing risks of accidents, as a method of management. It makes this one of the key elements of risk prevention policy.

  Risk assessment is a method which allows quantification and classification of the risks deriving from the Adif operation. Hence it is essential for it to be accepted and uniform for all. The aim is that comparison and classification should be uniform and feasible.

- Procedure for technical investigation of railway accidents –SGSC/ITAF- (from Title II, Chapter 6)

  Approved in October 2009, this establishes the main rules to obey in the railway accident investigation (IAF) process by Adif. It also prescribes the relations between the railway undertakings (RU) and Adif and the action taken by them in the process of obtaining field data and subsequent writing of railway accident reports.

3.2.2. SMS of the railway undertaking: Renfe Operadora

3.2.2.1. Structure and content

With regard to the safety of transport by rail in Spain, Law 39/2003 of 17 November 2003 on the rail sector requires railway undertakings to hold a safety certificate in order to operate. This proves compliance with the set requirements '*on the management of safety, driving and accompanying staff and rolling stock, and on any others prescribed by regulation'* (Article 57.2).

The safety certificate consists of a Part A, which confirms approval of the railway undertaking's Safety Management System, in accordance with the provisions of Article 15 and Annex 2 of Royal Decree 810/2007, and a Part B, certifying approval of the measures adopted by the railway

undertaking to comply with the specific requirements necessary for the provision of services in a safe way.

Renfe Operadora, specifically, holds the safety certificate issued by the Railway Directorate-General in force since May 2011. It is valid for the whole network, for the carriage of passengers and goods. It is in force until May 2016. The first certificate was issued on 30 June 2006.

The Safety Management System consists of: the company's organisation with safety-related skills; the safety procedures applicable to safety-related processes; and the bodies in which staff participate concerning traffic safety.

Below there is a summary of the SMS manual, approved in March 2011, followed by a list of some procedures which may have a bearing on this accident investigation.

The purposes of the manual are as follows:

- to describe the structure of the Safety Management System and highlight the responsibilities of the people and departments that fulfil functions relating to traffic safety;
- to instruct all members of the organisation on system content and further their commitment to safety policy, good practice and effective risk prevention; and
- to supply the necessary information to carry out system audits.

It is structured into 11 chapters with the following contents:

1. Introducing Renfe
2. Purpose of this Manual
3. Safety policy
   - 3.1. Renfe's mission
   - 3.2. Renfe's vision
   - 3.3. Principles of the safety policy
4. Safety objectives
5. The Safety Management System
   - 5.1. Functional structure and responsibilities
   - 5.2. Organs of governance of the SMS
   - 5.3. Processes
   - 5.4. Structure of the documentation system
   - 5.5. Control of documents and records
   - 5.6. Information supply
6. Resource management
   - 6.1. Training of railway staff in traffic safety functions

It also has the following four annexes:

Annex I: Organs of governance of the traffic Safety Management System

This governs the participation of people and coordination between departments. It is done via the various organs of governance which have been created with the mission of ensuring set-up of the traffic SMS.

Annex II: Manual of posts and functions with responsibility for traffic safety

This contains the functional structure and responsibilities of the people and sections in relation to the traffic SMS.

Annex III: List of basic documentation of the traffic Safety Management System

Annex IV: Table of relations between the Manual and the basic traffic Safety Management System documentation

This is designed to give an overall vision of the manual. It establishes traceability between the sections of the Safety Management System manual, the general procedures referred to in them, and the specific procedures developed from them. Furthermore, this Annex refers to other supplementary documents which form part of the traffic SMS and are used as back-up to the manual content.

3.2.2.2. Procedures

The Renfe Operadora traffic SMS is supplemented by 21 general procedures. These amplify the safety-related processes. They establish directives, methods, action modes and responsibilities. There are also 14 specific procedures relating to technical and human risk management. These develop the content of the general procedure for risk management and establish how specifically to proceed or carry out specific activities and actions.

As further information, details follow on the procedures which can be considered, directly or indirectly, in the investigation of this accident because they currently form part of the traffic Safety Management System of Renfe Operadora.

3.2.2.2.1. General procedures

- SMS-PG-04.- Internal audit of the SMS (system quality audits as per the SMS certification directive)

  This establishes the form in which internal audits of the traffic SMS are planned and executed. It ensures that the executing auditors are competent.

- SMS-PG-07.- Risk management

  This defines the process which Renfe Operadora follows to manage the railway risks inherent in its activity. It covers hazard identification and the processes for updating logs of such risks.

- SMS-PG-09.- Rolling stock commissioning authorisation

  The purpose of this document is to define the process whereby Renfe Operadora:

  - guarantees its rolling stock's compliance with the technical standards applicable to it for its commissioning authorisation (European standards, national safety standards and Renfe Operadora's in-house standards); and
  - obtains authorisation for commissioning from the national safety authority (NSA) and other administrative permits authorising the rolling stock to run.

- SMS-PG-14.- Management of certificates and authorisations of personnel performing traffic safety-related tasks

  Its aim is to establish rules of action which must be followed during the process of management of personnel certificates and authorisations. These may be employees or outsiders who are going to fulfil functions related to railway traffic safety at Renfe Operadora. The scope of this procedure excludes granting and renewal of driving licences.

- SMS-PG-15.- Inspection

  This establishes the methods of the various inspecting bodies within Renfe Operadora and defines the rules of action to follow in each case.

- SMS-PG-16.- Defect management

  The purpose of this procedure is to specify how Renfe Operadora identifies and manages defects which may impinge on its safety objectives.

- SMS-PG-17.- Action by Renfe Operadora to investigate accidents and incidents

  The purpose of this document is to establish the organisation and methods to apply in the process of investigating accidents and certain incidents in compliance with the provisions of the Law on the Rail Sector and the Safety Regulation. It also seeks to explain the action by Renfe contained in the joint procedure for '*Coordination and Collection of Data in Accident/Incident Investigations*' approved by the Adif and Renfe Operadora Corporate Traffic Safety Directors on 20 January 2006.

- SMS-PG-18.- Follow-up and checking of recommendations deriving from accident and incident investigation reports

  This describes how Renfe Operadora should proceed to follow up and check the recommendations deriving from the technical investigation of accidents and incidents, and the corresponding action.

- SMS-PG-19.- Management of traffic safety training

  The purpose of this document is to define the process whereby Renfe Operadora:

  - ascertains the training needs of its staff who perform traffic safety-related tasks;
  - plans the necessary training and provides it to those staff-members; and
  - evaluates the effectiveness of its training courses.

3.2.2.2.2. Specific procedures

- SMS-PE-01.-Accompanied trains

  The aim is to prevent risks incurred by driving staff during service, to correct malpractice by checking the action of driving personnel and also observing the surroundings which could impinge on driving (man - machine - organisation), to ensure good performance while trains are running or during manoeuvres.

- SMS-PE-04.- Management of safety recorder content

  The objective is to establish rules of action for the extraction, safekeeping, analysis and processing of the information stored in the safety recorders. Based on this, its purpose is to adopt the appropriate preventive and remedial measures to manage the risk situations identified during analysis of the recordings.

- SMS-PE-08.- Management of risks posed by the human factor

  This sets forth the methodology for the identification of hazards, analysis, evaluation and control of risks due to human behaviour during the operating stage. It involves establishing safety measures oriented towards mitigating and/or eliminating their consequences, as part of the continuous improvement of the SMS.

- SMS-PE-13.- Safety surveys

  A 'safety survey' is an inspection initiative, a sample taken in relation to set questions concerned with traffic safety. Its purpose is to obtain the necessary information to assess the situation regarding the survey topic and establish any necessary measures to resolve or improve it.

3.2.3. Application of the traffic Safety Management Systems to this accident

3.2.3.1. Regulation cab documentation

According to Adif Safety Directorate Notice 74, dated 9 December 2011, the route between Coto da Torre branch and A Grandeira branch km point 85.0 (i.e. line 082, where the accident occurred) falls within the regulatory scope of the Technical Operating Requirements for Traffic and Safety (PTO). The end sections at Ourense and Santiago de Compostela are governed by the General Traffic Regulation.

Thus, in accordance with PTO Article 106, the 'train logbook' informs the driver about the requirements relating to the running of the train, temporary speed limits and the composition and braking of the train. It also contains all other information which has to be passed to the driver. This logbook is unique to each train and day of operation.

Nevertheless, the running of the train is covered by a document with a longer term of validity, called the train timetable or timetable book. This contains the train number, the type of block on each

section, the kilometre point (PK) locating the stations and other important points on the line, the maximum speed which this train can reach in practice on each section, points where it must halt (for scheduling or technical reasons), length of stop, the times at which it has to pass these identified points (stations etc.) and the number of the radio channel which the driver must tune in to in the cab to communicate with the relevant control post.

There is another document. While it is not mandatory to have it in the cab, it complements the other: the Maximum Speed Table. This includes the maximum speeds per route (not per train), the permanent speed limits per track section, and other information.

The train logbook shows that braking availability was 200%, although 155% was necessary, and that the train was type 240 B (maximum speed for the type of rolling stock was 240 km/h, without considering other restrictions). On that day (24 July) a temporary speed limit of 200 km/h was in place, only on track 1. This had been imposed since 25 June 2012, between PK 77.6 and PK 80.1 of that line (082). There were no other recorded limits or restrictions.

The train timetable (book) for Alvia train 150/151 reflects that it had to stop for 10 minutes at Ourense station. It was scheduled to depart from there at 20:01 hours and arrive at Santiago de Compostela station at 20:41 hours, where it was to stop for two minutes.

Still according to the timetable, at the beginning of line 082 the maximum permitted speed is 110 km/h between Coto da Torre branch and PK 2+903. Between that point and PK 84+230, the maximum speed at which this train could travel (dictated by its own rolling stock) was 220 km/h. This point marked the beginning of the Angrois bend (the place of the accident), where the timetable shows a change of speed. This is limited to 80 km/h until the end of line 082 (A Grandeira branch km point 85.0). It then continued (on another line: 822) with another change of speed to 75 km/h as far as Santiago de Compostela station.

Between Ourense and Coto da Torre branch, the timetable indicates that ASFA is in operation with communication by radiotelephone (track-train: channel 62). Throughout line 082, i.e. between Coto da Torre branch and PK 85.0 (A Grandeira branch), the timetable states that ERTMS/ETCS level 1 applies with ASFA (as back-up). Communication is via GSM-R. However, in reality, the ERTMS ends at PK 80+069, as stated in previous sections.

Between PK 85.0 and Santiago station, apparently only ASFA is available with radiotelephony (track-train: channel 64).

The Maximum Speed Table for line 082, 'odd' direction (Ourense to Santiago de Compostela), indicates that the maximum speed for the stretch is 110 km/h from the beginning to PK 2+903. From there to PK 6+094, maximum speed is limited to 235 km/h. From there to PK 84+230 (start of the Angrois bend and place of the accident), the maximum speed rises to 300 km/h, but is reduced to 80 on the next section to A Grandeira km point 85.0 (end of the line). The information given in the last paragraph also applies to the Maximum Speed Table (ERTMS appears up to PK 85 but really only reaches PK 80+069).

Two permanent speed limits also appear on this section. They are at the beginning of the line (PK 1+250 and PK 2+903).

The Maximum Speed Tables for the stretches Ourense - Coto da Torre branch and A Grandeira km point 85.0 – Santiago de Compostela, both belonging to line 822, confirm the requirements of the train timetable: speeds of 105 and 75 km/h and track-train radio on channels 62 and 64 respectively, with ASFA.

Annex 3.2.3.1 contains the train logbook, train timetable (book) and Maximum Speed Table.

No regulation has been found concerning what type of fixed signage must be set up for changes of maximum speed, and in what circumstances these speed changes must be signed on the track.

3.2.3.2. Staff requirements

The driver of train 150/151 was born in 1961. He holds driving licence B and is authorised under Order FOM/2520/2006, of 27 July 2006 (Title V 'Driving Staff'). This is in force until 11 January 2019, by virtue of interim provision 8 of Order FOM/2872/2010, of 5 November 2010.

Driving licence B entitles him to operate and handle any class of railway vehicle on any line of the Public Rail Network (RFIG), provided that he also holds the due authorisations specified below.

As the holder of that licence since 1 January 2007, he has held the employment grade of Leader Driver within Renfe Operadora since 1 July 2010. Before that, he was a Principal Train Driver from 30 June 2008. He had been a driver with the former RENFE from June 2003, and had previously served as an assistant driver from October 2000. He joined that company in December 1982.

To maintain the driving licence, it is necessary to attend a triennial refresher course. He last attended one of these in January 2012.

A periodic medical check-up is also obligatory to assess psychological and physical fitness. Given the driver's age, the interval for this is also three-yearly. His last check-up was in September 2010.

Another requirement of the above-mentioned regulations in force is that the driver must hold authorisation to drive the corresponding rolling stock, and another to drive on a given line.

So the driver has held authorisation to drive rolling stock Class 730 since March 2013. He is also authorised for other types of rolling stock (medium and long-distance passenger, suburban and goods). The dates vary, but the oldest dates are from 2002.

His authorisation to drive on line 082 (Coto da Torre branch – A Grandeira branch) dates from January 2012. He has also been authorised for other RFIG lines from different dates, the oldest being 2004.

The licensed driver had been driving commercial missions on line 082 between Ourense and Santiago de Compostela from December 2011. He had completed a total of 59 missions in both directions, all

with the ASFA Digital driving assistance system switched on and operational. Of these, 18 were with Class 730 rolling stock (from November 2012).

The annual safety plans included periodic inspections of this driver's activity. He passed the following supervisions in the past five years: 43 train record checks (equivalent to 3022 km driven), most recently on 21 July 2013. He was accompanied on his train 16 times (equivalent to 1 426 km) including, on 1 July 2013, on the Ourense – Santiago de Compostela route. He underwent seven manoeuvre inspections and seven random drug and alcohol checks.

3.2.3.3. Controls and internal audits

The description in this section relates to the bodies within Adif and Renfe Operadora which allow participation with a view to improving traffic safety, in conformity to the corresponding Safety Management System. This gives staff (crew, drivers, train managers etc.) a say in safety management.

The inspections carried out by both organisations on the Ourense - Santiago de Compostela lines have therefore been reviewed within the purview of the accident zone.

3.2.3.3.1. Safety management participation bodies at Adif; review of their minutes

A) Participation bodies

Procedure SGSC/OPG, of 2009, governs bodies for participation in traffic safety management. In the wake of organisational changes, there are now three committees: the General Traffic Safety Committee; the Regional Traffic Safety Committee; and the Sectoral Technical Committee.

All are made up of staff members of the various Adif directorates and areas answerable to the Traffic Safety Directorate (various managerial tiers, depending on the committee in question). There are also trade union representatives from the Company-Wide Works Council.

- The **General Traffic Safety Committee** covers the whole scope of the network. It meets four times a year, and its duties include:
  - analysis and pooling of matters of general interest relating to traffic safety; and
  - resolving both on matters raised by the other committees and on those raised by its own members.
- There are three **Sectoral Traffic Safety Technical Committees:** one for each of the following fields: Conventional Network Operations and Engineering; High-Speed Network Operations and Engineering; and Logistical Services. The working scope of each committee is that of the operations and action of the directorates represented on each committee. Ordinarily they meet three times a year and their duties include:
  - studying detected traffic safety risks and proposing remedial measures;

- resolving on motions brought by their members and referring any matters relating to traffic safety, which require resolution at another level, to the competent bodies (the other committees, the operating areas etc.)

- There are six **Regional Traffic Safety Committees**, one for each region of the Traffic Safety Directorate. Their scope covers matters relating to their area. They hold four ordinary meetings per year and their duties include:

  - studying detected traffic safety risks and proposing measures to avoid them;

  - adopting proposals for action on infrastructure and facilities to minimise possible traffic risks; and

  - resolving on motions brought by their members and referring any matters relating to traffic safety, which require resolution at another level, to the competent bodies (the other committees, the operating areas etc.)

B) Review of the minutes

CIAF investigators undertook a review of the minutes of the safety committees relating to the accident under investigation (the General Committee, the Sectoral Technical Committee for Conventional Network Operations and Engineering, the Sectoral Technical Committee for High-Speed Operations and Engineering, and the Regional Committee for the North West). These committees had met in the period between commissioning of line 082 (December 2011) and the date of the accident (24 July 2013).

- General Traffic Safety Committee

  The following minutes were reviewed: from 2011, the meeting of 16/12; all four meetings in 2012 (10/2, 22/6, 5/10 and 14/12); and two during 2013 (18/2 and 21/6).

- Sectoral Technical Comittee for Safety of Conventional Network Operations and Engineering

  Three sets of minutes were reviewed from 2012 (meetings of 17/2, 25/5 and 11/10); and two from 2013 (15/2 and 24/5).

- Sectoral Technical Comittee for Safety of High-Speed Network Operations and Engineering

  Three sets of minutes were reviewed from 2012 (meetings of 16/2, 24/5 and 19/10) and two from 2013 (14/2 and 17/5).

- Regional Traffic Safety Committee for the North West

  Four sets of minutes were reviewed from 2012 (meetings of 25/1, 18/4, 12/7 and 21/10) and three from 2013 (23/1, 17/4 and 11/7).

No comments or observations relating to the accident zone were found in the reviewed minutes.

3.2.3.3.2. Safety management participation bodies at Renfe Operadora and review of their minutes

A) Participation bodies

These bodies are governed by Procedure SMS-MN-A01: Organs of Governance of traffic SMS. There are four traffic safety committees: the Central Committee; the Regional Committee; the Passenger Area Operational Committee; and the Freight Area Operating Committee.

They consist of staff from the various directorates and areas of Renfe Operadora answerable to the Traffic Safety Directorate (at various managerial levels according to the committee in question). There are also trade union delegates appointed by the Company-Wide Works Council. This ensures active participation by all operating staff.

- The **Central Traffic Safety Committee** is competent for the whole organisation. It holds four ordinary meetings per year, and two extraordinary meetings (on specific topics). Its duties include analysis and resolution on:
  - matters raised by the Regional and Operational Committees; and
  - matters brought up by its own members.
- There are two **Operational Traffic Safety Committees**: one for the Passenger Area and the other for Freight and Logistics. Its scope is limited to operations. It meets four times a year, and its duties include:
  - agreeing topics for referral to the Central Traffic Safety Committee and checking implementation of resolutions passed by that Committee;
  - analysis and resolution on matters raised by their own members; and
  - following up the matters referred to the Central and/or Operational Committees until they are finally closed.
- There are six **Regional Traffic Safety Committees**, one for each region of the Traffic Safety Directorate. Their scope is limited to issues within their regions. The hold four ordinary meetings per year and their duties include:
  - monitoring the solution of defects detected on safety visits and inspections, within the scope of their responsibility;
  - resolving on matters referred to it or raised by their members;
  - agreeing on matters for referral to or processing in the Central Traffic Safety Committee and checking implementation of the resolutions adopted by that Committee; and

- following up matters referred to the Central and/or Operational Committee until they are finally closed.

