



HM Railway Inspectorate

RAILWAY ACCIDENT AT WATFORD

A report of the investigation into
the collision that occurred on
8 August 1996 at Watford South
Junction on the line from
Euston to Crewe in the
Railtrack Midlands Zone



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List of abbreviations

ATP	Automatic Train Protection
AWS	Automatic Warning System
BRB	British Railways Board
BST	British Summer Time
BTP	British Transport Police
CPS	Crown Prosecution Service
DPP	Driver Performance Profile
DRA	Driver Reminder Appliance
DSD	Driver's Safety Device
ECS	Empty Coaching Stock
EIMC	Eastern Infrastructure Maintenance Unit
EMU	Electric Multiple Unit
GTRM	GEC-Tarmac Rail Maintenance
HMRI	Her Majesty's Railway Inspectorate
HRP	Hazard Ranking Process
HSC	Health and Safety Commission
HSE	Health and Safety Executive
HSL	Health and Safety Laboratory
LMR	London Midland Region (of British Railways)
NLR	North London Railways
NX	Entrance - Exit System
OLE	Overhead Line Electrification
PSB	Power Signal Box
PSR	Permanent Speed Restriction
SPAD	Signal Passed at Danger
SPADMIS	Signal Passed at Danger Management Information System
SPADRAM	Signal Passed at Danger Reduction and Mitigation
SSC	Signal Sighting Committee
SSI	Solid State Interlocking
SSP	Standard Signalling Principles
TCB	Track Circuit Block
TD	Train Description
TFM	Trackside Function Module
TMD	Train Maintenance Depot
TOC	Train Operating Company
TOWS	Train Operated Warning System
TPWS	Train Protection and Warning System
TSR	Temporary Speed Restriction
WCML	West Coast Main Line

EXECUTIVE OVERVIEW BY HM CHIEF INSPECTOR OF RAILWAYS

This document is a report of the investigation carried out by the Health and Safety Executive (HSE) into the collision between a passenger train and an empty coaching stock (ECS) train that occurred at Watford on Thursday 8 August 1996.

In view of the nature of the accident and the degree of public concern, the Health and Safety Commission (HSC) instructed the HSE to carry out a formal investigation under Section 14(2)(a) of the Health and Safety at Work etc Act 1974 and make a special report.

The publication of this report has been delayed for legal reasons because on 10 January 1997, the driver of the passenger train was charged with manslaughter by the Crown Prosecution Service (CPS). On 11 March 1998 the driver was found not guilty of the charge. It was not possible to publish this report while proceedings against the driver were outstanding.

The circumstances of the accident were that at 1724 on Thursday 8 August 1996, a collision occurred between two trains approximately 700 m (765 yds) south of Watford Junction station on the West Coast Main Line (WCML). A northbound passenger train that had left London Euston station at 1704 and was travelling along the Down Slow line was struck by a southbound ECS train that was progressing across the connections linking the Up Slow to the Up Fast lines. The ECS train was traversing the crossover linking the Down Slow with the Up Fast when the collision occurred.

A team from HSE's HM Railway Inspectorate (HMRI) investigated the accident and was satisfied from the evidence obtained from the signalling records and from the data collected by the train borne recorder on the northbound passenger train travelling towards Watford, that the driver failed to react correctly to two signals displaying caution aspects when approaching the red signal that protected the junction at Watford South. When that signal came into his view, his train was travelling at about 110 km/h (68 mile/h) and he made a full brake application. The distance between the point of the brake application and the red signal was insufficient to permit the train to stop at the signal and it eventually came to a stand 203 m (222 yds) beyond the signal, foul of the route set for the ECS train.

One person was killed in the accident and 69 were injured of whom 15 were detained in hospital.

No defect was found with the braking system of the rolling stock or with the permanent way and there was no evidence of vandalism. However, a number of contributory and mitigating factors were revealed by the HMRI investigation and these are explored in the discussion section of this report.

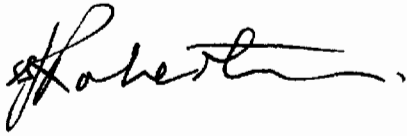
Two main factors emerge. Firstly, there is no doubt that had Automatic Train Protection (ATP) been fitted to both track and trains, the collision would have been avoided. Secondly, the inappropriate application of a signalling standard in respect to the positioning of a permanent speed restriction combined with the absence of a normal overlap (safety margin) at the signal that was overrun was a major element in the subsequent series of events. Had the speed restriction been appropriately placed or a normal overlap been provided, it is unlikely that a collision would have occurred even though the passenger train would have overrun the signal at danger.

The recommendations set out in this report are made in the belief that they reflect the lessons learned and represent reasonably practicable steps towards the control of risks arising from the operation of the railway network. As with all such reports, HSE will consider all representations by Railtrack PLC and others who have a role to play in satisfying the recommendations. HSE will be prepared to review or modify recommendations, or consider alternatives, where it is considered that risks of harm will be properly controlled and that statutory obligations will be met.

The issue of this report does not preclude HSE from taking formal enforcement action in relation to any of the issues raised if it becomes appropriate to do so and I expect a formal response from those to whom recommendations are addressed within two months.

Finally, I commend the hard work of colleagues in HMRI who have conducted a most thorough investigation. I am also grateful for the help given by officers of the British

Transport Police (BTP) and Hertfordshire Constabulary and for the use of some of their Photographs in this report. The help and willing co-operation of the railway industry in carrying out this investigation is also acknowledged.

A handwritten signature in black ink, appearing to read 'SSJ Robertson', with a stylized flourish at the end.

SSJ Robertson- HM Chief Inspector of Railways

INTRODUCTION

The accident site

1. The accident occurred approximately 700 m (765 yds) on the London side of Watford Junction station where connections are provided so that trains can transfer from the fast lines to the slow lines and vice versa. Watford Junction station is on the WCML that connects London Euston with Birmingham, Manchester, Liverpool and Glasgow. The station is 28 km (17m) from the London Euston terminus and is the junction for a branch line to St Albans and for passengers transferring from the main line to the Watford to Euston direct current (dc) electric suburban line.

2. In the area of the accident the railway has four tracks comprising the WCML and, on a separate formation, two additional tracks of the Euston to Watford dc line. The tracks are designated, reading from left to right for a driver travelling towards London, Up Slow, Down Slow, Up Fast, Down Fast and then some distance away, Up dc line and Down dc line. (*See Photo No 1*)

3. The maximum permitted line speed is 177 km/h (110 mile/h) on the fast lines and 145 km/h (90 mile/h) on the slow lines with a permanent speed restriction (PSR) of 120 km/h (75 mile/h) applying through the platforms of Watford Junction station on the slow lines. There are also PSRs of 80 km/h (50 mile/h) applying to movements from one running line to another through the Watford South Junction area.

4. The fast and slow lines are electrified by the 25000 volts (25kV) overhead line electrification (OLE) alternating current (ac) system and the suburban lines are electrified by the 750 V dc conductor or third rail system. The control rooms for both electrical systems are located at Willesden. The area is signalled using four aspect colour light signals with full track circuiting which operates in accordance with the track circuit block (TCB) regulations. The control point for the signalling is at Watford Power Signal Box (PSB) located approximately 500m (545 yds) north of the site of the accident.

The trains

5. Both trains involved in the collision were class 321 electric multiple units (EMUs), each unit comprises four coaches consisting of :

- DTCO Driving Trailer Composite Open (with first and standard class seating)
- MSO Motor Standard Open
- TSO Toilet Standard Open
- DTSO Driving Trailer Standard Open

The total seating capacity of a four coach EMU is 303, the overall tare weight (excluding passenger loading) is 142.3 tonnes and the overall length is 81 metres. The maximum permitted speed is 160 km/h (100mile/h).

6. The trains were built by British Rail Engineering Ltd at Derby between 1988 and 1990 and are of modern design having a monocoque construction designed to withstand high impact loadings. Electric traction is taken from the 25kV OLE system and the units are fitted with thyristor control, tightlock couplers, sliding powered doors, lightweight modern design bogies having hydraulic and pneumatic load sensitive damping, disc brakes, a public address system and cab secure radio.

7. The 1704 Euston to Milton Keynes passenger service (reporting number 2A17) consisted of one class 321 unit. The 1650 Bletchley to Euston ECS train (reporting number 5A35) consisted of two class 321 units, coupled together.

8. The passenger train carried its normal complement of driver and a trainman/guard who was travelling in the rear driving cab. It is estimated that there were about 190 to 200 passengers on the train after it departed from Harrow and Wealdstone station where a large number of those who had boarded at Euston disembarked and a much smaller number boarded the train. The driver and trainman/guard of the ECS train were the only persons on that train and they were both travelling in the driving cab.

The signalling system

9. A four aspect signalling system was installed in the Watford Junction area when the WCML was electrified and modernised in 1965. In a four aspect signalling system the driver is presented with signal aspects conveying the following information :

red	Danger (stop);
single yellow	caution, be prepared to stop at the next signal;
double yellow	preliminary caution, the next signal is at single yellow, adjust the train speed to a level that enables the train to be brought to a stand at the red signal;
green	clear, proceed at permitted line speed.

Red, single yellow and double yellow are collectively referred to as restrictive or cautionary aspects.

10. On the approach to junctions the main signal aspects may be supplemented by position light junction indicators consisting of a line of five white lamps that provide a route indication to the driver. In station areas route information may be provided by route indicators having a matrix of lamps forming a character to indicate to the driver the route he will be taking or the platform he will be entering.

11. The optical system of main signal aspects is designed to gather the light output of the tungsten filament lamp to give a focused light beam capable of providing long distance viewing that penetrates poor visibility and also gives a good display to the driver on the brightest of days. Where the line approaching a signal is curved, the signal is focused to a point on the line where it is most effective; normally on the approach side of the signal where the Automatic Warning System (AWS) magnets are located.

12. In the TCB system of working, trains are detected throughout all of the running lines by the use of track circuits. Signals are spaced to provide adequate stopping distance for traffic travelling at maximum permitted line speed between the signal showing the first cautionary aspect (double yellow) and the red signal. The line between any two signals capable of showing a red aspect is called a signal section and the clearing of the signal to a

proceed aspect at the entrance to the section establishes a route from that signal up to the next signal. In establishing the route, either automatically following the passing of a train or manually by the signaller, the signal section must be proved to be unoccupied by any other trains, no conflicting routes should be set and any points within the line of the route must be set, and locked, in the correct position.

13. The fundamental requirements for which any British Railways signalling system should be designed to achieve the safe and effective operation of trains have evolved over a very long period and have been encompassed in a set of standards known as Standard Signalling Principles (SSP).

14. In order to provide a safety margin against overrunning a signal, e.g. when poor rail adhesion may decrease the effectiveness of the brakes as the result of rain, frost, leaf fall, etc. and to allow for minor errors of judgement by drivers, the route is extended beyond the signal and into the next signal section. This extension is termed the overlap. The normal minimum overlap length for signals on passenger lines is defined in SSP 20 as 183m (200 yds). SSP 20 permits the use of shorter overlaps where line speeds are low and defines a relationship between line speed and permitted minimum overlap distance. *(See appendix 3)*

15. The AWS equipment at signals consists of a pair of track mounted magnets normally located about 183 m (200 yds) before the signal to which they apply. The AWS provides an indication to a driver that the signal he is approaching is either clear or showing a cautionary aspect. If the signal is at a cautionary aspect, a horn sounds in the cab. The driver can silence the horn by pressing a reset button. The driver's AWS indicator in the cab will then show an alternate yellow and black ('sunflower') display as a reminder that he has passed a signal displaying a cautionary aspect. If the driver fails to press the reset button within 5 to 7 seconds, the train brakes are automatically applied. If the signal is clear, a bell rings in the cab and the AWS indicator shows an all black display. Where a PSR is applied to a section of the railway line and a reduction in speed of about 30% or more is necessary, a lineside warning board is provided in advance of the PSR and the AWS system is used to warn the driver that he is approaching such a restriction. The indication to the driver is identical to that for a cautionary signal aspect.

16. Route control at Watford PSB uses the entrance - exit system known as NX in which the signaller sets a route by pushing down a button associated with the signal at the entrance to the section followed by pushing down another button associated with the exit signal. A signal can be restored to a red aspect when its associated button is pulled upwards. There is a facility in Watford Junction PSB enabling the signaller to restore all signals in the controlled area to red with one operation.

17. When a signal is restored to red by the signaller, the interlocking system checks to determine if there is a train within the sighting distance of any other signal that may change to a cautionary aspect at the same time as the signal that is being restored to red. In a four aspect signalling system, the interlocking detects any train included in the track circuits from the signal that has reverted to red up to the sighting point of the signal that changes from green to double yellow and will hold the route set ahead of the signal replaced to red, thus preventing any conflicting movements being set. If no train is detected, the interlocking allows the route ahead of the signal replaced to red to normalise, thus allowing the signaller to set alternative routes. This feature is known as approach locking.

18. In the process of setting a route using NX operation, the points are automatically set to the appropriate position for that route. Alternatively, the signaller may change the direction (lay) of points using the individual point keys located on the same panel as the buttons controlling the signalling. The centre position in which the point key normally rests is the position that enables the points to be automatically set by the route setting procedure.

19. There are two diagrammatic panels at Watford PSB. One incorporates the signal control buttons for route setting, the point keys, telephone controls and the train describer interface. The second is an indication panel, showing where trains are, where signals are located and whether the signals are showing a stop or proceed aspect. An indicator in the symbol for the signal on the panels shows red for a stop aspect and green for any proceed aspect, e.g. double yellow, single yellow or green. Routes that have been set, either automatically or by the signaller, are shown by a series of white lights along the diagrammatic representation of the railway on the panels. The white lights change to red for the line of route as the train progresses through it and occupies the associated track circuits.

As the train progressively leaves the track circuits, the red and white lights are extinguished. Thus when a route has been set and a train has progressed part way through it, that part of the route the train has not yet reached shows white lights, that part the train is occupying shows red lights and that part of the route the train has cleared has no indication on the panel. Should a track circuit register as being occupied without a route being set, all the red lights in the track circuit section of the indication panel associated with that track circuit show red, not only those in the line of route.

20. At Watford PSB, trains in the area and those approaching from adjacent signal boxes can be identified by a four character identification code or train description (TD) that is displayed in boxes on the panels. When the train passes a signal showing a proceed aspect the TD indication steps into the berth associated with the signal the train is approaching. Should a train pass a signal that is at danger, the TD will not step forward with the train and a special code to signify that a train without a TD is approaching the next signal is automatically inserted into the TD berth for that signal.

21. The train describer system provides data to a train reporting network that disseminates information on train movements to control offices and other points requiring train operating information. This system also generates a record of train movements as the train passes selected reporting points.

22. The commands of the signaller, in the form of key/push button operations are processed through the signalling interlocking where its legitimacy is verified before being relayed to the signals and points located at the lineside. The interlocking at the Watford Junction area was renewed when the junctions to the north and south of the station were replaced by high speed connections between the fast and slow lines. The current system, a British Railways Solid State Interlocking (SSI), was commissioned in 1993. Signalling controlled by the SSI system has been exhaustively tested, the software design logic has been validated and is accepted for use throughout the railway system.

23. Associated with the SSI is a technician's terminal fault log that records interlocking faults and malfunctions. A data logger also records details of every change in the coded

messages that exchange the data between the interlocking and the trackside functional modules (TFM). TFMs are housed in trackside cabinets and are fail safe devices with self-checking circuitry that translates the data messages from the interlocking to light the appropriate signal aspect or drive the points to the correct direction. The data logger provides a record of every occasion a signalling control is changed and records the indications of track circuit occupancy along with point and signal aspect information.

THE ACCIDENT

Description of Events (*see Appendix 6, diagram 1 for signalling plan*)

24. At 1704 on 8 August 1996, North London Railways (NLR) service 2A17 departed from Euston with a well-loaded train and a traincrew comprising the driver and the trainman/guard. This train was due to call at Harrow and Wealdstone at 1716, Watford Junction at 1724 and then call at all stations to Milton Keynes to arrive at 1811. When the train arrived at Harrow and Wealdstone a considerable number of passengers disembarked and a lesser number joined the train. As far as can be estimated from the number of people who registered with the emergency services following the collision and who responded to a BTP appeal for witnesses, the passenger loading of the train at the time of the collision was estimated to be between 190 to 200 people. The train left Harrow and Wealdstone at 1718, travelled along the Down Slow line, passing Carpenders Park station (14m 57ch) and Signal WJ167 (14m 58ch) by which time the train was travelling at about 129 km/h (80mile/h). (*N.B. Distances continue to be reckoned by Railtrack from a terminus or a junction in miles and chains, there being 80 chains in a mile.*)

25. ECS train 5A35 had left Bletchley at 1650 and travelled along the Up Slow line to Watford Junction. This train was to form train 2A35, the 1810 Euston to Milton Keynes service. The ECS train was routed along the Up Slow line and was travelling under signals at caution, following a slower freight train with the result that it was running two minutes late when it approached Watford.

