Rail Accident Investigation Branch

Rail Accident Report

Fatal collision between a Super Voyager train and a car on the line at Copmanthorpe 25 September 2006

Department for Transport

Report 33/2007
September 2007

This investigation was carried out in accordance with:

- the Railway Safety Directive 2004/49/EC;
- the Railways and Transport Safety Act 2003; and
- the Railways (Accident Investigation and Reporting) Regulations 2005.

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Contents

Introduction

1 The sole purpose of a Rail Accident Investigation Branch (RAIB) investigation is to prevent future accidents and incidents and improve railway safety.

2 The RAIB does not establish blame, liability or carry out prosecutions.

3 Access was freely given by Network Rail, Bombardier and Virgin Trains to their staff, data and records in connection with the investigation.

4 Appendices at the rear of this report contain glossaries:

- acronyms and abbreviations are explained in appendix A; and
- technical terms (shown in *italics* the first time they appear in the report) are explained in appendix B.

Summary of the report

Key facts about the accident

5 At 20:57 hrs on 25 September 2006 the 14:25 hrs Virgin train from Plymouth to Edinburgh struck a car on the site of the former Moor Lane level crossing at Copmanthorpe, south of York. The train was travelling at approximately 100 mph (161 km/h). The car driver was fatally injured.

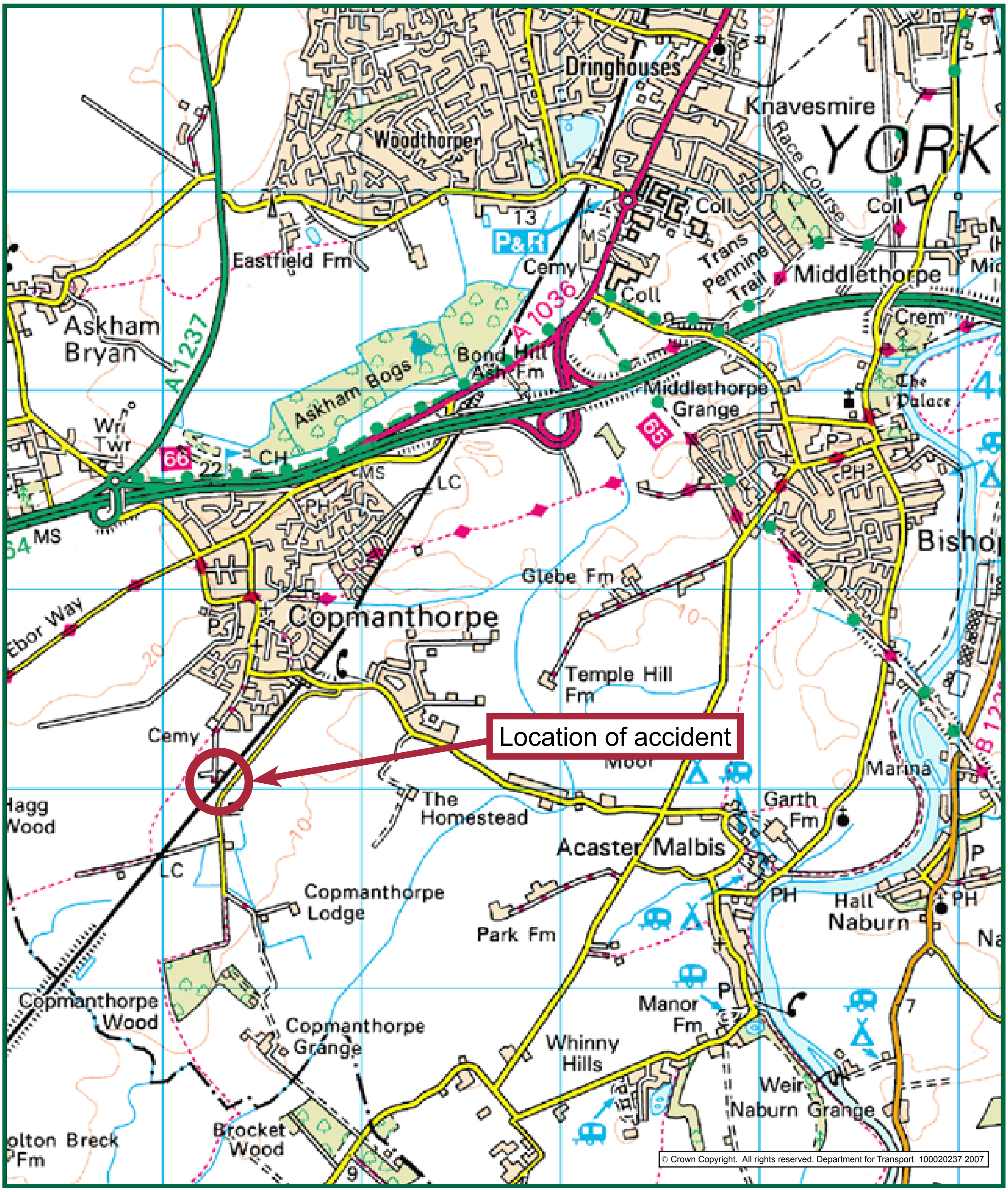

Figure 1: Extract from Ordnance Survey map showing location of accident

Immediate cause, causal and contributory factors, underlying causes

6 It has not been possible to establish why the car carried on past the end of the road at Moor Lane towards the railway. However, the car entering on to the railway through a fenced boundary was the immediate cause of the collision between the car and the train.

7 No additional causal factors can be determined.

8 It is not possible to state with certainty if the City of York Council and Network Rail's omission of a risk assessment into vehicle incursion on to the railway at Moor Lane was contributory to the accident. On balance, the RAIB judges it to have possibly contributed to the accident.

9 No relevant underlying causes have been identified.

Severity of consequences

10 There were no casualties on the train, three axles of which were derailed after the collision; the train remained upright and in line until its driver's action brought it to a halt. The car was destroyed in the collision, and its driver was fatally injured.

Recommendations

11 The RAIB makes no recommendations relating to the cause of the accident. Two recommendations are made at paragraph 108 relating to:

- assessment of cul-de-sacs adjacent to Network Rail's system; and
- protection of the underside of trains from damage after collisions.

The Accident

Summary of the accident

12 At 20:56 hrs on 25 September 2006, a car passed through the fence at the end of Moor Lane just outside Copmanthorpe, south of York. Moor Lane is the site of a former level crossing, closed in 1982. The car came to rest with its front wheels in the *four foot* of the nearest railway line, the *down* Leeds line. It was dark and the weather was drizzly with some fog.

13 At that time, a Virgin Cross Country class 221 Super Voyager train was approaching Copmanthorpe on the down Leeds line travelling towards York at 100 mph (161 km/h). The train was the 14:25 hrs Plymouth to Edinburgh service, reporting number 1S91.

14 The driver of the train sounded the horn and applied the emergency brakes after he first saw the car approximately a quarter of a kilometre ahead of him. However there was not sufficient time to decelerate, and at 20:57 hrs the train struck the car and pushed it along the track, breaking it up in the process.

15 The driver of the car died from his injuries.

16 As parts of the front-half of the car broke up, they passed under the train and caused wheelsets two, three, and four of the leading vehicle to derail. The leading wheelset remained on the track. However, the train remained upright and ran in-line throughout its deceleration; no one on the train was injured.

17 The train came to a stand 907 metres beyond the point of the collision. The train crew performed all necessary train *protection duties* and the emergency services were informed.

The parties involved

<u>The train operator</u>

18 Virgin Trains (formally Cross Country Trains Ltd) was the operator of train 1S91. The company also employed the crew of that train, including the driver.

<u>The infrastructure manager</u>

19 Network Rail own and maintain the infrastructure at Copmanthorpe. They also employ the signallers who control movements on the line from the *signalling control centre* at York.

<u>The car driver</u>

20 The car driver was a middle-aged male resident of York.

<u>The train driver</u>

21 The train driver is employed by Virgin Trains at Edinburgh. At the time of the accident he had worked in the railway industry for 24 years, and been a driver for 20 years.