B) Review of minutes

CIAF investigators undertook a review of minutes of safety committee meetings with a bearing on the event under investigation (the Central, Passenger Area Operational and León Regional Committees). These had met during the period between commissioning of line 082 (December 2011) and the date of the accident (24 July 2013).

- Central Traffic Safety Committee

  One set of minutes was reviewed from 2011 (the meeting of 29/11), six sets from 2012 (31/1, 27/3, 29/5, 31/7, 25/9 and 27/11) and three from 2013 (29/1, 26/3 and 30/7).

- Passenger Area Operational Committee

  Two sets of minutes were reviewed from 2011 (meetings of 7/9 and 1/12), four from 2012 (8/3, 14/6, 13/9 and 21/12), and two from 2013 (14/3 and 13/6).

- León Regional Traffic Safety Committee

  One set of minutes was reviewed from 2011 (meeting of 28/10), four from 2012 (27/1, 12/4, 12/7 and 25/10) and three from 2013 (24/1, 11/4 and 11/7).

No observations or comments were found about line 082 Ourense-Santiago de Compostela in the reviewed minutes which might be connected with what happened. There is only one point, in the minutes of the meeting of the León Regional Committee on 28/10/2011, about the visibility of signal S1/3 at the exit from Santiago de Compostela station, which was corrected.

3.2.3.3.3. Inspections by Adif

Adif's Traffic Safety Directorate sets a number of in-cab inspections of traffic safety during journeys in each region. These are specified in the Annual Traffic Safety Plan (PASC).

Procedure SGSC/ICC entails inspection in the cab of conditions of travel during journeys. The purpose is to check, from the driver's cab, compliance with the regulations for driving staff and crew, maintenance of the railway infrastructure and facilities necessary for operation, safety devices and appliances in service, fitness to run, and the deployment of the necessary staff.

Since line 082 was commissioned in December 2011, Adif has carried out eight in-cab inspections between Ourense and Santiago de Compostela: five in 2012 and three in 2013. One of these took place on a 150/151 train service (Class 730). Another detected the only defect (repeated defects of the inspected rolling stock). In all these cases, the driver's behaviour was correct and professional. In no case were defects of infrastructure or other incidents detected.

Annex 3.2.3.3.3 contains the records of the in-cab inspections carried out by Adif.

3.2.3.3.4. Inspections by Renfe Operadora

Renfe Operadora establishes an annual programme of accompanied train journeys, as part of the Annual Action Programme of the Annual Safety Plan. It sets a minimum number of checks of this type to carry out. For this purpose it provides Procedure SMS-PE-PCIA-01: Accompanied Train Journeys.

The aims of these checks are as follows:

- to check compliance with the regulations in force;
- to detect incorrect or incomplete practices by driving staff;
- to check correct fitting of safety devices on power cars;
- during the accompanied journey, to observe the condition of the infrastructure and signalling equipment which may affect traffic safety;
- to observe staff behaviour and psychological and physical conditions which may affect them; and
- to check the ergonomics of the vehicle and installations.

The methods of inspection include checking train safety logs. Hence Procedure SMS-PE-PCIA-04 governs management of safety recorder content.

Thus personnel of Renfe Operadora's León Regional Delegation of the Traffic Safety Directorate and of North Galicia Passenger Market Management were accompanied on journeys and their records were analysed. In the period from 10 December 2011 to 24 July 2013, on the Ourense-Santiago route, a total of 16 safety logs were analysed (equivalent to 1 411 km). 92 medium-distance train journeys were accompanied (equivalent to 8 114 km), and another 35 long-distance (equivalent to 3 087 km).

According to certificates produced by these two departments, the inspections accomplished during the stated period found no defect on the permanent way between Ourense and Santiago de Compostela stations, on the 10 km up to the point of the derailment.

Annex 3.2.3.3.4 reproduces those Renfe Operadora certificates.

3.2.3.3.5. Accident & Incident reports (PAIs) by Renfe Operadora

The Accident & Incident Report (PAI) is a form for notifying occurrences during railway operations. It has been in use since before separation of the now defunct RENFE.

Renfe Operadora driving staff use form PAI to explain an occurrence or report defects which might affect safety, and other business-related faults. The form includes details to identify where the incident occurred (train no, line, kilometre point etc.), description of the facts, measures adopted etc.

The Renfe Operadora Safety Management System includes the General Defect Management Procedure (SMS-PG-16), which deals with defects forwarded by operating staff, on PAIs, as one of the channels of communication of defects. The other channels it lists are: inspections; rolling stock defect logs; and notifications by external personnel to the company.

Form PAI is normally in paper form. It is passed to the driver's next in line, who processes it and forwards it for action, depending on the type of incident. Nevertheless, to help to make the information in the PAIs known as quickly as possible, a computer application has recently been developed. This makes it possible to e-mail the PAI to various addressees (not only the next in line).

Accordingly, CIAF investigators reviewed the PAIs in both paper and electronic format, originating from the North West Management and collected by the León Regional Delegation of the Traffic Safety Directorate. They also reviewed reports made by other personnel and forwarded to that centre by other means (memoranda, e-mails, telephone calls etc).

They reviewed a total of 21 reports, 4 of which were by PAI, for the whole of 2011. They reviewed 16 from 2012, of which 8 were PAIs. Up to 24 July 2013 (the date of the accident), there had been 17 reports, 10 of them by PAI.

The review carried out detected no incident at all relating to line 082 and therefore to the context of the accident.

Thus **Annex 3.2.3.3.5** contains a document from the León Regional Delegation of the Traffic Safety Directorate certifying that the PAIs contain no mention of any incident on the section of track where the derailment occurred, or on the 10 km leading to it.

3.2.3.4. Other considerations

Around 20 January 2014, we learned of the existence of a Renfe Operadora internal communication in which a Leader Driver assesses the hazard existing on the Angrois bend. The company was then asked for information about this.

The description of the facts, according to the documentation received, is as follows:

- Mr. JM1 is a middle manager and Leader Driver in the Galicia Management. He lives in Ourense. His next in line is Mr. JP1, who is Production Manager of Renfe's regional services in Galicia.

- On 23 December 2011 JP1 e-mailed five of his staff (all middle managers and Leader Drivers in Galicia and driver trainers). They included JM1. He asked for data and documentation for the next meeting (the fifth) of the monitoring group for Class 121 rolling stock in operation in Galicia, Aragón and Catalunya, which was to be held on 28/12/2011.

- On 26 December 2011 JM1 answered JP1's e-mail and copied his reply to the other colleagues. He attached a report entitled *'Defects in the ERTMS/ETCS changeover from Level 1 to Level 0 and peculiarities on the AV 082 line.'* Extracts from the comments in his report appear below:

– *'Given the way the changeover from ERTMS to ASFA has been arranged, if the driver does not reduce speed to 200 km/h on his own initiative before PK 77+600, ASFA switches on (at this point) in emergency mode. It is therefore urgently necessary to set back the entry to ASFA (from PK 77+600, where it currently is, to PK 79+500, the point where the changeover from ERTMS to ASFA takes place) or move the curve for reduction of speed to 200 km/h (from PK 79+500 to PK 77+600) sufficiently far forward to avoid triggering the ASFA emergency if the driver does not reduce speed to 200 km/h at this time, because he has some other priority task to carry out.'*

– *'Another peculiarity of line 082 (in the 'odd' direction, i.e. Ourense-Santiago) is a sudden change of speed downwards, for infrastructure reasons, from 300 km/h (200 km/h for Class 121) to 80 km/h. There is no advance notice of this from the trackside signalling, and no ERTMS cover, since trains are already running on ASFA. It seems important to study the possibility of requesting trackside installation of permanent 80 km/h speed limit signs, which could facilitate compliance with the maximum speeds.'*

The first comment therefore describes a defect in the changeover from ERTMS to ASFA, bound for Santiago, before the Angrois (or A Grandeira) bend. The second is a warning that this curve is dangerous.

JM1's four colleagues have made statements that they received his e-mail and did not forward it. They gave training to middle-distance drivers, with special advice on the speed transitions for the Angrois bend and elsewhere.

- On 27 December 2011 JP1 e-mailed documentation for the fifth meeting of the monitoring group for Class 121 rolling stock in operation in Galicia, Aragón and Catalunya, to be held in Madrid on 28 November 2011. He submitted it to three officers of Renfe Operadora who usually attended these meetings with him.

The points contained in that e-mail included that referred by JM1: the defect in the changeover from ERTMS to ASFA and the warning about the Angrois bend.

- On 28 December 2011 the Madrid meeting took place. Nine people were present: five from Renfe Operadora, two from Integria and two from Actren, the maintenance contractor in which CAF and Renfe Operadora have participating interests.

Agenda point 11 referred to '*Adaptation of the braking curve (< 200 km/h) for an adequate changeover from ETCS/ERTMS to ASFA*'. It mentioned the defect detected by JM1 and described in his e-mail on the changeover from ERTMS to ASFA.

The minutes for agenda point 11 read as follows: '*Renfe has forwarded the detected problems to Adif for assessment. Solutions are being studied jointly. Renfe is going to make a provisional request to*

Adif to impose a temporary speed limit on this section in order to adjust the braking curve to the signalling restrictions of the infrastructure'. There is no mention in these minutes of the warning about the Angrois bend.

JM1's first statement says: '*Given that the meetings for the monitoring of Class 121 rolling stock dealt with the topics relating to the ERTMS changeover, he [JM1] and JP1 analysed the last paragraph [this means the one referring to the A Grandeira bend, slowing from 300 to 80 km]. Given that the change of speed was in line with the regulations in force, they decided to intensify the training of all drivers, in the form of intermediate medium-distance driving assignments [JP1 corroborates this in his statement]. Similarly, during the accompanied runs in the cab and advice, driving staff were warned about the peculiar features of the line, to boost safety'.*

The following is emphasised from the statements of the three Renfe Operadora officers who received JP1's e-mail, and who usually attended these meetings: the subject of the sudden change of speed on the Angrois bend was not dealt with at that, or any subsequent, meeting. They only dealt with train maintenance and overhaul issues.

- On 26 January 2012 the sixth meeting of the group monitoring the Class 121s in operation in Galicia, Aragón and Catalunya was held in Madrid. Point 6 of the minutes deals with '*Braking curve for the changeover from ERTMS to ASFA'.* This corresponded to the subject dealt with in point 11 of the fifth meeting. The minutes record, among other things, that there was no change in the situation since the previous meeting, i.e. there had been no progress in resolving the defect in passing from ERTMS to ASFA. There was no mention of the warning of the danger of the Angrois bend.

- That same day, 26 January 2012, according to JM1's second statement, he submitted to a member of the Passenger Traffic Safety Management of Renfe Operadora (Mr GS1) the content of the above-mentioned document '*Defects in the ERTMS/ETCS changeover from Level 1 to Level 0 and peculiarities on the AV 082 line.'* This included the warning of the danger of the Angrois bend. He also says he had experienced computer problems which prevented him from viewing this file.

GS1, in his statement, claims that he has no record of receiving this e-mail. His line manager, the Passenger Traffic Safety Manager of Renfe Operadora, states that he has no record of receiving JM1's report on those dates.

- On 1 February 2012, notice was given by e-mail that Adif had introduced temporary speed limits on both tracks from PK 77+365 to PK 80+278 of the Ourense-Santiago line (082).

- On 6 March 2012 the seventh meeting of the monitoring group of the Class 121 rolling stock in operation in Galicia, Aragón and Catalunya took place. Point 6 of the minutes, '*Braking curve adjusted to changeover from ERTMS to ASFA*' states '*Adif has introduced a temporary speed limit, which has solved the problem from the operational viewpoint…. Point closed.'* There are no comments at all in the minutes about the danger of the Angrois bend.

So, as far as JM1's comments made in his document are concerned, the problem posed by the defective changeover from ERTMS to ASFA in the Santiago-bound direction (between PKs 77 and 80) before the Angrois bend was passed on to Adif. The problem was solved by setting up temporary speed limits. All this formed part of the business of the meetings which were being held on the operation of the Class 121 rolling stock. There is no record that JM1's second comment was passed on to Adif: his warning of the danger of the curve itself.

On the other hand, as commented in previous sections (3.2.3.3.2), the Renfe Operadora SMS does include organs for participation in safety management. Among these are the six Regional Traffic Safety Committees (CTSCs) - one for each region. One of these is León regional CTSC, which includes the area of the North East Management (including Galicia).

As it happens, JP1 and his subordinate JM1 attended the meetings of that Regional Traffic Safety Committee. Information about this was requested from Renfe Operadora. JM1 attended 36 of the 43 meetings of that committee from 2005. He attended all but one of the meetings held in 2011, 2012 and 2013 (he was absent on 15 April 2011).

To sum up, with regard to JM1's second comment, warning of the danger of the Angrois bend, at least nine members of Renfe Operadora were in a position to know about this. It was not dealt with either at the meetings monitoring the operation of Class 121 rolling stock, or at the meetings of the Regional Traffic Safety Committees (or in the other safety committees: the Central Committee and the Passenger Operational Committee). JM1 attended those meetings. There is no record, either, of the warning being passed on to Adif.

3.3. LEGAL FRAMEWORK

3.3.1. National legislation

- Law 39/2003, of 17 November 2003, on the Rail Sector.
- Royal Decree 2387/2004, of 30 December 2004, adopting the Railway Sector Regulations.
- Royal Decree 810/2007, of 22 June 2007, adopting the Regulation on Traffic Safety on the Public Railway Network.
- Order FOM/233/2006, of 31 January 2006, setting the conditions for approval of railway rolling stock and maintenance centres, and fixing the rates chargeable for the certification of this rolling stock.
- Title V of Order FOM/2520/2006, of 27 July 2006, establishing the conditions for obtaining qualifications and authorisations allowing railway staff to carry out safety-related duties, as well as the system of training centres for such personnel and assessment of their physical and psychological aptitude.

- Order FOM/2872/2010, of 5 November 2010, setting the conditions for obtaining licences and authorisations allowing fulfilment of safety-related functions of railway staff and the system of centres for the training of such staff and for checking their psychological and physical fitness.

- Circular Resolution 10/2008 of the Directorate-General of Railways validating modifications to existing vehicles.

3.3.2. Other rules

- General Traffic Regulations.

- Technical and Operating Requirements for Running and Safety (PTOs).

- Adif. Operating Manual.

- *Procedure for the technical investigation of rail accidents* published by the Railway Accidents Investigation Commission (October 2008).

- Adif (Traffic Safety Directorate - DSC). Engineering rules for the positioning of ASFA balises on the track. Version 5 dated 18 February 2010. (This says that they shall be positioned at signals, level crossing and temporary speed limits).

- Adif (DSC). Functional requirements and engineering rules for ERTMS levels 1 and 2. Version 2.4.0.

- Adif (DSC). Experimental 'C' Instruction no 7: New system of announcement of signals and automatic digital braking (ASFA Digital). 25 March 2010.

- Renfe. Circular 1/96. Determining and setting up maximum speeds, and trackside signalling of permanent speed limits. (The purpose is an absolute match between permanent speed limits and the corresponding trackside signage).

- Adif. NAV 5-0-1.0.- Signalling and balises. Signals under the responsibility of the Permanent Way and Works Department. March 1994.

- Adif (DSC). Experimental Instruction 'C' no 76. August 2007: train logbook.

- Adif (DSC). Experimental Instruction 'C' no 17 (16 February 2012) and Annexes: European Rail Traffic Management System (ERTMS/ETCS).

- Adif (DSC). Notice No 74 (dated 9 December 2011): Commissioning new lines, routes and traffic bypasses.

- Renfe (Civil Defence and Traffic Safety Directorate). Notice no 102 (dated 21 April 1997): Use of communication media in the driver's cab.

- Adif (DSC). Instruction 'C' no 25, of 13 June 2012. Special requirements for running Class 102, 112, 130 and 730 locomotives on lines of the REFIG.
- Adif (Network Operation and Development – EyD Red). Instruction Series 'A' no 2993 dated 16 July 2012. CTC LAV Ourense – Santiago de Compostela.
- Adif (Network Operation and Development – EyD Red). Instruction Series 'A' no 2556 dated 16 July 2012. Santiago de Compostela Interlocking System.
- Adif. NAV 7.3.2.0. Track classification: track gauge.
- Adif. NAV 7.3.5.0. Track classification: cant, warping and stability of sleepers.
- Renfe Operadora (Traffic Safety Directorate - DSC). Sheet DSC-FIM 3: Use of the mobile telephone while driving.
- Renfe Operadora (DSC).- Guide to Good Driving Practice (pages 24 and 25).

3.4. FUNCTIONING OF THE TECHNICAL INSTALLATIONS AND RAILWAY ROLLING STOCK

3.4.1. Control, Command and Signalling system

The context of the accident begins at signal E7 at the entry to A Grandeira branch. As stated in Notice 74 by Adif DSC, it falls within the electronic interlocking system of Santiago de Compostela, which is governed by Instruction Series A no 2556, of 16 July 2012.

This interlocking system can be managed by central control from Ourense Control Post and in local control from Santiago de Compostela station. At the time of the accident, it was under local control.

So, in order to find out what indications the track signals were giving in the immediate run-up to the accident, Adif and Renfe Operadora staff compiled an extract from the interlocking records, in the presence of CIAF investigators.

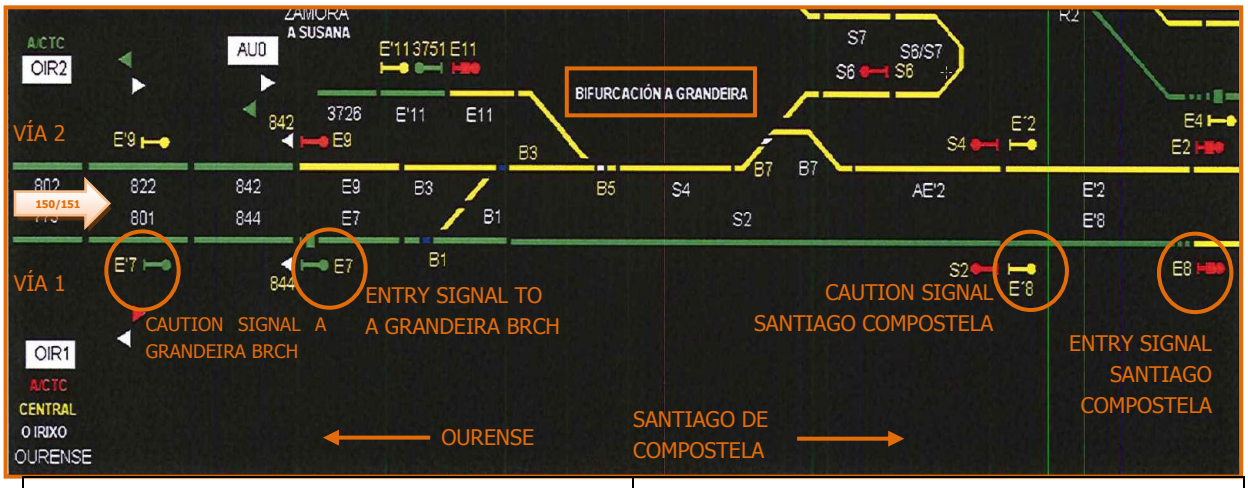
With the cooperation of the provider of this technological installation (Dimetronic), the consistency of the recorded data has been checked against the sequence of events on the video footage during the time, and within the area, of the accident.