26. To avoid further delay to train 5A35 the signalling staff at Watford PSB decided to change the route of the ECS train from the Up Slow line to the Up Fast line at Watford South Junction. To do this, the signaller placed the signals protecting the junction, Signal WJ748 on the Up Fast line and Signal WJ759 on the Down Slow line, to red. The signaller took this action at 1720. The routes from WJ748 and WJ759 signals were cancelled immediately the signaller pulled the control buttons. Restoring Signal WJ759 to a red aspect resulted in the preceding signal (WJ755) reverting to a single yellow aspect and the one before that, (Signal WJ751) to a double yellow aspect. Signal WJ167, the one before Signal WJ751, remained at green. At this time, train 2A17 was more than one mile away from Signal WJ167 and in excess of 3 miles from signal WJ759.

27. At 1721 the freight train that was preceding ECS train 5A35 passed Signal WJ750 on the Up Slow line and had progressed to a point clear of Watford South junction to allow for the setting of the route for train 5A35 from the Up Slow line to the Up Fast line. The signaller set Signal WJ750 and the signal initially displayed a single yellow aspect with a junction route indicator that shortly afterwards cleared to green. At this time train 5A35 had just passed Watford North Junction and was about to enter the station platform. Train 5A35 was travelling at slightly over 96 km/h (60mile/h) when entering Watford Junction station, after which the brakes were applied to bring the train speed down to 80 km/h (50 mile/h) for the speed restriction through the connections between the Up Slow line and the Up Fast line.

28. At 1722, passenger train 2A17 slowed down for the 96km/h (60 mile/h) PSR that exists through Bushey station. On leaving the speed restriction, the train accelerated for a short distance up to the point where Signal WJ759 (by now showing a red aspect) became visible to the driver and he applied the train brakes. The train passed the signal at about 76 km/h (45 mile/h) still braking hard and came to a stand with the front of the train 203 m (222 yds) beyond the signal and foul of the connection between the Down Slow line and the Up Fast line.

29. Meanwhile, ECS train 5A35 passed Signal WJ750 and entered the connection between the Up Slow line and the Down Slow line at 80 km/h (50 mile/h). The train traversed these points and then entered the connection between the Down Slow line and the Up Fast

line, the connection on which 2A17 was by now standing foul. Part way through the connection the stationary passenger train was struck by the ECS train that was still travelling at about 80km/h (50 mile/h). The two trains came into contact at a slightly oblique angle offset one from the other by just over half a train width resulting in crushing of the driving position of both the cabs (the left hand side of the front of both trains in the direction of movement).

30. The slightly angled impact caused the leading coaches of both trains to be thrown to their right and forced upwards. The momentum of the ECS train caused the passenger train to be thrown backwards some 25 m (27 yds) and the leading coach was thrown outwards as it rolled onto its side coming to rest partially overhanging the embankment on the east side of the WCML. Similarly, the leading coach of the ECS train was forced to its right and as its leading bogie embedded into the ballast, the coach turned partially onto its side, overhanging the embankment on the west side of the WCML. *(See photo No 1 for an aerial view of the collision scene)*. The second coach of the ECS overrode a detached bogie, causing it to ride up and demolish an OLE gantry and to tear out part of the side of the second coach of the passenger train.

Injuries to Passengers

31. The statistics as recorded by the emergency services were :

- 1 passenger fatally injured;
- 15 passengers taken to hospital and detained overnight or longer;
- 54 passengers taken to hospital and released the same evening;
- 56 passengers treated on site and allowed to go home.

The passenger who was killed was ejected through the rearmost right hand window of the first coach at the moment of impact and died as the result of her injuries. The number of passengers who walked away without any injury cannot be accurately stated, but in the week following the collision BTP mounted a campaign at Euston and Harrow & Wealdstone stations aimed at tracing all passengers who had travelled on the 1704 train from Euston on 8 August. 53 passengers who did not report to the emergency services on the evening of the collision subsequently came forward and provided personal details.

Injuries to train crew

32. The driver of the passenger train, when realising that collision was inevitable, threw himself to his right and came to rest in the right hand corner of his cab by the roof. He sustained a number of injuries and was taken to Watford General Hospital. He was detained in hospital for three days and then allowed to return home. It is almost certain that had he not taken immediate evasive action, he would have been more severely injured as the impact caused massive damage to the driver's side of his cab. (*See photo no 2*)

33. The trainman/guard of the passenger train was in the rear cab at the moment of impact. The force of the collision resulted in his being thrown to the floor of the cab and he struck his head heavily. He was also later taken to hospital and was released on the day after the accident.

34. The driver and trainman/guard of the ECS train were both in the leading cab. They had left open the connecting door from the cab to the passenger compartment and when they realised that collision was inevitable, they were able to vacate the driving cab quickly but were thrown about by the force of the collision. Again, had the driver remained in his seat, it is likely that he would have been seriously injured as the cab suffered similar impact damage to that of the passenger train. (*See photo no 3*) The driver was injured sufficiently to warrant a five day stay in Watford General Hospital. The trainman/guard was also taken to hospital but released on the day after the accident.

35. Drugs and alcohol screening were carried out on all four members of staff. The results were negative in every case.

Immediate consequences and actions of those involved

36. When the signaller saw on his signal box panel that the track circuit beyond signal WJ759 was occupied indicating that the signal had been passed at danger, he realised that there was likely to be a collision. He immediately took action to place all signals in the area to danger and while he was carrying out this operation he heard the noise of the trains

colliding. The window of the signal box was open and the collision occurred only 500 m (545 yds) to the south of the signal box. The signaller immediately sent the emergency alarm to Willesden signal box to prevent any trains from moving northwards and while he was doing this, the Signalling Supervisor alerted the emergency services and the Electrical Control Room at Willesden to order an emergency isolation of all the 25kV overhead line supply. As a precautionary measure, the dc control room was also requested to switch off power to the adjacent Watford to Euston 750V dc lines.

37. The trainman/guard of the passenger train, despite his injuries, telephoned the signaller from the nearest signal post telephone invoking the emergency procedures in accordance with the rule book. He then went back to his train and with the help of a doctor who was a passenger on the train and an off-duty railway employee he assisted and reassured injured passengers until the emergency services arrived. He was then taken to hospital.

HSE INVESTIGATION OF THE ACCIDENT

Background

38. Two HMRI inspectors arrived within an hour or so of the accident occurring and with the assistance of BT Police and the emergency services ensured the preservation of essential evidence. HMRI inspectors were at the accident scene continuously for the following 24 hours and then as required through the ensuing weekend receiving full co-operation from the emergency and railway organisations at all times.

As to the direct cause of the accident

39. In the initial stages of the HSE investigation, possible causes of the accident were identified as :

- a defect in the permanent way (the railway track);
- a failure of the signalling system to an unsafe mode (a wrongside failure);
- a design or installation fault in the signalling system;
- defective rolling stock;

vandalism or causes outside the railway environment;
human error.

40. It was readily apparent that there was no damage to the infrastructure to suggest that either of the trains had been derailed prior to the collision. The permanent way was therefore excluded from the investigations at an early point although, for completeness, an assessment of the condition of the track was carried out by the British Rail Research Derailment Investigation Team. The Derailment Investigation Team found no defect in the track that could be considered in any way to be a contributory factor to the accident. HMRI exercised an oversight of the work of the investigation team and agreed with their conclusions.

41. While the possibility of vandalism was not eliminated at the early stages of the investigation, debris that was removed from the track during the clearing up operation was all identified as train and track components. No objects were found that may have caused a derailment, therefore vandalism was eliminated as a cause of the accident.

42. The HSE Investigation, therefore, initially concentrated on :
the signalling system and the signalling data recorders;
the rolling stock, including the braking system and the train borne data recorders;
the possibility of human error.

Later, the investigation widened, studying underlying factors that may have contributed to the accident.

As to the condition of the rolling stock

Background

43. NLR operate 37 four coach class 321 EMUs between London Euston and Birmingham New Street with maintenance being performed at Bletchley Train Maintenance Depot (TMD). Following a study carried out by consultants in 1995, class 321 fleet maintenance schedules were changed to mileage based rather than time based intervals. All units undergo a structured maintenance schedule based on a 11,500 mile, (broadly monthly) periodicity ('B' exam), with intermediate essential tasks such as disc brake pad changing and

testing of the AWS equipment being carried out at 6000 mile, (broadly fortnightly) periodicity ('A' exam). In January 1996, Bletchley TMD received a certificate of conformity for maintenance and overhaul policy as required by Railway Group Standard GM/RT 2004. The TMD also holds an ISO 9001 Quality Assurance Certificate.

Maintenance of the 1704 Euston - Milton Keynes passenger train

44. A summary of the maintenance records for this four coach unit (321420) showed that a 'B' exam was due on the night of the collision. Maintenance carried out immediately before was an 'A' exam on 29 July 1996 at which a number of disc brake pads were changed. Previous 'A' exams had been completed at the correct mileage periodicity on 21 June, 28 May and 27 April 1996 with 'B' exams having been undertaken, also at the correct periodicity on 7 July, 9 June and 14 May 1996. There is nothing in the maintenance history to cause concern about the mechanical or electrical condition of this four coach unit.

Maintenance of the empty coaching stock train

45. The circumstances of the collision were such that it was considered that there was no requirement to investigate the condition of this train other than to confirm that maintenance had been carried out at the correct periodicity.

Maintenance of the on board train data recorders

46. The on board train data recorder is a sealed unit. Works maintenance at Bletchley TMD is limited to a six-monthly check and calibration to ensure that the time database is re-adjusted to Greenwich Mean Time and that a correction factor is entered to accommodate changes in the wheelset diameter on which the pulse generator is mounted, as a significant variation will result in errors in mileage and speed recording data.

47. The maintenance record of four coach unit 321420 (the passenger train) showed that the calibration referred to above was not carried out during the most recent works six-monthly inspection that took place at Bletchley TMD on 9 June 1996.

Braking systems and controls

48. The brakes of 321 units are controlled by the 'Westcode' electro-pneumatic system whereby movement of the drivers brake handle causes an electrical signal to be sent through train wires to brake control units mounted under the coach bodies where the signal is translated into pneumatic pressure. The system is 'fail-safe'; should the train wires be de-energised, the brakes are automatically applied at full braking pressure. Braking effort is applied to every wheel in the train by disc brake units that apply friction pads to steel discs attached to the wheels.

49. The braking system is also coupled to the bogie air suspension system so that an increase of air suspension pressure resulting from a greater passenger loading results in a corresponding increase in braking effort. The system also takes into account the unladen weight of each carriage (the motor coach being considerably heavier than the other coaches) thus ensuring that braking is applied evenly along the train.

50. The driver's brake handle has three service steps plus an emergency position. Step 1 provides 30% of the full braking effort, step 2 provides 66% and step 3 provides full brake pressure taking into account the variables noted above. The emergency position applies the same brake pressure as step 3. In the emergency step position, the electrical supply to the train wires is broken and a full and immediate train brake application is made, thus providing a 'fail-safe' back up in the event of an electrical defect.

51. A long-standing project is in place to increase the brake retardation rate from the current value of 9.8%g to 12%g when the brake handle is placed in the emergency position. Because it is not possible to couple together four coach EMUs having differing braking capabilities, it is necessary to carry out wiring and equipment modifications on all the fleet during major overhauls before the final step is carried out to implement the modification on all units simultaneously. At the time of the incident, NLR had completed the wiring and equipment modifications on 17 out of 37 four coach EMUs and estimated that it would be another two years before 12%g emergency braking could be introduced on the complete fleet.

As to the brake testing of the trains involved

52. Following the collision, a comprehensive series of tests was carried out at the Wolverton Works of Railcare in order to establish the condition of the braking system of the passenger train (2A17). These tests were carried out by the Brakes Engineer of W S Atkins NTES under the supervision of and witnessed by one of the HMRI Inspectors who was satisfied as to the probity of the work that was designed to show that :

- (a) the brake control units on all 4 coaches responded to the electrical signal received from the drivers brake handle. This was achieved by measuring the actual output air pressure against the design pressure;
- (b) the brake control units responded to an increase in the number of passengers in all four coaches. This was achieved by increasing the pressure in the air suspension system to simulate the effect of an increased passenger load and noting the corresponding effect on the air pressure transmitted to the disc brake units;
- (c) the disc brakes were applied to the wheels within the specified time and that 95% of effective air pressure was achieved at the disc brake units in less than 3 seconds from the time the driver actuated the brake handle in the cab. This was achieved by means of timing the rise of brake pressure to the specified level;
- (d) undamaged cables and terminations were in good condition and the electrical resistance between train wires and earth was high thus indicating that the insulation of the wires from each other and earth was unbroken.

53. Testing on motor coach 63082 (the second coach of the passenger train), that had suffered extensive damage in the collision, showed that the brake equipment was working to specification except that it was not possible to increase air suspension pressure owing to damage to the air reservoirs. However an increased air pressure through a controlled external source resulted in the brake pressure rising in accordance with specification.

54. Testing on the leading coach 78114 was also hampered owing to the damage suffered in the collision, particularly as both bogies had parted from the coach during impact. However, by providing an external electrical signal and air supply, it was established that the brake actuator was providing the correct air pressure to the disc brake units and that effective

air pressure was achieved at the disc brake units within three seconds of the driver applying his brake.

55. Verification of (d) above was achieved by carrying out electrical resistance testing. A visual examination was carried out also to verify that apart from the extensively damaged leading coach, all the brake equipment fitted to the passenger train was in good order and properly maintained.

56. In summary, the comprehensive tests carried out provided evidence that the braking system of passenger train 2A17 was working to specification and this is verified by the evidence from the on board train data recorder (*see para.65*) that showed that the deceleration rate was a uniform rate of 9.77%g. In view of the sequence of events leading up to the moment of impact, it was not considered necessary to carry out exhaustive tests on the braking system of the ECS train.

As to the evidence from the on board train data recorders.

General Description of equipment

57. The on board train data recorder, fitted to all NLR class 321 units and commonly known as 'the Hasler' is a Teloc 2200 data recorder manufactured by Secheron Hasler of Switzerland. Each four coach EMU has two data recorders, one for each of the driving cabs.

58. The data recorders are designed to monitor essential functions; speed, acceleration, brake cylinder pressure, brake application, driver's vigilance response and AWS activity. They also automatically record other activities such as wheel slide protection activation, door release and other functions relating to driver's controls and train performance none of which are relevant to this investigation and report.

59. Functions that are cab specific are recorded by the data recorder in the leading cab only, for example the indication of the AWS warning or bell. Functions that are present throughout the train are recorded by both data recorders. Examples of these are the

activation of train wires 10 and 11 (brake application), the position of the power controller, train speed, acceleration and brake cylinder pressure.

60. Data is stored in four discrete memories, short term, long term, event and statistical. The short term memory records the most recent 2 - 3 hours of operation, while the long term memory records the most recent 8 - 9 hours of data. The event memory records when the recorder is actually recording and the statistical memory logs the total occurrences and duration of selected data.

Security of the on board train data recorders

61. One of the HMRI inspectors who was on site instructed that the data recorders be recovered under BTP supervision, sealed in evidence bags and taken into custody for delivery to an independent analyst for data recovery. The recorders were delivered to W S Atkins NTES, an independent consultancy, at Derby by a BTP Officer on the following day. Their removal from the sealed evidence bags and downloading was carried out by W S Atkins NTES in the presence of a HMRI inspector and representatives from Railtrack and NLR.

Evidence obtained - passenger train (see Appendix 6)

62. The data recorder for the leading car (78114) of the passenger train was found to have stopped recording at 0708 on 8 August 1996, just over 10 hours before the accident occurred. Unfortunately, the failure of this data recorder resulted in the loss of the cab specific data that would have shown whether or not the driver of the passenger train received an AWS bell or warning horn. The failure of this piece of equipment is dealt with in paras. 70 to 75 below. The recorder for the trailing car (77962) of the passenger train stopped at the time of the collision, however a full set of data up to the moment of impact was downloaded graphically and digitally and compared with the route topography. (See appendix 4 and appendix 6, diagram No 2)

63. Interpretation of the data obtained showed that 12 min 02 sec after the train had left Euston, it stopped at Harrow & Wealdstone station. After standing for 51 sec at Harrow &

Wealdstone, the driver moved away and accelerated, reaching a maximum speed of 132 km/h (82 mile/h) at a point about 1.6 km (1 mile) short of Bushey station. At this point, the train brake was gently applied to reduce speed to 96 km/h (60 mile/h) for the PSR board that is located 216 m (236 yds) short of the south end of Bushey station.

64. The train travelled at 90km/h (60 mile/h) through Bushey station before accelerating again and passing Signal WJ755 (that was known from other evidence to be showing a single yellow aspect) at a speed of 105 km/h (65 mile/h) with the controller in notch 4 (full power) reaching a maximum speed of 110 km/h (68.3 mile/h) about 435 m (475 yds) past Signal WJ755 at which point, about 416m (455 yards) before Signal WJ759, the data recorder shows a simultaneous shut down of the controller and a step 3 brake application. From the time that the brakes started to take effect, the train took 30 seconds to come to a stand during which time it travelled 613 m (670 yds).

65. The actual position of the train and evidence on the ground indicated the initial point of impact had taken place 203 m (222 yds) beyond Signal WJ759. The deceleration rate of the train was a uniform 9.77%g from the initial application of the brake, this being within the design parameters for a 321 EMU at full brake application on dry track.