Location

22 Copmanthorpe is located some 4.25 miles south of York on the line from York to Leeds. The line consists of four tracks, two running to Leeds, and two to London. The two routes separate at Colton Junction, 0.5 miles to the south of Copmanthorpe. The railway is straight through Copmanthorpe, and runs at ground level. The maximum permitted speed of the *up* and down Leeds lines is 100 mph (161 km/h), and on the up and down main lines (to and from London) it is 125 mph (201 km/h).

23 The line is signalled with four aspect colour light signals, which are controlled from the York signalling centre. Both routes south of York are under the control of a single signaller.

24 At 184 miles 27 chains (measured from London Kings Cross), the line intersects with the alignment of Moor Lane, a minor road from Copmanthorpe village. In earlier times there was a level crossing taking the lane across the railway lines, but this was closed on 3 October 1982 as part of an upgrade of the London to York railway. Since then Moor Lane has been a cul-de-sac, and road traffic has crossed the line on a bridge some 700 metres to the north of the former level crossing. The crossing gates were removed and a wooden fence was installed across the road on its north-western approach. The tarmacadam surface of the road was removed for some 7 metres on the north-west side of this fence, and this area was covered in low, grassy vegetation (Figure 2).

25 Moor Lane is a narrow lane with grass verges. It is illuminated within Copmanthorpe village, but not once the lane leaves the village. The road is signed as a no through road at the point beyond which no other exit route is available. In the village the cul-de-sac is subject to a 30 mph (48 km/h) limit, but this is signed as ending at the end of the lit section of the lane. The nature of the paving and verges would indicate to a road user that they were driving along a minor road. Outside the speed limit the road surface narrows to little over a car's width, and the road is bordered on both sides by verges of long, uncut grass leading to mature hedges.

26 The fence at the north-west approach to the former level crossing was renewed in August 2006. A regular three-monthly examination by Network Rail on 14 September 2006 reported that the fence was in good condition. There is no access gate in the north-west fence.

External circumstances

27 At 20:56 hrs on 25 September 2006 it was dark, and the weather was drizzly with patchy fog. In view of this a car driver on the unlit Moor Lane was unlikely to be able to see further than the visibility of his headlights, some 25 to 30 m.

Train and car equipment

28 The train involved was a five-car *diesel electric multiple unit* class 221 Super Voyager number 221 136, designed and manufactured by Bombardier; the train contained the following vehicles (in the order in which they were travelling):

- Driving Motor First.
- Motor Second.
- Motor Second.
- Motor Second.
- Driving Motor Second.

29 The car was a Vauxhall Astra estate with a six-cylinder diesel engine, manufactured in 1999, and owned by the car driver.

Events preceding the accident

30 The train driver had joined train 1S91 at Leeds. The train departed Leeds at 20:35 hrs, 26 minutes late, and proceeded towards York. As the train approached Copmanthorpe the driver was running under green signals and driving at the permitted speed of 100 mph (161 km/h). Subsequent analysis of the train's data recorder confirmed that he drove the train to the requisite speed limits, and accelerated and braked for all signals and speed restrictions in accordance with the *professional driving policies* laid down by Virgin Trains.

31 Shortly before the accident the car driver had undertaken local trips in the vicinity of York. He had stated that his intention was to return to his home, also in York; he gave no reason why he might have chosen to drive to Copmanthorpe, or onto Moor Lane, a cul-de-sac to the south of the village.

Figure 2: The site of the damaged fence

32 Shortly before 21:00 hrs the car collided with and broke through the fence at the end of Moor Lane, and ran onto the railway (see Figure 2 and Diagram 1). The front wheels of the car came to rest in the four foot of the down Leeds line.

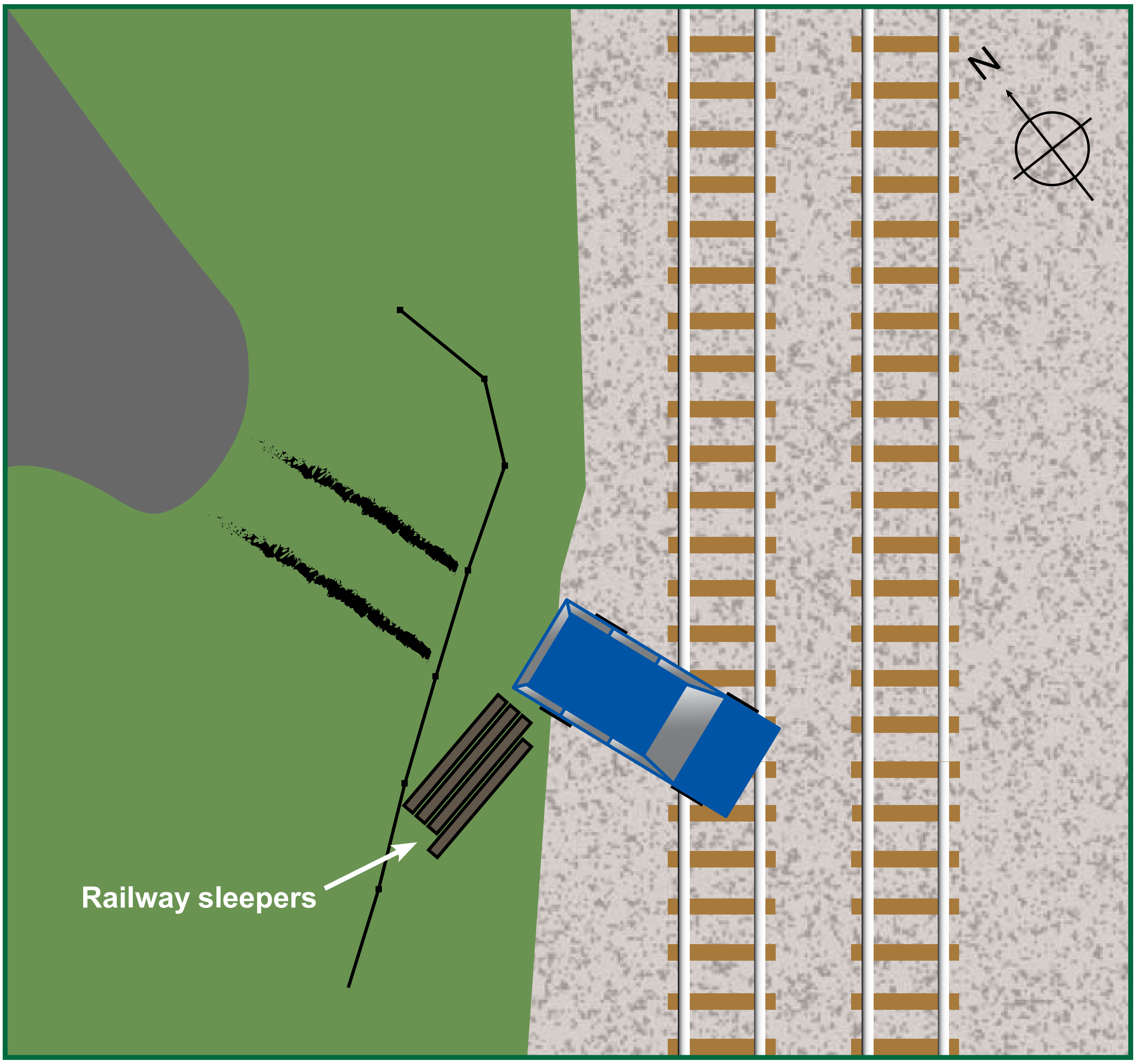

Diagram 1: Location where the car came to rest

Events during the accident

33 The driver of 1S91 saw the lights of the car in his path. The driver sounded the horn and applied the emergency brakes to his train; however, the train struck the car. The train's data records show that the collision took place at 20:57 hrs, 3 seconds after the brake lever was moved. The train had not decelerated measurably from its speed of 100 mph (161 km/h) as the brakes had not had time to apply fully between the driver moving the lever and the collision.

34 A witness living on Moor Lane had heard the car hit the barrier, and stated that approximately 30 seconds later he heard a collision.