The interlocking events have been compiled from 20:40:00 to 20:43:39 hours on 24 July 2013. Attention is drawn to the time mismatch between the train's safety recorder (which is taken as a reference) and the recorder of interlocking events. This mismatch amounts to 2 minutes 32 seconds (the derailment occurred at 20:41:06 hours on the train's safety recorder and at interlocking time 20:43:38).

Analysis of the interlocking records against the video, from which photographs are attached, proves that the path set for train 150/151 was, at all times, up to signal E8 at the entry to Santiago de Compostela station on track 1.

Therefore the caution signal and the entry signal (E´7 and E7 respectively) for A Grandeira branch were showing 'track clear' (green). The next signal E'8, a caution signal for entry to Santiago de Compostela was showing 'stop' (yellow); while entry signal E8 at Santiago was showing 'stop' (red).

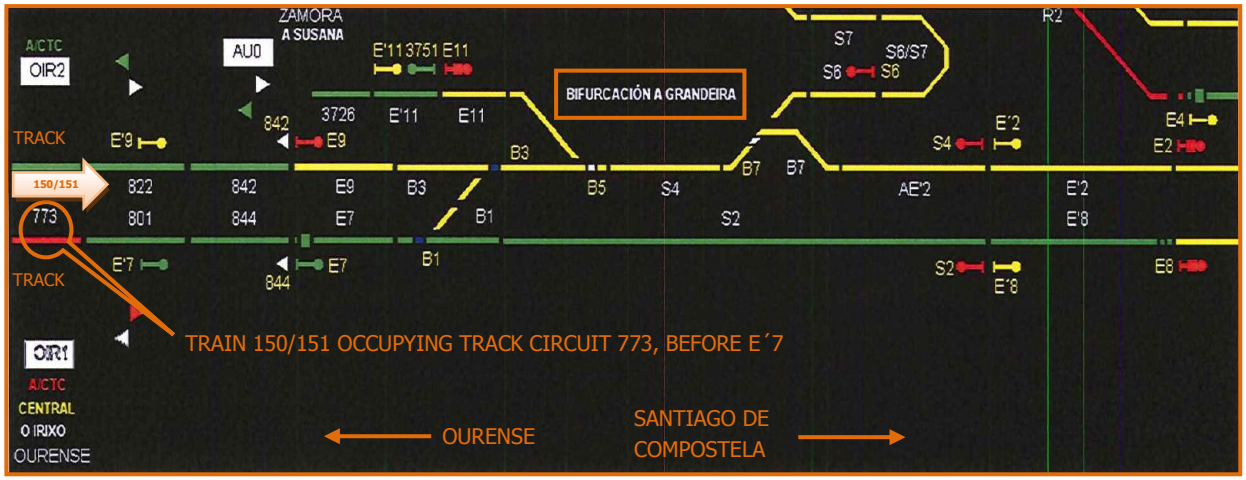
1.- 20:40:00 hours: initial situation



Bif. (Bifurcación)	Branch
Vía	Track

However, train 150/151 did not get near caution signal E´7. That is why none of the circuits in the picture is occupied. The path of entry to Santiago de Compostela station via track 1 is already established, with signals E´7 and E7 at green, E´8 yellow and E8 red.

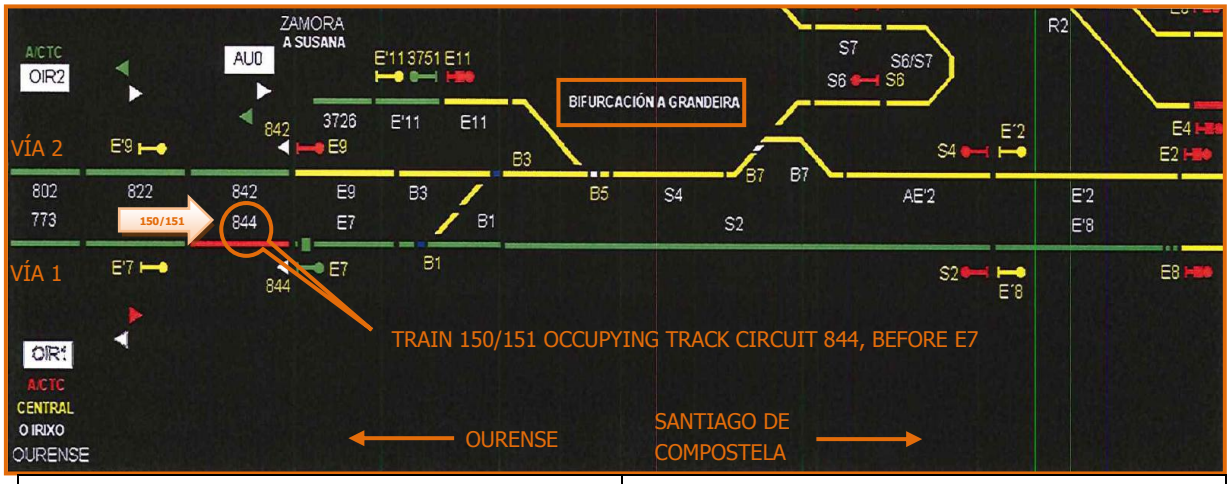
2.- 20:41:28 hours: approach to caution signal E´7



Bifurcación	Branch

The train is occupying track circuit 773, before caution signal E´7. Signals E´7 and E7 are at green, E´8 at yellow and E8 at red.

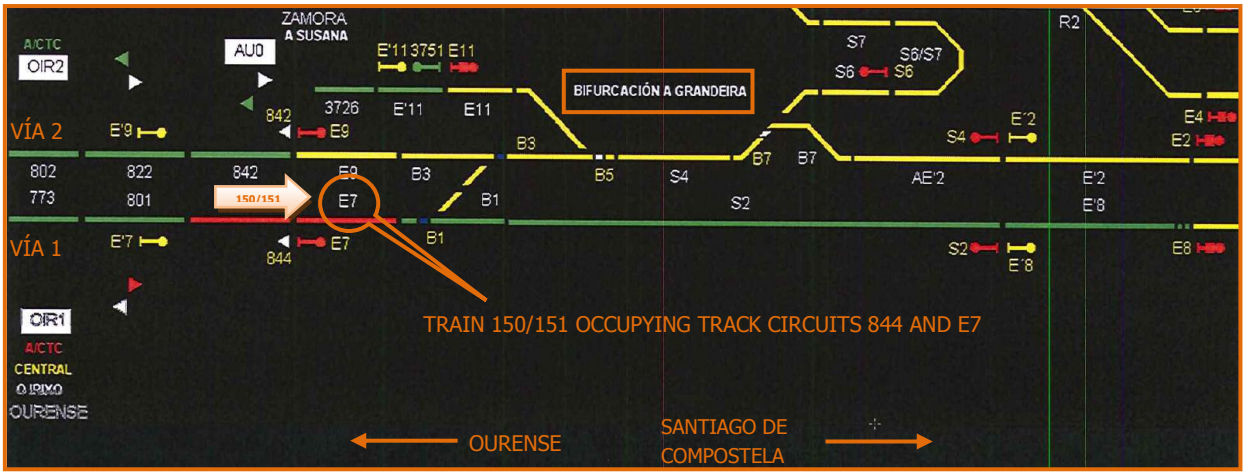
3.- 20:43:03 hours: approach to entry signal E7



Bifurcación	Branch
Vía	Track

The train is occupying track circuit 844, before entry signal E7. Signal E´7 switches to yellow (because this signal has already been lowered for the train) while E7 remains on green; E´8 on yellow and E8 on red.

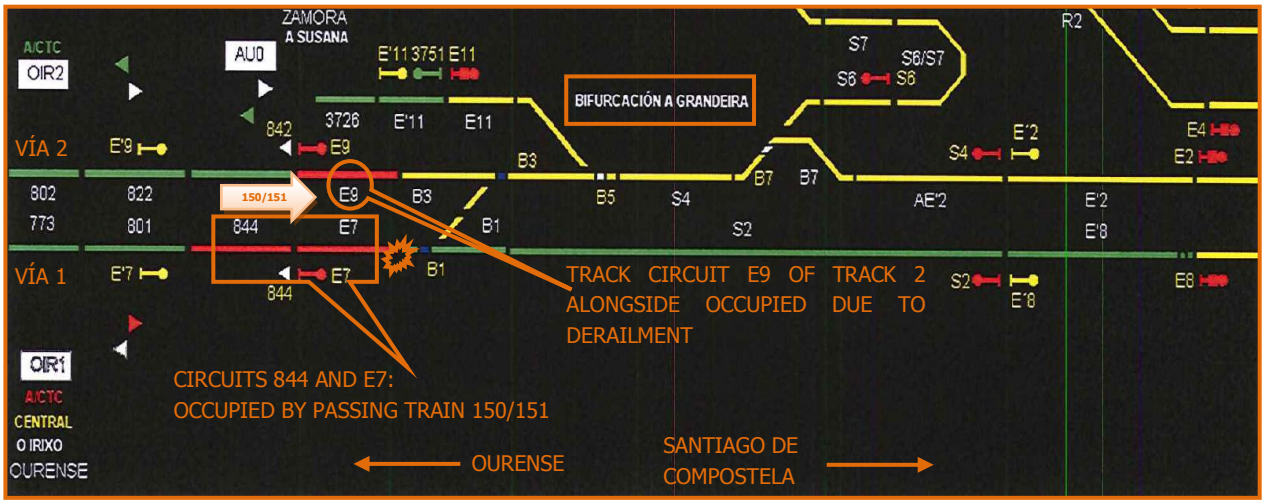
4.- 20:43:29 hours: passing signal E7



Bifurcación	Branch
Vía	Track

The train is occupying track circuit E7, while still occupying 844 (before E7). Signals E´7 and E7 are at yellow and red respectively (because the train has passed them). E´8 is at yellow and E8 at red.

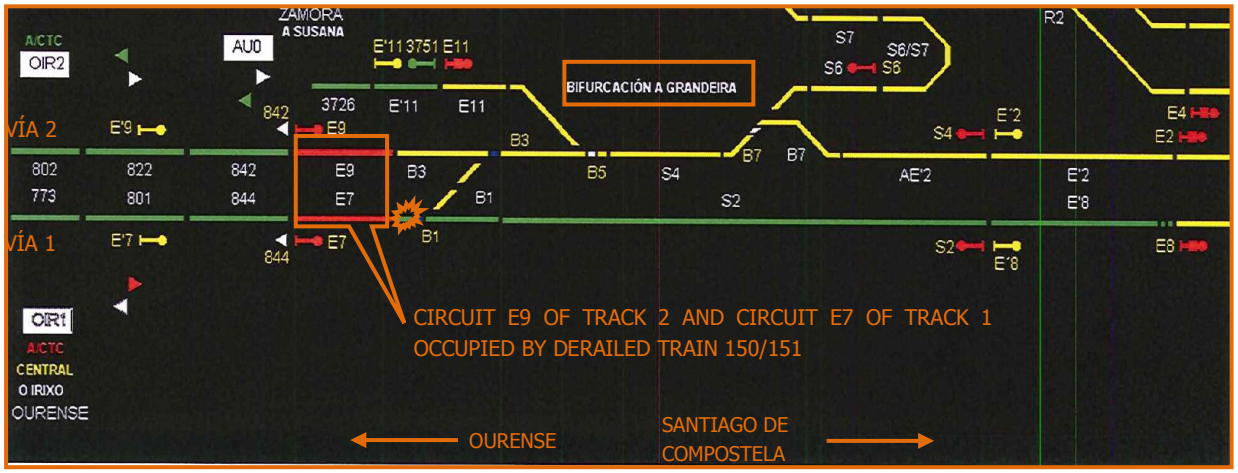
5.- 20:43:38 hours: Derailment



Bifurcación	Branch
Vía	Track

The train is still occupying track circuits 844 and E7 as it leaves the rails. The damage also causes occupation of circuit E9 on the adjacent track 2. Signals E´7 and E7 remain at yellow and red respectively (both already passed). Signal E´8 is at yellow and E8 at red.

6.- 20:43:39 hours: final situation



Bifurcación	Branch
Vía	Track

The train, now derailed, frees circuit 844 but continues to occupy circuits E7 of track 1 and E9 of track 2. Signals E´7 and E7 remain at yellow and red respectively. E´8 is on yellow and E8 on red.

3.4.2. Infrastructure

3.4.2.1. Background

Information study

The Directorate-General of Railways of the Ministry of Development launched the Information Study for the Project to Provide Railway Access to Galicia, Ourense - Santiago Leg in December 1999. It considered five alternative routes, with the same solution for access to Santiago de Compostela.

This underwent the official public information procedure in November 2001. 310 written submissions were received, and the Information Study was altered as appropriate. None of the submissions raised objections to the route in the accident zone.

In May 2002 the file was submitted to the Ministry of the Environment for the requisite environmental impact declaration, which was given in March 2003.

The State Secretariat of Infrastructure at the Ministry of Development finally approved this Information Study in April 2003. It opted to go ahead with alternative Solution C, with the modifications contained in the public information file and in the environmental impact declaration.

Projects

By resolution of 30 April 2002, the State Secretariat of Infrastructure at the Ministry of Development ordered the former Railway Infrastructure Manager to draft the corresponding projects. It divided the line into two sections (Ourense-Lalín and Lalín-Santiago) and began formalities to draw up the basic projects in April 2003. It did not deal with access to Santiago and Ourense.

These two basic projects served for the tendering in the competitive procedure for the design and building of the track formation of the line. For this purpose, each of these two sections was initially divided into six subsections (making a total of 12). These were put out to tender in April 2003. The construction projects were drawn up and approved between June 2005 and April 2006.

For access to Santiago station (track formation), tenders were invited for a basic project in March 2006 and the construction project in April 2008. For access to Ourense station (track formation), tenders were invited for a basic project in August 2005 and the construction project in November 2008.

Bidding also proceeded for the construction projects for the track assembly (November 2008), electrification (July 2008) and installations (September 2009) for the whole line. The tender was subsequently drawn up.

This line was designed with track of the standard (UIC) gauge. Two gauge changers were installed: one at Ourense (on the Santiago side, at PK 1+700 of line 082) and the other at Santiago de

Compostela station itself (on the A Coruña side). The aim was to connect the line to the rest of the rail network on the Iberian gauge.

Consideration was also given to installing ERTMS between these two gauge changers. This system therefore extended to Santiago de Compostela station, although it only covered the new tracks laid out.

This means that the standard gauge tracks planned between the Ourense gauge changer and that at Santiago de Compostela station are governed by ERTMS from CRC at Madrid-Atocha, whereas the other tracks continue to be managed via the various interlocking systems (from Ourense and Santiago) which incorporate ASFA.

The changeovers between the ERTMS installed on the new, standard-gauge tracks and the ASFA system present on the conventional gauge tracks at Ourense and Santiago de Compostela stations were planned at these gauge changers, using the manoeuvres to change the gauges of the trains.

Construction works

The contract for the track formation works on the Ourense-Santiago leg, on the section giving access to Santiago de Compostela station, was awarded in July 2009. The works were completed in November 2011.

The contract for assembly of the track on the section from O´Irixo to Santiago de Compostela was awarded in May 2010 and the contract for the works of electrification between Ourense and Santiago (the whole line) was awarded in February 2010.

The contract for the works on the safety and communications facilities (signalling, centralised traffic control etc.) between Ourense and Santiago was awarded in April 2010 and for the civil defence and tunnel safety installations in April 2011.

The line commenced service in December 2011.

Modification of the original solution

During the course of the works, it was decided to make a modification. This was to provide Iberian track gauge (rather than standard) throughout the line. This ensured continuity of the Iberian gauge throughout the Galician rail network. The originally planned gauge changers were cancelled, because two gauge changeovers in just 90 km would seriously erode the time savings achieved by the new section. In future, when standard gauge might be available on other, basically southward, stretches, the switch would be made to this gauge with multi-purpose sleepers available.

The change of gauge, from standard to Iberian, also made it possible to increase the functionality of the new line (082). It no longer entered single track at Santiago. Instead, connection was possible with the Eje Atlántico towards Vigo (line 824) without the need for manoeuvres at Santiago de Compostela station. However, the A Grandeira and Río Sar (line 842) branches had to be available for this purpose.

Thus, in June 2010, the initially planned solution was reconsidered. A proposal was made in October 2010 to modify it. The Ministry of Development authorised this in April 2011.

This decision necessitated a change of plan, mainly to the safety and communication installations (ERTMS and ASFA location), track assembly (sleepers and track gear) and electrification (catenary).

As regards the signalling and control installations, given that the new gauge allowed movements to/from other existing lines managed by the Santiago interlocking system, it was arranged that this interlocking system would also manage the section of this new line where it accessed Santiago de Compostela, plus the A Grandeira and Río Sar branches. As commented, this access section had ASFA, not ERTMS.

It was therefore necessary to set the new boundaries of management of the interlocking system of Santiago de Compostela station (and the boundaries at Ourense). This would now include governance of the access sections to the new line and its interconnections with the existing tracks.

Further thought then had to be given to the locations of the changeovers between the ERTMS safety system planned on the new line and the ASFA system on the conventional rail network. So far these changeovers had been provided at the planned gauge changeovers. Now, the new boundaries were set between both systems on the new build line (082).

These changeovers must comply with the Adif standard 'Functional Requirements and Engineering Rules for ERTMS L1 and L2. Version 2.4.0 dated 22/10/2009'. More specifically, section 5.2.6 'Changeover from ERTMS/ETCS Level 1 to ASFA' states that changeovers to ASFA must be announced and arranged on the route, and always before a caution signal.

As the Santiago de Compostela interlocking system includes the bypass A Grandeira branch (and the Río Sar branch), it was then necessary to position this changeover in the Ourense - Santiago direction before the caution signals E´7 (for track 1) and E´9 (for track 2). Both of these are located at PK 80+619. Hence, in deference to the standard, the changeover was located at PK 80+069 (actual PK; the PK 80+169 in the project).