66. As explained in para. 59, because the second data recorder was in the trailing coach (77692) at the time of the accident, there is no record of the AWS or driver's safety device (DSD) functions or driver's responses. However, before this journey, when 77962 was the leading coach, the AWS bell, horn and indicator systems were energised and the vigilance horn sounded with the driver pressing the AWS cancel button and resetting the DSD when required. This indicates the correct functioning of these systems.

Evidence obtained - empty coaching stock train

67. The data recorder fitted to the leading coach (77960) of the ECS train was in full working order. Detailed examination of the data for the events immediately before the collision revealed that the train passed Signal WJ764 about 915 m (1000 yds) north of Watford Junction station where the driver received an AWS warning horn indicating that the

signal was showing a cautionary aspect. He acknowledged this by pressing the AWS cancel push-button. The train speed at this point was 85 km/h (53 mile/h). The driver then accelerated to 106 km/h (66 mile/h) and coasted with his controller in notch zero. It should be noted that the action of the driver in accelerating after passing Signal WJ764 displaying a caution aspect was perfectly correct and in accordance with the Rule Book as the cautionary aspect being displayed was a flashing yellow aspect, indicating to the driver that the facing points at the Watford South Junction were set to a diverging route (in this case to the Up Fast line). The drivers route knowledge would tell him that he could safely traverse this junction at 80 km/h (50 mile/h). At Signal WJ750, located at the south end of platform 9 of Watford Junction station, the data recorder shows that the driver received an AWS bell (indicating the signal was showing a green aspect). Eight seconds later, the driver braked to decelerate the train to 88 km/h (55 mile/h) for the Up Slow line to Up Fast line crossovers, then coasted for nine seconds. The driver then made a Step 3 brake application and four seconds later the data recorder ceased to operate.

68. All operations monitored by this data recorder indicate that the recorder had been functioning correctly and are confirmed by the readings obtained from the data recorder mounted in the trailing coach of this four coach EMU (78112).

69. The data obtained from the leading coach (77948) of the attached second four coach EMU is identical to that of the leading coach of the first EMU, thus providing further verification of that information. Similarly, the data from the trailing coach (78100) of the attached second four coach EMU is a repeat of that contained in the trailing coach of the leading first coach EMU.

Data recorder failure

70. It was unfortunate that owing to the failure of the data recorder at the leading end of the passenger train, important information concerning the AWS indications to the driver and his responses at Signals WJ751 and WJ755 was not available. There were three possible reasons for the failure of this recorder :

- (a) loss of electrical power to the data recorder;

- (b) damage to the data recorder memory due to the accident;
- (c) failure of the pulse generator mounted on the axle of the leading bogie.

71. Verification of an electrical supply to the data recorder is part of the driver's pre-duty check that requires him to carry out a check to see that a green light is visible through a small spy hole in the data recorder housing. Evidence from the long term memory of the on board data recorder shows that the recorder was working at the start of the duty turn. It is concluded, therefore that reason (a) is invalid.

72. Analysis of the event memory for the previous four days revealed that on two separate occasions the data recorder did not record for significant periods of time (10 - 12 hours). Correlation with operational records shows that on each of these occasions the vehicle was in service, operating between London Euston and Milton Keynes or Northampton. It is a reasonable conclusion that since the data recorder was not recording on previous occasions, reason (b) is also invalid.

73. The data recorder is triggered by receiving an input signal from the pulse generator. If no input is received, the recorder will not start recording. It follows therefore that the most likely reason for failure is (c) in that either the pulse generator or the connections to the data recorder were defective. Following exhaustive tests, no obvious defect could be found within the pulse generator, the pulse generator junction box or the continuity and insulation of the wiring between the pulse generator and the on board train data recorder.

74. Further tests were carried out consisting of connecting the pulse generator to a different Hasler data recorder on a speedometer test rig set to an equivalent of 105 km/h (65 mile/h) and leaving it to run for 24 hours. On down-loading data, it was found that the signal from the pulse generator was missing for a 114 minutes in the middle of the test period. Further investigation revealed that there was an intermittent loss of contact within the pulse generator thus causing a loss of output signal to the on board train data recorder.

75. At the time of the collision, random downloading of on board train data recorders was not a practice used by NLR to audit driver technique. It is unlikely therefore that intermittent

failures of the data recorders would be noticed by train crew managers unless they were significant in number. The subject of random downloading in order to assess driver performance is discussed in detail in the driver monitoring section of this report.

As to the signalling equipment

Background

76. The accident site was examined and it was found that the points were set for a move from the Up Slow line to the Down Slow line (Point Nos. 3008 and 3007). Also, so far as could be determined under the debris of the accident, the points were also set for a move from the Down Slow line to the Up Fast line (Point Nos. 3004 and 3003)

77. The investigation initially concentrated on observation of evidence available on site followed by tests on the equipment that was operational at the time of the accident. Critical pieces of signalling equipment were then removed from site for detailed examination and laboratory tests. The off site tests were all carried out to HMRI requirements and with HMRI agreement and supervision.

78. Immediately following the accident, the data tape that recorded the coded messages exchanged between the SSI and the control panel or the lineside equipment was removed from the data recorder in Watford PSB by staff from GEC-Tarmac Rail Maintenance Ltd (GTRM) and taken to their offices at Melton House, Watford. A print-out of this tape was examined by a HMRI inspector during the night following the accident.

Evidence at the signalbox

79. Apart from placing signals to red to protect the accident site, the signaller confirmed that no action had been taken to alter the controls of the signals from the panel and the point keys had all been covered to prevent inadvertent changes by other people. The indications showing on the panel for the area of the accident site were :

- (a) track circuits BA and BB on the Down Fast line occupied with all indication lamps showing red;
- (b) track circuits HQ (only those in the line of route through 3003 points reverse) and HP (all indication lamps) on the Up Fast line occupied;
- (c) track circuits MA and MB on the Down Slow line occupied;
- (d) track circuit UY on the Up Slow line occupied. (The apparent occupancy of track circuits on the Up Slow line and Down Fast line was caused by the debris from the accident creating short circuits across the rails.);
- (e) white 'route set' lights in the track circuit section HR on the approach to Signal WJ744 were illuminated;
- (f) no other 'route set' lights were illuminated;
- (g) train identification number 5A35 was displayed in the train describer display associated with Signal WJ744;
- (h) there was no description in the displays for Signals WJ759 or WJ767 (the signal following WJ759);
- (i) train identification number 1A81 was showing in the display for Signal WJ753 on the Down Fast line, a signal changed to red by the signaller to protect the accident site;
- (j) the point operating keys for points 3001 to 3008 were in the centre, route setting, position;
- (k) the point indications adjacent to the keys showed points 3002, 3005 and 3006 reverse and points 3004, 3007 and 3008 had normal indications. Points 3001 and 3003 had a flashing white light indicating that there was a detection failure or for some other reason the point detection did not conform to the to the instruction from the interlocking (Points 3001 and 3003 had been damaged in the accident).

80. These indications were consistent with the signaller having set a route from Signal WJ750 to Signal WJ744 on the Up Fast and train 5A35 having passed Signal WJ750 and proceeded through the route up to a point where the tail of the train had cleared the Up Slow line.

81. Train 2A17 had been described in the train describer prior to the accident, progressing along the Down Slow. The fact that the TD code had not stepped into Signal WJ767 display was consistent with that train passing signal WJ759 at red.

Testing of the signalling equipment

82. Eastern Infrastructure Maintenance Company (EIMC) was engaged by Railtrack as an independent party to test the integrity of the signalling system at Watford Junction. Throughout the day following the accident EIMC examined the accident site and other evidence in the form of data records and panel evidence. During this period EIMC produced a signalling test plan, the contents of which included tests required to satisfy HMRI inspectors who were fully consulted on the extent of the testing.

83. The test plan included checks that the lineside signals reacted correctly to the coded messages issued from the interlocking and that the route locking and route holding associated with Signal WJ750 and WJ759 were installed to safe standards. Tests were also carried out to ensure that Signal WJ759 could not be changed from a proceed aspect to red aspect and a conflicting route be set across any previously set route from Signal WJ759. The operation of the lineside equipment, including cables, was also checked to ensure that the signals gave clear indications of their aspects and that AWS equipment was within specification.

84. The implementation of the testing plan was carried out with HMRI observers in attendance using the equipment that was in service at the time of the accident. These tests proved that the interlocking was sound and the lineside equipment was functioning correctly. They also proved that if a train was within 1140 metres (1247 yds) on the approach to Signal WJ751 (i.e. within 3.275 km or 2 mile 62 yd from Signal WJ759) the setting of a conflicting route beyond Signal WJ759 was prevented until 4 minutes had elapsed following the restoration of WJ759 from a proceed aspect. This demonstrated that the approach locking was working as required. At the time that the signaller cancelled the route of the passenger train, it was in excess of 5 km (3 miles) from signal WJ759.

Testing of the lineside equipment

85. The trackside function modules that drive Signals WJ750 and WJ759 were recovered on 10 August 1996 and during the following week those feeding Signals WJ755 and WJ751, including the AWS inductors, were also recovered. These modules were examined and tested at the Opal Engineering Technical Investigation Centre, Crewe to ensure that each module would only respond to messages addressed to that module and any attempt to generate incorrect signal aspects would be aborted. No faults were found on any of the trackside function modules.

Testing of the AWS

86. The trainborne AWS equipment was recovered from the front cabs of the passenger and ECS trains after the damaged coaches had been moved to Railcare Ltd at Wolverton (the driving cabs of both trains were both in such a hazardous position that recovery of the equipment at the accident site would have been dangerous) and transported to the Technical Investigation Centre at Crewe where it was tested. Although there was extensive damage to the front cabs of both trains, the AWS equipment was recovered with little damage other than to the cable looms and it was possible to carry out a full programme of testing.

87. At the commencement of the tests it was found that the isolation switch for both sets of AWS equipment was in the normal position and the AWS was operational. The driver's indicator for the ECS cab showed an 'all black' indication signifying that the train had passed over magnets indicating that the signal he was approaching was clear. The indicator for the passenger train cab showed a 'sunflower' display signifying that the driver had passed a signal at a caution aspect and that he had acknowledged the warning horn.

88. To ensure that the AWS permanent magnets associated with the Signals WJ751 and WJ755 on the Down Slow line approaching Watford South Junction all had sufficient field strength for a trainborne receiver to react to the magnetic field, the heights of the magnets were checked in situ. It was found that all the magnets were in a good physical condition and were mounted within the set parameters other than the magnet for Signal 751 that was set

higher than specification. However, this would increase the field at the receiver and would not adversely affect the AWS operation. The permanent magnets were recovered and taken to the Opal Engineering Technical Investigation Centre, Reading, where the field strength of each magnet was measured. The testing of magnetic field strengths revealed that they were all within the design specification.

89. The tests did not reveal anything to suggest that either the trainborne or track mounted AWS equipment was faulty at the time of the accident. The equipment was within the accepted operational parameters and was in use in both trains at the time of the collision. It should be noted, however, that AWS indicators are electro-mechanical devices and evidence obtained from the equipment in the drivers' cabs cannot be conclusive as it may have been affected by the impact of the collision.

Signal sighting

90. As part of the investigation, a visibility assessment of Signals WJ751, WJ755 and WJ759 was made to determine if the view of the signals was a reason for drivers approaching Watford on the Down Slow to misread, react late or fail to react to them.

91. The signals were sighted from a 321 unit driving cab. It was found that Signal WJ751 came into the driver's view approximately 370 m (405 yds) before the signal. This gives a driver of a train travelling at the maximum permitted line speed a viewing time of slightly over nine seconds which exceeds the minimum viewing time of seven seconds. At the limit of the viewing distance the light beam was focused above and to the right of the driver but as the train approached the signal the light beam became focused into the driver's cab.

92. Signal WJ755 is approached around a left hand curve and initially comes into the driver's view about 430 m (470 yds) before the signal although the structures supporting the OLE system interrupt the sighting momentarily until 350 m (383 yds) from where there is uninterrupted view. The driver of a train travelling at the maximum line speed has 12 seconds sighting of the signal from the initial sighting point and over nine and a half seconds from where the view is uninterrupted by OLE structures. The focusing of this signal was good.

93. Signal WJ759 is approached around a left hand curve being initially obscured by trees on the left hand side of the railway and is visible to the driver 368 m (403 yds) from the signal. The driver of a train travelling at the maximum permitted line speed has 9.2 seconds sighting of the aspect shown by signal WJ759 although after about a second the Down Fast Signal (WJ757) that is mounted on the same gantry as WJ759, comes into view. Signal WJ757 would have an apparently brighter aspect because it is focused onto the Down Fast line and a train on the Down Slow line crosses the maximum strength of light beam from Signal WJ757 before it reaches the focusing point for Signal WJ759.

94. The interiors and the lens systems of all three signals were in a reasonably clean state. It was not considered that the little dirt that was present would cause a marked reduction in the light output of the signals.

95. The day of the collision was fine and sunny and consideration was given to the possibility that optical effectiveness of the signals was impaired by the position of the sun at the time. Observations at roughly the same time as the collision occurred on a sunny day during the following week led to the conclusion that in all cases the sun was well to the left of the signals and high in the sky. There was no evidence that viewing of the Down Slow line signals on the approach to Watford would be hindered by the sun at the time of the accident.

96. While the preferred position of lineside signals is for the signal with the red aspect to be at driver's eye level (about 2.75 m or 9 ft above rail level), placing of all signals in this preferred position is rendered impracticable as the formation of the railway south of Watford Junction is on a viaduct and an embankment. The signals approaching the site of the accident are suspended from gantries spanning the tracks above the OLE system with the red aspect of the signal varying between 4.6 m (15 ft 1 in) and 5.41 m (17 ft 9 in) above rail level. The norm for a signal suspended from a gantry is 5.03 m (16 ft 6 in).

As to the evidence from the signalling data recorders

97. There are three separate systems that record events in the various parts of the signalling control system. These are:

- a) a fault log recording the faults that have occurred in the signalling system both in lineside equipment and in the interlocking equipment;
- b) a data log recording the data passing between the SSI interlocking, the control panel and the lineside in the form of coded messages in sequence within a one minute timebase. This provides a sequential record of signallers' actions, the progress of trains through the occupancy of track circuits and the aspects of signals;
- c) a train reporting recorder recording the progress of trains from signal to signal using the train description (TD).

98. The Fault Log was not available for examination by the HMRI investigation team having been apparently mislaid at some time during the testing of the signalling system. The other two records were examined and checks were carried out during the week following the accident to ensure the two records were in synchronism. It was found that the SSI data logger was 60 seconds fast to British Summer Time (BST) and the train reporting recorder was 5 seconds fast to BST.

99. The data log showed that passenger train 2A17 left Harrow and Wealdstone in the 1717 minute time span and proceeded towards Watford at which time the ECS train was near Apsley some five miles north of Watford. Train 2A17 was following the 1654 from London Euston that had departed from Watford Junction station at 1718, running seven minutes late and going north along the Down Slow line. Following the passage of the 1654 train, Signals WJ751, WJ755 and WJ759 had cleared to green, double yellow and single yellow respectively. At 1720 the signaller at Watford PSB changed Signals WJ748 and WJ759 to red and the two signals were recorded as having changed some seconds later. The routes associated with these signals cancelled immediately because there were no trains approaching the signals within the approach locking distance. At this time, train 2A17 was in the section for Signal WJ163 between Hatch End and Carpenders Park and had not reached the first approach locking track circuit.

100. As a result of restoring Signal WJ759 to red, Signals WJ751 and WJ755 changed to a double yellow and single yellow respectively and these changes in aspect were recorded as happening in the same minute time band. The freight train that was preceding train 5A35

entered the platform line at Watford at 1721 running on green signals and progressed beyond UX track circuit on the Up Slow line clearing Watford South Junction. Following the passage of this freight train, Signal WJ750 reverted to red and the signaller started setting the route from the Up Slow line to the Up Fast line from Signal WJ750 at 1722. At about the same time as the setting of the route from Signal WJ750, train 2A17 had moved into track circuit 77, 1140 m (1247 yds) before Signal WJ751 that was now showing a double yellow aspect and 3.275 km (2 m 62 yds) from Signal WJ759 showing a red aspect.

101. The points set for a route from the Up Slow line to the Up Fast line were detected as being in the correct position, the route indicator was shown to be illuminated and Signal WJ750 was set to a single yellow aspect before the 1723 time band. At the same time, train 2A17 was approaching Signal WJ751 and the TD was displayed in the berth for that signal. Just before 1723, train 2A17 passed Signal WJ751 travelling at about 119 km/h (74 mile/h), (the speed of the train is interpreted from the on board train data recorder) and the TD stepped to Signal WJ755 berth at the same time as train 5A35 passed Watford North Junction.

102. Shortly after 1723, train 2A17 passed through Bushey station travelling at 96km/h (60 mile/h) at about the same time as train 5A35 entered Watford station approaching Signal WJ750 that was displaying a green aspect with a route indication showing a route set to the Up Fast line. The on board train data recorder shows that train 2A17 passed Signal WJ755 travelling at 103 km/h (64mile/h) as train 5A35 was passing through Watford Station travelling at 96 km/h (60mile/h), passing Signal WJ750 between 1723 and 1724.