35 The leading wheels of the train remained on the track, but the second, third and fourth wheelsets of the train were derailed (Figures 3 and 4). All other wheels remained on the track, and the train decelerated to a halt 907 metres north of the point of collision. The train remained upright and inline on or close to the track throughout its deceleration.

36 At the time of the collision the car driver was still in the driving position of the car with his seat belt fastened.

Figure 3: The derailed train - front view

Consequences of the accident

37 The car driver received fatal injuries from the collision. No one was injured on the train. The car broke into many parts and was scattered by the impact (see Figure 5).

38 The derailed train did not obstruct the adjacent line. There was considerable damage on the underside of the vehicles (see paragraphs 90 to 96); as a result fuel leaked into the track ballast from three of the train's fuel tanks and the *tilt system* became completely unlocked on two of its five vehicles.

39 The railway track and signalling were damaged.

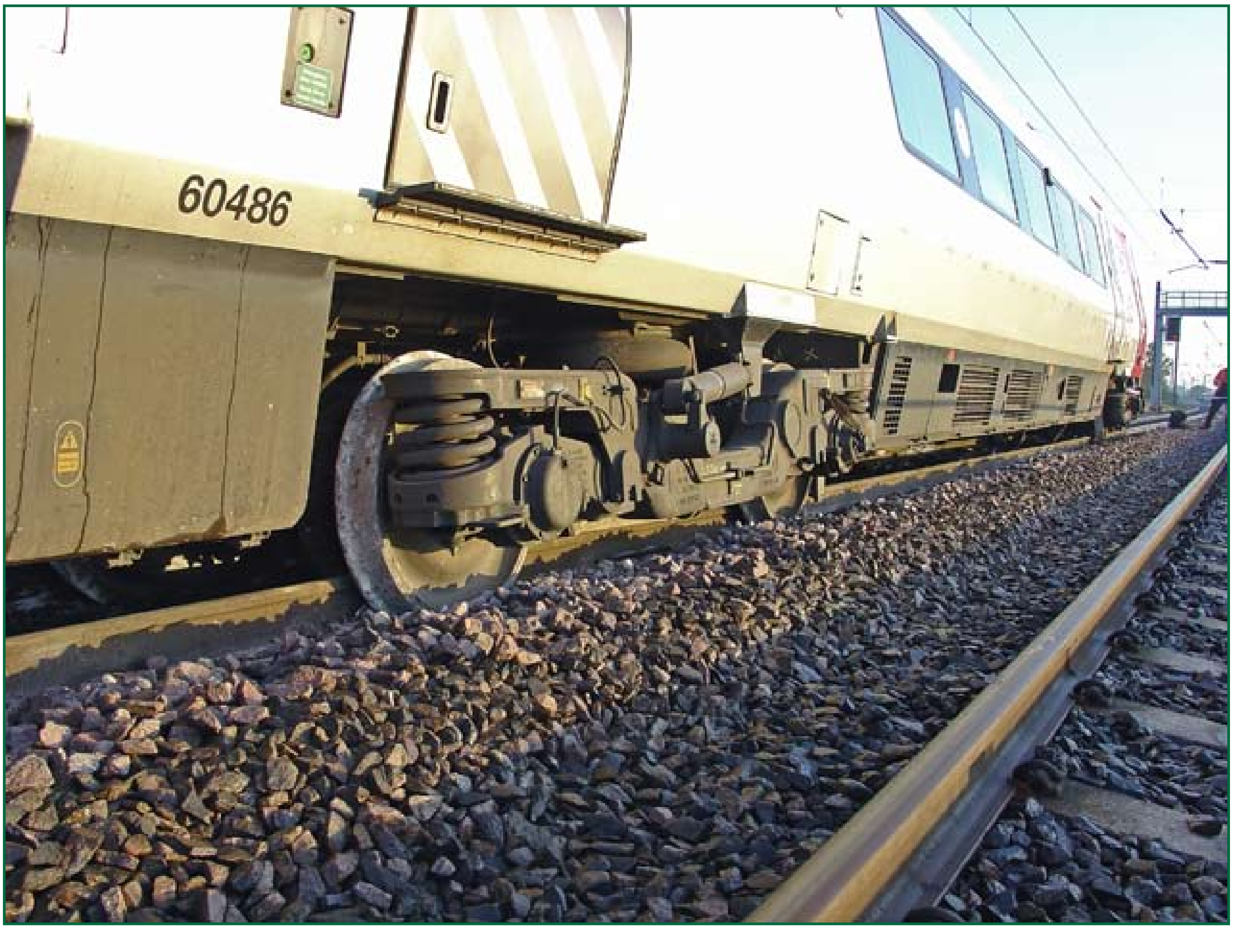

Figure 4: The derailed wheelsets, 2, 3 and 4 from the front, on the leading vehicle

Figure 5: Debris from the car after the collision

Events following the accident

40 The emergency services attended the scene of the accident and assisted in the evacuation of the train. North Yorkshire Police investigated, and reported on, the state of the car and the highway, and the British Transport Police investigated the incursion of the car onto the railway.

41 The 74 passengers in the train were detrained on foot, and taken to onward transport, by 23:20 hrs. The up and down main lines were handed back to traffic at 05:32 hrs on 26 September 2006 in time for the morning peak traffic flows. The up and down Leeds lines were returned to traffic on 20 October 2006 after repairs to them had been carried out.

42 The train driver was tested for drugs and alcohol in accordance with normal industry practice; neither was detected.

43 Post mortem examination of the car driver did not indicate alcohol or drugs in his body. There was no evidence of illness that might have caused him to lose control of the car. No evidence was found as to whether the car driver was or was not fatigued.

The Investigation

44 The RAIB has investigated the results of the collision on the railway infrastructure and trains, but has not investigated the reasons as to why the car was driven onto the railway at Moor Lane.

Sources of evidence

45 The RAIB has obtained evidence from the following sources:

- examination of the site and surveys of road and rail layouts, equipment and damage;
- examination of the train, including ; its *on train monitoring recorder* (OTMR) downloads;
- witness statements;
- the North Yorkshire Police report on the road vehicle technical aspects of the collision;
- Network Rail documentation about risk assessments of vehicle incursions onto the railway;
- data supplied by Rail Safety and Standards Board (RSSB) relating to the general risk of vehicle incursion onto the railway;
- Health and Safety Executive (HSE) report into the accident at Great Heck on 28 February 2001 (see paragraph 58);
- Department for Transport (DfT) report 'Managing the accidental obstruction of the railway by road vehicles' published in 2003; and
- RSSB report into the accident at Ufton Nervet 6 November 2004 (see paragraph 88).

Key Facts

<u>The car</u>

46 There is no evidence that the car had any fault prior to the impact which would have caused a loss of control.

47 Evidence from the tyre marks indicate that the car's brakes were not applied as the car approached the boundary fence.

48 The car was split into two major portions by the collision; the front part of the car, including the engine and front axle, remained between the rails of the down Leeds line, whilst the rear part was pushed into the down *cess*.

49 The rear part of the car was propelled along the cess as the car broke up during the collision. Large subassemblies of the rear part of the car remained intact, though substantially damaged.

50 The front portion of the car was broken up by the collision into pieces of varying size. Some of these were ejected from under the train shortly after the collision, some were increasingly broken up and battered by bouncing between the ballast and objects in the train's underframe equipment space until they became ejected, and others were carried by the train (lodged or wedged) until it came to a halt.

51 This breaking up of the car left debris scattered into the cess and across all four tracks throughout the 907 metres that the train ran after the collision.

<u>The train</u>

52 Wheelsets two, three, and four of the leading vehicle became derailed and sustained damage by running on *track fasteners* and over collision debris. Marks on the derailed wheel flange crowns support this.

53 There was extensive, but not major, damage to the train underframe area:

- the obstacle deflector was tilted back and superficially deformed in the collision (paragraph 83 et seq);
- three of five fuel tanks leaked fuel from damaged valves into the track ballast;
- the bogie-mounted *stone guards,* designed to protect the tilt system were damaged and hydraulic hoses were knocked off the tilt cylinders.