The arrangements for changeover from ASFA to ERTMS are established in section 5.2.5: 'Changeover from ASFA to ERTMS/ETCS Level 1' of the standard. It states that the order to change to level 1 must be given in a group of fixed signal balises. Thus, in the opposite direction, Santiago - Ourense, on the access tracks to Santiago the changeover was made at signals 844 (track 1) and 842 (track 2), the first signals located after the bypass of A Grandeira branch, at PK 84+200.

On the access tracks to Ourense, the changeovers were made in a similar way. In the Santiago-Ourense direction (change from ERTMS to ASFA), it was at PK 7+206, before caution signals E´8 (for track 1) and E´6 (for track 2), both located at PK 6+701. In the Ourense-Santiago direction (change from ASFA to ERTMS) it was at signals 17 (track 1) and 19 (track 2), both located at PK 1+857.

Changeovers from ERTMS to ASFA (and vice versa) also occur on other high-speed lines on the RFIG, generally at access routes to stations. One example is Madrid-Atocha (access from the Madrid-Barcelona high-speed line), Málaga, Valladolid and Albacete.

It should be pointed out that the decision taken at the time, to modify the physical cover of the ERTMS, has no direct bearing on the establishment of the specific causes of this accident, since the circumstances of incompatibility, which obliged that train to travel on BSL and ASFA, might have occurred just the same if the ERTMS had included Santiago de Compostela station.

Annex 3.4.2.1 contains a diagram of the originally planned tracks and those actually laid after the approved modification.

3.4.2.2. Authorisation to commission line 082

Article 81h of Law 39/2003 on the Rail Sector lists, among the matters for which the Ministry of Development is competent, the granting of certificates of opening of lines to public transport before operation thereof commences.

Article 16 of the Regulation under the Rail Sector Law, passed by Royal Decree 2387/2004, develops the above. It requires Ministry of Development authorisation to be held before commissioning a line on the RFIG. This must state that it can be commissioned, provided that it meets the safety conditions required by the applicable regulations.

The same Article adds that such authorisation must be granted by the Director-General of Railways, having seen the following documentation:

- Report of conformity of the built structures to the technical regulations applicable, issued by the personnel responsible for their construction and supervision;
- documentation received proving completed execution of the test plan established by the infrastructure manager or, as applicable, the Directorate-General of Railways (DGF); and
- certification from the infrastructure manager (in this case Adif) of fulfilment of the set conditions concerning safe railway operation.

So, based on the above, Adif passed its application file to DGF for authorisation to commission the new line 082, from Ourense (PK 0+000) to Santiago de Compostela (PK 88+241).

It is worth noting that this included commissioning documentation for the electrification of the 25 kV section from Santiago to A Coruña on the Eje Atlántico, but this has no bearing on the investigation of this accident.

The documents in that file belonged to the various subsystems into which the various actions which gave rise to completion of line 082 can be grouped.

These subsystems are: Infrastructure (subdivided into Track Bed and Track Assembly), Power (subdivided into Overhead Contact Line, Substations and Remote Control), Civil Defence (referring to the tunnel safety installations) and the Control, Command and Signalling subsystem.

In accordance with the above-mentioned regulations, each of the subsystems described was backed by the following documents:

- Reports of conformity of the built structures to the technical regulations applicable, issued by the personnel responsible for their construction and supervision and including, beyond the scope of the applicable regulations in each case, documents proving acceptance of the works; and

- Reports proving completed execution of the test plan, issued by those responsible for executing and supervising it; including a description of the test method defined by Adif and DGF.

A certificate issued by the Adif Traffic Safety Directorate, of compliance with the required traffic safety conditions, was also submitted.

The following is the detailed documentation submitted for each subsystem, referring to conformity to the technical standards and execution of the test plan and, finally, the corresponding safety certificate.

Infrastructure subsystem (track bed):

- *Report of conformity to the technical regulations of the infrastructure works (track bed) laid on the North-Northeast High-Speed Corridor. Ourense-Santiago de Compostela leg. Line 082 from PK 1+000 to PK 88+127.* This includes a list of the technical standards used to build the works. The records of acceptance of the track bed works are also included as documentary evidence.

- *Report certifying the test method for the infrastructure (track bed) works on the North-Northwest High-Speed Corridor. Ourense-Santiago de Compostela leg. Line 082 from PK 1+000 to PK 88+127.* Encloses the quality certificates issued by the contractors responsible for technical support and quality control, as documentary evidence.

Infrastructure subsystem (track):

- *Report of conformity to the technical regulations for the track assembly works on the following sections: Ourense -O Irixo (line 082: from PK 2+100 to PK 28+510), O Irixo-Santiago (line 082 from PK 28+510 to PK 84+500), access sections to Ourense station and remodelling Santiago station (line 082: from PK 1+036 to PK 2+100, line 842: from PK 0+000 at A Grandeira branch to PK 1+060 at Río Sar branch).* It includes the records of delivery to Adif Maintenance of the track assembly works and the list of the technical standards followed while carrying out the track assembly, as documentary evidence.

- *Report certifying the test method for the track assembly works on the following sections: Ourense-O Irixo (line 082 from PK 2+100 to PK 28+510), O Irixo-Santiago (line 082, from PK 28+510 to PK 84+500), access sections to Ourense station and upgrade of Santiago station (line 082, from PK 1+036 to PK 2+100, line 842 from PK 0+000 at A Grandeira branch to PK 1+060 at Río Sar branch).* It annexes the method of the tests carried out and the list of standards applied while doing so.

Power subsystem (overhead power line):

- *Report of conformity to the technical regulations of the corresponding installation works on the overhead power line and related systems on the Ourense-Santiago leg of the North-Northeast High-Speed Corridor. Line 082 (PK 0+903 to PK 88+241).* It encloses the records of delivery of the works to Adif Maintenance and also annexes the list of technical standards and record of (provisional) acceptance.

- *Report certifying the conformity of the test plan for the works of execution of the construction project and maintenance of the overhead power line and associated systems for the Ourense-Santiago leg of the North-Northeast High-Speed Corridor. Line 082 (PK 0+903 to PK 88+241).* It encloses the methods and tests carried out on the various equipment and components making up the works governed by the contract.

Power subsystem (substations):

- *Report of conformity to the technical regulations of the works in execution of the construction project and maintenance of the two traction substations and self-transforming units associated with the Ourense-Santiago leg of the North-Northeast High-Speed Corridor. High-speed line 082 Ourense (PK 0+000)-Santiago de Compostela (PK 88+241).* It encloses a record of provisional acceptance of the works and a record of delivery of the installations to Adif Maintenance, with a list of the technical standards applied to the implementation of the works.

- *Report certifying the test method for the works executing the construction project and maintenance work on the two traction substations and auto-transformer units associated with the Ourense-Santiago leg of the North-Northwest High-Speed Corridor. High-speed line 082 Ourense (PK 0+000)-Santiago de Compostela (PK 88+241).* It includes the method of tests carried out on each constituent part of this project.

Energy subsystem (remote control):

- *Report of conformity to the technical regulations of works for the remote control of power on high-speed line 082 from Ourense (PK 0+000) to Santiago (PK 88+241), on the Northwest High-Speed Line.* It includes records of provisional acceptance and delivery of the installations to Adif Maintenance, and a list of technical standards followed to implement the works.

- *Report certifying the test method for the works of remote control of power on high-speed line 082 from Ourense (PK 0+000) to Santiago (PK 88+241) on the Northwest High-Speed Line.* It includes equipment acceptance documentation. An annex contains the methods for the tests carried out on the equipment governed by this contract.

Civil defence subsystem (tunnel safety):

- *Report of conformity to the technical regulations of the works of the project for the construction and initial maintenance of the civil defence and safety installations in the tunnels on the Ourense-Santiago leg - line 082 from PK 1+000 to PK 88+127.* It includes an annex listing the technical standards followed to implement the works.

- *Report certifying the test method for the works of the project for the construction and initial maintenance of the civil defence and safety installations in the tunnels on the Ourense-Santiago leg - line 082 from PK 1+100 to PK 88+127.* It includes certificates relating to the materials used in the tunnels. It is also accompanied by the documentation with a certificate from the contractor appointed to provide technical assistance, certifying that it complied with the requirements of the Special Technical Specifications.

Command/Control and Signalling subsystem:

- *Report of conformity to the technical regulations of the works of interlocking installations, train protection systems (ASFA and ERTMS L1), centralised traffic control, auxiliary detection systems (DCC hot box detection and SCVL sidewind control), falling object detectors (DCO), power supply, construction of fixed telecommunication systems, videosurveillance systems, access control and anti-intrusion devices, GSM-R mobile telecommunications installations and infrastructure for public operators of the Ourense-Santiago de Compostela section between Coto da Torre branch (PK 0+903) and A Grandeira branch (PK 84+188) on line 082, part of the North-Northwest High-Speed Corridor.* The list of technical standards followed when executing the works is annexed.

▪ *Report certifying the test method for the works of installation of interlocking and train protection systems (ASFA and ERTMS L1), centralised traffic control, auxiliary detection systems (DCC and SCVL), falling object detectors (DCO), power supply, construction of fixed telecommunication systems, videosurveillance systems, access control and anti-intrusion devices, GSM-R mobile telecommunications installations and infrastructure for public operators of the Ourense-Santiago de Compostela section between Coto da Torre branch (PK 0+903) and A Grandeira branch (PK 84+188) on line 082, part of the North-Northwest High-Speed Corridor.* The list of tests carried out on the various components of the project ensemble is annexed. It is certified that the Validation and Verification Plan was fulfilled, corresponding to the specific application and physical implementation of the ERTMS L1 subsystem.

▪ *Report of conformity to the technical regulations for the works of installation of interlocking and train protection systems (ASFA) and centralised traffic control on the sections: Ourense-Coto da Torre branch on line 822, A Grandeira branch-Río Sar branch on line 842, A Grandeira branch-Santiago station on line 822 and Coto da Torre branch-A Grandeira branch (line 082, PK 84+188 to PK 85+041) allocated to the new Ourense-Santiago de Compostela section of the North-Northwest High-Speed Corridor.* The list of technical standards followed to implement the works is annexed.

▪ *Report certifying the test method for the works of installation of interlocking and train protection systems (ASFA) and centralised traffic control on the sections Ourense-Coto da Torre branch on line 822, A Grandeira branch-Río Sar branch on line 842, A Grandeira branch-Santiago station on line 822 and Coto da Torre branch-A Grandeira branch (line 082, PK 84+188 to PK 85+041) allocated to the new Ourense-Santiago de Compostela section of the North-Northwest High-Speed Corridor.* The methods of the tests carried out on each system included in the project is annexed.

Traffic safety certification:

On 7 December 2011 the Adif Traffic Safety Directorate issued the traffic safety certificate for line 082, A Grandeira branch km point 85.0 to Coto da Torre branch, in the following terms:

> *The Traffic Safety Directorate of Adif, the department competent for analysing safety documentation, has analysed compliance with the conditions applicable to safe railway operation on the route in question.*
>
> *Based on that analysis, we hereby certify that the ENCE and ASFA conventional signalling systems and the ERTMS/ETCS level 1 train protection system on the route concerned conform to the safety requirements for railway operation.*

Authorisation of commissioning:

The Directorate-General of Railways (DGF) has analysed the said technical documentation and found that it provides sufficient evidence of due compliance with the formal and technical regulations in force applicable to railways for the authorisation, requested by Adif, to be granted.

Therefore, by Resolution of 9 December 2011, DGF authorises commissioning of the works on the new line 082 (track gauge 1668 mm) from Ourense (PK 0+000) to Santiago de Compostela (PK 88+241), subject to the completion of certain repairs which are not considered relevant to the investigation of this accident.

3.4.2.2.1. Safety file

Issue of the safety certificate by Adif (which is necessary for the Ministry of Development/DGF to authorise commissioning) is based, with reference to the Command/Control and Signalling subsystem (CMS), on the safety file in accordance with Adif's internal procedures.

Thus Adif has a procedure 'certification of fulfilment of applicable traffic safety conditions by the Command/Control and Signalling subsystem,' which forms part of its Safety Management System.

According to that procedure, the traffic safety certificate is based on the safety file. This file, which concentrates on the Command/Control and Signalling subsystem, consists of documents demonstrating the safety of the system installed on the track. The safety case and Independent Assessment Report supplement this file.

Among the standards followed by these documents are CENELEC EN-50129 (and also EN-50126 and EN-50128), conformity to which is mandatory under the technical specification for interoperability (TSI) relating to the Command/Control and Signalling subsystem dated 7 November 2006. This does not apply to the existing subsystems and equipment.

The safety case specifically applicable to the line or section to be operated contains the necessary documentation to guarantee the installations from their conception and design stage to installation, operation and maintenance. The contractors prepare it and Adif checks it. The Independent Assessment Report is carried out (by a third party unconnected with the works) on the safety case specific to the line or section to be operated.

Specifically, on the new Ourense-Santiago line 082, the documentation making up the safety file divides into three parts:

A) OURENSE–SANTIAGO from PK 1+857 to PK 84+188 of line 082

Section controlled by electronic interlocking –ENCE- from O´Irixo, controlled by Madrid-Atocha high-speed control post. Section equipped with ERTMS L1 and ASFA.

The safety cases are included for the electronic interlocking, ASFA and ERTMS systems. There is also the report of the independent assessment body.

B) OURENSE. From Ourense link to PK 1+857 on line 082

This section is controlled by ENCE at Ourense station from the Ourense conventional network control post. It is equipped with ASFA.

The safety case is included for the Ourense station interlocking system. This was undertaken considering that this was a significant change in an existing installation, in the terms of Regulation 352/2009/EC, of 24 April 2009.

C) SANTIAGO. From PK 84+188 to the Santiago de Compostela link

This section is controlled by ENCE at Santiago de Compostela from the Ourense conventional network control post (or Santiago de Compostela station itself, when in local control mode). Equipped with ASFA.

The safety case is included for the Santiago station interlocking system. This was undertaken considering that this was a significant change in an existing installation, in the terms of Regulation 352/2009/EC, of 24 April 2009.

After reviewing the documentation contained in the safety cases for the three sections into which the line has been divided, we can identify, as related to the accident now under investigation, that the part relating to the completed hazard monitoring identified a series of risks which are 'exported' outside the actual system analysed (command/control and signalling), so that complete mitigation of these risks fell outside the scope of this hazard monitoring.

The operator is bound to cover these risks by acting in accordance with the regulations, or by maintenance. In some cases, they are already dealt with in the existing general regulations (the General Traffic Regulation (RGC), the Technical Operating Requirements for Traffic and Safety - PTO) and other specific documents such as instructions, orders etc.

In the system safety case for the Ourense-Santiago section, in the part headed 'Conclusions. Exported Risks,' the following are highlighted as related to the present accident:

- The Maximum Speed Table for the line must respect the restrictions set for the infrastructure. Risk exported to Adif.
- Trains running under cover of trackside signalling or ASFA must comply with the Maximum Speed Table issued for the line by Adif. Risk exported to the driver.
- The driving assistance system ASFA does not provide supervision on board. Therefore the driver has to obey the indications displayed by the trackside signalling. Risk exported to the driver.

Ineco, as the independent assessment body recognised by the Directorate-General of Railways, drew up the Independent Assessment Report for this section. It also lists the first two risks listed above in its 'Exported Risks' section, without saying where they are exported.

The safety case for the Santiago section in which the derailment occurred also lists the first two risks cited above in its 'Exported Risks' section, with the same recipients.

In the analysis carried out on safety installations of this type, risks which cannot be assumed by the Command/Control and Signalling subsystem itself are exported to other environments. Those environments accept them according to the established regulations, at least as far as those relevant to the circumstances of this accident are concerned.

3.4.2.3. Maintenance

Rail network maintenance operations include preventive maintenance, such as inspection and monitoring of railway lines. With regard to monitoring, a distinction can be made between dynamic monitoring, monitoring of track geometry, and other forms. Track monitoring relies on moving vehicles which collect readings of various parameters for further processing and analysis.

Geometric monitoring takes place using specialist vehicles and generally takes place annually. It takes direct readings of longitudinal level, transverse level (cant), warping, track gauge, plane line alignment etc. There are three levels of analysis: I, II and III. Basically, level I records safety parameters; level II ride comfort; and III track fatigue via the rail (vertical, lateral and rolling contact fatigue) and track gauge.

Dynamic monitoring can be performed on specialist vehicles or on the rolling stock in service, at operating speed. This generally takes place quarterly and is an indirect method of finding out the condition of the track. It measures the accelerations to which the vehicle is exposed in given zones, by positioning accelerometers at strategic points.

Dynamic monitoring measures transverse (or lateral) acceleration on bogies (or wheelsets, as in this case), which is associated with static or dynamic warping and misalignments with a short wavelength. It also detects vertical acceleration on the axle box, which is associated with short-wave levelling defects on each rail (welds, slipping etc.), and lateral and vertical acceleration on the vehicle shell (body), which is associated with long-wave levelling defects and misalignment which affect passenger comfort. Finally, it detects uncompensated lateral acceleration.

In the accident zone, the last geometric monitoring (before the accident) took place on 21 November 2012. The readings for all parameters were good, except a small levelling defect (low point) which could hardly be classed 'ZUT' (a zone requiring urgent attention).

This low point was located towards PK 84+245, at the start of the Angrois bend, and corresponded to the transition wedge of the first pier of viaduct E-01 (in the direction of travel of the train involved in the accident). It was repaired in December 2012.

The last dynamic monitoring took place on 8 May 2013. It used specialist vehicle BT-2, which confirmed the good condition of the track. All the acceleration values measured on the vehicle were far from the minimum monitoring thresholds and well in excess of the values for scheduled or urgent intervention.

Annex 3.4.2.3 contains the data from the geometric monitoring (analysis I) carried out in November 2011 and the dynamic monitoring carried out in May 2012.

The geometric monitoring record shows (from the top down) the longitudinal level (of the left-hand rail, axis and right-hand rail), transverse levelling (cant), warping (for 3, 5 and 9 metres), plane alignment (curvature) (for the left-hand rail, axis and right-hand rail), lateral rail wear (left and right), track gauge and cant again.

It is pointed out that there is a slight mismatch with the actual kilometre count, although the location of kilometre points is feasible from external references shown on the graph (underpasses, overpasses, signals etc). On the other hand, significant fluctuations were apparent in some of the measured parameters (curvature) up to PK 85.2. These were attributable to the diverging route of the bypass track at crossover B1-B3 at A Grandeira branch, after the Angrois bend.

The record of the dynamic monitoring shows (from the top down): lateral acceleration measured on both wheels on the same side; vertical acceleration measured on the axle boxes of the two wheels on both sides; lateral and vertical acceleration on the box (of one of the coaches); and unbalanced acceleration. The kilometre count in this case does correspond to reality. New and larger fluctuations emerge in some of the accelerations, though they are not of significant value. They were attributed to transit of the straight track at the existing bypasses (B1-B3) at the A Grandeira branch after the Angrois bend.