103. The sequence of events up to the time of the accident as recorded by the signalling data recorders then was :

- (a) the TD for train 5A35 stepped into the berth of Signal WJ744;
- (b) train 2A17 passed Signal WJ759 and occupied track circuit MA and this resulted in the TD display of 2A17 disappearing from the indication panel.
- (c) track circuit UT was occupied by train 5A35;
- (d) track circuit MB was occupied by train 2A17;
- (e) train 5A35 occupied track circuit UX and entered the connections at Watford South Junction;

- (f) at almost 1724 the signaller pulled the buttons for Signals WJ757 and WJ759, setting WJ757 to red (WJ759 was already at red);
- (g) at 1724 the detection of 3001 points on the Down Fast line was broken probably due to damage as a result of the collision;
- (h) track circuits HP on the Up Fast line, UY on the Up Slow line and BA on the Down Fast line showed occupation as a result of the collision.

As to the evidence from the drivers' controls

104. Owing to the condition of both drivers' cabs after impact, it was impossible to establish positively the position of the brake handles and power controllers due to the massive damage and movement of equipment that had taken place. However what visual evidence was available indicated that the brake handles in both cabs had been placed in full application (step 3) and the controllers were in the 'off' position. This is confirmed by the printout of both on board train data recorders. The AWS isolation switches in both driving cabs were in the 'operate' position, this indicated that they had not been isolated.

As to the evidence from witnesses

The driver of the passenger train.

105. The driver of the passenger train made a written statement declaring that he did not recall a double yellow aspect and AWS horn at Signal WJ751 before Bushey station neither did he recall a single yellow aspect and AWS horn at Signal WJ755 after Bushey station. He stated that he saw the red aspect at Signal WJ759 as he came around the bend from Bushey and applied the brake straight away. He then saw the train approaching in the opposite direction and could see that the points were set for it to cross over to the Up Fast line. He realised that he was not going to stop in time so he applied the warning horn in one long continuous blast. He was absolutely sure that his train had come to a stand before it was struck almost instantaneously by the oncoming ECS train as he threw himself to his right to avoid being crushed in his seat.

106. Subsequent questioning by a HMRI Inspector revealed that he had no idea why there is a 60 mile/h speed restriction board at the 15¾ mile post just before Bushey station. He recalled that previously there had been a temporary speed restriction (TSR) at the same location that was replaced by the current PSR board. He assumed that it was related to either track condition or the platform clearances at Bushey station. He also stated that the permitted speeds shown on the subsequent 80 and 90 mile/h speed restriction boards after Bushey station bore little resemblance to the speeds that could actually be achieved after passing through the 60 mile/h speed restriction area.

107. When asked about his recollection of the Watford Resignalling Scheme, he stated that the only information given to him was Special Notice 25E. (*See appendix 2*). No special briefing was ever given to drivers based at Watford depot at the time of installation or since and he had no idea that there was a reduced overlap after Signal WJ759 or that the 60 mile/h speed restriction south of Bushey station related to the reduced overlap at Watford South junction. (The subject of reduced overlap is discussed in paragraphs 151 to 156).

The trainman/guard of the passenger train

108. The trainman/guard was in the rear driving cab in accordance with the procedure laid down in the Rule Book. He described the journey from Euston as far as Bushey as being uneventful. He heard the train warning horn being blown when the train was about 365 to 550 m (400 to 600 yds) north of Bushey station, but disregarded it as he thought that there may have been either contractors or trespassers on the line. He then felt the brakes being fully applied so he went to the left hand side of the cab, looked out of the droplight window and saw the front of the ECS train appearing across the front of his train. Immediately afterwards, the trains collided and he was thrown against a control panel and then hurled to the floor of the cab. He got up almost immediately and moved into the passenger section of the fourth coach where he reassured passengers and told them to stay where they were. Accompanied by another railway employee who had identified himself, he left the train by means of the rear driving cab door and saw what had happened.

109. He ran to the nearest signal post telephone which he estimated to be about 110 m (120 yds) from the rear of the train and advised the signaller at Watford PSB of an emergency. While doing this, he saw passengers getting off the train, so as soon as he was able he returned to the train and guided them to a position of safety in case there were other trains still moving in the area. He re-boarded the train and continued to reassure and assist passengers until the emergency services arrived and took control of the situation. He then realised that he had suffered injuries in the collision requiring hospital treatment and was taken to Watford General Hospital.

The driver of the ECS train.

110. The driver of the ECS train booked on at Bletchley at 1550, prepared his train and accompanied by his trainman/guard drove uneventfully towards Watford where he saw the signal indication that told him that he would be transferred from the Up Slow line to the Up Fast line at the junction south of Watford Junction station. Just before his train entered the first set of points from the Up Slow line to the Down Slow line, he saw a train approaching in the opposite direction on the Down Slow line and realised that a collision was inevitable. He made a full brake application and ran back through the driver's communication door. Within seconds, he was thrown around the coach as the trains collided. After having released himself from the wreckage of the first coach, he was examined at the scene by a doctor and taken to Watford General Hospital.

The trainman/guard of the ECS train.

111. The trainman/guard admitted that he travelled with the driver in the leading cab when the train left Bletchley. He confirmed the driver's version of events up to the point where he said to the driver that the passenger train on the Down Slow line didn't look as though it was going to stop and he simultaneously vacated the cab with the driver as fast as he could. He was also thrown around the first coach as it toppled over. Within a short time of getting out of the train, he was able to make contact with the trainman/guard of the passenger train who assured him that the lines had been protected. Later he was taken to Watford General Hospital.

The Railtrack Area Production Manager

112. By chance, this Railtrack manager happened to be travelling on the following NLR service out of Euston, the 1710 departure. This train came to a stand at signal WJ753 on the Down Fast line (this signal is on the same gantry as Signal WJ755 on the Down Slow line). Within two minutes he received a message on his pager that a collision had occurred, so he left the train and walked forward along the line and saw that all four lines were blocked and there were about 50 passengers on the tracks. He immediately phoned Railtrack Control to tell them that a major accident had occurred. Having briefly talked to the crew of the ECS train, who confirmed the facts of the situation, he continued on to Watford PSB where he took over the role of Incident Commander in accordance with the Railtrack Accident and Emergency Procedure. On arrival at the PSB, he confirmed with the signaller and the signal supervisor that the control panel had not been touched, other than to put signals back to danger to protect the site.

The passengers

113. About 200 statements were taken by BTP from passengers who travelled on the 1704 from Euston and from local householders. These were made freely available to HMRI investigators. There is nothing in these statements that conflicts with the conclusions drawn from the reconstruction of the accident sequence although there are naturally some differences of opinion concerning the precise details of the accident. The majority of statements are in accord with the following sequence of events :

- (a) the journey from Euston to the point of collision was uneventful and there is no suggestion that the train was being driven in an irregular or erratic manner;
- (b) a considerable number of passengers alighted at Harrow & Wealdstone station, leaving the number on the train well below its seating capacity of 303;
- (c) regular travellers were not surprised when the train started to slow down well before Watford Junction station, the implication being that it was a regular occurrence and a local point of minor delay;
- (d) the train warning horn had sounded loudly and continuously prior to the collision;

- (e) the train had been stationary for a very short time - generally estimated to be from one to two seconds up to ten seconds - before being struck by the ECS train;
- (f) there were two distinct impacts, the first one being of less severity than the second, thus confirming the hypothesis that the first impact was the glancing blow between the leading coaches followed by the more severe impact when the second coach of the ECS train rode up over a detached bogie and tore through the left hand bodyside of the second coach of the passenger train driving it backwards along the line;
- (g) witnesses seated in the second coach described the bodyside being torn out followed by a bogie entering the passenger space through the hole created;
- (h) immediately following the collision, passengers trapped in the first and second coaches failed to open the passenger doors by means of the emergency lever;
- (i) the first of the emergency services gained access to the interior of the coaches giving assistance and comfort within 15 to 20 minutes of the collision occurring;
- (j) the more seriously injured passengers were mostly carried down the temporary access laid by the Hertfordshire Fire and Rescue Service on the east side of the embankment at Radlett Road playing fields. A few were carried through the ECS train and down the concrete access steps on the west side of the railway at Radlett Road and were then taken to Watford General Hospital without delay;
- (k) Less injured passengers ('walking wounded'), finding their way towards Watford Junction station blocked by the wreckage of the trains, walked along the railway line back towards Bushey and found an access point to the railway close to a Tesco supermarket where store management and staff provided first aid and put the store coffee shop at the disposal of the injured. Contact was made from here with the Police control point, and they were eventually either taken to hospital or other arrangements were made for them to continue on to their homes. At this point, a number of passengers made their own arrangements; some were picked up by relatives, some went home and some made their way to the Watford General Hospital on foot, this latter action causing a difference between the number of casualties listed at the accident site by the emergency services and the figures compiled by the hospital authorities.

As to drivers' histories and working patterns before the collision

114. The passenger train driver had been a railway employee since 1957 and at the time of the collision had been a driver for 29 years. During this period, his record showed that he had a total of six driving offences, one in 1988, three in 1990 (all station signal overruns at Hatch End caused by poor adhesion conditions), one in 1992 and one in 1994. Five of these offences were recorded as Signals Passed at Danger (SPAD) incidents, the sixth was a speeding offence. None of these offences were considered by the management of the day to be anything worse than misjudgement and resulted in disciplinary action being limited to a reprimand. Records show that he had attended the biennial review and updates of rules and regulations and had attained a good standard. His driving technique had regularly been monitored by traction inspectors; the most recent monitoring having taken place on 17 April 1996 when the result of his assessment was good.

115. He had booked on duty at 1615 and at the time of the collision was just over one hour into his rostered period. He had booked off his previous turn of duty at 0009 on 8 August 1996 and had thus had about 16 hours between working shifts. He was working his fifth successive turn of late duty (nominally 1600 to 2359) having returned to work on 4 August 1996 after 13 days of annual leave.

116. The ECS train driver had been an employee of the railway since 1970 and at the time of the collision had been a driver for 22 years. During this period, his record showed one minor offence for which he was reprimanded. He had also been on duty for just over an hour, having booked on at 1550 and working the previous day from 1550 to 0023. He was on his fifth successive turn of duty having taken a rest day on 4 August 1996.

As to the damage to the Rolling Stock

The 1704 Euston to Milton Keynes Passenger Train

117. This four coach EMU was stationary when struck by the ECS train. The force of the impact resulted in its being forced backwards some 25 m with the leading coach being turned

onto its right hand side and the driving cab end being laterally displaced towards the Up Slow cess by about 12 m. The second coach was derailed but remained upright. The third and fourth coaches also remained upright and were pushed backwards without being derailed.

Driving trailer composite open vehicle 78114 (the leading coach)

118. The driving cab of 78114 collapsed by about 2.5 m on the left hand side and the bodyside was destroyed as far back as the trailing pillar of the driver's access door. (*See photo no 2*). The impact also crushed the left hand side of the first class passenger area immediately to the rear of the driving cab to an extent that the one passenger seated in that area was very seriously injured and taken by air ambulance to the London Hospital. There was little damage on the right hand side of the leading end other than some buckling of the main longitudinal members. The roof was badly buckled over a length of about 4 m. At the trailing end, the headstock and drawgear were severely damaged when the coach turned onto its side and rolled through 90 degrees relative to the second coach. On the left hand side of the body and just forward of the trailing passenger doors, there was a deep scoremark and penetration damage in the region of the solebar. There was little other structural damage.

119. The windows were generally intact; two on the right hand side had the exterior skin broken and the rearmost window on that side was completely smashed. The interior was badly damaged with seats displaced, partitions partially collapsed and various interior windows completely smashed. All the fluorescent light diffusers and diffuser holders were displaced from their seatings. Both bogies broke away due to failure of the central pivot housing assembly. The leading bogie was found adjacent to the impact point and the trailing bogie was deposited in front of 63082 (the second coach).

Motor standard open vehicle 63082 (the second coach)

120. The main damage to this coach was on the left hand side where the bodyside was completely torn out between the cantrail and solebar as far back as the leading passenger doors resulting from penetration by the overriding second coach of the ECS train. (*See photo no 5*). The left hand side seating and interior structure were severely damaged over a similar

area. Between the two sets of passenger doors, the window pillars were all torn out. The roof was also stoved in. Both bogies were still attached with little discernible damage. The interior of the vehicle suffered damage similar to the leading coach, namely the leading three rows of seats torn out, other seats displaced, seat cushions thrown about and fluorescent light diffusers and holders displaced from their seatings.

Toilet standard 71968 and driving trailer standard 77962 (third & fourth coaches)

121. Apart from a number of displaced and missing seat cushions along with a small number of light fitting diffusers displaced from their housings, there was little damage to these coaches. It is conjectured that the missing seat cushions may have been used by the rescue services to provide temporary trackside seating for injured passengers while they were waiting to be taken down the embankment to waiting medical facilities.

The 1650 Bletchley to Euston empty coaching stock train.

122. The leading coach jack-knifed and came to rest with its leading end in the down fast cess having rotated through about 135 degrees and with the driving cab end pointing back towards Watford Junction station. The coach was partly on its side having rolled about 60 degrees. During the course of the collision, either the trailing bogie of the leading coach or the leading bogie of the second coach contacted the bogie that had become detached from the leading coach of the passenger train thus providing a ramp for the second coach of the ECS train to ride up into the bodyside of the second coach of the passenger train and rip out its side. The leading end of the second coach came to rest about 3 m in the air resting partly on the trailing end of the leading coach and partly on an overhead line electrification gantry that had been demolished during the collision. (See photo no 4). The leading wheelset of the third coach was derailed to the left.

Driving Trailer Standard Open Vehicle 77960 (the leading coach)

123. The driving cab suffered similar damage to that of 78114 in that the driver's side collapsed by about 1.5 metres, as far back as the rear door pillar of the driver's access door.

(See photo no 3). The solebar, bodyside and cantrail were completely crushed. The headstock was bent backwards by about 300 mm at its lower end. The vehicle floor and roof were badly buckled over the leading 2.5 to 3 m but there was little damage to the underframe or superstructure on the right hand side of the vehicle. The drawbar between this and the second coach fractured and there was severe distortion and tearing of the headstock at the trailing end of the coach. The remainder was largely undamaged apart from displaced seat cushions, light fittings and waste bins. The leading wheelset of the leading bogie became detached and the remainder of the bogie had buried itself in the down cess ballast having become detached from the coach underframe following failure of the centre pivot assembly. The trailing bogie remained attached to the coach.

Toilet Standard Open Vehicle 71966 (the second coach)

124. The left hand side was severely damaged with the solebar suffering considerable crushing. Assorted debris from the torn bodyside of the second coach of the passenger train was found hanging from the solebar indicating that 71966 had ploughed into 63082 and ripped out its side. The left hand side lower body panel was crushed and the leading left hand side seating was torn out. There was minor damage to the trailing end of this vehicle and seat cushions and light fittings were detached throughout. The leading bogie was detached, but the trailing bogie was still attached to the underframe by the anti-rollbar connection.

Remaining vehicles

125. The leading end of the roof of the third coach, was stove in as a result of 71966 having been lifted up at its front end. Apart from this there was little damage except for displaced seat cushions and light fittings. On first visual examination, the last four coaches in the train were undamaged. They were uncoupled and driven back to Bletchley TMD at reduced speed later on 8 August for detailed examination at the depot.

SAFETY MANAGEMENT ISSUES

Train drivers

Background

126. Railway undertakings have traditionally imposed a strict control regime governing the training and assessment of employees' competence. This regime was strengthened from 1 April 1994 by the introduction of The Railways (Safety Critical Work) Regulations 1994 that placed specific statutory duties on employers to ensure the competence and fitness of those carrying out work essential to the safe operation of the railway, including train drivers.

127. Evidence presented by NLR to the Railtrack Formal Inquiry relating to driver competence assessment and management control of drivers who have been involved in incidents, caused HMRI to investigate extensively a number of aspects relating to the control exercised by Railtrack and NLR over the criteria governing driver competence.

Driver Monitoring

128. Monitoring of driver performance is carried out in four ways: by traction inspectors accompanying drivers and observing their driving technique; by examinations to ensure that drivers have a comprehensive knowledge of the rules; by traction inspectors riding in the passenger section of trains unbeknown to the drivers and by speed checks at trackside using radar guns. The investigation revealed that NLR made no use of on board train recorder data to compare driving techniques with a standard speed and braking profile obtained under controlled conditions. Data recorders were used, however, in post incident investigations.

129. NLR drivers are required to attend six rostered safety briefings per annum. NLR driver safety briefings are carried out by traction inspectors or by specialist driver instructors who cover a wide variety of safety related matters. NLR records show that drivers of both trains had attended all of their scheduled safety briefing sessions in the previous 12 months.

Driver performance profile

130. Driver Performance Profile (DPP) was first introduced by NLR at the time that it was formed from the Network North division of the disbanded Network South East organisation, and was originally produced in order to comply with British Railways Board (BRB) Group Standard GO/OTC 508 'Signals Passed at Danger - Code of practice for incident prone drivers' (published - September 1993). This code reported that research had identified that one in every five drivers involved in a SPAD incident will have had a similar incident within the previous ten years. It also identified that drivers with poor disciplinary records are more likely to be involved in incidents than drivers with clear records. Guidelines were set out in the code to assist in the identification of incident prone drivers and to provide a basis for necessary action to improve safety performance. The guidance notes in the NLR DPP document stated that 'the system relies on the gathering of evidence and personal judgements about each individual driver'. DPP was also necessary to meet with NLRs Safety Case statement, namely to 'ensure that the train crew .. perform to the required level of safety'.