54 However, no major system or component came loose from the train, and there was no interior damage as a result of the accident.

<u>The track and signalling</u>

55 Track fasteners were broken and some track and signalling system components were damaged throughout the 907 m that the derailed train ran before stopping.

<u>Site of Moor Lane level crossing</u>

<u>*Condition of the fence*</u>

56 No measures over and above a wooden fence were in place at the end of Moor Lane to protect the railway from road vehicle incursion. A fence of this design adequately marks the boundary of the railway, and will prevent trespass and large animal incursion, but is not capable of stopping a car which hits it.

57 The fence was substantially damaged by the collision with the car. However, the fence had been removed and reinstalled in August 2006 and was in a good condition.

<u>*Assessment against vehicle incursion*</u>

58 Following the derailment at Great Heck on 28 February 2001, where 10 people lost their lives after a vehicle incursion, the Department for Transport (DfT) set up a working group, drawing from road and rail industries, which reviewed the risk of road vehicle incursions on to the railway. In February 2003 the DfT published a final report (Managing the accidental obstruction of the railway by road vehicles), which can be found at www.dft.gov.uk/pgr/roads/tpm/tal/trafficmanagement/managingtheaccidentalobstruc4113. This report offered 'guidance on how highway authorities and rail authorities can demonstrate that they have ranked sites where roads cross or run alongside railways according to their relative risk, and that they have considered how to manage that risk.' The guidance was specifically mentioned as 'most relevant to', inter alia, 'cul-de-sacs ending at railways'.

59 The DfT document sets out a means of assessing sites where the road and railway intersect to achieve a risk 'score', and Table 1.3 of the document suggests levels of expenditure that are appropriate for the scored risk.

60 No assessment had been conducted for the end of Moor Lane on the north-western side of the railway at the time of the accident. Assessments had been conducted for the new diversionary road on the other side of the railway (south-eastern side) leading to the road-over-rail bridge that had replaced the former level crossing. Network Rail has not been able to explain why the north-western approach was not assessed.

Previous occurrences of a similar character

61 In the forty years from 1967 to 2006 there were 235 occasions when road vehicles entered the BR / Railtrack / Network Rail system at other than level crossings, and collisions occurred that led to fatalities in 14 of these. In two cases, one in 1976 and one in 2001 (see paragraph 58) fatalities occurred on trains. In total 17 people have lost their lives in road vehicles from these incidents, and 12 on trains, of which 10 were at Great Heck. Table 1 shows the number of events over the last nine years.

Analysis of incursion statistics					
Year	**Road vehicle incursion and train collision**	**Road vehicle incursion but no train collision**	**Total road vehicle incursions**	**Total fatalities in road vehicles from road vehicle incursions**	**Total fatalities in trains from road vehicle incursions**
1998	2	32	34	0	0
1999	1	28	29	0	0
2000	0	20	20	0	0
2001	5	22	27	1	10
2002	2	22	24	1	0
2003	2	29	31	0	0
2004	2	30	32	0	0
2005	3	16	19	0	0
2006	1	18	19	1	0
1998-2006	**18**	**217**	**235**	**3**	**10**

Table 1 – Road vehicle incursions other than at level crossings on Britain's main line railways since 1998[1]

62 The RSSB Safety Risk Model states that an average of 0.76 *fatalities / weighted injuries* per annum result from road vehicle incursions other than at level crossings. The accident at Copmanthorpe does not appear to be greatly different from the majority of such accidents, being an event where an occupant of a road vehicle loses his or her life, but no-one on the train is injured. In recent years only at Great Heck (paragraph 58) and Ufton Nervet (paragraph 88), have casualties in trains resulted from collisions between cars and trains; in both cases the trains were diverted after an initial derailment from the collision by a pair of points further along the line.

[1] Source: RSSB supplied data from Safety management Information System - Professor Andrew Evans - Fatal train accidents on Britain's main line railways, 2006 analysis, published January 2007

Analysis

Identification of the immediate cause

<u>The incursion of the car onto the railway</u>

63 It has not been possible to establish the reason why the car carried on past the end of Moor Lane towards the railway. However, the car hit the railway boundary fence with sufficient speed to break and pass through it before coming to rest obstructing the down Leeds line of the railway. The car hitting the fence at sufficient speed to reach the railway is thus the immediate cause of the incursion.

<u>The collision between the car and the train</u>

64 There is no evidence that the following issues caused or contributed to the collision:

- the driving of the train;
- the maintenance of the train and its physical state; and
- the state of the track and the signalling.

65 The train collided with the car as an inescapable consequence of the car coming to rest in the four foot of the track on which it was approaching. There was insufficient time to warn the train of the obstruction. The immediate cause of the collision was the incursion of the car onto the railway.

<u>The car driver fatality</u>

66 The car driver was killed as a direct result of the impact between the car and the train.

Identification of causal and contributory factors

<u>Signing on Moor Lane</u>

67 As a car leaves Copmanthorpe towards Moor Lane the driver sees a no through road sign at the junction of Moor Lane, Station Road and Main Street, about 1 km before reaching the crossing. There is also a sign indicating that through traffic should turn into Station Road. Both signs were in good condition, and, whilst neither was illuminated, they were in an area with street lighting.

68 As the lane leaves Copmanthorpe village, and road lighting ceases, there is a national speed de-restriction sign, located between half and three quarters of a kilometre from the site of the former crossing. This sign, which appears neglected, was positioned to mark the end of the village speed limit before the Moor Lane crossing was closed in 1982, and its position has remained unaltered since. However, advice from the City of York Council (the local highway authority) is that the road does not justify a 30 mph (48 km/h) limit under current DfT guidelines. For the 500 – 750 m distance between the speed limit sign and the site of the level crossing the national speed limit of 60 mph (96 km/h) applies.

69 The Highway Code (clause 104) states that:

'The speed limit is the absolute maximum and does not mean it is safe to drive at that speed irrespective of conditions. Driving at speeds too fast for the road and traffic conditions can be dangerous. You should always reduce your speed when:

- the road layout or condition presents hazards, such as bends;
- sharing the road with pedestrians and cyclists, particularly children, and motorcyclists;
- weather conditions make it safer to do so;
- driving at night as it is harder to see other road users.'

70 On the narrow lane with no lighting, no pavement, several bends, and signed as a cul-de-sac, and in misty, dark weather, it would not be safe to drive at the de-restriction speed of 60 mph (96 km/h). North Yorkshire Police estimate that the car was being driven at a speed between 30 and 40 mph (48 and 64 km/h), and state that the brakes were not applied, before the car hit the railway fence. At a speed of 40 mph (64 km/h) a driver would not be able to stop within the length of his headlights' illumination, and the car would be at risk of hitting any unlit obstacle before the driver could properly react. In view of the estimate of the car's speed the RAIB does not consider that the fact that the road was de-restricted from the end of the village to the crossing contributed to the accident.

<u>The incursion of the car onto the railway</u>

71 As stated in paragraph 60 the western site of the closed crossing had not been assessed against the risk of a vehicular incursion prior to the accident. After the accident the City of York Council and Network Rail did assess the north-west side of the crossing using the procedures described in paragraph 59. This assessment, based on the facts known before this incident, indicated that the location had an extremely low risk of an incursion, and only mitigation measures up to a maximum value of £5,000 would be justified. Mitigation measures within this cost limit were likely to have been restricted to reflective warning signs on the fence and its approach. Given the narrow, overgrown state of Moor Lane and the low probability of any car coming to the end of it at all, there is no evidence that further precautions would have been warranted.

72 It is possible that, had such signs existed at the time of the accident, the vehicle incursion might not have taken place. However, it is also possible that such signs would have made no difference to this particular accident. Since it has not been possible to find the cause of the incursion, it is not possible to say with certainty whether such warning signs, had they existed, would have helped prevent the accident or not, but they would have improved the visibility of the fence to an oncoming driver, even if the driver had accelerated from the de-restriction sign.

73 The oversight in not performing the risk assessment against vehicle incursion on to the railway is thus possibly contributory to the accident.