3.4.2.4. Measurement of track data

After the event, in the morning of 25 July 2013, safety technicians from Renfe Operadora and Adif, in the presence of CIAF members, proceeded to measure various track parameters in the derailment zone.

They measured the track from point 0 (beginning of derailment - PK 84+413) forwards for 15 m and backwards for 35 m (normally this is only done for 15 m). They measured the values for track gauge and cant, metre by metre. This interval also fell entirely within the transition curve (clothoid) leading to the 402 m circular curve (the Angrois bend).

Annex 3.4.2.4 contains the sheet of measured track data.

With regard to track gauge, the theoretical value is 1668 mm. Standard NAV 7.3.2.0 - *Track qualification: track gauge* sets maximum tolerances of -3 mm and +15 mm for the theoretical value for curves of radius greater than or equal to 400 m. The measurement on location found values ranging from -0.1 to +0.9 mm in the 15 m after point 0. On the 35 m before, the values ranged from 0 to +2.3 mm. The track gauge values were therefore within tolerance.

For track gauge variation, the same standard allows a tolerance of 2 mm between successive sleepers. This implies 3.33 mm/m (for speeds greater than 60 km/h). Here, the maximum variations measured were 1 mm (between points +9 and +10) and 1.6 mm (between points -29 and -30), relating to the sections before and after point 0 respectively. Hence the readings for gauge variation were within tolerance.

For cant, the theoretical value ranged from 96.9 mm at point -35 to 119.6 mm at point 0. Since this is the transition zone, it increases steadily up to 130 mm on the circular curve. Standard NAV 7.3.5.0 - *Track qualification: cant, warping and sleeper stability* sets maximum tolerances of + 10 mm for the theoretical value, for speeds below 120 km/h.

The measurement carried out at the site found values greater than permitted on the section after point 0, which reached -46.2 mm at point +15. This is logical as a result of the derailment. On the section before, the values range from -4.2 mm (at point -33) to -7.9 mm (at point 0). The cant values were therefore within tolerance.

For cant variation (warping), the same standard permits a tolerance of 6 mm per 3 metres, for speeds less than 120 km/h. The measurement at the site found values greater than permitted on the 15 m section after point 0. This made sense as a result of the derailment. On the section before, the cant variation was no higher than 2.3 mm per 3 m, which was therefore within tolerance.

The rail cross section was also measured at three points (84+176: signal E7; 84+230: start of curve; and 84+413: point 0). The purpose was to check for the presence of possible fatigue. This was a new rail (in service since 2011), grade 60 kg/m, and was found to have maintained its theoretical dimensions.

3.4.2.5. Verification of maximum permitted speed admissible on Angrois bend and fixed signalling in the zone

A plane survey was carried out on location on the Angrois bend. This confirmed its layout parameters. After a straight section, the curve begins at PK 84+228. A first section of curve represents a 200 m transition, in the form of a clothoid where parameter A = 283.8. This ends at PK 84+428, the start of the circular curve 402 m in radius and 265 m in length. This ends at PK 84+693, where another transition section, similar to the first, begins. This is 200 m in length and has a clothoid of parameter A = 283.8 ending at PK 84+893, where a straight begins.

The curve has a 130 mm cant, so that the variation in the transition zones is 0.65 mm/m. Both values are normal. As there is an 80 km/h speed limit on the curve, the unbalanced acceleration (Asc) obtained for that speed is 0.50 m/s^2, below the normally established value for type N (normal) trains, which is 0.65 m/s^2. The latter value would be reached at a speed of 85 km/h.

Considering the 8 mm cant deficiency found by the measurement on location in the transition zone (in the immediate vicinity of point 0), the actual cant on the curve would be 122 mm (theoretical: 130 mm), giving rise to an unbalanced acceleration of 0.54 m/s^2. That value is still below the permitted maximum (0.65 m/s^2).

Nevertheless, the dynamic monitoring commented on in a previous section took place at 72 km/h while taking the Angrois bend. It resulted in an unbalanced acceleration of 0.26 m/s^2, consistent with the presence of an actual cant of 130 mm.

The train involved in the accident took the Angrois bend at 179 km/h. This gave rise to an unbalanced acceleration of 5.41 m/s^2, more than eight times the permitted maximum for type N trains (0.65 m/s^2). It is 4.5 times the permitted maximum for the type of train involved in the accident (1.2 m/s^2).

With regard to signalling, on the other hand, there is a series of sign boards in the Santiago-Ourense direction on line 082. These run from the end of the ERTMS (PK 80+069) to point 0 (PK 84+413) of the derailment. These supplement the coloured-light signals E´7 (caution) and E7 (entry to A Grandeira branch). It is worth analysing the reasons and relevance of these signs.

- Board marked 'change ASFA mode' at PK 80+803

Notice 74 'Commissioning new lines, routes and traffic bypasses,' dated 9 December 2011, refers to the new line 082 and other lines affected. It specifies that this signal must be set up for trains running to and from line 082 with ASFA equipment connected. It indicates the point where the change of mode must take place (from high-speed to conventional ASFA - as in this case - or vice versa).

Taking into account that the ERTMS finishes at PK 80+069 (and therefore also the high-speed back-up ASFA), the sign board indicating the changeover is further on (at PK 80+803).

- Board marked 'RGC' at PK 84+176 (post of entry signal E7)

As specified in Notice 74, referred to above, this board is set up to mark the exact scope of application of the regulations: General Traffic Regulation (RGC) or Technical and Operating Requirements for Traffic and Safety (PTOs). It must be set up near the signals delimiting the areas covered (by the RGC or PTO).

Notice 74 adds that the PTOs apply from Coto da Torre branch to A Grandeira branch (PK 85.0). That is why the 'RGC' board is positioned at PK 84+176, to indicate that the train is about to enter this area (from PK 85.0).

- Fixed sign to reduce speed at PK 84+273

As PTO Article 217 states: 'change of maximum speed', this sign marks the point on the line where the maximum speed permitted for the infrastructure changes, as per the Maximum Speed Tables. The kilometre point on the line is written on the inside of the sign (in orange when the change is to a lower speed, and in blue when it is to a higher speed). This is the point from which the new maximum speed must be complied with. The sign is positioned 100 metres along the line where the change of speed occurs.

According to the Speed Table for line 082, it is compulsory to slow to 80 km/h at PK 84+230 (the Angrois bend). Hence this sign is located within the corresponding 100-metre length (at PK 84+273) and is orange (because it marks a reduction). It is marked '84.2'.

Notice 74 appears in **Annex 3.4.2.5**.

3.4.3. Rolling stock

The 730.012 unit involved in the accident is the result of a modification of the 130.012, to allow it to run on unelectrified lines. Basically, therefore, the end passenger coaches (Nos 2 and 12) were modified, and converted into end diesel generator cars ('CET' vehicles).

CETs incorporate the diesel generation plant and auxiliary installations necessary to operate themselves (refrigeration, diesel fuel supply, air intake and silencer) and to supply electricity to the motors.

To function in diesel-electric mode, Class 730 trains are equipped with a 1800 kW diesel engine and a 1600-litre diesel fuel tank which supplies it. There is one of these in each of the two CET cars.

Because of the weight of the diesel generation plant, the CET car has a towed bogie at the end and shares a wheelset with the adjacent coach. Logically, both are of variable gauge. The bogie was developed from the Class 130.

Annex 3.4.3 shows a general diagram of the Class 730 and a detail of a CET generator car.

3.4.3.1. Authorisations

The regulation governing conditions of railway rolling stock approval is Order FOM/233/2006, of 31 January 2006. In this case, it is supplemented by Circular Resolution 10/2008 on the validation procedure in cases of applications for authorisation to commission modified rolling stock, which develops this aspect and makes it more specific.

Therefore, based on the above-mentioned regulations, the modified Class 730 rolling stock, like new rolling stock, must have the mandatory authorisation of commissioning issued by the Directorate-General of Railways, and the relevant authorisation to run, issued by the Adif Traffic Safety Directorate, since this is a significant modification in the terms of Circular 10/2008.

Authorisation is granted for commissioning once proof has been given of fulfilment of the requirements, conditions and technical regulations applicable, and after an approval and test process. Next, the authorisation for running certifies the vehicle's compatibility with the infrastructure and specifies the conditions in which it may travel on the lines of the RFIG.

The 130.012 unit held a running authorisation dated 27 June 2008. The 730.012 unit had likewise been granted authorisation for commissioning on 11 June 2012, and authorisation for running on 13 June 2012.

Annex 3.4.3.1 shows the documents which constitute evidence of these authorisations.

3.4.3.2. Maintenance Plan

For the purpose of obtaining running authorisation from Adif, the order referred to above also requires approval of the appropriate maintenance plan and the maintenance centres earmarked to carry out the operations described in that plan.

The maintenance centres in turn must hold the appropriate approval issued by the Directorate-General of Railways based on the company's technical competence, personnel and finances.

The appropriate Adif approval must also be held for each type of maintenance work to be done, depending on the features of the railway vehicle for maintenance.

Renfe Operadora is the body responsible for maintaining the Class 730 railcar units, which it owns. The companies responsible for maintaining this rolling stock are Patentes Talgo, S.L., and Btren Mantenimiento Ferroviario, S.A. (in which Renfe and Bombardier have participating interests).

Both companies hold the relevant approvals from the Directorate-General of Railways, granted on 19 November 2008 and 29 September 2011, respectively.

Talgo and Btren jointly maintain the Class 730 units at the workshop at the Fuencarral High-Speed Maintenance Base, 28022 Madrid. For this purpose they hold the mandatory Adif authorisation, dated 13 June 2012 and valid for five years. This allows them to carry out operation types IS, IB, IM1, IM2, IM3 and IM4, in increasing order of importance (see annexed table).

The maintenance plan is structured into intervals, depending on the number of kilometres travelled in each case. Thus, when a given level of servicing is carried out, it includes all the operations of all the lower levels of servicing.

In its original configuration as a railcar, unit 130.012 was subject to Maintenance Plan code PM.1300.10, edition 0 of which was dated 26 November 2007. Version 5 is currently in force.

Rake 130.012 had travelled 715 504 kilometres before conversion. In accordance with its maintenance plan, the following servicing was carried out:

- 1 maintenance operation IM3 at 497,942 km, on 29 April 2010;
- 1 maintenance operation IM2 at 253,322 km, on 22 June 2009;
- 3 maintenance operations IM1 (the last at 627,037 km, on 27 October 2010);
- 12 basic operations IB (the last at 714,822 km, on 7 December 2011);
- 106 services IS (the last at 709,077 km, on 22 September 2011).

As a railcar, unit 730.012 is subject to Maintenance Plan code PM.7300.10, drawn up on 9 March 2012 and currently in version 1 dated 30 March 2012. This covers the following servicing and kilometres:

		Minimum km	Medium km	Maximum km
Servicing	IS	4 800	6000	7 200
Basic intervention	IB	33 600	42 000	50 400
Maintenance operation	IM1	100 800	126 000	151 200
Maintenance operation	IM2	201 600	252 000	302 400
Maintenance operation	IM3	403 200	504 000	604 800
Maintenance operation	IM4	806 400	1 008 000	1 209 600
Maintenance operation	IM5	1 612 800	2 016 000	2 419 000
General repair	R	3 225 600	4 032 000	4 838 400

Rake 730.012 had run 202 747 km since conversion and before departing from Madrid-Chamartín station on 24 July 2013. Therefore its total km count since its origin was 918 251.

The vehicle history shows that it had fulfilled its maintenance plan. The work had been done at the set intervals.

The operations at the various intervals were as follows:

- 1 maintenance operation IM3, at 497 942 km, on 29 April 2010 (as Class 130);
- 1 maintenance operation IM2, at 761 097 km, on 14 September 2012;
- 1 maintenance operation IM1, at 875 845 km, on 16 May 2013;
- 2 basic operations IB (the last at 844 029 km, on 13 March 2013); and
- 34 services IS (the last at 918 251 km, from 22 to 24 July 2013, the day of the accident).

The operations carried out under the maintenance plan for railcar units 130.012 and 730.012 are listed in **Annex 3.4.3.2**.

3.4.3.3. Remedial maintenance

The trains have a log in which driving staff enter faults they detect in the rolling stock. The pages of these logbooks have to be numbered. In them, the date of the defect is entered with a brief description of what happened. Later, the staff responsible for the repair enter the repair and its date. There is one log per driving cab.

The repair log for power car 1 (UIC number 96719730046-0), which was at the rear when the accident occurred, has the following note dated 22 July 2013 on the last page (numbered 11201): '*Test of blending valve at head completed with errors. Converter 2 disconnected*.

In the workshop operations section of the log, there is a note of 'pending' relating to the first entry (blending valve). Nevertheless, at the servicing (IS) of the air and brake system carried out on the same day, 22 July, an automatic brake test was carried out. The result was correct and without errors. The second entry (converter) appears as 'repaired.'

Page 30575 of the repair log for power car 2 (UIC number 96719730045-2), which was at the head at the time of the accident, shows the following for 5 July 2013: '*When hauling, sometimes indicates braking when none takes place. The generator car automatically balances this to return it to normal. Noticed that automatic brake duct (TFA) rises to 5.4 kilos until balancing takes place and it stabilises.'* In the part of this sheet reserved for workshop operations, it says: '*Nothing abnormal noted*.

However, page 30579 dated 19 July 2013 contains a note '*Repeat of abnormality in generator car, entered on page 30575*'. The part of this page reserved for workshop operations records that it was checked and no fault was found. This was verified in the workshop, but the defect was not reproduced. This verification is backed by operation report 00125, dated 23 July 2013.

Annex 3.4.3.3 contains the pages from the fault logs, the report of operation 00125 and the report on the air and brake system from the last servicing (IS) carried out from 22 to 24 July 2013).

3.4.3.4. Check of running gear

After the accident, from 25 July 2013 onwards, Adif and Renfe Operadora personnel, in the presence of a CIAF investigator, measured the following running gear parameters: flange thickness; flange height and qR. No values outside those prescribed by the maintenance plan and regulations were detected.

The measurements of the other two parameters - wheel diameter and distance between internal faces of wheels - were obtained from the last measurements carried out by Talgo-Btren in the workshop between 13 May and 24 July 2013. All values were within the limits prescribed for the parameters indicated by the maintenance plan and the regulations.

The table below shows the figures for the running gear.

Annex 3.4.3.4 contains the limit values set in the maintenance plan and listed in the records, which reflect the running gear parameters measured in the field after the accident.

COMPOSICIÓN EN SENTIDO DE LA MARCHA

					Campo			Taller	Campo			Taller	Taller
					Espesor (mm)	Qr	Altura (mm)	Diámetro (mm)	Espesor (mm)	Qr	Altura (mm)	Diámetro (mm)	Distancia entre caras internas (mm)
Numeración UIC	**Tipo vehículo**	**Bogie**	**Posición del eje**	**Eje/Rodal**	**Rueda derecha**				**Rueda izquierda**				
96719 730 045-2	CABEZA MOTRIZ 2	BG130-159	22	Z130-003	**Nº 65450-241**				**Nº 65450-234**				
					28,7	10,1	28,2	970,9	29,4	10,1	28,1	970,6	1.358,8
			21	Z130-004	**Nº 65448-262**				**Nº 65448-263**				
					31,7	10,6	28,3	973,4	31,7	10,3	28,2	973,4	1.359,0
		BG130-006	20	Z130-283	**Nº 35399-035**				**Nº 30841-067**				
					29,3	9,6	29,1	1.010,0	30,1	9,4	28,6	1.010,0	1.359,1
			19	Z130-114	**Nº R30841-047**				**Nº 30841-057**				
					29,4	9,3	28,3	1.010,0	29,4	8,8	28,7	1.010,0	1.358,9
90717 730 132-8	COCHE CET TURISTA	BG130-012	18	Z130-407	**Nº 65094-174**				**Nº 65093-127**				
					29,3	9,3	28,0	964,8	29,7	10,4	28,4	964,7	1.359,0
			17	Z130-408	**Nº 65094-210**				**Nº 65094-209**				
					29,5	11,1	28,2	966,6	29,3	10,1	28,2	966,5	1.359,3
90717 730 131-0	COCHE TURISTA		16	RRH0018	**Nº 65357-214**				**Nº 65357-131**				
					30,0	10,2	30,6	847,2	30,9	9,3	30,7	846,1	1.360,8
90717 730 130-2	COCHE TURISTA		15	RRH0132	**Nº 65357-231**				**Nº 65357-118**				
					28,4	9,3	30,9	873,7	28,2	7,4	31,0	873,1	1.360,6
90717 730 129-4	COCHE TURISTA		14	RRH0084	**Nº 65520-189**				**Nº 65521-124**				
					30,4	9,8	30,0	880,0	30,9	9,3	30,5	880,0	1.361,1
90717 730 128-6	COCHE TURISTA		13	RRH0060	**Nº 65357-040**				**Nº 65357-101**				
					28,2	10,1	30,9	874,9	28,6	9,9	30,0	875,1	1.360,8
90717 730 127-8	COCHE TURISTA		12	RRH0077	**Nº 65357-142**				**Nº 65357-216**				
					28,3	9,4	31,1	876,6	28,4	9,5	31,4	876,6	1.361,0
90717 730 126-0	COCHE TURISTA		11	RRH0047	**Nº 65357-218**				**Nº 65357-021**				
					30,0	9,7	30,2	869,9	29,2	9,4	30,2	870,3	1.361,0
90717 730 125-2	COCHE CAFETERIA-BAR		10	RRH0242	**Nº 65357-215**				**Nº 65357-230**				
					29,3	10,0	30,5	872,2	30,2	11,3	30,5	869,9	1.360,8
			9	RRH0297	**Nº 65357-224**				**Nº 65357-157**				
					28,7	9,4	29,6	866,5	27,8	7,4	30,7	866,3	1.360,1
90717 730 124-5	COCHE ACCESIBLE PREFERENTE		8	RRH0373	**Nº 65357-039**				**Nº 65357-225**				
					29,1	9,7	30,6	845,6	28,3	9,8	31,1	845,9	1.360,4
90717 730 123-7	COCHE PREFERENTE		7	RRH0590	**Nº 69805-10**				**Nº 69613-02**				
					29,6	10,1	30,8	861,4	28,6	7,6	30,8	863,0	1.360,5
90717 730 122-9	COCHE CET PREFERENTE	BG730-007	6	Z130-415	**Nº 56922-033**				**Nº 56922-032**				
					28,3	9,6	28,3	986,6	29,0	10,4	28,5	986,4	1.359,0
			5	Z130-418	**Nº 56922-066**				**Nº 56922-024**				
					28,3	9,2	28,2	983,5	28,5	9,8	28,0	983,5	1.359,2
96719 730 046-0	CABEZA MOTRIZ 1	BG130-156	4	Z130-372	**Nº 65448-239**				**Nº 65448-226**				
					28,7	8,0	28,4	1.010,0	29,7	8,3	28,7	1.010,0	1.359,8
			3	Z130-272	**Nº 065448-218**				**Nº 065448-242**				
					28,6	7,8	28,0	1.010,0	29,1	9,5	28,9	1.010,0	1.358,8
		BG130-100	2	Z130-083	**Nº 65462-230**				**Nº 65450-253**				
					29,6	10,2	28,2	982,1	29,6	10,3	28,2	982,3	1.359,1
			1	Z130-088	**Nº 65450-250**				**Nº 65462-232**				
					30,1	9,2	28,1	979,4	30,3	11,9	28,7	979,3	1.359,2

[In numbers] .	,
Campo	In the field
Taller	In the workshop
Espesor	Thickness
Altura	Height
Diámetro	Diameter
Distancia entre caras internas	Distance between internal faces
Composición en sentido de marcha	Make-up in direction of travel
Numeración UIC	UIC number
Tipo veiculo	Vehicle type
Posición del eje	Axle position
Eje - rodal	Axle - wheelset
Rueda derecha / izquierda	Right-hand / left-hand wheel
Cabeza motriz	Power car
Coche (CET) turista	Passenger (generator) car
Coche (accessible) preferente	Club class coach (with mobility access)

3.4.3.5. Brake test

3.4.3.5.1. At Madrid-Chamartín and Ourense stations

As specified in Article 538 of the General Traffic Regulation, before allowing a train to depart from its station of origin, or an intermediate station where its make-up has been altered, it is necessary to carry out operating tests on the brake, in accordance with the provision of this Regulation and of the Operating Manual (Chapter 4: Brake Tests), in order to check that the braking of the trains is in working order.