131. Prior to DPP, the only information to the management of the day was an individual drivers' history file that would have to be studied to determine if a driver was considered to be incident prone. In order to comply with GO/OTC 508 and to conform to the requirement to have a SPAD management business policy (*see paras. 145 & 146*), NLR management carried out an assessment of every driver, using historical evidence from drivers' personal files. A points rating system was devised relating to safety of the line incidents and other personal factors. Each driver was placed into one of three categories of performance; probably, possibly and non-incident prone. Drivers falling into probably and possibly incident prone categories were to be interviewed and an action plan, specific to the individuals' shortfalls, was to be agreed with the driver. 'Incident prone' ratings based on incidents recorded in the drivers' history files were drawn up and this work was completed by the summer of 1994.

132. In September 1994, Railtrack issued Railway Group Standard GO/RT 3251 'Safety requirements for train drivers'. The NLR DPP guidance notes were accordingly amended to comply with Section B Para. 14.1(c) 'Train operators must have systems in place to monitor drivers to establish whether they are potentially prone to incidents'.

133. While the above work was going on at NLR, the Safety Directorate of BRB issued in December 1994 a revised and more detailed Code of Practice BR/BCT 508 entitled 'At risk drivers'. The purpose of this document was 'to provide guidance on the provision of systems for identifying at risk drivers so that remedial action can be taken'. It expanded on systems for identifying drivers who are potentially 'at risk' along with advice on corrective action and the requirement to maintain records. A points system was used to determine driver ratings into three categories - at risk, potentially at risk and low risk. Suitable procedures were laid down for dealing with these three categories. The points system was such that a driver in the 'at risk' category was likely to remain 'at risk' particularly if he was involved in another serious incident such as a SPAD within 6 years. This process was designed to ensure that drivers who were involved in repetitive incidents were constantly monitored. The principles in the BRB Code of Practice were more stringent than those that had by now been put into place by NLR but were not adopted as NLR had already devised their own system that they considered to satisfy the requirements of Railtrack Railway Group Standard GO/RT 3251.

134. Having carried out initial assessment of all their drivers, NLR carried out annual reviews in 1995 and 1996 to update the 'incident prone' rating, at which time the points rating of all SPAD and safety of the line offences were automatically reduced in value provided that there had been no further incidents in the year being reviewed, with a further reduction in points being left to the discretion of the manager making the assessment. Investigation by HMRI revealed that under certain circumstances, a driver could move from the 'probably incident prone' to the 'non incident prone' category at one review. In the case of the driver of the passenger train involved in the Watford South collision, he was identified at the start of 1995 as being 'probably incident prone' but at his 1996 assessment was reduced to 'non-incident prone' based partly on the fact that there had been no incidents in the year under review and partly on a discretionary management decision.

135. At the time of the collision, NLR driver 'incident prone' register stood as follows :

Category A	- Probably Incident Prone	- 18 (7%)
Category B	- Possibly Incident prone	- 45 (18%)
Category C	- Non Incident Prone	- <u>184</u> (75%)
		247 - Total

Of the 63 drivers in Categories A and B, individual action plans were due to be drawn up. These were to be agreed with drivers and actioned. This process was in progress at the time of the collision, but only three individual action plans had been drawn up by 8 August 1996.

136. The procedure for monitoring the performance of Category A drivers involves a process of retraining and close observation by traction inspectors. A driver perceived to be not improving his driving technique can, in extreme circumstances, be suspended from duty and be subject to a full review of his performance. Although the practice of traction inspectors riding with drivers has been the traditional method of carrying out assessment and monitoring performance, HMRI question the effectiveness of this system of monitoring on the grounds that only a foolish or genuinely poor standard driver would handle his train incompetently whilst the traction inspector is in the cab whereas a driver who may be prepared to take risks such as anticipating a signal clearing, would not do so while being supervised directly. It is already noted that on board train data recorders were not used at random to monitor driver performance.

137. Following the collision of 8 August 1996, a full review of the DPP document was undertaken by an Operational Safety Improvement Group set up by NLR. Management systems were strengthened and the guidance associated with management's use of the points rating system was revised and reissued. The revised procedures were briefed down to the driver managers and traction inspectors by means of face to face discussions where feedback was invited. A system was set up whereby the NLR Operations Standards Manager may audit the system independently. Drivers may not have their incident prone assessment reduced by more than one category under any circumstances and drivers in category 'A' - probably incident prone - may not be removed from this category without the authority of the Operations Standards Manager and the Driver Manager. In the event of a serious incident, a driver may be moved from category 'C' to category 'A' directly. Driver performance reviews for those in category 'A' are programmed to take place at six-monthly intervals, category 'B' drivers will be reviewed annually and category 'C' drivers will be reviewed bi-annually.

138. Also, following the collision, traction inspectors were trained to download Hasler data recorders in order to obtain random information on the handling of trains by NLR drivers in

relation to an acceptable standard . Traction inspectors are also encouraged to enhance their personal relationship with drivers, particularly those with less experience, by providing confidence and reassurance during the course of cab riding.

SPAD Management.

Overall picture.

139. The Safety Directorate of BRB has, since 1985, used a structured reporting process that gathers information gained from interviews with drivers following a SPAD incident. This information is entered into a central record system called SPADMIS (Signals Passed At Danger Management Information System) for trend analysis. Information gathered in SPADMIS showed that the number of SPADs rose consistently to a peak in the fiscal year 1991/92 when a total of 953 incidents was recorded, 800 (84%) of which were attributed to Driver Error. In the years 1992/93 and 1993/94 the number of SPADs recorded remained unacceptably high at 869 and 879 respectively. Various reasons were put forward, among which were introduction of new types of traction, new signalling schemes, driver inexperience and improved reporting systems.

Recent Developments

140. In September 1993, BRB Group Standard GO/OTC 508 'Signals Passed at Danger' introduced a hazard ranking process(HRP) and a requirement for TOCs to carry out a detailed analysis of any SPAD and then take appropriate corrective action where a train passed a signal at Danger without authority . If a SPAD was rated as having potential for serious consequence it was identified and examined in detail to seek out the underlying causes. HRP has led to improvements in several areas, resulting in signalling alterations, lineside vegetation control, personal interviews with drivers, driver monitoring by traction inspectors along with an improved and increased use of safety briefings that relate directly to SPADs.

141. In January 1995, a quarterly publication was launched by the BRB Safety Directorate under the name of 'Red Alert' that was specifically aimed at reducing the number of SPAD

incidents. 'Red Alert' contains information for driver standards managers, traction inspectors and traincrew leaders and is intended to be used as a basis for providing information to drivers at safety briefings. It also contains discussion items designed to keep the subject of SPAD incidents to the fore in the safety management system. It is used by NLR at driver safety briefings, although copies of 'Red Alert' are not made available to NLR drivers.

142. The introduction of improvements from HRP investigations and what is claimed to be greater awareness resulting from briefing of 'Red Alert' has coincided with a small but welcome reduction in SPAD incidents from 879 in 1993/94 to 832 in 1994/95 and to 771 in 1995/96 of which 676 (88%) were attributed to driver error.

Railway Group Standard GO/RT 3252 'Signals Passed at Danger'

143. BRB Group Standard GO/OTC 508 was superseded in March 1995 by Railtrack Railway Group Standard GO/RT 3252 that clarified the duties and obligations of Railtrack and Train Operators and became effective on 22 April 1995. One of the key changes in this Group Standard was a requirement for Railtrack to convene a signal sighting committee where a signal had been passed at danger more than once in twelve months or three or more times in any three year period. It is of considerable concern to note that SPAD incidents occurred at signal WJ759 in February and June 1994, August 1995 and July 1996 and yet no signal sighting committee had been convened at the time of the collision which was, in fact, the fifth SPAD incident at this signal in two and a half years.

144. A signal sighting committee was convened and carried out a survey on 18 August 1996, ten days after the fifth SPAD incident at WJ759. Their conclusion was that signals WJ751, WJ755 and WJ759 were all in excess of the recommended 145km/h (90 mile/h) sighting distance. It was additionally noted that removal of some trees on the left hand side of the left curving line would increase the sighting distance of signal WJ759 to about 735 metres (800 yards).

SPAD Management - North London Railways.

145. The fact that the driver of the passenger train had been previously involved in a SPAD incident had brought him into the requirements of Railtrack Group Standard GO/RT 3251 'Safety requirements for train drivers' Section 17.5 that states 'Where a driver is involved in a SPAD incident, the requirements of Railway Group Standard GO/RT 3252 - Signals Passed at Danger - must be complied with'.

146. Railway Group Standard GO/RT 3252 (Issued September 1994) dictates that following a SPAD incident, the Train Operator (NLR in this case) must arrange for the driver to be interviewed by a competent person at the first opportunity in order to establish the driver's fitness to continue driving and establish the facts of the incident. The driver must be relieved from duty if he is found to be under the influence of drugs or alcohol, medically unfit, shocked insofar as his judgement is impaired, if he disputes that he passed the signal at danger or there is evidence suggesting gross negligence. In applying the above, the Train Operator must take into account the drivers past record. NLR SPAD Policy and Investigation Procedure was found to be in accordance with the requirements of Group Standards GO/RT 3251 and 3252.

The future of SPAD Management

147. The SPAD Management group at the BRB Safety Directorate has ceased to exist in line with the dissolution of the BRB. Railtrack have agreed to carry out performance monitoring of the Train Operating Companies (TOCs) regarding their SPAD performance and have undertaken to continue with such initiatives as 'Red Alert', a SPAD Management Group and the organisation of conferences and workshops. A video 'Signals Passed at Danger' is also to be produced. A training package is to be formulated and briefed down to TOC driver managers and traction inspectors. HMRI will observe with interest the commitment made by Railtrack to the continuation of effective SPAD management.

Previous SPAD incidents at Signal WJ759

148. There are four recorded SPAD incidents at Signal WJ759 as follows :

- | | | | | |
|----|------------------|------|---------------------|--------------------------|
| a) | 15 February 1994 | 0850 | Unit No 321411 | North London Railways |
| b) | 6 June 1994 | 1559 | Locomotive No 90013 | Rail Express Systems |
| c) | 16 August 1995 | 1925 | Locomotive No 90133 | Railfreight Distribution |
| d) | 4 July 1996 | 1711 | Unit No 321409 | North London Railways |

149. In all cases a SPAD investigation was carried out in accordance with Group Standard GO/RT 3252 (previously GO/OTC 508) with the following findings :

- a) The driver of a NLR Euston to Milton Keynes train overran the signal by 44m (48 yds). He admitted to a lapse of concentration as he had been running on clear signals and expected the aspect to be clear to proceed into the platform at Watford Junction station. The traction inspector concluded that the driver had suffered from a serious lapse of concentration, recorded the cause for the SPAD as disregard and removed the driver concerned from driving duties pending a medical examination. Further investigation by HMRI revealed that when the driver contacted Watford PSB via his cab radio having passed Signal WJ759, he was told that a move was about to take place from the Up Slow to the Up Fast and that he was to set back to signal WJ759. The circumstances of this SPAD and that of 8 August 1996 are remarkably similar.
- b) The driver of a single locomotive travelling from Willesden to Watford overran the signal by 18m (20 yds). He admitted to misjudgement of the locomotive's braking behaviour. No further action was taken.
- c) The driver of single locomotive travelling from Wembley Freight Centre to Crewe overran the signal by 37m (41 yds) He admitted to misjudgement but claimed that the locomotive brakes were below standard. No further action was taken.
- d) The driver of an eight car NLR train from Euston to Tring overran the signal by 49m (54 yds). In this case the driver had a record of one previous SPAD only seven months previously. He was therefore interviewed by a traction inspector immediately after the incident. The recommendation of the traction inspector was that the driver

should undergo a period of retraining, to cover defensive driving techniques with particular regard to his method of approach to red signals.

150. It is of interest to note that in all four cases above, the SPAD took place fairly early in each driver's turn of duty. Taking the events in the order as stated above, the incidents took place 2 hr 0 min, 2 hr 0 min, 0 hr 15 min and 1 hr 06 min into the turn of duty. It seems unlikely, therefore, that fatigue could have been a consideration in these events.

Approval of the Watford junction station area resignalling

151. When the design associated with the resignalling works at Watford Junction was begun in 1988 the relevant regulations relating to approval processes were contained in Section 41 of The Road and Rail Traffic Act 1933. The Act required a railway to obtain the approval of the Minister for new or altered railway works (such as those proposed at Watford). In practice, the functions of the Minister were delegated to the Chief Inspector of Railways.

152. The Act allowed for approval to be given with or without an inspection taking place. In practice, it would have been normal for works such as the Watford re-signalling to have been inspected. Although the requirement under the Act was for fully completed works to be approved, in order to maintain train services, the railway would need to bring various stages of an altered signalling system into use progressively and before the whole works were complete. Shortly after the Act came into force, an administrative procedure was introduced under which an outline design was submitted for 'provisional approval' prior to the works starting.

153. In October 1988 the General Manager of the London Midland Region (LMR) of BR submitted Plan No 880066/21 to the Railway Inspectorate (RI) for provisional approval. This plan showed the signalling alterations associated with the remodelling of the junction layouts at both sides of Watford Junction Station. In response to queries raised by RI, additional information was supplied in November 1988 and BRB gave March 1990 as the commissioning date for the alterations. In February 1990 BRB re-issued Plan No 880066/21

with a letter explaining differences from the original scheme comprising the addition of a Train Operated Warning System (TOWS) to enhance the safety of staff working on or about the line and other changes to improve the sighting of some signals. A revised commissioning date of September 1990 was given, this was further revised in October 1990 to March 1991.

154. There were a number of exchanges of correspondence over the following year. In October 1991, a re-issue of Plan No 880066/21 together with a revised set of Control Tables and a letter listing the differences between the enclosed plan and previous issues was submitted. These differences consisted of deletion of the TOWS, removal of marker boards in tunnels and the provision of an indicator to inform train drivers of the route they are taking when passing signal WJ769. HMRI sent an acknowledgement to the BRB and stated that there were no comments relating to the changes listed. *(Note. RI became HMRI in December 1990, when it was transferred from the Department of Transport to the HSE)*

155. In October 1993 the Director Inter-City West Coast wrote to HMRI giving notification that the Watford Junction Resignalling scheme had been completed and commissioned in May/June 1993 and included a certificate of compliance. This letter was not received and was resubmitted in March 1994. The certificate of compliance stated that the overlap beyond signal WJ759 was less than the preferred norm of 200 yds, but that it complied with Standard Signalling Principle (SSP) 20 because a permanent speed restriction (PSR) of 60 mile/h had been imposed on the approach to signal WJ759. The letter stated arrangements were in hand to extend the overlap to 183 m (200 yds) and remove the PSR. The reduced overlap and associated PSR were still in force at the time of the accident.

156. Between November 1994 and the time of the accident, HMRI made a number of attempts to arrange an inspection but without success. The Railtrack Zone concerned was originally West Coast Main Line but changed to Midlands Zone during this period.

Safety Case Issues - North London Railways

157. The Railways (Safety Case) Regulations 1994 require that before any company can set up as a railway operator, it must prepare a safety case. The safety case must be accepted

by the infrastructure controller (Railtrack) before the operator can start operations. In the case of NLR, their safety case was accepted by Railtrack and was issued in September 1995.

158. While statements are made in the NLR safety case such as 'The Production Director will ensure that the train crew..... perform to the required level of safety' and 'The Driver Manager is responsible for the safe management of drivers' there is nothing specific that identifies the exact methods whereby management can measure performance in order to achieve the required level of safety. In Section 8.4 of the NLR safety case, compliance of drivers with the Railways (Safety Critical Work) Regulations 1994 is generally covered but without any specific methods being quoted other than '.....employees will betrained and continually assessed in accordance with the relevant Railway Group Standards.'

159. When NLR were formed from the former Network North Division of the now defunct Network South East organisation, the management structure did not contain the post of Production/Operations Standards Manager. The demands of the Safety Case requirements however, and a recognition by NLR of deficiencies in the management structure resulted in the appointment of a Production Standards Manager in July 1996, part of whose job remit was to put into place systems that ensure compliance with the relevant Railway Group Standards relating to driver competence and SPAD management systems.

Safety Case issues - Railtrack

160. Relevant clauses of the Railtrack Railway Safety Case Volume 1 Principal Information are listed in Appendix 1.

161. Following the investigation of the accident, a review of the Railtrack Safety Case was undertaken, so as to assess Railtrack's actual performance against the undertakings given in support of their submission to be the responsible controller of the railway infrastructure.

162. Numerous weaknesses were identified. These are detailed in the discussion section of this report and various recommendations are made with the object of eliminating these shortcomings.

DISCUSSION

Disregard of signals

163. HMRI is satisfied that the driver of the passenger train disregarded cautionary aspects at signals WJ751 and WJ755. The reasons are not clearly established as the driver's original statement was that he did not recall the double yellow aspect and AWS horn at Signal WJ751, neither did he recall the single yellow aspect and AWS horn at Signal WJ755. Later, however, he stated that his feelings, that were supported by his actions, were that both Signals WJ751 and WJ755 were at green.