Driving of the train

74 The time from the car entering the railway to the collision was estimated at around 30 seconds (paragraph 34). Based on this time estimate, although recognising that it is not necessarily exact, the train would have been over 0.8 miles (1,280 m) from Moor Lane when the car entered the railway. The railway is straight at this point, but at this distance it was difficult for the train driver to establish if the car lights were intruding on the railway, particularly bearing in mind the weather conditions. The train driver would not have been expecting to see a car on the railway, and the RAIB considers that it is not surprising that he did not apply the brakes until he was much closer to the car, and able to see more clearly that the lights were from an obstacle that was obstructing the railway. Allowing two seconds reaction time the driver would have been about one eighth of a mile (220 metres) from the car when he decided to apply the brakes.

Derailment mechanism of the train

75 The mechanism of the derailment was established by examination of:

- the marks at the point of derailment;
- the damage to the track;
- the damage to the car;
- the damage to the train;
- the data records from the train and the signalling; and
- the evidence given by the train driver.

76 As previously explained (paragraph 33) the train hit the car at 100 mph (161 km/h); the car disintegrated, both from the impact and during subsequent passage of the train. The damage to the train's obstacle deflector and the marks on remnants of the car, in particular the engine block, show that large components of the engine were hit by the obstacle deflector and pushed down into the four foot as the break-up process started. As a result of these components being pushed down, the first wheelset of the train passed over the car's components without its wheel flanges coming into contact with them. Consequently, the leading wheelset remained on the track.

77 This finding is supported by three of the leading wheelset's four brake calliper arms' grease nipples being intact, whilst others, further back in the train, were knocked off (paragraph 81). The grease nipples are very exposed and vulnerable items at the bottom extremity of the *brake rigging*.

78 Marks and distortion on the right hand lifeguard indicate that it also prevented a part of the car structure from getting between the leading wheelset's right hand wheel and the rail. The life guard thus functioned as designed in reducing the risk of derailment of the leading wheel.

79 The train driver's evidence indicated that the cab 'lifted up' during the collision. This supports the assessment that the leading end of the train forced a large object down; however, the lift was not sufficient to derail the leading wheels.

80 Marks show that the engine block or large transmission parts came into contact with the right-hand wheel flanges of wheelsets two, three and four of the leading vehicle as they passed over the car wreckage. As a result, all three wheelsets derailed to the *six foot* side. The train continued to run derailed under full emergency braking for 907 metres until it came to a stand. It remained upright and in-line throughout. None of the derailed wheelsets deviated from their intended path on the rail by more than 170 mm.

81 The debris knocked almost all the brake calliper arm grease nipples off on wheelsets 2, 3 and 4. As the debris continued to bounce up and down under the slowing train it caused further damage to many systems under the whole length of the train (see paragraphs 90 to 96). However, no further wheelsets were derailed. This may be due to the disintegration of the engine block and transmission into smaller components as they progressed under the train: the main cylinder block, for example, was detached from the cylinder head and transmission, and broken so that the largest component was only four cylinders of the engine block, from a six cylinder engine.

Identification of underlying causes

Incursion of the car onto the railway

82 No underlying factors were identified.

Severity of consequences

Performance of the train's obstacle deflector

83 Trains that are built to current *Railway Group Standards,* which include class 221 trains, are fitted with an obstacle deflector at the leading end. This is a steel structure, usually attached to the underside of the leading body shell in front of the first bogie, which is designed to prevent large objects from entering under the train (Figures 6 and 7).

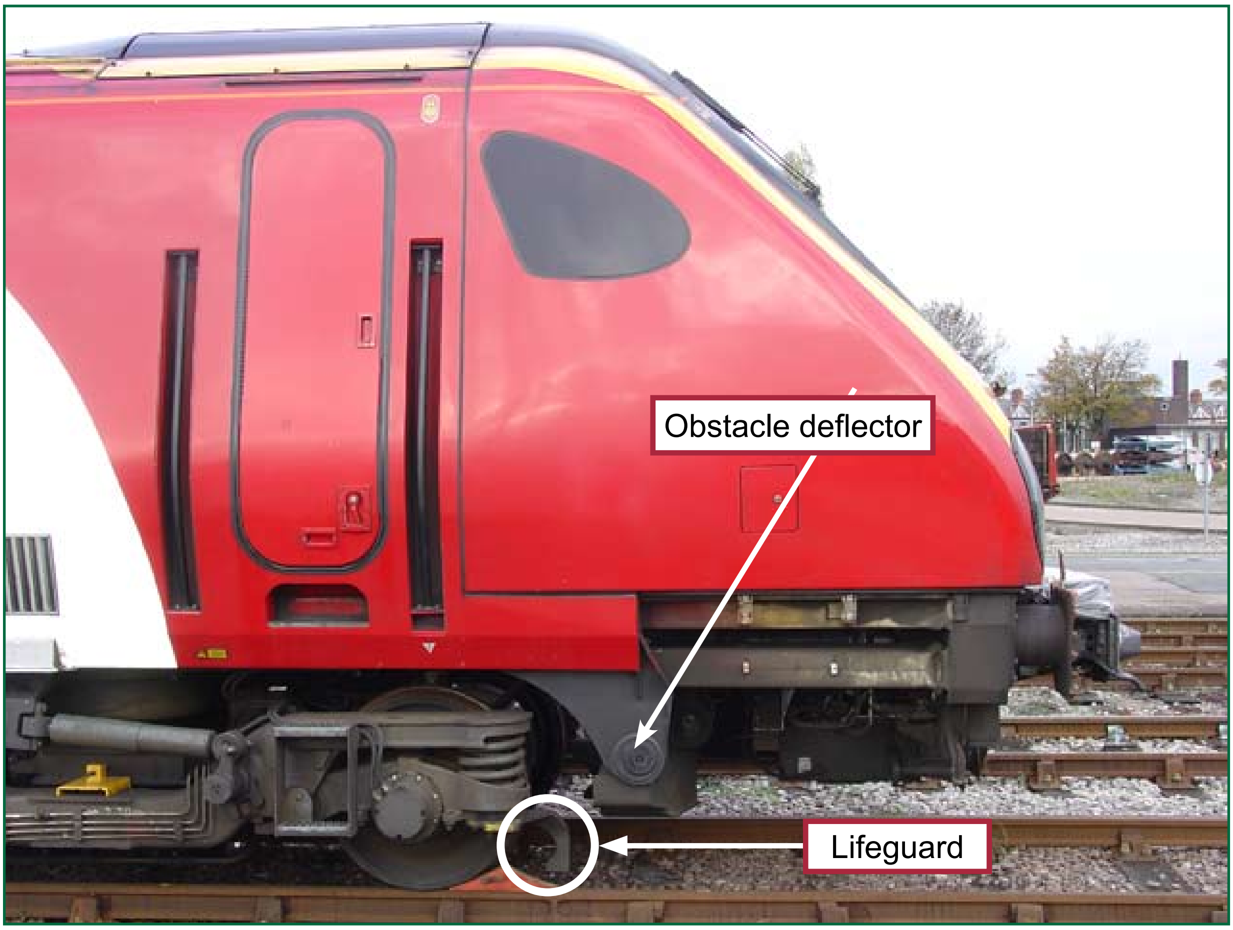

Figure 6: Location of obstacle detector seen from side of train

Figure 7: Undamaged obstacle detector at the rear of the train (note that horn covers are missing)

84 The performance of the obstacle deflector was contributory to the train remaining in-line and upright after striking the car as it prevented the leading wheelset from derailing and also ensured that only relatively small bits of the car passed under the train (see Figure 8).