Train 150/151 left Madrid in its direction of travel with 730 class rakes 013 and 012 coupled. At Ourense they were separated. One went towards Pontevedra and Vigo (rake 013) and the other (rake 012, involved in the accident) headed for Santiago de Compostela, A Coruña and Ferrol.

The required brake tests were carried out on the train involved in the accident at Madrid-Chamartín, its station of departure, and at Ourense, its intermediate stop. On this class of rolling stock, the brake test is carried out automatically from the driver's cab. The data are stored in the safety recorder.

The data recorded at the brake test carried out at Madrid-Chamartín show that it was carried out at around 14:30 hours, before the train departed, and that there was one axle with a brake overridden.

The train's departure was not conditional on this, as Adif Instruction C 25, of 13 June 2012, establishes. This contains special requirements for running Class 730 and other locomotives on RFIG lines. It allows a double rake to run with up to 12 axles with brake overridden (six for a single rake), although there is a speed limit. This does not apply if a brake is not available on just one axle.

After the two rakes (013 and 012) were uncoupled at Ourense, the brake tests of both were repeated. According to the recorder for rake 013, the test took place at around 20:00 hours, before departure for Pontevedra, and showed that one axle still had a brake overridden. Logically, this was the one detected in Madrid. The recorder for rake 012 shows that the brake test was also carried out at around 20:00 hours, and that it had brakes on all its axles. There was no sign of a brake overridden on any axle.

Annex 3.4.3.5 contains the safety recorder data. It shows that one brake was unavailable on one axle at Madrid and Ourense.

3.4.3.5.2. Brake check *in situ*

Train 150/151, consisting of rake 730.012, carried out emergency braking on 24 July 2013, near the Angrois bend moments before the accident. The data from the safety recorder, located on power car 045, which was running in position 1 as power car, show that this braking began by the driver operating the service brake handle, by moving it to the emergency position (rapid braking).

According to information from Talgo (diagnosis), the figures obtained from the record of the train's technical parameters show that, at the time the emergency brake was applied, the train was moving at a pre-set speed. Therefore, when it entered a 12.5‰ slope, traction did not apply and the electric brake was applied lightly. This took place automatically, to counter the effects of the slope in order not to exceed the pre-set speed.

On the section between the time of application of the emergency brake (PK 84+009) until the derailment occurred (PK 84+413), the train's braking curve has been compared with the following two curves: braking curve under the conditions set by the Rolling Stock Technical Specification for Interoperability (TSI) and the braking curve most similar to the actual curve from the tests carried out during approval of the Class 730 rolling stock.

These two curves have been adjusted to the conditions under which rake 730.012 was running on the day of the accident. This means they have been corrected to take account of wheel diameter, train loading and longitudinal track profile (slope/incline).

It can be deduced from this comparison that the behaviour of rake 730.012 during the emergency braking prior to the accident matches the description for braking curves in the TSI and in the approval of the Class 730 rolling stock. Hence the braking performance was correct.

On the other hand, based on the data gathered by the safety recorder in the power car, the value of deceleration produced by the emergency braking near the Angrois bend can be estimated.

It is recorded that the emergency brake was applied at 20:40:59 hours while travelling at 195 km/h (at PK 84+009). The system delayed three seconds before actually braking. Hence it was 20:41:02, speed 195 km/h (at PK 84+171), when deceleration began. The train left the rails (point 0) at 20:41:06 (four seconds later) while moving at 179 km/h (at PK 84+413).

In the four seconds of effective braking, a distance of 242 m was covered and the speed was reduced by 16 km/h. This resulted in deceleration of 1.11 m/s^2. This value, plus the equivalent three seconds (delay in actual application of the brake), conform to the provisions of the Rolling Stock TSI (decision 2008/232/EC, table 7, box A). This states that, for speeds between 230 and 170 km/h, the minimum deceleration is 1.05 m/s^2 and the time equivalent is three seconds.

3.4.3.6. Withdrawal of authorisation to run Class 730 rolling stock on ERTMS between Ourense and Santiago de Compostela

To function correctly, a safety system, whether ASFA or ERTMS, must not only be correctly installed, both on the track and in the train, but the versions must be mutually compatible.

Article 15 of Directive 2008/57 on the interoperability of the rail system within the Community provides that the Member States shall authorise the placing in service of structural subsystems, checking the technical compatibility of these subsystems with the system into which they are being integrated.

With reference to the Command/Control and Signalling subsystem, Spain therefore carries out 'integration tests', previously called 'supplementary tests', which seek to verify the technical compatibility of the train with the network. This is not a validation either of track equipment or of the train's on-board equipment.

Thus the complementary tests of the Class 730 units on line 082 took place to analyse the train-track integration of the ERTMS L1. They were carried out in February 2012 on different parts of line 082.

More specifically, the tests relating to the changeover from level STM EBICAB (with ASFA functionality) to ERTMS L1 took place on track 2, towards Ourense, at the first group of balises on the Santiago side.

Commercial service on the new line 082 between Ourense and Santiago de Compostela began on 10 December 2011. Initially the Madrid-A Coruña link was still served by make-ups consisting of a diesel locomotive and Talgo coaches, as serving on the conventional line. Since this rolling stock did not have on-board ERTMS, it ran under cover of ASFA Digital.

From 16 June 2012, this rolling stock was replaced with Class 730 railcar trains. These only ran for a week with ERTMS switched on. Then, in the early days of service, problems were detected with the on-board ERTMS which had not been noticed during the complementary testing in February 2012.

The reason for these problems was that the version 3.1.0.1 ERTMS installed on Class 730 trains made by Bombardier had incompatibilities with the version installed on the track of line 082, made by Thales.

More specifically, one of the faults was failure to reach the first group of balises on track 1, Ourense side, during changeover from ASFA to ERTMS, while bound for Santiago de Compostela. This meant that, for one-fifth of the distance of line 082, the train was travelling in 'driver's responsibility' mode, without the complete supervision of ERTMS and without the protection of ASFA. This had traffic safety implications.

That is why, on 23 June 2012, Renfe Operadora applied to Adif for authorisation for those trains on line 082 to return to their previous conditions of travel, i.e. with ASFA Digital. This authorisation was granted on 25 June 2012.

To correct the reported defects and enable this rolling stock to use line 082 with ERTMS, the manufacturer (Bombardier) developed a new version of the software (version 3.1.1.2). It delivered the documentation for this to Renfe Operadora in November 2012. Renfe Operadora arranged to carry out the relevant trials on the track to check that it performed properly. The trials were carried out, with a positive outcome, until April 2013.

Although the risk had been minimised, it was still possible that the balises might not be read. Hence the manufacturer's proposed solution was to disable another of the on-board safety systems (EBICAB-ATP). This is being studied (March 2014).

While it is possible that the rolling stock involved in the accident might have travelled with ERTMS in its current configuration and extent (up to PK 80+069), this system would not have limited the speed of entry to the Angrois bend because, from that point, it could travel at 200 km/h with ASFA. It would still have been up to the driver to reduce speed, although he would have had to press the button recognising exit from ERTMS on the cab DMI screen. In theory, this would have been one more factor calling for attention during driving. If this had not been activated, the system would have applied the service brake, which would have been released at the time of pressing the button.

Annex 3.4.3.6 contains Renfe Operadora's application to run on ASFA and Adif's authorisation to do so.

3.4.3.7. Safety recorder data from the train in the accident

The safety recorder installed on power car 2, at the head of the train involved in the accident, was a Hasler Teloc 2510, type 5.2620.014/02, serial no. 07071729. This model not only records various parameters of the vehicle's functioning, but records the ambient sound generated in the cab.

From the safety recorder, the main features of the journey from departure at Ourense are listed here:

- 20:05:13 hours: train moves off from Ourense station.
- 20:08:54 hours: another person in the cab (according to audio recording).

- Steady increase in speed to 96 km/h.
- 20:09:29 hours: button pressed on panel to switch from ASFA conventional mode to ASFA high-speed at 98 km/h (passing the 'change ASFA mode' board).
- 20:12:01 hours: other person leaves cab (according to audio recording).
- 20:15:19 hours: acoustic signal of activation of dead man (DM) (according to audio recording).
- 20:15:21 hours: emergency brake activated by DM at 110 km/h (first DM activation).
- Speed is reduced to 48 km/h at 20:16:14. At that moment, speed begins to increase. At the same time, driver confirms (by luminous button) that he has passed into a 'neutral zone' (without electric power).
- 20:17:03 hours: acoustic signal of activation of DM (second signal, according to audio recording).
- 20:17:05 hours: activation of emergency brake by DM (second DM activation). Speed reached: 109 km/h.
- Slowing. 86 km/h reached at 20:17:20 hours, after which speed again increases.
- 20:17:42 hours: start of ringtone for a telephone call (first call in motion). Conversation starts at 20:17:45 hours and ends at 20:18:31 (according to audio recording). Speed continues to increase.
- 20:19:02 to 20:28:33 hours: train passes successive signal balises showing 'track clear' (with corresponding acoustic signals from the system). Speed increases until 20:23:47 hours, when it remains steady at nearly 200 km/h (the permitted maximum) without further slowing.
- 20:29:02 hours: start of acoustic signal (according to audio recording) associated with first speed advice from the ASFA digital system, on exceeding 201.25 km/h (first speed advice).
- 20:29:49 hours: end of first acoustic signal (according to audio recording) associated with first speed advice from ASFA Digital as speed is reduced below 197 km/h.
- 20:30:33 hours: another acoustic signal (according to audio recording) associated with first speed advice from ASFA Digital system, on exceeding 201.25 km/h (second speed advice).
- 20:31:45 hours: end of second acoustic signal (according to audio recording) associated with first speed advice from ASFA Digital signal, as speed is reduced below 197 km/h.

- Until 20:36:58 hours, train passes several signal balises showing 'track clear' (with corresponding acoustic signals from system). Speed is close to permitted maximum (200 km/h) and not further reduced.

- 20:39:06 hours: ringtone begins for a telephone call (second call in motion) and, at 20:39:15, telephone conversation starts (according to audio recording). Speed: 199 km/h.

- 20:39:52 hours: train passes previous balise (PK 80+319) for caution signal E´7 for A Grandeira branch, showing 'track clear' (with acoustic signal from system), at 199 km/h.

- Passing PK 80+803, where there is a board warning to change ASFA mode (from high-speed to conventional), driver does not make this change.

- 20:40:55 hours: last sound of driver's voice recorded in telephone conversation (according to audio recording), at 195 km/h.

- 20:40:56 hours: train passes previous balise (PK 83+876) for signal E7 on entry to A Grandeira branch showing 'track clear' (with acoustic signal from the system), at 195 km/h.

- 20:40:59 hours: driver applies emergency brake (brake handle) at 195 km/h.

- 20:41:02 hours: train passes balise (PK 84+171) of signal E7 at entry to A Grandeira branch showing 'track clear' (with acoustic signal from the system), at 195 km/h.

- 20:41:06 hours: start of dragging sound of derailing train (according to audio recording) at 179 km/h (point 0).

- 20:41:16 hours: dragging sound ends (according to audio recording); end of derailment.

Annex 3.4.3.7 contains graphs of the safety recording from the unit in the accident.

3.5. VERBAL MESSAGES EXCHANGED ABOUT ACCIDENT

The safety recorder installed on the Class 730 rolling stock recorded ambient sound in the cab. The recording corresponding to the route between Ourense and Santiago has been extracted.

The conversations between the driver and the Atocha traffic control centre on this route are also available.

3.5.1. Audio recording in cab

The following facts are singled out:

- 20:08:54 hours: voice recording begins. A conversation is recorded in the cab with the off-duty driver (who had driven the route to Ourense and is travelling on to A Coruña).

- 20:12:01 hours: recording of sound of cab door opening and closing (as the off-duty driver goes in and out), and end of conversation in cab. The conversation in this period is about various technical aspects of some device which is malfunctioning (without a bearing on the investigation). The person leaving is going to solve the defect outside the cab.

- 20:12:01 - 20:17:42 hours: various acoustic signals are recorded from the 'dead man' (DM) vigilance device as the DM pedal is pressed. According to data from the recorder, in this period the DM twice activates emergency braking: at 20:15:21 and 20:17:05. Although the driver immediately presses the pedal after the acoustic signals, emergency braking in any case takes place.

- 20:17:42 hours. Acoustic signal advising of a mobile telephone call. Conversation begins at 20:17:45 and lasts 46 seconds (unit 20:18:31). Caller is the off-duty driver, and the call is about solution of the incident and activation of the emergency brake by HM. Driver comments that he does not know why this is happening. At best he would have to give a warning [*more time*] before going off-duty.

- 20:18:31 - 20:29:02 hours: a number of acoustic signals are recorded (10), but all mark balises passed showing 'track clear.' Several activations of the DM pedal are also heard (without prior acoustic signal).

- 20:29:02 hours: start of an ASFA Digital acoustic signal is heard, due to excess speed (on exceeding 201.25 km/h), and is maintained for 46 seconds.

- 20:30:33 hours: another ASFA Digital acoustic signal is heard due to excess speed (again exceeding 201.25 km/h). It lasts 72 seconds.

- Until 20:39:06 hours: activations of DM pedal are heard, some without prior acoustic signal, and various balises are passed (5), showing 'track clear.'

- 20:39:06 hours: ringtone begins for a mobile telephone call. After 9 seconds, conversation starts at 20:39:15. This time it is the train manager, who asks the driver if the train will fit on track 2 (section) at Puentedeume station. Driver answers yes, it fits either track. Train manager seems to insist on the matter. Driver repeats three times that it will enter either track. Conversation lasts 100 seconds.

Throughout this time, the acoustic signal can be heard on passing a balise (the one before caution signal E´7, at 20:39:52, 32 seconds after the start of the conversation) and the DM pedal is pressed several times (without prior acoustic signals).

- 20:40:55 hours. Last sound of driver in mobile telephone conversation.

- 20:40:56 hours: acoustic signal as a balise is passed (prior to signal E7) indicating 'track clear.' According to the recorder, the driver applies the emergency brake at 20:40:59.

- 20:41:02 hours: acoustic signal as balise is passed (at the foot of signal E7) indicating 'track clear.'

- 20:41:03 hours: DM pedal is heard being pressed.

- 20:41:06 hours: start of dragging sound (train derailment).

- 20:41:16 hours: end of dragging sound.

- 20:42:42 hours: end of voice recording.

Annex 3.5.1 contains the transcribed cab voice recordings from 20:08:54 (departure from Ourense) to 20:42:42 (after derailment).

3.5.2. Conversations between driver and Atocha Regulation and Control Centre

The Madrid-Atocha Regulation and Control Centre (CRC), like the other control posts, records conversations between itself and the drivers of the trains running in its territory. In this case, conversations are by GSM-R telephony.

The recording of the conversations between the driver of train 150/151 and the Traffic Manager at CRC Atocha has been extracted, from going on duty at Ourense until the last recordings after the accident.

Four conversations were held, all on channel 13. Start times were 20:02:04, 20:42:25, 20:46:53 and 21:10:06. The main points of each call are highlighted below.

- Conversation from 20:02:04 to 20:02:55 hours: 51 seconds' duration

Driver of train 150/151 calls CRC from Ourense station to say that his name does not appear on the train logbook, though it does not matter. CRC asks him if he is carrying the train log and if he is going on BSL [*i.e. without ERTMS but with ASFA*]. Driver replies in the affirmative.

- Conversation from 20:42:25 to 20:42:57 hours: 32 seconds' duration

Driver of train 150/151 calls CRC to say that there has been an accident. He has derailed, overturned and is at kilometre 80.

- Conversation from 20:46:53 to 20:52:04 hours: 5 minutes 11 seconds' duration

Driver calls CRC to report that there must be many injured because he has overturned. Cannot get out of cab. Has derailed. Should have taken it at 80 [*km/h*] but took it at 190. Had already told safety person that it was dangerous and they would derail one day and it [*the curve*] would get the better of them. He had been coming on green [*with the signals at green*]. The driver had to be there, but we are human.

- Conversation from 21:10:06 to 21:14:11 hours: 4 minutes 5 seconds' duration

CRC calls to ask if help has arrived. Driver replies that it has not reached him, but they are attending to the passengers first. He had told this [*he must be referring to the curve*] to someone from safety some time ago, that we are human, and this could have happened to any colleague. It isn't acceptable on a clear track with a limit of 80 [*km/h*], it's inhuman. He had told it to someone from safety and, no, this is the driver's responsibility.

Another two calls follow: at 21:26:18 and 21:26:37 hours, 12 and 5 seconds' duration respectively, but without conversation or even sound recording.

Annex 3.5.2 contains the transcribed calls mentioned above, between the driver of the train involved in the accident and CRC.

3.5.3. Regulations on communications in the cab

Chapter 15 of the Operation Manual deals with communication between the driver and the control post. Communication is possible by radiotelephony (track-train) and, since the high-speed lines opened, by mobile telephony (GSM-R), as in the case of line 082.

As regards the use of mobile telephones by driving staff, the existing regulations consist of Notice 102, from the defunct RENFE, and Driver Information Sheet FIM 3, issued by Renfe Operadora.