164. There are four underlying causes that account for the majority of SPAD incidents that are classed as 'disregard' :

- (a) over-reliance on previous experience with the signal (i.e. false expectation of the signal clearing);
- (b) lack of attention;
- (c) unfamiliarity with track or signalling layout;
- (d) lack of confidence that the signalling is operating reliably.

165. Given that the driver of the passenger train had many years of experience of the route and knew that he was following a previous late running departure from Euston timed at 1654 that was due to stop at Watford Junction, it must be a consideration that he anticipated Signal WJ759 clearing as he approached it, as had probably happened on numerous previous occasions. Indeed, witness statements from regular passengers commented on the fact that they were not surprised when the train started to slow down well before Watford Junction Station as it was a regular occurrence in this area.

Information provided to drivers

166. NLR have provided a written statement to the effect that there is no record of any information provided by what was, at the time, the InterCity West Coast Operations Department regarding special provisions as part of the Watford resignalling scheme. NLR

drivers and traction inspectors who were interviewed by a HMRI Inspector were firmly of the opinion that the 60 mile/h PSR board at the 15³/₄ milepost south of Bushey station was either due to condition of track or because of reduced platform clearances through the curve at Bushey station. The Watford resignalling special notice 25E of May 1992 (*see Appendix 2*) provided no reference to temporary speed limits, reduced overlap or any other information other than the signalling detail.

167. The fact that drivers of trains operating on this stretch of line were not made aware of the short overlap to Signal WJ759 or why the 60 mile/h speed limit was introduced (to accommodate the short overlap) is not directly relevant to the accident. As far as drivers are concerned the signal section terminates at the signal, their training and driving technique should reflect this. An overlap to a signal is provided to give some protection against misjudgement or poor rail adhesion, not to encourage driving to the limit of the vehicles' capabilities. However, in the interests of good management and communication, it is considered that wherever possible, drivers ought to be made aware of areas where special conditions (such as a short overlap) introduce an extra hazard into the consequence of an overrun or a misjudgement. It is a matter of conjecture that if NLR drivers realised the real significance of the 60 mile/h permanent speed restriction board at Bushey, they might not accelerate at the 80mile/h PSR board and pay closer attention to the speed of their train when approaching Signal WJ759. *It is therefore recommended that Railtrack consider providing information in sectional appendices and traffic notices to identify reasons for permanent speed restrictions [Recommendation 1]*

Signal sighting

168. The constricted space on the West Coast Main Line results in frequent provision of gantry mounted signals and the fact that Signals WJ755 and WJ759 are mounted on gantries is not considered to have a bearing on the events leading up to the accident.

169. The position at which all signals are mounted on the Down Slow line approaching Watford Junction station gives drivers of trains a sighting time of more than seven seconds, a time that is considered adequate for main line running signals. However, the line curves to

the left when down trains approach Watford Junction station and signal light beams are directed across the curve with the result that trains on the Down Slow line cross the focused beam of Signal WJ757, the signal for the Down Fast line, before the full benefit of the aspect of Signal WJ759, the signal for the Down Slow line is seen, thus possibly causing misconception in a driver's mind as to which signal he has seen, although his route knowledge, which is tested regularly, should ensure the driver is able to discriminate between the two signals.

170. Records show that there have been previous instances of trains passing Signal WJ759 when it was displaying a red aspect, but little had been done prior to the accident to identify the causes of these driver errors. A SSC convened after the accident concluded that although the minimum sighting time was available the viewing distance should be extended to 730m (800 yds) by trimming some of the vegetation obstructing the view of the signal from a point just past Signal WJ755.

171. It is a matter of conjecture as to whether or not a SSC survey correctly convened after the third SPAD incident in August 1995 would have had any material effect on the events of 8 August 1996, but it is a matter of fact that train 2A17 did not take 730 m (800 yards) to come to a stand from 110 km/h (68.3mile/h) on the day of the collision. In fact it stopped within 613 m (670 yds). Had the SSC convened earlier and had the offending trees been removed, it is possible that the driver of the passenger train may have seen signal WJ759 earlier and may have applied his brake in time to avoid the collision even though he would probably have still overrun the signal. It should be re-stated, however, that there was more than the minimum sighting time of seven seconds for Signal WJ759 before the recommendation of the SSC was made (see para. 93).

172. It is a matter of concern that Railtrack failed to comply with their own Group Standard in respect to convening a SSC following the third SPAD incident at signal WJ759 in August 1995. The SPAD database should automatically highlight those signals where SPAD incidents exceed the limits laid down in Group Standard GO/RT 3252 and appropriate action should be taken as soon as possible after the incident.

173. While HMRI consider that the requirement of Railway Group Standard GO/RT 3252 in convening a SSC to investigate multiple SPAD incidents is a step forward in safety management, it is noted that SSCs appear to restrict their activities purely to the rules covering the visibility of signals as laid down in Railway Group Standard GK/RT/0037 'Signal Sighting'. This Standard states *'a Signal Sighting Committee...shall consider and decide the most suitable and safe form and position of each signal and associated equipment'*. It makes no reference to other factors that can increase the risk of a SPAD incident occurring. It is noted that although there is a junction ahead of Signal WJ759, with risk of both opposing and converging train movements, no regard was taken of the implications of a SPAD incident at this signal in that a serious overrun may result in a head-on collision. Had the SSC considered all the factors associated with overruns at this signal, it may have put into motion some mitigation to reduce the risk. *It is recommended that Railtrack review their procedures to ensure compliance with their own Group Standard GO/RT 3252 in respect to the convening of SSCs and it is further recommended that the Standard itself be reviewed so that, following multiple SPAD incidents at a given signal, an assessment of ALL risk factors that could contribute to a SPAD incident be considered by the SSC. [Recommendation 2]*

Short overlaps and Standard Signalling Principles (SSP 20)

174. The overlap to Signal WJ759 was 148 m (162 yds). At the time that the resignalling scheme at Watford Junction was designed, the rules relating to the lengths of overlaps were given in SSP 20 (*see appendix 3*). The basic requirement of SSP 20 is that the overlap to a signal shall normally be 183 metres (200 yards) for running signals on passenger lines, but clause 3 of SSP 20 states *'when it is considered essential to avoid restrictions to traffic movements the overlap may be reduced in length. The length of overlap shall be based on the maximum attainable train speed (with no signal restrictions) at a distance of 440 yards on the approach to the signal.'* There then follows a table that shows that for an overlap distance of 150 yards, the maximum train speed allowed is 60 mile/h. The wording of SSP 20 is imprecise and has given rise to different interpretations as to which signal should have the speed restriction on its approach. HMRI's view is that the only acceptable interpretation of SSP 20 is that the signal referred to is the one having the reduced overlap.

175. Correspondence produced at the Railtrack Inquiry showed that there was discussion of the differing interpretations of SSP20 among those involved at the time that the scheme was proposed. 'The signal' was variously thought to be WJ751, WJ755 or WJ759, depending upon how SSP 20 was interpreted. Eventually, it was agreed that the start of the 60 mile/h PSR should be placed 440 yds in rear of the point where a train with the worst braking characteristics would have to start braking from 60 mile/h in order to stop at signal WJ759 and the end of the PSR should be at the point where a driver would first see Signal WJ755. The reasoning behind this decision seems quite sound, as if Signal WJ755 was at yellow, the driver would continue to brake, alternatively, if Signal WJ755 was clear, the driver could accelerate to line speed. The 60 mile/h PSR board was therefore placed at 15m 60ch, and a 80mile/h board was placed at 16m 02ch at the start of Bushey Viaduct. With the benefit of hindsight, this decision was wrong, as it gave drivers the message that they may accelerate, as did the driver of train 2A17, up to 90 mile/h while still approaching Signal WJ759, the signal having the reduced overlap.

176. Had the 60 mile/h PSR sign been placed 440 yards short of Signal WJ759 instead of Signal WJ755, and given the assumption that the driver observed the speed limit in the same way as he observed the PSR south of Bushey station, the accident would, in all probability, have been avoided as the on board data recorder shows that train 2A17 took 338m (370 yds) to come to a stand from 96km/h (60 mile/h). Allowing for a maximum of three seconds for the brake cylinders to apply full brake pressure to the wheels during which time the train would have travelled 80m (88 yds), the overall stopping distance would have been about 418m (458 yds) plus an allowance for driver reaction time, thus making the train stopping point only a short distance past Signal WJ759 and well within the overlap safety margin.

177. It is noted that Railtrack had not taken measures to remove the reduced overlap as indicated to HMRI in 1994 (see Paragraph 155) despite the fact that the problem was first identified within the InterCity West Coast profit centre of BR in 1992 and recommendations for change were made in December 1992. There is no information available on how the extension of the overlap to a standard length was to be achieved although references to changes to the interlocking imply that it was not the intention to reposition the signal gantry carrying Signals WJ757 and WJ759 which would involve additional modifications to signal

positions leading up to these two signals. *It is recommended that Railtrack, following discussion with HMRI, amend the wording of SSP 20 in order to eliminate any ambiguity and to ensure that all persons involved implement the Standard in the same manner. [Recommendation 3].*

178. If signals WJ757 and WJ759 are to remain in the location they were in at the time of the accident and a full length overlap is to be provided, then it follows that points No. 3004 will be in the overlap and therefore must be locked in the normal position prior to signal WJ755 (the signal before Signal WJ759) can be allowed to show a proceed aspect. When the signaller is required to set the route from the Up Slow to the Up Fast at Watford South Junction, thus reversing 3004 points, both Signals WJ759 and WJ755 will have to be set to red and the driver of a train approaching on the down slow will receive a single yellow aspect at Signal WJ751 and a double yellow aspect at Signal WJ167. *It is recommended that Railtrack identify all locations with reduced overlaps, carry out a risk assessment at each one and take appropriate action to mitigate any hazards that may be present. It is further recommended that Railtrack adopt a track layout risk assessment method in order to identify the risk of a collision at specific locations resulting from a signal being passed at Danger, taking into account the pattern of the train service and passenger loading. Railtrack should then identify and prioritise those junctions that may require redesign or the adoption of additional safety measures. [Recommendations 4 & 5]*

Multiple permanent speed restriction boards

179. Presentation of multiple permanent speed restriction boards to drivers of trains on the Down Slow line between Bushey and Watford may be confusing. Evidence from the Sectional Appendices dated February 1989 and April 1991 shows that an 80 mile/h permanent speed restriction was in force on the Down Slow line from 16 miles to 16 miles 20 chains. Given that the line speed was raised to 90 mile/h from 75mile/h at some time in the 1980s, this will also explain the presence of the 90 mile/h speed board at the 16¼ milepost. There is anecdotal evidence that the 80 mile/h speed limit was placed at the time of the raising of the line speed in order to protect Watford viaduct in this area from additional forces placed on it by trains running at the increased line speed of 90 mile/h. *It is recommended*

that Railtrack carry out a full audit of speed restrictions shown in sectional appendices in order to identify locations where conflicting information is provided to drivers. A work programme to remove anomalies should be implemented as soon as possible and a record of the reason why each permanent speed restriction has been applied should be made and used as in Recommendation 1 [Recommendation 6].

Monitoring of drivers

180. It is debatable as to whether general statements of intent by TOCs are sufficiently acceptable to ensure the continuing safety of the rail network. In the NLR Safety Case, there were deficiencies in respect to the robustness of the system of monitoring of incident prone drivers that have been recognised and rectified as far as is reasonably practicable. While it is noted that at the time of the accident, NLR had identified incident prone drivers, the implementation of a plan of action to reduce the number appeared to be unacceptably slow. *It is recommended that NLR provide a programme of action to reduce substantially the number of incident prone drivers. [Recommendation 7]*

181. It is of some concern that in September 1994, Railtrack issued a Group Standard GO/RT 3251 'Safety requirements for train drivers' that required train operators to have systems in place to monitor drivers to establish if they are potentially prone to incidents and yet only three months later BRB issued a detailed Code of Practice BR/BCT 508 'to provide guidance on the provision of systems for identifying 'at risk' drivers'. NLR, in the belief that they were already conforming with the Railway Group Standard, did not take up the BRB Code of Practice. Had this latter document been followed, the passenger train driver would have been identified 'at risk' under the parameters laid down in the BRB Code of Practice.

182. Paragraphs 128 to 138 have highlighted deficiencies in the NLR Safety Case and the fact that their recognition of these has led to a strengthening and reorganisation of their management structure. The divergence of NLR from the code of practice for assessing 'incident prone' or 'at risk' drivers, did not infringe the general intent of their Safety Case. Further inquiries outside the immediate scope of this investigation however, show that other TOCs have differing means of assessing driver competence and liability to incident. There

appears to be little guidance from Railtrack as to whether all TOCs ought to have a standardised and common means of assessing if drivers are incident prone. *It is recommended that Railtrack complete its current round of audits of TOC Safety Cases to ensure compliance with Railtrack's requirements and, with particular reference to driver assessments, introduce measures to ensure that there is a degree of consistency between TOCs. Railtrack should provide guidance where assessments are not considered sufficiently robust. [Recommendation 8].*

183. Monitoring of driver technique and competence relies mainly on traction inspectors carrying out an assessment during a cab ride. It is considered that this procedure is of limited effectiveness as it is more likely that drivers will handle their trains strictly according to the rule book while they are under direct supervision. NLR have confirmed that downloading and interpretation of the on board train data recorder information is not used as a means of checking on driving technique and performance, but is limited to analysis of incidents. *It is recommended that NLR should extend the use of the information obtained from the on board train data recorders to carry out random checks of driving-technique compared with a master profile of correct speed and brake application obtained under closely controlled conditions. [Recommendation 9]*

SPAD Management

184. Despite a small reduction in the high number of SPAD incidents during the past two years, HMRI are concerned that in 1995/96, 676 out of 771 (88%) SPAD incidents were attributable to driver error. It is of interest that during the period 1992 to 1994, when the number of SPAD incidents was running at a constantly high level, that three of the four main reasons put forward (*see para. 139*) could have been addressed by improved training of drivers. *It is recommended that TOCs audit their own SPAD management systems to ensure that driver briefings are effective and that signalling issues that concern drivers are pursued vigorously with Railtrack in order to provide satisfactory solutions. [Recommendation 10]*

185. HMRI do not accept that SPAD incidents are a natural consequence of running a railway, every SPAD is potentially a highly hazardous incident and all reasonably practicable

steps must be taken to prevent them. It is in Railtrack's crucial interest to reduce SPAD incidents, as each one imports a risk onto the infrastructure and can adversely affect the safety and efficiency of other operators. SPAD management systems need to be enhanced to study driver behaviour and seek out underlying causes of SPAD incidents that are not necessarily related directly to driving technique. Railtrack and TOCs should be jointly promoting research into such matters as human behaviour when driving in a repetitive situation. *It is recommended that Railtrack take pro-active ownership of, and develop the SPAD Management Programme formerly undertaken by the BRB Safety Directorate and instigate studies into the human and other factors that result in driver attributable SPAD incidents. [Recommendation 11].*

186. It is of note that Clause 4.5 of GO/RT 3252 is ambiguous in that it states 'Railtrack must communicate mandatory or recommended actions resulting from the investigation of SPAD incidents to all other parties to whom they apply.....'. Railtrack's interpretation of this clause is that they are only required to communicate to the Train Operator who committed the initial SPAD. HMRI interpret this to mean that all Train Operators who use the route should be informed so that they may learn from the experiences of others. It is of concern to learn that NLR were unaware of the two separate SPAD incidents that had occurred at Signal WJ759 in 1994 and 1995 owing to overruns by Rail Express Systems and Railfreight Distribution drivers. *It is recommended that the wording of Group Standard GO/RT 3252 be amended to eliminate ambiguity and to ensure that all TOCs using a railway route are informed of a SPAD incident on that route [Recommendation 12]*

HMRI approval of signalling

187. In considering HMRI's role in approving schemes the basic premise relating to safety on the railways should be restated. This premise is that 'it is the railway operator's responsibility to ensure that the infrastructure is properly designed and is safe for the operations to be carried out upon it, and the methods of operation are, so far as is reasonably practicable, risk free and the whole is maintained to a safe standard.

188. In checking the Watford Junction resignalling proposals, HMRI carried out the assessment of the first signalling plan submitted effectively and promptly. The scheme, as submitted, did not contain any unique features and the technology used was in use throughout the railway network having been approved previously. It was only after the scheme had been commissioned in 1993 that HMRI learned of the reduced overlap protecting an overrun past Signal WJ759 and the imposition of a 60 mile/h PSR as a means of complying with SSP 20. It was not stated where the marker board for the start of the 60 mile/h PSR had been placed as this requirement was covered by SSP 20. Subsequent investigation (*see paras. 174 to 177*) revealed that it had been placed in an inappropriate location and not strictly in accordance with the SSP.

189. In the case of the Watford resignalling, Railtrack took over the responsibility for a signalling scheme that included a reduced overlap and a PSR in accordance with the SSP. The original intention had been for this reduced overlap to be brought up to the norm of 200 yds (183m) at the earliest convenient date. However, action to implement this change was not completed. Unfortunately, the scheme suffered from being planned and executed over a period of six years, during which time there was continual reorganisation of railway businesses. Major changes in the methods of implementing signalling schemes following the Clapham Junction accident and the implementation of the Railways and other Transport Systems (Approval of Works, Plant and Equipment) Regulations 1994 that replaced the 1933 Act approval process may also have been factors that have caused delay.