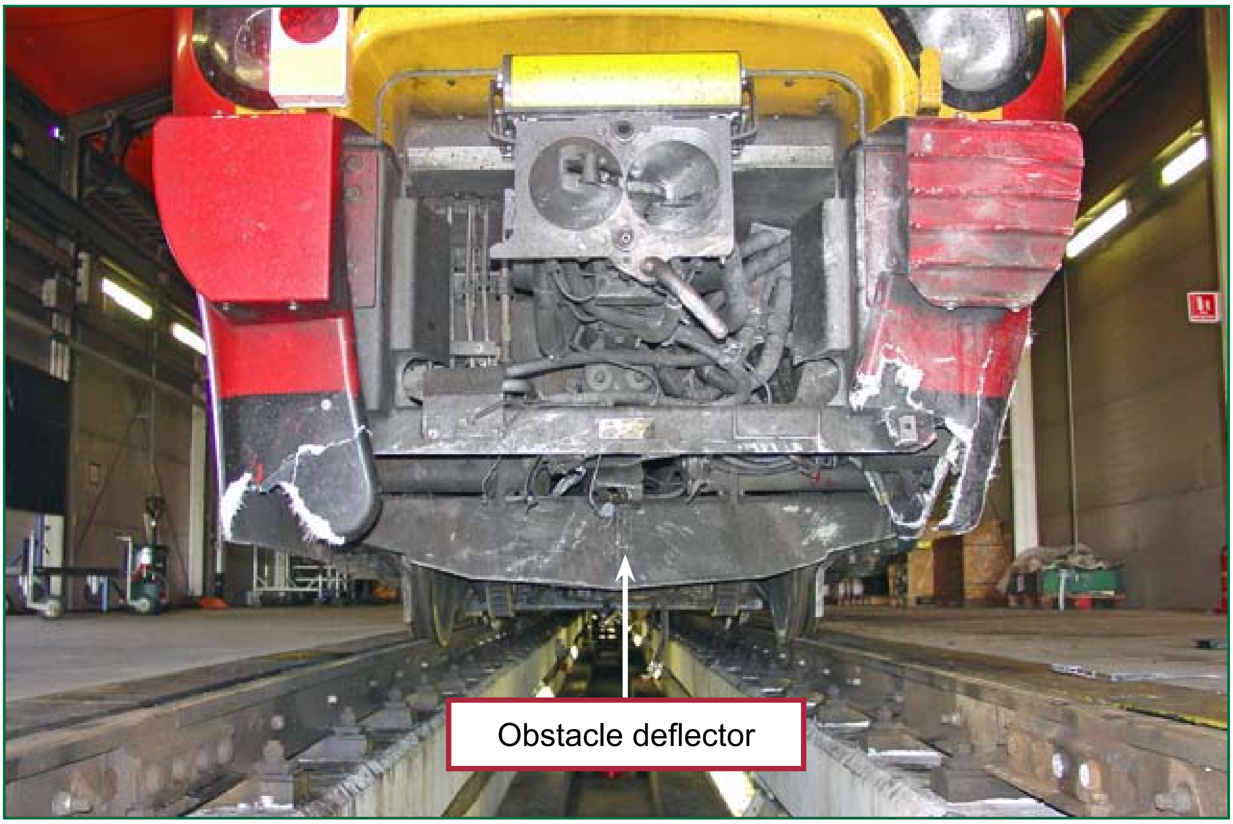

Figure 8: Obstacle deflector at the front of the train after the accident

85 The obstacle deflector performed structurally in accordance with its design purpose. The obstacle deflector withstood the loading imposed by the collision with the car and remained attached to the train. There were no signs of distress at any of the attachment points. The deflector had rotated backwards before returning to a permanent plastic deflection on its mounts of seven to seven-and-a-half degrees.

86 At its maximum rotation backwards the lift force component of any normal force on the obstacle deflector would be significant, as would the equivalent downward force on the object hit. The driver's evidence of the cab 'lifting up' (paragraph 79) and the fact that the front wheel did not derail both support the argument that these forces were present.

87 Due to the design need to keep the obstacle deflector clear of the rails at all times, and the depth of the rails on the sleepers, there is a gap of approximately 400 mm between a sleeper top surface and the bottom of the obstacle deflector. This is large enough for the engine block and transmission of a standard car to be pressed under the obstacle deflector, especially if the obstacle deflector rotates backwards and hence lifts the train slightly upwards.

Comparison with collision at Ufton Nervet

88 On 6 November 2004, a car was stopped by its driver on the level crossing at Ufton Nervet causing the car to obstruct the railway lines between Reading and Westbury. As a Paddington to Plymouth passenger train approached, the warning lights flashed and alarms sounded, and the level crossing barriers lowered automatically, but the car remained in its position. The train then struck the car at high speed. One pair of wheels derailed and the train ran on in line until it came to a pair of points; this led to the catastrophic derailment of the train. As a consequence of the collision, 7 persons were killed, including the car driver, and 71 were injured, 18 of whose injuries were serious. This accident is not included in Table 1 as it was at a level crossing, but the speed and results are compared with those at Copmanthorpe.

89 Both the train involved at Copmanthorpe on 25 September 2006, and that involved at Ufton Nervet on 6 November 2004 collided with a private passenger car at a speed close to 100 mph (161 km/h). However, the outcome for those on the train at Ufton Nervet was catastrophic compared to that at Copmanthorpe. Reasons that may have contributed to the very different outcomes include, in the order that they happened:

- The leading wheels of the train at Ufton Nervet derailed, leading to the train being in a less stable state than the Copmanthorpe train. This may be due to:
  a. the lack of an obstacle detector on the Ufton Nervet train;
  b. the provision of an electric traction motor and gearbox on the leading axle of the Ufton Nervet train, which was not present on the Copmanthorpe train, making it more likely that debris would be caught under that axle; and
  c. the collision at Ufton Nervet took place on a level crossing, with a deck surface level with the rail head, whereas at Copmanthorpe there was no such surface. This also increased the probability of debris getting trapped.
- The Ufton Nervet train encountered a pair of facing switches 95 m after it collided with the car and initially derailed, causing it to veer at a considerable angle from the tracks on which it was running. There were no such points at Copmanthorpe, and this difference was the main cause of the catastrophic outcome at Ufton Nervet.
- At Ufton Nervet bogies became detached from the vehicle bodies after the train left the rails, subsequently impacting with the bodies and causing considerable damage. No such events occurred at Copmanthorpe.

Performance of the train's tilt system

90 The debris from the car hit several elements of the train's tilt system. In particular it knocked two hydraulic connectors off the *tilt actuators* located on the trailing bogie of the leading vehicle, and 60 % of the *locking actuators*' hydraulic connections (see Figure 9) The removal of the connectors from the tilt actuators caused a loss of system pressure which was detected by the *tilt control system's* pressure monitors. In accordance with its programming, the tilt control system then commanded the locking actuators to centre the tilt system, and to lock it in that position. However, due to the damage to the locking actuators' hydraulic connectors, the locking system failed completely on two vehicles (the leading and the third vehicle from the front) and partially on the other three. This left the leading and third vehicles free to tilt in a passive mode as dictated by the kinematics of the unlocked tilt pendulum system interacting with the vehicle body's centre of gravity.