The notice is published to give operating staff the necessary information about this. It is not a regulation.

Notice 102 of the Directorate of Civil Defence and Traffic Safety, of 21 April 1997, reminds staff that, due to the many means of communication in the cab, the driver must prioritise the use of the radiotelephone system [track-train] and keep any other personal medium of communication switched off.

The Technical Office for the Human Factor at Renfe Operadora was created in 2010. Its purpose is to study the risks of the human factor and how to mitigate them. Most of these centre on driving. The Office therefore studies the most common errors (real and potential) and brings them to the attention of those concerned (mainly drivers). It also forwards suitable recommendations on preventing them as far as possible. All this information can be found in the FIM leaflets, which later provided input to the Guide to Good Driving Practice. This literature is for information; it is neither a regulation nor a standard.

The use of mobile telephones and other electronic devices is widespread nowadays. They have also been introduced to working activity on a wide scale. Hence FIM leaflet 3 on *Safe Use of Mobile Telephones while Driving*, dated 18 July 2011, notes that using mobile telephones and other communication devices may pose a risk, and recommends using them appropriately.

The leaflet says that, from the first minute of conversation, the person becomes more involved in it and relegates driving to second priority, not processing the information. One of the recommendations

is that, when it is necessary to use a mobile telephone, the conversation should be limited to what is strictly necessary.

Annex 3.5.3 contains Notice 102 and leaflet FIM 3.

3.6. MAN-MACHINE INTERFACE OF STAFF INVOLVED

3.6.1. Working hours of staff involved

According to the report from Renfe Operadora, the driver in charge of train 150/151, involved in the accident, is attached to the base in A Coruña.

On 24 July 2013 he had begun his working day at 11:55 hours in A Coruña, from where he travelled off-duty to Pontevedra. At 14:42 hours he began his own work driving an Alvia 252 train from Pontevedra to its destination at Madrid-Chamartín. He drove it to Ourense, where he arrived at 16:49. He stayed there until 20:05, when he began driving duty on the train involved in the accident.

Therefore, by the time of the accident, his working day had been 8 hours 47 minutes. Actual driving time had been 2 hours 44 minutes. He had taken the regulatory rest in the previous 48 hours.

Additional provision 11 of Royal Decree 2387/2004, approving the Rail Sector Regulation, sets a maximum continuous driving period of 6 hours, and maximum driving in one day of 9 hours.

Likewise Royal Decree 1561/1995, of 21 September 1995, on extraordinary working days, establishes a maximum working day of 12 hours and a minimum period of rest of one-and-a-half days per week. The section on rail transport establishes a maximum of nine hours of actual ordinary working which may, exceptionally, be exceeded.

Collective Bargaining Agreement II of Renfe Operadora also applies. The professional development agreement (part on driving) deals with the working day, which it quantifies at 8 hours. This may rise to 9½ in specific cases. The agreement refers to the provision of the Single Driver Regulation (the recast text of the Renfe Labour Regulation, Article 606). This specifies the content on maximum continuous driving times, which it quantifies at 5½ hours.

All the periods worked by the driver (working day, driving and rest) were within the current regulations.

3.6.2. Medical and personal circumstances

The driver's medical and personal circumstances on the day of the accident are not known. Nevertheless, in his two statements in court, he says nothing about this. He only says he was driving calmly.

Likewise, CIAF asked Santiago de Compostela Magistrates' Court 3 for the results of the alcohol and drug tests carried out on the driver after the accident. The forwarded documentation records that

samples of serum and plasma were obtained at 23:15 hours on 24 July 2013 and at 21:08 on 25 July 2013.

The chemical and toxicological analysis for alcohol, drugs and medicines proved negative.

3.6.3. Design of equipment with effects on anthropometric interface

The Class 730 rolling stock derives from Class 130, which was designed according to the regulations in force at the time. Hence the technical regulations applicable to the 730 class has continued to be as per the first interim provision of Order FOM/233/2006 (which governs conditions for approval of railway rolling stock). More specifically, NTC MA-001 (*technical requirements for conventional rolling stock)* and NTC MA-007 (*conditions for variable-gauge axles to fulfil at speeds up to 250 km/h)*.

Annex 3.6.3 shows pictures of the driving desk of a driver's cab of the 730 class. It shows parts of the 'dead man' system, the brakes, ERTMS-ASFA Digital and communications.

This layout of the console on the Class 730 logically derives from that of the Class 130 rolling stock. There have been very minor modifications (addition of diesel traction). The design of the Class 130 was based on the regulations existing at the time. Basically that meant UIC booklet 651 (drivers' cabs), to which NTC-MA-001 refers.

3.7. SIMILAR EVENTS IN THE PAST

Of the accidents and incidents known to CIAF, none has occurred either on line 082 Coto da Torre branch - A Grandeira branch km point 85.0 (in service since 2011), or on the accesses to Ourense or Santiago de Compostela where they connect with line 082.

Nevertheless this Commission has investigated the following accidents caused primarily by excess speed while passing curves on the RFIG:

- **Case 0029/2008.-** Derailment on 5 July 2008 on the Adif conventional network of a passenger train at Medina del Campo station (Valladolid), due to excess speed. It was going at 151 km/h on a curve with a permanent speed limit of 90 km/h.

- **Case 0013/2009.**- Derailment on 23 February 2009, on the former Feve network, involving a passenger train near the Ozanes halt (Asturias), due to excess speed. It was going at 77 km/h round a curve with a permanent speed limit of 40 km/h.

- **Case 0028/2010.**- Derailment on 14 June 2010, on the former Feve network, involving a goods train at Ortigueira (A Coruña), due to excess speed. It was going at 77 km/h round a curve with a permanent speed limit of 60 km/h.

- **Case 0038/2010.**- Derailment on 14 July 2010, on the former Feve network, of a goods train at Ribadeo (A Coruña), due to excess speed. It was going at 73 km/h round a curve with a permanent

speed limit of 60 km/h, and also failed to adjust to the features of the curve at the set maximum speed.

- **Case 0006/2012.**- Derailment on 19 January 2012, on the former Feve network, of a goods train at Arriondas (Asturias), due to excess speed. It was going at 70 km/h round a curve with a permanent speed limit of 40 km/h.

- **Case 0012/2013.**- Derailment on 31 January 2013, on the former Feve network, involving a goods train at Pesués (Cantabria), due to excess speed. It was going at 61 km/h round a curve with a permanent speed limit of 40 km/h.

Thus this Commission has investigated six events: one on the Adif network and five on the Feve network. All occurred on curves with permanent speed limits, duly signalled on the track according to the regulations. ASFA balises were not set up on any of these, because they are not mandatory with permanent speed limits.

The recommendations issued by CIAF to Feve basically sought to reinforce action to avoid risky behaviour by driving staff.

Adif was also requested to report events (accidents and incidents) occurring on its rail network due to excessive speed.

From 2005 until 24 July 2013, there were 20 events (14 incidents and 6 accidents) for which the main cause was classed as excess speed. Only two of these (accidents) occurred on curves (one was on 5 July 2008 at Medina del Campo, investigated by this Commission, and the other was the accident reported on here, of 24 July 2013).

Another five (four incidents and one accident) occurred in temporary speed limits (due to works or the state of the infrastructure). The 13 remaining (10 incidents and 3 accidents) occurred while passing track equipment (bypasses and crossovers).

To sum up, none of the events investigated by this Commission or occurring on the Adif network (since 2005) have had features similar to the Santiago de Compostela derailment, i.e. exceeding the maximum speed prescribed for the route in the Maximum Speed Table and in the timetable.

4. ANALYSIS AND CONCLUSIONS

4.1. FINAL DESCRIPTION OF SEQUENCE OF EVENTS

The events took place at 20:41 hours on 24 July 2013, at PK 84+413 on track 1 of line 082, Coto da Torre branch - A Grandeira branch, km point 85.0, near Santiago de Compostela station.

Alvia Class 730 long-distance passenger train 150/151, belonging to Renfe Operadora, consisted of 13 vehicles (rake 012). At 15:00 hours it departed from its station of origin, Madrid-Chamartín, in

double make-up (rakes 012 and 013). End-destination was Ferrol (rake 12), with arrival timetabled for 22:36 hours.

It arrived at Ourense station at around 19:55 hours, where it made a scheduled halt. This was to allow passengers to board and alight, to unhitch the two rakes of the double make-up in which it was running, and change drivers. Rake 012 went to Ferrol as train 150/151 and rake 013 to Pontevedra and Vigo.

At 20:02:04 hours, the driver contacted CRC Madrid-Atocha (the control post) via GSM-R to identify himself and say he was going on duty. The call lasted 51 seconds.

Then the driver received two calls on the corporate mobile telephone, from the train manager. One, which lasted 35 seconds, was to say hello and identify the train manager. Then the other, lasting 15 seconds, was to confirm that he could lock the doors (operations completed).

At 20:05:13 hours, the train moved off from Ourense station. At least from 20:08:54 (start of audio recording), the off-duty driver, relieved at Ourense, was also in the cab. Speed increased gradually.

The off-duty driver stayed in the cab conversing until 20:12:01 hours. Subject of discussion was an unresolved technical problem (of no significance to what happened). At that time, the off-duty driver left the cab to resolve the defect outside.

At the time, the driving proceeded normally, passing balises showing 'track clear.' At 20:09:29 hours the driver pressed the button on the panel to switch from ASFA Conventional mode to ASFA High-Speed mode (on passing the 'change ASFA mode' board). Speed of travel was 98 km/h. Then he passed a voltage changeover zone, beginning at 20:10:01, slowed from 105 to 12 km/h (time 20:11:36), then regained speed.

At 20:15:19 an acoustic signal sounded to press the dead man's switch (DM), and the driver depressed the DM pedal. In any case, the emergency brake was activated through the DM at PK 8+889, with the train going at 110 km/h (first DM activation). This reduced the speed to 48 km/h, as the train passed through a neutral zone between PKs 8+909 and 9+585. The driver confirmed that this had been passed and regained speed.

At 20:17:03 the acoustic signal sounded to press the DM. The driver pressed the DM pedal. In any case, the emergency brake was again activated via DM (second DM activation) at around PK 10+857, at a speed of 109 km/h. This slowed to 86 km/h at 20:17:20, after which it again increased.

At 20:17:42 the driver received a telephone call by corporate mobile telephone (the first call while in motion). This was from the outgoing driver. The conversation began three seconds later (around PK 11+958). It lasted 46 seconds. The driver was interested in whether the incident was already resolved, and in the braking by DM. The speed continued to increase.

Between 20:19:02 and 20:28:33, the train passed successive signal balises showing 'track clear' (with corresponding acoustic signals from the system). Speed continued to increase until 20:23:47

hours, when it stayed close to the permitted maximum (200 km/h) with no further slowing. Progress was normal.

At 20:29:02 an acoustic signal began associated with the first speed alert from the ASFA digital system, as 201.25 km/h was exceeded. The signal ended at 20:29:49, when speed slowed to below 197 km/h. Total duration of alert: 47 seconds (first speed alert).

At 20:30:33 another acoustic signal began, associated with the first speed alert from the ASFA digital system, when 201.25 km/h was again exceeded. The signal ended at 20:31:45, with speed back below 197 km/h. Total alert duration: 72 seconds (second speed alert).

Various signal balises were passed until 20:36:58. These showed 'track clear' (with corresponding acoustic signals from the system). Speed was close to the permitted maximum (200 km/h) and was not reduced.

At 20:39:06 (PK 77+780) the driver received another call on the corporate mobile telephone (second call in motion). Nine seconds later, at 20:39:15, the conversation began. At this moment, the train was at PK 78+280 at a speed of 199 km/h.

The conversation lasted 100 seconds. It ended at 20:40:55, level with PK 83+821. The caller was the train manager asking if the train would fit on to track 2 (section) at Puentedeume station. This was to help a family to alight and get out of the station. During this time (100 seconds) the following events occurred:

- At 20:39:23 (eight seconds into the conversation) it passed a neutral zone between PKs 78+646 and 79+056, and the driver pre-acknowledged (by pressing a button).

- The train passed the first two proximity signs (boards at PKs 80+086 and 80+278) for caution signal E´7 and maintained speed.

- At 20:39:52 it passed the approach balise (PK 80+319) to caution signal E´7 for A Grandeira branch. This showed 'track clear' (the system gave an acoustic signal). Speed was 199 km/h. Then it passed the third and last proximity sign (PK 80+398) for E´7.

- Around 20:39:58 it passed signal E´7 (PK 80+619, no balise) and maintained speed.

  According to the driver's statement, in this zone he had the instruction to reduce speed to the limit (80 km/h) in force 3 600 metres further on (PK 84+230, Angrois bend at A Grandeira branch). In this case he did not do so.

- The train entered the Marrozos tunnel (marked by a board at the entrance, PK 80+671).

- In the tunnel at 20:40:01, it passed PK 80+803 where there is a board warning of the change of ASFA mode (from high-speed to conventional), but the driver did not make this change. Speed was maintained. This was 46 seconds into the telephone call.

- It crossed O Eixo viaduct (marked at the start by a board, PK 82+112).
- It entered the Santiago tunnel (marked at the entrance by a board, PK 83+465).
- In that tunnel at 20:40:55, the last sound of the driver's voice can be heard in the telephone call. This was 100 seconds after the start of the call, during which 5 540 metres were travelled.

The train went on through the tunnel. At 20:40:56 it passed the approach balise (PK 83+876) to signal E7 at the entrance to the A Grandeira branch, showing 'track clear' (with acoustic signal from the system). At 20:40:59, PK 84+009, the driver applied the emergency brake (on the service brake handle) while travelling at 195 km/h. The train then emerged from the tunnel (PK 84+106).

At 20:41:02 it passed the balise at the foot of signal E7 (PK 84+171), which was showing 'track clear' (with acoustic signal from the system) at 195 km/h.

Then, at PK 84+228, the transition to the Angrois bend began. This is the start of the 80 km/h speed limit according to the timetable. Hence, at around 20:41:03, the train slowed to around 191 km/h. It also passed the speed reduction sign (PK 84+273) and viaduct E-01 on which the sign stands.

Near the end (PK 84+428) of the initial transition stretch of the Angrois bend, the derailment began (point 0), at PK 84+413. Time was 20:41:06; speed 179 km/h.

Images recorded by the security cameras installed on line 082 show that train 150/151 had reached the Angrois bend at the time of derailment. The head power car, in position 1, had entered the bend.

The end generation car, in position 2, began an upward movement and then (but almost simultaneously) a sideways shift towards the outside of the curve (right-hand side in the direction of travel of the train).

Apparently the generation car, as it left the track, also pulled the power car off the track and the coaches in the positions behind the generation car. A large flashover was noticed near the catenary, possibly as the contact wire touched part of the train, or part of the catenary masts which it dragged along.

The power car ran on, going off the side of the track (outside of the curve, right-hand side in direction of travel of the train). It twisted to the right along its longitudinal axis (still in the direction of travel). It ended up resting on its right side on which it slid (already off the track), dragging catenary masts, including the post supporting the security camera.

At 20:41:16 (according to the audio recording) the derailment ended at PK 84+684. The 13 coaches making up the train were derailed off track 1, on which they had been travelling. The first three (power car, end generation car and the next coach) formed a first group. This was 11 metres away from a second group consisting of the next two coaches, which had been in positions 4 and 5. All

these were sharply tilted to the outside of the curve (the right in the direction of travel), except the power car, which was slightly tilted to the left.

A last group was 33 metres from the second. This consisted of the remaining vehicles: the coach in position 6, which was derailed and tilted to the right; the seventh was across the track; and the eighth pushed away from the group and off the embankment towards an adjacent road. The ninth carriage was overturned, with one end lying on top of the seventh. The tenth and eleventh were overturned towards the right. The twelfth (the rear generator car) caught fire and was crushed, while the thirteenth (the tail power car) was tilted to the right.

At 20:42:25 hours (CRC time) the driver used the GSM-R system to call the control post, i.e. Madrid-Atocha Regulation and Control Centre (CRC). The conversation lasted 32 seconds and he reported what had happened. Later two more conversations were held.

Both main tracks of line 082 were blocked at the A Grandeira branch. A third track, which starts at that point, next to the others but belonging to line 822 (Zamora - A Coruña), was also treated as out of service, to facilitate the work of assistance and repair, although this third track was not affected by the accident.

Track 2 was not opened to traffic until 26 July and track 1 remained closed until 29 July.

4.2. DISCUSSION

With regard to the driver's statement [section 3.1]

- The driver's statement to Magistrates' Court No 3 of Santiago de Compostela says that he should have been travelling at 80 km/h at PK 84+300, i.e. on the Angrois bend. He therefore started to reduce speed normally at caution signal E´7 [located at PK 80+619], but that day he took it [the bend] at around 190 km/h.

With regard to the regulatory documents in the cab [section 3.2.3.1]

- The driver had the required documentation at his disposal: the train logbook and train timetable (timetable book).

- According to the train logbook, there were no temporary speed restrictions near the point of derailment (PK 84+413 of line 082).

- The train timetable (book) showed a change of maximum speed of travel from Santiago from PK 84+230, down from 220 to 80 km/h. This coincided with the Angrois bend where the accident took place. This change of maximum speed of travel was also reflected in the Maximum Speed Table for line 082, and was also indicated in the PTOs.

- There is no rule on what type of fixed preventive signalling must be set up at changes of maximum speed, or in what circumstances these speed changes have to be signed on the track. (Recommendations 1 and 2).

With regard to personnel requirements (driver) [sections 3.2.3.2 and 3.6.2]

- The driver was compliant with the regulations in force with regard to qualification, refresher courses, medical check-ups and clearances (for rolling stock and line).

- He had driven missions along line 082 in both directions with the ASFA system switched on. Hence he was familiar with it.

- The driver's activity had been periodically inspected and found in order.

- His working day, driving times and breaks complied with the regulations in force.

- Toxicology tests for consumption of alcohol, drugs and medicines proved negative.

With regard to internal controls and audits [section 3.2.3.3]

- The minutes of the meetings of the Adif and Renfe Operadora safety committees (which allow staff participation in safety and traffic management) contain no point dealing with the accident zone, or comments on it, in the period between commissioning of the line (December 2011) and the date of the accident (24 July 2013).

- The cab inspections carried out by Adif on line 082 from commissioning detected no infrastructure faults or incidents. The professional conduct of driving personnel was correct.

- Accompanied train journeys with in-cab monitoring, and analysis of the rolling stock safety recorders carried out by Renfe Operadora after commissioning of line 082, found nothing wrong with the stretch of track in the accident zone. There are also no reports of accidents or incidents (PAIs) relating to that area.