190. The 1994 Regulations have recognised the need to sometimes bring changed signalling systems into use prior to the approval being given in order to enable train services to be maintained. The Regulations contain specific powers that allow a railway to do this. HMRI have recently put in place a computer based tracking system for approvals that should ensure that any delays are readily identified and appropriate action taken.

191. Improved methods of highlighting changes in proposal details, particularly those where safety may be compromised, need to be incorporated on drawings, plans and written submissions to HMRI. *It is therefore recommended that Railtrack review all current*

resignalling works inherited from BRB to ensure that the designs are safe and comply with appropriate Group and Signalling standards. [Recommendation 13]

Automatic Train Protection

192. Following the train accident at Clapham Junction on 12 December 1988 and the public inquiry chaired by Sir Anthony Hidden, British Rail undertook to examine and pilot a system of Automatic Train Protection (ATP) aimed at preventing accidents arising from trains overspeeding and passing signals at danger.

193. Two pilot schemes were implemented, and in March 1994 BR submitted a report to the Secretary of State for Transport describing the results. The main conclusion was that ATP was too expensive to be adopted generally on the railway system and that the money saved would be better spent addressing other safety risks, and in its advice to the Secretary of State for Transport the HSC accepted this as a reasonable conclusion. In setting out its alternative strategy to the nation-wide fitment of ATP, Railtrack undertook, among other things, to consider the inclusion of ATP in future major re-signalling schemes.

194. The HMRI report into the accident at Cowden on 15 October 1994 further refined this by recommending that where a major re-signalling scheme does not have a proposal for fitting ATP it should be demonstrated that it has been considered for fitment later and is accompanied by a risk assessment of the measures selected for the mitigation of SPADs until ATP is fitted. Railtrack have yet to accept this recommendation from the Cowden Report.

195. There is no doubt that had ATP been fitted and functioning on both track and trains at Watford the accident would have been prevented. There are plans to carry out a wide-ranging modernisation and upgrading of the West Coast Main Line infrastructure, which will include the re-signalling of the route. *It is recommended that whatever the form of new signalling provided in conjunction with the modernisation and upgrading of the WCML, Railtrack should reaffirm its existing commitment for ATP to be incorporated in the scheme for both track and trains using this route. [Recommendation 14]*

196. In place of ATP, a range of other measures has been proposed within a project known as Signals Passed at Danger Reduction and Mitigation (SPADRAM). One of these is the development of a Train Protection and Warning System (TPWS) which could replace the current AWS system fitted to rolling stock. In addition to the functions provided by AWS, TPWS would provide train stop and red signal speed trap facilities. The red speed trap would prevent those SPADs where the speed of the train at the trap was just above the permitted level, and where the emergency braking rate and available adhesion were sufficient to bring the train to a stand before the signal that is showing a Danger aspect.

197. TPWS can be expected to prevent some, but not all, accidents of this type. It is an open question as to whether TPWS would have prevented the accident at Watford Junction had it been fitted. *It is nevertheless recommended that Watford South junction be assessed as a priority to determine whether the fitment of TPWS can be justified as an interim measure pending full re-signalling of the line with the incorporation of ATP. [Recommendation 15]*

198. The other principal solution arising from the SPADRAM study is the driver reminder appliance (DRA). This is designed to protect the driver from starting away from a red signal, typically at stations, where in the past accidents have resulted from the guard having given the 'right away' authority to the driver with the signal at red, and the driver has then set off without checking the aspect of the signal. Trials of the device have been made where, on coming to rest at a red signal, the driver applies the DRA which then prevents power being applied. When the signal clears, the driver must disengage the DRA. It will be seen therefore in the circumstances giving rise to the accident at Watford that even if driver reminder appliances had been fitted to the trains involved, the accident would not have been prevented.

199. It is a basic principle of Health and Safety legislation that 'reasonably practicable' is a term that requires the degree of risk to be placed on one side of the scale and the sacrifice, whether in money, time or trouble, required to avert the risk be placed on the other side. If there is a gross disproportion between the two sides and the risk is insignificant in relation to the sacrifice, the person upon whom the duty lies can assert that compliance with legislation is not reasonably practical.

200. BRB's report (see para. 193) showed that the provision of network wide ATP as piloted was not a cost effective solution to enhancing railway safety. However with the immediate, visible costs of this accident running into several millions of pounds and the hidden costs likely to multiply this figure several fold, it is appropriate that Railtrack uses data from this accident to verify costs previously calculated and reviews the cost benefit analysis supporting its train protection strategy making full use of this new data. A determination of the true costs of this accident ought to be used to assess whether or not ATP is cost effective. Any revised costs of the fatal accident at Cowden on 15 October 1994 that would also have been prevented had ATP been fitted ought also to be taken into account. The case for the wide-spread provision of ATP throughout the railway system may be found to be stronger than formerly supposed. *It is recommended therefore that Railtrack evaluates the full cost of this accident and other recent accidents that could have been prevented by ATP and review whether this affects the cost benefit assessment that determined its train protection strategy. [Recommendation 16]*

Crashworthiness and Bogie Retention

201. The circumstances of the accident were such that an almost head-on collision occurred at a closing speed of 80 km/h (50 mile/h) and the passenger train weighing 142 tonnes plus the weight of approximately 200 passengers (estimated to be about 13 tonnes) was pushed backwards about 25m (27 yds) by the ECS train weighing 284 tonnes. Considering also that the front coach of the passenger train was turned onto its side and a substantial part of the bodyside of the second coach was ripped out by the overriding ECS train, (*see photos Nos. 2 & 5*) then the high passenger survival rate is noteworthy and is due in no small part to the inbuilt crashworthiness of the type 321 units.

202. The crashworthiness of this relatively modern rolling stock is extremely favourable when compared with older rolling stock and must be the main contributory reason for the high survival rate in the circumstances. Examination of the trains revealed that apart from extensive damage and crumpling of the left hand side of both driving cabs and the tearing out of the bodyside of the second coach of the passenger train, the units were relatively unscathed.

203. Displaced objects appeared to be limited to seat backs, seat cushions and fluorescent light fittings. The likelihood of padded seat backs and cushions causing injury to passengers is considered remote, but sharp edged fluorescent lighting diffusers and other similar fittings flying through the coach are potentially dangerous. It was noted that the retention of these items was, for the reasons of easy maintenance, minimal and in most cases by means of a fragile spring clip. *It is recommended that owners of rolling stock carry out an assessment of the methods of retention and of the integrity of interior of internal fittings under crash conditions and take measures as far as reasonably practicable to ensure that they are retained in a secure manner. [Recommendation 17].*

204. There are always lessons to be learned from an accident causing damage to rolling stock that are of value to designers and engineers. To investigate this further, HMRI have sent a questionnaire to all of the passengers identified by BTP as being on the train at the time of the collision in order to establish how their injuries were caused. The results of the survey will take a considerable time to analyse and will be discussed with the industry.

205. A hypothesis of the sequence of events based on the final location of the coaches and bogies immediately after the incident has deduced that four bogies became detached from their parent vehicles during the collision and a fifth was retained only by an anti-rollbar connection. Furthermore, the deposition of one of these bogies on the track may well have been the means whereby the second coach of the ECS train reared up and caused substantial damage to the second coach of the passenger train and then demolished an OLE gantry. Bogie retention is a wide ranging subject for study and work is already being carried out in the railway industry. The Health and Safety Laboratory (HSL) have been asked to carry out a study into bogie retention for this type of EMU stock and the HSL work will add to the fund of knowledge that is being accumulated. *It is recommended that owners of rolling stock study the HSL report on bogie retention when published and where reasonably practicable carry out a modification programme in accordance with any recommendations made in that report. [Recommendation 18]*

The on board train data recorders

206. There are some 600 data recorders fitted to modern rolling stock in operation in the U.K. and anecdotal evidence from the W S Atkins NTES consultants is that failures have been extremely rare during the past four years. This indicates that it is normally a very reliable piece of equipment.

207. Although five out of six on board train data recorders were found to be working perfectly when downloaded following the accident, it was unfortunate that the data recorder that was not functioning properly was the one that would have provided evidence of the sounding and cancelling of the AWS warning horn when train 2A17 passed signals WJ751 and WJ755. This data recorder was not receiving a signal from the wheel mounted pulse generator due to an intermittent fault that was eventually reproduced under controlled conditions at Bletchley TMD. The maintenance regime for on board train data recorders is based on a well-established record of reliability and it should be noted that the recorder was actually working earlier on the day of the accident. The failure of the pulse generator to provide a signal could not be detected whilst the train was running as there is no monitoring system in place on 321 units. NLR have, since the incident, amended their maintenance regime to reduce the periodicity of downloading of information from six-monthly to three-monthly. NLR are also examining with the Rolling Stock Leasing Company, the feasibility and cost of providing in-cab information to drivers of an on board train data recorder failure.

208. It was noted in para. 59 that apart from cab specific information, the data recorded by both recorders on a four car unit is identical. It would be advantageous to have both recorders able to record a full set of identical data so that in the rare event of one of them failing, the essential data would be available on the other one. This may be preferable to providing an indication to the driver that the recorder linked to the cab he is working has failed, as this situation cannot be rectified until the unit returns to the TMD for maintenance and the likelihood of a double failure is extremely remote. *It is recommended that owners of rolling stock evaluate the possibility of linking both cab recorders on four car units to provide identical information. [Recommendation 19].*

Braking systems and controls

209. It is of some concern that the completion of conversion of the NLR fleet of class 321 units to 12%g braking is of such extended timescale. It is a reasonable assumption that 12%g braking would have brought train 2A17 to a stand more quickly and possibly before the fouling point with the oncoming ECS train was reached, although signal WJ759 would still have been overrun by some distance. *It is recommended that NLR explore means whereby the conversion of class 321 units to 12%g braking can be completed in the shortest possible timescale [Recommendation 20]*

Post accident procedures for signalling technicians

210. The evidence available from the SSI data logger proved essential in the investigation following the accident. While there is no suggestion that the evidence obtained from the recording tape recovered from the data logger in the SSI had been modified or tampered with in any way, the signalling technicians at Watford PSB carried out recovery without an independent presence monitoring the trail of this piece of evidence. The action they took was correct according to their instructions as defined in BRB Group Standard GO/OT 0004 Appendix D5 as it is necessary to recover the records as soon as practicable to minimise the risk of loss owing to equipment malfunction.

211. However it is considered that the current procedure should be modified when a major incident occurs involving serious injuries to persons or extensive damage to either the infrastructure or rolling stock. A procedure should be identified that requires an independent party to observe the recovery of the data recording tape and to act as its custodian pending the arrival of BTP on the scene at which time it should be placed in their care so that the person removing the tape is protected against any accusation of tampering with the content. The downloading of the original should only be carried out under the supervision of an enforcement agency. *It is recommended that Railtrack modify Group Standard GO/OT 0004 to reflect the necessity of protecting evidence provided by data recorders following a fatal or major accident or collision. [Recommendation 21]*

Performance of traincrew

212. Numerous passengers stated that the trainman/guard of the passenger train took prompt action in protecting the train from any following trains and despite being injured himself, attended to and reassured his passengers as far as he was able. His actions in carrying out his duties efficiently in a stressful situation are commendable.

213. The trainman/guard of the ECS train, while acting contrary to section 6.1.6(b) of the Passenger Guard Rule Book GO/RT 3006 in travelling with the driver in the leading cab, appears not to have distracted the driver from his duties or affected the circumstances of the collision. However, Train Operating Companies must take positive steps to discourage this practice.

The involvement and performance of the emergency services

214. Fortunately, the accident scene was easily accessible to public highways and none of the emergency services had far to travel. In accordance with well-established practice and using the experience of numerous emergency exercises, a command post was set up within a very short time and assistance was rendered on site to those with minor injuries, the more seriously injured being taken to Watford General Hospital. It is an indication of the efficiency of the operation that by 1958 hrs, approximately one and a half hours after the arrival of the first of the emergency services, all the injured had been either treated on site or had been safely conveyed to Watford General and other hospitals.

215. The Bedfordshire and Hertfordshire Ambulance service received the first 999 call at 1724. Vehicles and officers arrived within a few minutes where paramedics proceeded with their task of attending to the injured. 66 persons were transported to Watford General Hospital by ambulance and one seriously injured person was taken to the London Hospital by air ambulance.

216. The Hertfordshire County Council Fire and Rescue Service received five separate 999 calls at 1726. The first of the rescue appliances arrived at the scene of the collision at 1733

where, having been informed almost immediately by the railway authorities that the power from the OLE was off, officers proceeded to enter the first coach of the passenger train followed by paramedics who removed the injured from the coaches. As further Fire and Ambulance personnel arrived, they were deployed into the second, third and fourth coaches to assist with evacuation and first aid requirements. Rescue of the passengers was effected quickly and stability of two coaches overhanging the embankments was also achieved by means of winches and wire ropes. The ECS coach that had risen up was secured by steel props.

217. The Hertfordshire Constabulary log shows that a 999 call was received at 1724 and at 1727 the first mobile fast response unit was on site and a forward control point was immediately set up. Within minutes, the Hertfordshire Constabulary put their Major Incident Procedure into place in order to control traffic and onlookers, speed the flow of ambulances, free trackside access for authorised persons and generally ensure that the area was properly secured and controlled. A police helicopter carrying a thermal imaging camera was mobilised from Luton at 1739. This was used during the early stages of the incident to search the embankments to ensure that there were no injured passengers buried in the thick undergrowth unable to be seen by the ground rescue services.

218. The British Transport Police were alerted by means of a telephone call from the Watford PSB at 1735. Within minutes of the arrival of BTP, inter-agency meetings had been arranged and continued throughout the night. The prompt arrival of HMRI field inspectors also assisted BTP in advising on the preservation and protection of vital evidence such as the on board train data recorders.

219. The Watford General Hospital was alerted at 1806 that a serious accident had occurred and immediately put its major incident procedure into place thus ensuring that medical and auxiliary staff were in the hospital treating the injured as they arrived by ambulance. Social Services and voluntary services were also on hand to dispense advice and comfort as needed. The accident receiving officer records that a total of 68 persons were received at the hospital of whom 14 were detained overnight.

220. Internal debriefings and the observation of HMRI inspectors at the scene of the accident concluded that all the emergency services performed to a very high standard and there was an excellent spirit of co-operation amongst them. During the critical hours following the collision the value of multi-functional emergency exercises organised by BTP and others was well proven.

221. This section of the report would be incomplete if the work of the Women's Royal Voluntary Service were not recognised. Within a very short time, this organisation was alerted through the emergency planning procedures of the Local Authority and had set up a facility next to the Police Command Post where they dispensed hot drinks, snacks and words of comfort to rescuers and rescued alike. No praise can be too high for these ladies who performed admirably for long periods without payment of any sort other than seeing the satisfaction of a well worth-while job carried out quietly and efficiently.

Data Protection Act 1984

222. HMRI were unable to obtain names and addresses of those taken to hospital once their names had been electronically stored on the hospital records. Railtrack, who have a statutory duty under the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 to report passenger injuries were equally prevented from doing so by the Data Protection Act 1984 that generally precludes the release of information to parties other than those specifically nominated in the Act.

Health and Safety Legislation

223. Both Railtrack and NLR are subject to the Health and Safety at Work etc. Act 1974 for which the HSE is the enforcing authority. The HSW Act contains general duties on employers towards employees, members of the public and others. Sections 2 and 3 require that employers shall ensure, as far as is reasonably practicable, the health, safety and welfare of their employees and others who are not in their employment and who could be affected by their actions. Section 7 of the HSW Act place duties on employees to take reasonable care for the health and safety of themselves and of other persons who may be affected by their acts

or omissions, also to co-operate with their employer to ensure that duties laid down are complied with. Section 8 of the HSW Act places a duty on employees not to recklessly interfere with or misuse anything provided in the interests of health, safety or welfare.

234. The Management of Health and Safety at Work Regulations 1992 require suitable and sufficient assessments of the risks arising from the conduct of an undertaking to be made and appropriate measures to be put into place to plan, organise, monitor and review those measures including the procedures to be carried out in emergencies.

235. The Railways (Safety Case) Regulations 1994 require train operators and railway infrastructure controllers to have an accepted safety case in place. These regulations also require the different parties involved in an accident to co-operate with the infrastructure controller in his own inquiry into the cause of an accident.

236. All those who build, own, maintain or operate railway vehicles have legal obligations of one sort or another concerning the safety of those vehicles and all need to be aware of the lessons learned from this incident and act appropriately. Infrastructure Controllers need, in turn, to be satisfied that vehicles that they allow to come onto their network do not import risk.

237. A prosecution of the driver of 2A17 was initiated by the CPS, but it is considered that there is insufficient evidence of breaches of other legislation serious enough to justify legal proceedings against any of the other parties involved. As far as NLR is concerned, considerable improvements to their systems were being and have continued to be made. The use of HSE's formal enforcement powers has not, to date, been considered.