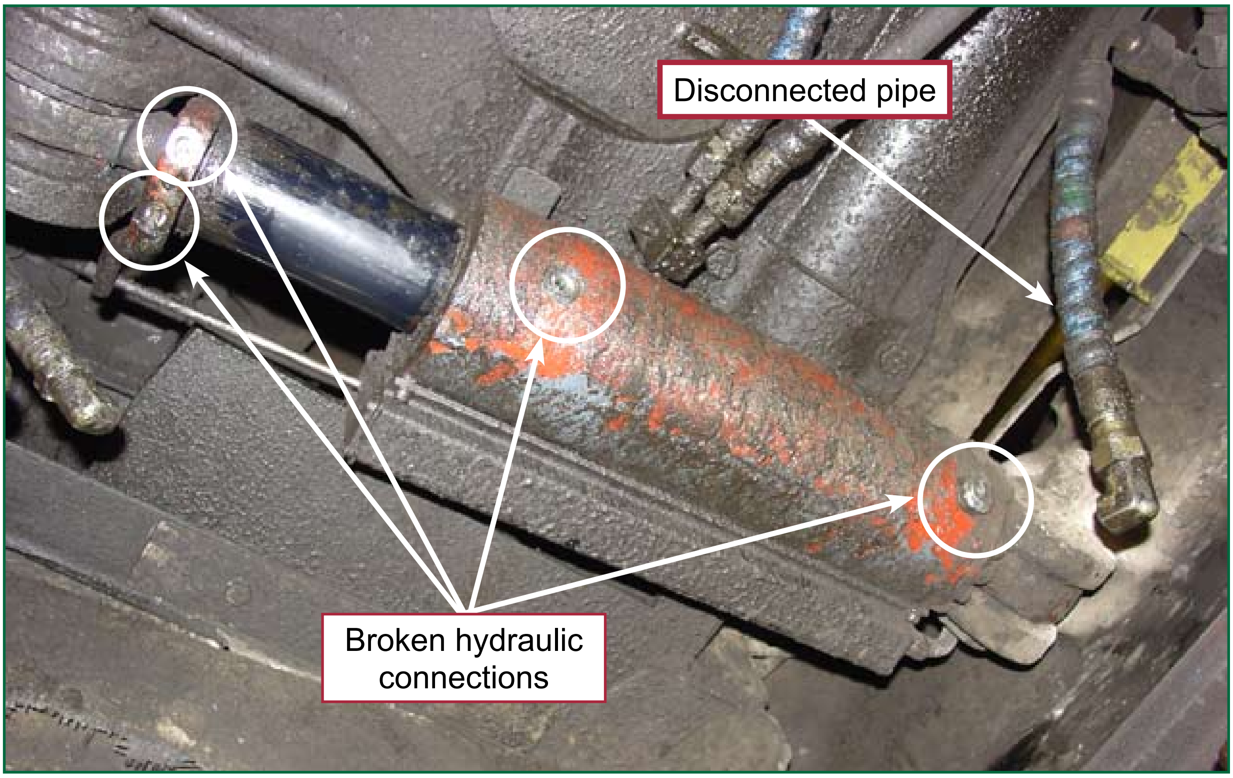

Figure 9: Tilt actuator showing all four hydraulic connections knocked off

91 The tilt control system is designed to monitor the operation and condition of the tilt system's constituent parts. When the tilt control system detects problems it instructs the tilt system to deactivate, and the tilt and locking actuators to power to the centre position and lock the tilt system. The probability of a wrong-way tilt being commanded or experienced for trains operating in normal conditions is thus very low. If a train loses hydraulic connectors, whether to the tilt actuators, the locking actuators, or both, as happened at Copmanthorpe, the train will not tilt beyond the permitted *kinematic envelope*, even at maximum permitted cant deficiencies. This is because the design of the mechanical components of the tilt system, when it is acting un-powered and free, is stable and moves the vehicle body to a position at or very close (+/- 1.5°) to the vertical relative to the bogie.

92 Concurrent loss of tilt actuation and total loss of locking, as occurred on two vehicles at Copmanthorpe, is still a safe condition that does not put the vehicle at risk of passively tilting '*out of gauge*'.

93 More locking connectors were knocked off than tilt connectors as the former are close to the longitudinal centre-line of the bogie, where the stone guard's design contains significant openings to facilitate access to the tilt pipe work, which expose the locking connectors (Figure 10). The tilt actuator connectors are off-set to either side and are better protected by the stone guard.

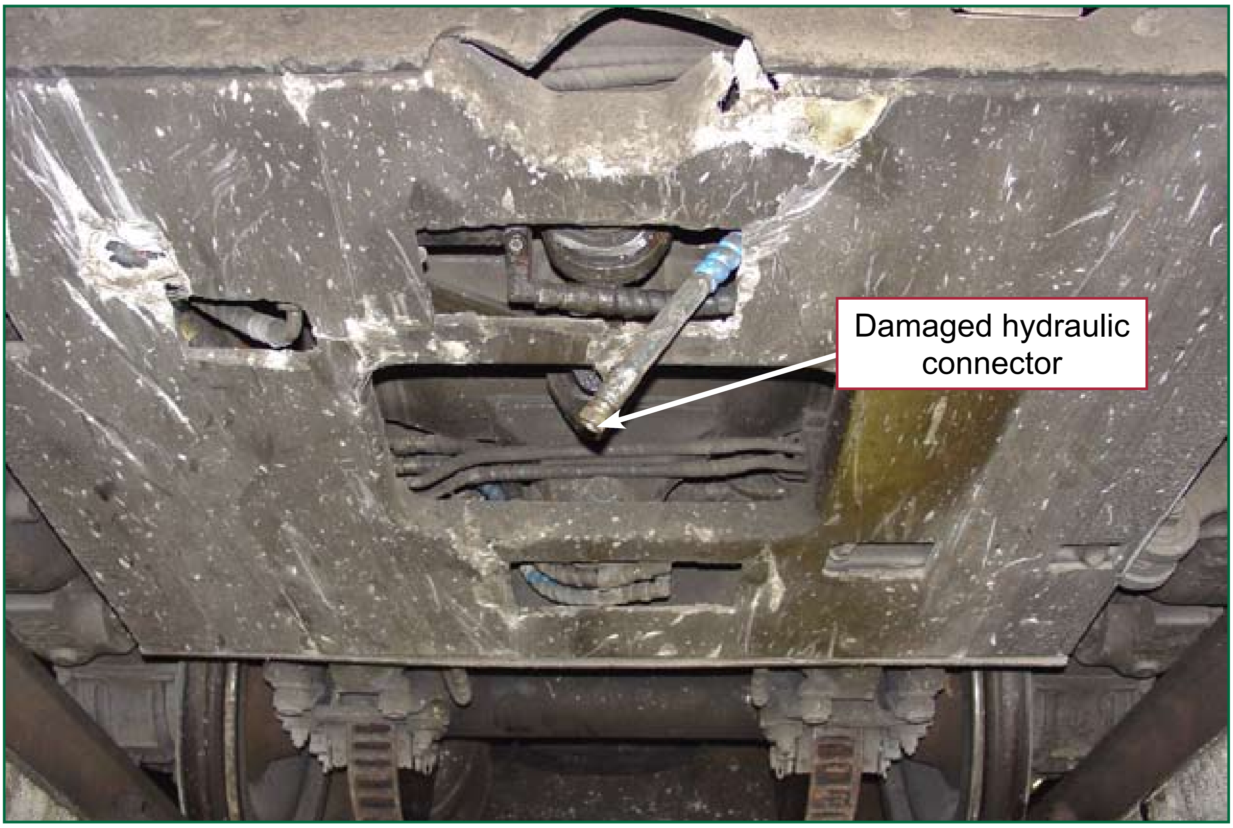

Figure 10: Stone guard showing openings and damaged hydraulic connector

Performance of the train's fuel system

94 Debris from the car smashed the plastic protective cover on four of the five diesel tanks' *'dead-space' drain valves*, and damaged the valves and their protective brass covers to such an extent that a large quantity of diesel fuel, possibly up to 1,500 litres from each of the four vehicles affected, leaked out into the ballast (see Figures 11 and 12).

95 The plastic cover, which was designed to protect against small objects such as pieces of track ballast, was not strong enough to withstand the impact with the collision debris at 100 mph (161 km/h) and therefore did not protect the valves or their protective brass covers.

Performance of the train's interior

96 There was no deformation or detachment of any part of the train interior, which performed well in the collision.

Response of others

97 The train crew and the emergency services satisfactorily managed the evacuation of the passengers from the train. They received considerable help and assistance from off-duty railway staff from Transpennine and Cotswold Advenza who were travelling on the train.

Figure 11: Plastic cover over fuel tank 'dead-space' drain value

Figure 12: Fuel leaking from a damaged fuel tank 'dead-space' drain valve

Conclusions

Immediate cause

98 It has not been possible to establish why the car carried on past the end of the road at Moor Lane towards the railway. However, the car entering on to the railway through the boundary fence was the immediate cause of the collision between the car and the train, which in turn was the immediate cause of the death of the car driver.

Causal factors

99 No additional causal factors can be determined.

Contributory factors

100 It is not possible to state with certainty if the City of York Council and Network Rail's omission of a risk assessment into vehicle incursion onto the railway at Moor Lane was contributory to the accident. On balance, the RAIB judges it to possibly have contributed to the accident (paragraph 73, Recommendation 2).