- A leader driver carried out a safety observation within Renfe Operadora in December 2011. This consisted of a hazard assessment for the Angrois bend. This was only dealt with in a training context. There is no record of any referral of the matter to the safety management bodies, although at least nine members of the organisation knew about it. Two of these were members of the León Area Safety Committee (the scope of which includes Galicia). There is also no record of the warning being forwarded to Adif (Recommendations 3 and 4).

With regard to the technical installations [section 3.4.1]

These were working correctly:

- On the day of the accident, the surroundings of the accident zone were under local control from the control post at Santiago station. Analysis of the control post log shows that train 150/151 had its

path established up to the entry to Santiago de Compostela station. Signals E´7 and E7 were therefore showing 'line clear' (straight ahead to the section of the A Grandeira branch). E´8 gave warning of a stop, while E8 (at the entrance to Santiago station) was at stop.

With regard to infrastructure [section 3.4.2]

It was functioning correctly:

- The Ministry of Development had issued commissioning authorisation for line 082, which commenced service in December 2011.

- The regulations applicable from Coto da Torre branch to A Grandeira branch point at km 85.0, the section where the accident occurred, are the Technical and Operating Requirements (the 'PTOs").

- The new line 082, from PK 80.1 (end of ERTMS and start of ASFA) to PK 85.0 (end of line and junction with line 822 at Santiago station), only has ASFA (as its main system). This is the stretch where the accident occurred.

- The safety case documentation for the Command/Control and Signalling subsystem on the new line 082 (these include the 'safety file') includes a risk assessment. This identifies the risks and considers that those which cannot be covered by the specific subsystem should be exported to other environments. These environments then take over the risks according to the established rules (at least those relating to the circumstances of this accident).

To be specific, and with direct application to this accident, the safety case states that 'trains travelling under cover of the lateral signalling or ASFA (as is the case) shall comply with the Maximum Speed Table for the line issued by Adif. This risk shall be exported to the driver.'

So the risk assessment in the strict sense is applied to this subsystem (command/control and signalling). The remaining subsystems are governed by other risk acceptance principles. A joint analysis is therefore appropriate, taking account of the interaction between subsystems (Recommendation 5).

- The last dynamic examination, in May 2013, yielded figures indicating that the track was in good condition on the stretch where the accident took place. This finding was corroborated by collection of field data from the track. All values were within tolerance.

- The maximum permitted speed on the Angrois bend (80 km/h) is reflected in the Maximum Speed Table and train timetable. It is compatible with the horizontal layout and camber of the curve.

- The fixed signals in the form of signage arranged near the derailment zone (change of ASFA mode, RGC and speed reduction) comply, in both location and content, with the requirements of the PTOs. In fact the PTOs do not require prior, fixed trackside signalling of downward changes in maximum speed.

With regard to the rolling stock involved in the accident [section 3.4.3]

It was functioning properly:

- Rake 730.012, involved in the accident, had received authorisations for commissioning and running.

- It had an approved maintenance plan. Approved contractors had carried out all servicing required by that plan, at authorised centres.

- The fault logs for the tractor units of the trainset involved in the accident contained no notes of outstanding brake defects.

- The figures for running the whole make-up were within the limits set by the maintenance plan and by the regulations.

- The brake test, carried out at Ourense, showed that rake 012, involved in the accident, had braking on all its axles and wheelsets. An estimate of the deceleration achieved by the emergency braking, carried out moments before the derailment, yields values commensurate with the provisions of the Rolling Stock TSI.

- Due to ERTMS problems from June 2012, the rolling stock was authorised to run with the ASFA Digital system switched on throughout the length of line 082. ERTMS was not active at any time on the Ourense-Santiago stretch. The train was therefore running under cover of lateral signal blocking, at the then maximum permitted speed of 200 km/h. This was still so in March 2014.

Therefore the decision taken at the time to modify the physical extent of the ERTMS bore no direct relation to the specific causes established for this accident. The incompatibilities which obliged this train to travel on BSL and ASFA might have arisen even if the ERTMS had covered Santiago de Compostela station.

While it is possible that the rolling stock involved in the accident could have travelled with ERTMS at its current extent (up to PK 80+069) and configuration, this system would not have limited the speed of entry to the Angrois bend. This was because, from that point, the train could travel at 200 km/h with ASFA. It was the driver who had to reduce speed, although he would have to have noticed in the cab that the train had left the ERTMS. Theoretically, this would have been one more factor focusing his attention on driving. If this had gone unnoticed, the system would have turned on the brakes.

- The data log from the safety recorder on the head locomotive of the train involved in the accident makes it clear that it left Ourense four minutes late, at 20:05 hours. It was travelling normally, reaching its maximum speed of 200 km/h around 20:23 hours, having passed all signals at green.

It did not start braking at PK 80+619 (signal E´7 to adjust to the 80 km/h limit at PK 84+230 - start of the Angrois bend). Instead, it maintained a speed of nearly 200 km/h up to PK 84+009. Here, the emergency brake was applied. It entered the Angrois bend practically at this speed. It was derailed

there (at PK 84+413) while travelling at 179 km/h at 20:41:06 hours. This was in breach of the train timetable and the Maximum Speed Table.

- The cab audio recording made by the safety recorder in the front power car of the train in the accident is corroborated by the driver's and the train manager's statements. It shows that a (corporate) mobile telephone call from the train manager to the driver started at 20:39:15 hours (towards PK 78+280, and near signal E´7 - PK 80+619 - the point where braking normally commences). The call lasted 100 seconds and was about stopping at the station at Puentedeume (between A Coruña and Ferrol).

The conversation is over-long (100 s), since there was no emergency. It did not use the train's internal intercoms. Furthermore, its content was repetitive. Given the train manager's (presumed) insistence, the driver makes the same reply three times: that the train will certainly fit on to either of the tracks at Puentedeume station.

In this whole duration there was a considerable length of track (5 540 m) on which he did not carry out part of the normal driving activity. He did not begin reducing speed at the usual place (E´7, which he passed 43 seconds after the start of the call), but maintained speed (200 km/h). He did not notice the change of ASFA mode in the cab (from high-speed to conventional), which he passed three seconds later.

The only existing regulations on the use of electronic devices (mainly mobile phones, but also others) on the date of the accident was Notice 102 of 1997, issued by the former RENFE, and a 2011 recommendation by Renfe Operadora. Neither had the status of a rule or regulation (Recommendation 6).

- In this Commission's experience of investigating incidents, this has been the first time that a cab audio recording has been available. This has given a much more thorough picture of the driver's behaviour, attitude, activity and interfaces (human and machine). Hence it would be worth studying the possibility of gradually fitting this type of recording to the other rolling stock. Likewise, if possible, it would be very useful if accident investigations could look at in-cab video recordings (Recommendation 7).

Driver's conversations with CRC Atocha (Madrid) [section 3.5.2]

- At 20:02 hours the driver reported from Ourense station that he had the train logbook and was travelling in BSL mode (trackside signal block, i.e. on ASFA).

- After the accident he stated that he had become derailed, should have been travelling at 80 and had taken the curve at 190 km/h.

4.3. CONCLUSIONS

Consequently, in view of the description of events and taking the earlier considerations into account, together with the special reports from Adif and Renfe Operadora, the chief investigator concludes that:

The cause of the accident was excessive speed of the train (going at 179 km/h) on the curve entering the A Grandeira branch (Angrois bend, limited to 80 km/h). The driver was in breach of the requirement of the timetable book for train 150/151 and the maximum speed table for line 082.

As a contributory cause, we note that the driver was distracted by answering an internal telephone call from the train manager on his own train, which explains why he did not brake hard enough to reduce speed before entering that curve.

4.4. FURTHER FINDINGS

Minor discrepancies have been found between the set timetable for train 150/151, the Maximum Speed Table for line 082 and the practical arrangements (relating to the scope of the ERTMS). These discrepancies are unrelated to the accident causes.

5. MEASURES ADOPTED

5.1. GENERAL MEASURES

5.1.1. Proposals by the Railway Accident Investigation Commission (CIAF)

Based on the analysis of the facts of what had happened, completed by that date, the plenary meeting of the CIAF, on 30 July 2013, agreed to issue advance safety recommendations which, if and when possible, were to include this report when completed.

The purpose of those preliminary recommendations was to avoid possible repetition of the situation of the Santiago accident. They were submitted to the Directorate-General of Railways (DGF), as the national rail safety authority, on 1 August 2013. DGF then forwarded them to Adif, which was competent for them. They are as follows:

1.- *Ensure that all reductions of maximum speed programmed on the main track between stations, from a certain deceleration, are signed on the track.*

2.- *In these situations, arrange progressive set-up of ASFA balises which check train speeds and ensure immediate braking if the maximum speed of entry to the next track section is lower.*

5.1.2. Measures announced by the Ministry of Development

The Minister of Development attended the meeting of the Development Commission of the Congress of Deputies on 9 August 2013 about this accident. She has planned a set of 20 measures which tackle

various aspects of the rail sector, with a view to improving it and setting out lines of action for the future.

The measures she announced relate to improving infrastructure (signalling), personnel (selection and training), rolling stock, passengers (improving passenger management) and regulations. As of March 2014 the list of these measures, including action on the CIAF preliminary recommendations referred to above, was as follows:

1.- Revise the maximum speed tables for all lines, with speed graduation analysis, and setting criteria for variation of the maximum speeds.

Those tables, and the existing speed transitions, have been revised. A definition has been reached for a 'significant change of speed', which has been detected at 375 points on the Adif network (51 on high-speed lines and 324 on the conventional network).

2.- Revise the signalling on the track of the lines identified by the above analysis, which are not marked with any other type of sign. This will be done by signs warning of a change of speed, and of the commencement of that speed.

Signs have already been set up at 122 significant changes of speed, where the speed difference is at least 40% of the lower speed. These are either on high-speed lines (37) or on lines belonging to the conventional network with maximum speed over 160 km/h (85).

3.- Provide protection, by means of a set of ASFA balises, on the sections where there is a significant reduction of the maximum speed, like the protection for temporary speed limits on the track.

The 122 significant changes of speed above already have balises.

4.- Work with the industry to promote further development of ASFA Digital so that it has greater capacity to transmit information from track to train, allows greater versatility, and offers the possibility of transmitting voice signals in addition to acoustic signals, as at present.

The development framework for ASFA Digital (already fitted to most rolling stock) includes a plan for on-track trials of the new prototype 11-frequency balise (analogue ASFA currently offers five). Some of the new frequencies will be allocated to speed control.

5.- Analyse the engineering rules of the technical procedures for transition from ERTMS to ASFA.

This measure has already been finalised. The applicable rules have been reviewed and analysed, in addition to the conditions on which each existing transition is carried out in the infrastructure. The study was limited to scheduled and automatic transitions between ERTMS Level 1 and ASFA. It did not include manual transitions or transitions degraded due to malfunctioning.

6.- Explore in depth the possibility of installing a satellite system for trains as back-up to the signalling systems.

This is a driving assistance system. It works through audio and video messages. These alert the driver in advance of speed reductions. Laboratory and track tests are being developed.

7.- Revise the admission requirements for rail sector jobs and assess whether to devise ad hoc academic training.

A file has been compiled to amend Ministerial Order 2872/2010. Joint work has begun with the Ministry of Education, Culture and Sports to draw up a list of railway jobs and the training courses for them.

8.- Revise the scheme of medical check-ups of physical and psychological fitness, by analysing the required periods and levels.

Renfe Operadora has signed an agreement with medical professionals from Valladolid University to define criteria and tools of medical assessment at check-ups.

9.- Reinforce the analysis of psychological aspects of driving (stress control, repetitive activity, concentration etc.), as a guide to the continuous training of drivers.

The Ministry of Development and Renfe Operadora have signed a co-operation agreement with the Official Board of Psychologists to analyse the psychological aspects of driving.

10.- Write down the procedure for going on duty each day at the start of work, which the driver has to check with the management centre.

This means setting up a formal verification procedure in the form of a checklist for drivers to complete at the beginning, handover and end of duty, leaving a record of possible incidents. There is already a file for a checking procedure for long and medium-distance goods and passengers.

11.- Assess the possibility of recording work in progress on trains.

Install audio and video recording systems in the cab, but restrict their use to accident or incident investigations alone. A technical specification has been drawn up about this. New trains must conform to it.

12.- Revise the rules on the use of (mobile) communication equipment by staff on board trains. A single, integrated system of communication will be set up, so that the driver can activate communication via a hands-free system.

This means regulating the safe use of the communication technology and appliance in the cab, and including them in a single system which allows hands-free mode. Renfe Operadora has issued Circular Resolution 3 on '*Proper use of communication devices and electronic appliances during train driving and manoeuvres,'* dated 28 February 2014. This prohibits mobile telephone use by drivers, except in cases of communication failure or emergency. This applies not only to drivers, but to all personnel who have relations with drivers.

On the other hand, the Directorate-General of Railways (DGF) has launched a study for the inclusion of this resolution in the new Railway Traffic Regulations (being drafted) for communications with the control centre, and for the definition of recommendations for the other railway undertakings.

13.- Increase the checks of legal (safety) recorders, with systematic analyses of the information contained on them, to promote improvement measures.

There has been an increase in the technical staff responsible for analysing Renfe Operadora safety recorders. A bid has been made for automatic record analysis software.

14.- Improve positioning and protection of crew inside coaches.

This is to minimise injury from crew falling during journeys. Rolling stock manufacturer's solutions have been studied, and Renfe Operadora has signed an agreement with the Technical University of Madrid to develop a 3D simulation model of behaviour of crew exposed to powerful acceleration. An agreement is also to be signed between Renfe and Talgo to devise tests of the solutions provided.

15.- Extend computerisation to access controls.

To give a better knowledge of numbers of passengers travelling on high-speed and long-distance services, technology solutions are being studied to improve access controls at stations and on board trains. This involves installing fixed terminals (automated check-ins) on the ground, and installing mobile terminals on board.

16.- Issue free tickets to children under four years old.

This measure has already been implemented, to facilitate control of these children on high-speed and long-distance trains.

17.- Promote passenger identification systems.

The aim is to improve identification of passengers on high-speed and long-distance services. The passenger name and a telephone number or e-mail address will be added at the time of adaptation of the computerised system for selling tickets (via the Internet or Renfe card). These particulars will not be printed on the tickets.

18.- Update the General Traffic Regulations and other implementing regulations.

This means providing a single regulation (the Railway Traffic Regulations). The aims include grouping together and combining the current provisions of the General Traffic Regulations (generally applicable to the conventional network) and the rules applicable to the high-speed and metric gauge networks. They also include considering the present situation of separation of skills and responsibilities between infrastructure managers and railway undertakings.

The main body of the new Railway Traffic Regulations has already been written. The remaining parts (appendices, annexes and interim specifications) are still being drafted.

19.- Pass a Royal Decree on integral assistance to victims of railway accidents including a National Plan listing all action to look after those affected.

A draft royal decree has been written and is now at the negotiation stage.

20.- Involvement of the Congress of Deputies in forming the Railway Accident Investigation (CIAF).

A law has been passed adding a new provision to Law 39/2003 on the Rail Sector. It concerns the membership, functioning and legal status of CIAF. An amendment to Royal Decree 810/2007, implementing this provision, has been drafted and is at the negotiation stage.

Another two measures have meanwhile been added:

21.- Revise and update the Regulation on Compulsory Passenger Insurance for the collective public transport of persons.

Include an increase in the level of compensation payable to the insured persons or beneficiaries under such insurance. Add a provision to the draft royal decree on full assistance to victims of railway accidents and their families (Measure 19). This must comprise a considerable increase in the amounts of compensation under the Compulsory Passenger Insurance.

22.- Create a Spanish railway safety agency.

As the independent body regulating, controlling and supervising everything to do with rail sector safety, fulfilling the safety authority functions prescribed in Directive 2004/49/EC on the Safety of the Community's Railways. To authorise its creation, a Royal Decree has already been approved in amendment of the Agencies Law 28/2006.

5.2. SPECIFIC MEASURES IN THE ACCIDENT ZONE OF LINE 082

On 13 August 2013, after the accident, Adif installed signage corresponding to two temporary speed limits on track 1 of line 082 heading towards Santiago de Compostela, and near Angrois. These were 160 km/h, with signs in the run-up (PK 78+778) and at the start of the restriction (PK 80+338); and 30 km/h (initially due to the repair of this track after the accident), and also with signs in the run-up (PK 81+669) and at the start of the restriction (PK 84+400). A balise was also set up with the sign announcing the temporary 30 km/h speed limit. These signs remained in place on track 1 in March 2014.

In the same direction on track 2 (Ourense-Santiago), signs were also set up on the Angrois bend as a permanent speed limit. There was a sign giving advance notice of the speed restriction (as the speed was greater than 160 km/h) and signs giving warning, and at the start, of the 80 km/h speed limit. These signs were backed by a balise at the pre-warning sign.

6. RECOMMENDATIONS

The recommendations proposed below result from the technical investigation into the accident. Some tend to reinforce the measures announced by the Ministry of Development, as mentioned.

Final addressee	Number	Recommendation
Adif	54/13-1	Make it a rule that all speed reductions, from a certain deceleration onwards, must be marked on the track by fixed speed limit signs.
Adif	54/13-2	For these situations (significant speed reductions), arrange progressive set-up of balises which may help to control the speed of trains, so that they brake in case the speed limit for entry into the next section is lowered. Therefore, implement the necessary ASFA Digital (Automatic Braking and Announcement of Signals) systems.
Renfe Operadora	54/13-3.1	Reinforce the procedures set in the Renfe Operadora SMS so that safety-related defects detected at any level are referred to the departments with the prescribed function of analysing and considering them, thereby assuring effective preventive management.
DGF	54/13-3.2	The national railway safety authority will ensure that Recommendation 54/13-3.1 is extended to the other railway undertakings.
DGF	54/13-4	The national railway safety authority should consider whether to reconvene the Joint Traffic Safety Committees, including representatives from Adif and the railway undertakings, and under the authority's supervision. These committees can analyse risk situations deriving from the interaction between driving, vehicle and track.

DGF	54/13-5	The process of commissioning new railway lines and alternative stretches should include a specific risk assessment. This should include identification and management of possible hazards driving from the interaction between subsystems, in normal and degraded operating conditions, and their links with the driving and traffic staff involved when a train is travelling from beginning to end of the line or alternative stretch, and its connection to the existing network. Also analyse the viability of the layout at the various construction stages. In justified cases, promote the application of such assessments to lines which are in service.
DGF	54/13-6	Make the necessary arrangements for communications with driving staff in the cab to take place safely and avoid possible distractions. Make these arrangements part of the general regulations and pass them on to the railway undertakings for inclusion in their safety management systems.
Renfe Operadora	54/13-7.1	Promote the progressive implementation of an audio recording system in drivers' cabs. Assess the feasibility of adding a video recording system as well.
DGF	54/13-7.2	The national railway safety authority will ensure that Recommendation 54/13-7.1 is extended to the other railway undertakings.

Madrid, 20 May 2014