Underlying causes

101 No relevant underlying causes have been identified.

Other factors affecting the consequences

102 The provision of an obstacle deflector meant that the leading wheelset did not derail, assisting the train to remain upright and in line (paragraph 84).

103 The train did not encounter any points between the impact with the car and coming to a stand (paragraph 88).

104 The lack of robust protective covers to the fuel tank 'dead-space' drain valves resulted in damage to the valves from the impact of car debris under the train. This led to four of the five fuel tanks leaking fuel into the ballast (paragraph 95, Recommendation 3).

105 The designed openings in the bogie stone guards meant that the car debris caused considerable damage to the tilt actuators' hydraulic connections (paragraph 93, Recommendation 3).

Actions reported as already taken or in progress relevant to this report

106 Network Rail and the City of York Council have assessed the north-west approach to the former Moor Lane level crossing in line with the DfT guidance note referred to in paragraphs 58 and 59, taking into consideration this accident. As a result they have installed an earth bund at the end of Moor Lane.

107 Bombardier, the manufacturer and maintainer of the Class 221 trains, commenced upgrading the stone guards of these trains in early 2006, prior to the accident. The new stone guards are of a more robust, single piece, construction, and have wire grids over the openings to prevent ballast incursion whilst not preventing inspection. The new guards are installed as and when existing guards need replacement as a result of damage, and there is no scheduled programme for completion.

Recommendations

108 The following safety recommendations are made[2]:

Recommendations to address causal and contributory factors

1 There are no recommendations relating to the cause of the accident.

Recommendations to address other matters observed during the investigation

2 Network Rail should ensure that all cul-de-sacs currently leading directly to their railway are or have been assessed in line with the DfT guidance referred to in paragraph 58, and that their procedures enforce such assessment for any future changes to the highway infrastructure immediately adjacent to their boundary (paragraph 100).

3 Bombardier, in conjunction with HSBC, Voyager Leasing and Angel Trains, should review the protection provided to vulnerable components in the underfloor equipment areas of Class 220, 221 and 222 trains, and assess whether further improved protection against being struck by objects likely to pass under the train can be provided to reduce the risk of damage to safety or environmental related systems in accidents (paragraphs 104, 105, 107).

[2] Responsibilities in respect of these recommendations are set out in the Railways (Accident Investigation and Reporting) Regulations 2005 and the accompanying guidance notes, which can be found on RAIB's web site at www.raib.gov.uk

Appendices

Glossary of abbreviations and acronyms — Appendix A

DfT	Department for Transport
HSE	Health and Safety Executive
OTMR	On Train Monitoring Recorder
RSSB	Rail Safety and Standards Board
HST	*High Speed Train*

Glossary of terms

Appendix B

All definitions marked with an asterisk, thus (*), have been taken from Ellis' British Railway Engineering Encyclopaedia © Iain Ellis. www.iainellis.com

Brake rigging	Mechanical arrangement of links and levers connecting the brake actuators to the brake pads.
Cess	The part of the Track Bed outside the Ballast Shoulder that is deliberately maintained lower than the Sleeper Bottom (SB) to aid drainage.*
'Dead-space' drain valves	Valves at the bottom of the train's fuel tanks used to allow the accumulation of water at the bottom of the fuel tank to be drained during maintenance and to drain fuel to filter and clean it.
Diesel electric multiple unit	A multiple unit train whose source of power is a diesel engine and whose transmission is electrical, typically a generator and motor pair.*
Down	The direction of trains from London and Leeds to York.
Four foot	The area between the two running rails of a standard gauge railway.*
Fatalities / weighted injuries	An index used by the RSSB to measure relative risk from fatalities, major and minor injuries.
High Speed Train	While this term can be applied to any particularly fast passenger train, in the UK it has become synonymous with the Class 43 diesel locomotive and attendant mark 3 Coaches, the InterCity 125 (IC-125).*
Kinematic envelope	The maximum sectional outline that a vehicle occupies under various conditions of speed, tilt, wheel wear, cant deficiency, track tolerances, loading, load distribution, suspension failure, wind and aerodynamic factors.*
Locking actuator	A component within the tilt actuators that physically locks, upon activation, the tilt system out of use with the vehicle bodyshell in the centre upright position relative to the bogies.
On Train Monitoring Recorder	An 'on-board' data logging system that records the state of various train controls and systems. It also records train speed.
Out of gauge	Any load on a rail vehicle, or a rail vehicle that is itself larger than the Loading Gauge.* In the context of a tilting train this would refer to a train tilting outside the loading gauge. In all cases there would be a risk of striking other trains or structures.

Professional driving policies	A policy prepared by TOCs that describes, inter alia, train driving practices that the company expects its drivers to adopt in order to ensure safe and efficient train operations. Such practices include: ● braking at an early stage to avoid passing signals at danger; ● stopping 20 m short of signals at danger; ● always assuming that the next signal after a caution aspect will be at danger; ● reduce speed to 20 mph (32 km/h) by 200 m before a signal at danger; and ● reduce speed to 10 mph (16 km/h) by the platform ramp when approaching a terminal station platform with buffer stops.
Protection duties	The duties carried out by the driver and guard in accordance with the rule book (Module M, Train stopped by train accident, fire, or accidental division) to protect trains from other traffic in the event of an accident.
Railway Group Standards	A document mandating the technical or operating standards required of a particular system, process or procedure to ensure that it interfaces correctly with other systems, process and procedures. Network Rail (NR) produces Network Rail Company Standards (NRCS) that detail how the requirements of the Railway Group Standards are to be achieved on its system.*
Six foot	The colloquial term for the space between two adjacent tracks, irrespective of the distance involved.*
Stone guard	A five piece fibre glass plate, retrofitted with plastic plates on leading edge, installed under the bogies to enhance ballast protection of the tilt system.
Signalling control centre	A term used to describe more modern signal boxes housing electronic signalling control systems (SCS).*
Tilt actuators	Hydraulic or electric rams mounted between a bogie and a bodyshell that, through extension or contraction, cause a difference of roll angle between the bogie frame or a bogie-mounted bolster beam and the vehicle bodyshell. The actuators are controlled by the tilt control system. The locus or arc of the relative movement of the bodyshell on the bogies is constrained and defined by pendulum links between the bogies and the bodyshell.
Tilt control system	The tilt control system comprises sensors and computers with associated programs that, depending on the input from the sensors and the processing by the programs, control servo valves or amplifiers that in turn drive the tilt actuators hydraulically or electrically to provide the bodyshell tilt function. The control system also has an interface to the driver and the track-side and onboard authorisation system that enables the tilt to operate in active mode or locks it out of use as inactive. The control also contains feedback monitoring and a fault monitoring and handling section.

Tilt system	All the components required to form the function of a train tilting its bodyshell relative to the track plane in curves. The system is provided to enable trains that are designed to negotiate track curves safely at enhanced speed compared to ordinary trains to be able to do so without causing discomfort to the passengers that a lack of installed track cant for the enhanced speed otherwise might do. Installed cant (the degree to which the track is tilted or canted over towards the curve centre) is normally set for the comfort of ordinary trains and can not be changed for the passage of a train at enhanced speed. Passenger comfort of such trains is provided instead by tilting the bodyshell towards the curve centre to compensate for the increased centripetal acceleration the train must have to follow the track with its pre-set installed cant value at enhanced speed. The components comprise: the tilt actuators and pendulum links; the power source to provide the energy for the tilt action; the tilt control system including all sensors, computers, programs, interfaces and monitoring; and the transmission of the controlled power to the actuators.
Track Fasteners	Any device used to secure Rails into Chairs, onto Baseplates or directly to Sleepers or Bearers.*
Up	The direction of trains from York to London and Leeds.

Key standards current at the time

Appendix C

Network Rail Standard NR/GN/RSK/0012, dated June 2003	Road Vehicle Incursions: Risk Assessment of Bridge and Neighbouring Sites

This report is published by the Rail Accident Investigation Branch,
Department for Transport.

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