RECOMMENDATIONS

241. Some of the recommendations that follow require a review of existing procedures, there is also longer term investigation work in respect to analysis of injuries to passengers and how they were incurred, along with the work being carried out by HSL in relation to bogie retention. HMRI will continue to monitor all items that are not complete at the time of publication of this document.

242. The recommendations that follow are not solely targeted at Railtrack and NLR, but also at all those who build, own, operate or maintain railway vehicles and who have duties under their Safety Cases. Notwithstanding that, most of the recommendations require Railtrack, as the Infrastructure Controller to take on a pro-active and co-ordinating role so that they can be satisfied that risk is being properly controlled on their infrastructure by the train operators and others:

- 1 Railtrack to consider providing information in sectional appendices and traffic notices to identify reasons for permanent speed restrictions. (*Paras. 166 & 167*)
- 2 Railtrack to review their procedures to ensure compliance with their own Group Standard GO/RT 3252 in respect to the convening of SSCs and that the Standard itself be reviewed so that following multiple SPAD incidents at a given signal, an assessment of ALL risk factors that could contribute to a SPAD incident be considered by the SSC. (*Paras. 170 to 173*)
- 3 Railtrack, following discussion with HMRI, to amend the wording of SSP 20 in order to eliminate any ambiguity and to ensure that all persons implement the Standard in the same manner. (*Paras. 174 to 177*)
- 4 Railtrack to identify all locations with reduced overlaps, carry out a risk assessment at each one and take appropriate action to mitigate any hazards that may be present. (*Para. 178*)
- 5 Railtrack to adopt a track layout risk assessment method in order to identify the risk of a collision at specific locations of a collision resulting from a signal being passed at Danger, taking into account the pattern of the train service and passenger loading.

- Railtrack should then identify and prioritise those junctions that may require redesign or the adoption of additional safety measures. *(Para. 178)*
- 6 Railtrack to carry out a full audit of speed restrictions shown in sectional appendices to identify locations where conflicting information is provided to drivers. A work programme to remove anomalies should be implemented as soon as possible and a record of the reason why each permanent speed restriction has been applied should be made and used as in Recommendation 1. *(Para. 179)*
- 7 NLR to provide a programme of action to reduce substantially the number of incident prone drivers. *(Para. 180)*
- 8 Railtrack to complete its current round of audits of all TOC safety cases to ensure compliance with Railtrack's requirements and, with particular reference to driver assessments, introduce measures to ensure that there is a degree of consistency between TOCs. Railtrack should provide guidance where assessments are not considered sufficiently robust. *(Paras. 181 & 182)*
- 9 NLR to extend the use of the information obtained from the on board train data recorders to carry out random checks of driving technique compared with a master profile of correct speed and brake application obtained under closely controlled conditions. *(Para. 183)*
- 10 TOCs to audit their own SPAD Management systems to ensure that driver briefings are effective and that signalling issues that concern drivers are pursued vigorously with Railtrack in order to provide satisfactory solutions. *(Para. 184)*
- 11 Railtrack to take pro-active ownership of, and develop the SPAD Management Programme formerly undertaken by the BRB Safety Directorate and to instigate studies into the human and other factors that result in driver attributable SPAD incidents. *(Para. 185)*
- 12 Railtrack to amend the wording of Group Standard GO/RT 3252 to eliminate ambiguity and to ensure that all TOCs using a railway route are informed of a SPAD incident on that route. *(Para. 186)*
- 13 Railtrack to review all current resignalling works inherited from BRB to ensure that the designs are safe and comply with appropriate Group and Signalling Standards. *(Paras. 187 to 191)*

- 14 Whatever the form of new signalling provided in conjunction with the modernisation and upgrading of the WCML, Railtrack should reaffirm its existing commitment for ATP to be incorporated in the scheme for both track and trains using this route. *(Paras. 192 to 195)*
- 15 Railtrack to carry out an assessment of Watford South junction as a priority to determine whether the fitment of TPWS can be justified as an interim measure pending full re-signalling of the line along with the incorporation of ATP. *(Paras. 196 & 197)*
- 16 Railtrack to evaluate the full cost of this accident and other recent accidents that could have been prevented by ATP and review whether this affects the cost benefit assessment that determined its train protection strategy. *(Para. 200)*
- 17 Owners of rolling stock to carry out an assessment of the methods of retention and of the integrity of interior fittings under crash conditions and take measures as far as is reasonably practicable to ensure that they are retained in a secure manner. *(Para. 203)*
- 18 Owners of rolling stock to study the HSL report on Bogie Retention when published and, where reasonable, carry out a modification programme in accordance with any recommendations made in that report. *(Paras. 204 & 205)*
- 19 Owners of rolling stock to evaluate the possibility of linking both recorders on four car units to provide identical information. *(Para. 208)*
- 20 NLR to explore means whereby the conversion of class 321 units to 12%g braking can be completed in the shortest possible timescale. *(Para. 209)*
- 21 Railtrack to modify Group Standard GO/OT 0004 to reflect the necessity of protecting evidence provided by data recorders following a fatal or major accident or collision. *(Paras. 210 & 211)*

FURTHER ACTION

243. HMRI will expect to receive action plans from Railtrack and NLR within two months of the issue date of this report. These should describe how Railtrack and NLR intend to satisfy the recommendations that relate to them or be satisfied that alternative measures will meet them. The responses should propose a timescale for the completion of the work required. Inspectors from HMRI will monitor the progress made in satisfying the recommendations to the agreed timescale and ensure that they are carried out.

APPENDIX 1

Extracts from the Railtrack Safety Case (as of August 1996)

NOTE! These extracts are in some cases part of the paragraph referenced.

- 4.13 As the Infrastructure Controller of the Railway Group, Railtrack has statutory obligations to manage safety on the system overall and consequently Railtrack inherited the continuation of a directing mind for safety within the restructured industry.
- 4.15 A vital process employed by Railtrack to ensure that unacceptable risk is not imported onto the railway system is Railtrack's scrutiny of new operators arrangements for safety. In particular Railtrack ensures that all operators intending to come onto its system adopt standards that ensure compatibility and safety of operation.
- 6.6 Key safety issues relating to infrastructure, rail vehicles and operations are given in Appendix 6.1. These key safety issues align with the revised 'Railway Safety Principles and Guidance' proposed by HMRI. Standards, previously Group Standards, addressing these key safety issues have been developed through the Railway Group Standards processes for ensuring safety and safe interworking. Appendix 6.1 states that signalling must prevent conflicting movements and provide protection from 'obstructions'. May also provide speed control and operational information (covered by a range of signalling principles).
- 7.1 Railtrack accepts that as Infrastructure Controller it has prime responsibility for the safety and security of the railway.
- 7.28 Railtrack is responsible for the design, installation and maintenance of track, signalling, electrification systems, level crossings and operational buildings, tunnels, viaducts, bridges and other such structures together with the major stations.
- 7.30 Railtrack conforms with Railway Group Standards as mandatory technical documents. These standards determine design, installation, testing and commissioning, and maintenance requirements.
- 10.15.1 Railtrack aims to ensure effective and successful communications to provide accurate information at the right time to those who need to know and to ensure that there is an

appropriate level of awareness and comprehension among the recipients. It is a two way process and therefore everyone has a responsibility to ensure this is carried out.

10.15.22 Railtrack advises all organisations that interface with it, the type of safety information to be passed to Railtrack, the timescales and methods to be used.

10.15.23 Railtrack ensures that all parties employed on business on or about its controlled infrastructure are informed of the additional hazards and risk presented by that environment.

11.3 Railtrack seeks to ensure that no-one undertakes safety critical duties unless fit to do so.

10.10.1 Railtrack ensures that all projects that significantly change the design of the infrastructure are designed, planned, constructed and implemented in accordance with statutory requirements.

BRITISH RAILWAYS
(INTER-CITY WEST COAST)

Watford Resignalling
Special Notice 25E

**NOTICE TO DRIVERS, GUARDS,
SIGNALMEN AND OTHERS CONCERNED
RESPECTING THE PROVISION OF NEW JUNCTIONS
AND SIGNALLING IN THE
WATFORD AREA**

IMPORTANT – This Notice to be acknowledged immediately on receipt to "Operating OD14 Crewe" using the code "ARNO 25E"

The altered permanent way layout and signalling will be as shown on the attached diagram and list of routes.

The up slow line will be signalled in both directions between Watford North and South Junctions.

Permanent Speed Restrictions

The existing 75 mph permanent speed restriction over the down and up slow lines through Watford will continue to apply.

The following permanent speed restrictions will apply through the new connections at Watford North and South Junctions.

<i>Route</i>	<i>Speed</i>	<i>At</i>
Down Fast to Down Slow	50 m.p.h.	Watford South Junction
Down Slow to Up Slow	50 m.p.h.	between 16m. 78chs. and
Up or Down Slow to Up Fast	50 m.p.h.	17m. 13chs.
Up Fast to Up Slow	50 m.p.h.	Watford North Junction
Up Slow (down direction) to Down Slow ...	50 m.p.h.	between 17m. 66chs. and
Down Slow to Down Fast	50 m.p.h.	18m. 01chs.

There will be no increase in speed through any other connections at Watford.

Flashing yellow aspects will be displayed at the signals detailed below and will apply to the route shown (see Rule Book, Section C, clauses 3.1.1 and 3.1.2).

<i>Line</i>	<i>Flashing double yellow at signal</i>	<i>Flashing single yellow at signal</i>	<i>Indicates steady single yellow at</i>	<i>Jn. indicator displayed</i>
Down Slow	WJ.755	WJ.759 (Down Slow to Down Fast at Watford North Jn.)	WJ.767	Pos. 1
Down Fast	WJ.749	WJ.753 (Down Fast to Down Slow at Watford South Jn.)	WJ.757	Pos. 4
Up Slow	WJ.768	WJ.764 (Up Slow to Up Fast at Watford South Jn.)	WJ.750	Pos. 4
Up Fast	WJ.182	WJ.766 (Up Fast to Up Slow at Watford North Jn.)	WJ.762	Pos. 1

Signal WJ.766 (up fast) and Signal WJ.768 (up slow) in Watford Tunnel are additional 4-aspect signals.

Signal WJ.761 (down fast) and Signal WJ.758 (up fast) are additional 3-aspect signals to allow trains to be brought close to Watford Junction Station when the platform line concerned is still occupied by the previous train. When Signal WJ.761 or WJ.758 is at Danger, the signal next in rear will not clear until the train has been brought quite or nearly to a stand.

The meaning of steady double yellow aspects will be as follows:—

<i>Line</i>	<i>Steady double yellow aspect at signal</i>	<i>Indicates line is clear to signal</i>	<i>Braking distance</i>
Down Fast	WJ.749	WJ.757	2346 yards
	WJ.753	WJ.765	2120 yards
	WJ.757	WJ.775	2684 yards
Down Slow	WJ.751	WJ.759	2346 yards
	WJ.755	WJ.767	2120 yards
	WJ.759	WJ.777	2583 yards
Up Fast	WJ.186	WJ.766	2657 yards
	WJ.182	WJ.762	2665 yards
	WJ.766	WJ.748	2402 yards
	WJ.762	WJ.744	2940 yards
Up Slow	WJ.72	WJ.768	2660 yards
	WJ.183	WJ.764	2705 yards
	WJ.768	WJ.750	2325 yards
	WJ.764	WJ.746	3008 yards

“Ready to Start” Indicators

“Ready to Start” “R” indicators will be provided on the following platform starting signals.

<i>Platform</i>	<i>Signal</i>
No. 8	WJ.756 (south end)
No. 9	WJ.769 (north end)
No. 10 (Bay Platform)	WJ.754

Signal post telephones will be provided at all signals capable of showing a red aspect.

LIST OF SIGNAL ROUTES - Main running signals with more than one route indication.

SIGNAL	ASPECT	JUNCTION INDICATOR	ROUTE TO
WJ.748	PL	-	Sidings *(see footnote)
	M	Pos.1	Up Slow *(see footnote)
	M	-	Up Fast
WJ.750	M	-	Up Slow
	M	Pos.4	Up Fast
WJ.754	PL	-	Sidings
	M	-	Up Slow
	M	Pos.4	Up Fast
WJ.756	PL	-	Sidings
	M	Pos.1	Up Slow
	M	-	Up Fast (via B crossover)
	M	-	Up Fast (via C crossover)
WJ.757	M	-	Down Fast
	M	Pos.4	Down Slow
	M	Pos.5	Platform 10
WJ.759	M	Pos.1	Down Fast *(see footnote)
	M	-	Down Slow
	M	Pos.4	Up Slow
	M	Pos.5	Platform 10
	PL	-	Sidings
WJ.762	M	Pos.1	Up Slow
	M	-	Up Fast
WJ.767	M	Pos.1	Down Fast
	M	-	Down Slow
WJ.769	M	Pos.1	Down Slow
	PL	-	Sidings

* This signal route will not be brought into use until further notice.

LIST OF SIGNAL ROUTES - Position light shunt signals.

SIGNAL	ASPECT	INDICATION	ROUTE TO
WJ.2001	PL	DF	Down Fast *(see footnote)
	PL	DS	Down Slow
	PL	US	Up Slow
	PL	10	Platform 10
	PL	SG	Sidings
WJ.2002	PL	NK	Along Siding
	PL	US	Up Slow
	PL	UF	Up Fast
WJ.2003	PL	-	Down Fast *(see footnote)
	PL	-	Down Slow
	PL	-	Platform 10
	PL	-	Along Siding
WJ.2004	PL	NK	Sidings
	PL	US	Up Slow
	PL	UF	Up Fast (via B crossover)
	PL	UF	Up Fast (via C crossover)
WJ.2005	PL	-	Down Fast
WJ.2006	PL	DS	Down Slow *(see footnote)
	PL	UF	Up Fast
	PL	SG	Tip Siding
	PL	DC	Up DC Electric
WJ.2007	PL	-	Down fast
WJ.2009	PL	-	Along Up Fast
WJ.2014	PL	NK	Neck
	PL	US	Up Slow
WJ.2016	PL	DS	Down Slow
	PL	UF	Up Fast
	PL	DF	Down Fast
WJ.2018	PL	US	Up Slow
	PL	DS	Down Slow

* This signal route will not be brought into use until further notice.

BRITISH RAILWAYS BOARD

STANDARD NO. 20
SIGNALLING
PRINCIPLEDirector of S & T Engineering
Ref: 206-66-12Director of Operations
Ref. MM/S/3/20

OVERLAPS

In colour light signalling territory overlaps shall be provided and controls effected in accordance with the following:-

1. Separate overlap track circuits shall be provided at the following types of signal:-
 - a. Controlled signal protecting connections.
 - b. Controlled signal performing other interlocking functions e.g. swing bridge, flat crossing, interlaced track etc.
 - c. Controlled signal protecting manually controlled level crossing.
 - d. Controlled signal for which route locking has been provided.
 - e. ALL types of signal where permissive movements are permitted to approach the signal.
 - f. Semi-automatic signal if it satisfies any one of 'a' to 'e' above.

The berth and overlap track circuits of automatic signals shall normally be combined except as shown in 'e' above and certain signals which protect automatic level crossings (see level crossing principles).

2. The minimum overlap length shall normally be 200 yards for running signals on passenger lines.

Normally no overlaps shall be provided on goods lines where the line speed is 40 m.p.h. or less, but there may be operating circumstances that require special application. In all cases where the line speed exceeds 40 m.p.h. overlaps shall be provided as if the line were a passenger one.

Continued....

3. When it is considered essential to avoid restrictions to traffic movements the overlap may be reduced in length. The restriction shall be based on the maximum attainable train speed with no signal restrictions at a distance of 440 yards on the approach to the signal, in accordance with the following table:-

<u>Speed Not Exceeding</u>	<u>Minimum Overlap Distance</u>
15 m.p.h.	50 yards
20 m.p.h.	60 yards
25 m.p.h.	65 yards
30 m.p.h.	75 yards
35 m.p.h.	80 yards
40 m.p.h.	90 yards
45 m.p.h.	100 yards
50 m.p.h.	115 yards
55 m.p.h.	135 yards
60 m.p.h.	150 yards

4. Trailing points in the overlap and opposing signals applying to the overlap, must be locked until the route and route locking are normalised. The overlap shall be released, if the route locking is the only locking holding the overlap, after the exit signal berth track circuit is occupied for such time that the train has come to stand [see S&T drawing BRS-SW67-2E]. This release shall be ineffective if the overlap is occupied.
5. Facing points in the overlap may only be moved if an alternative overlap is available. When an overlap is extended beyond the minimum length required, to avoid providing another track circuit, then facing points positioned beyond the minimum overlap length need not be proved as part of the overlap (see appendix 'A' points 706).
6. When facing points within the required length of overlap lead from a passenger line into a goods line or siding then the overlap shall set along the passenger line unless a route is set for the next train into the goods line or siding (or the points have been locked on the individual point switch). This requirement does not apply when the track leading to the goods line or siding is of the required overlap length and proved to be clear and protected by trap points. Appendix 'A' shows examples of acceptable overlaps.
7. Facing trap points in an overlap shall normally be required set locked and detected reverse [closed] whenever the overlap is locked. Trap points equipped with a sand drag may remain normal [open] when the overlap is locked provided the required overlap distance is available within the sand drag or the sand drag is designed such that it will safely arrest any likely unauthorised movement which passes the protecting signal at danger. Appendix 'B' illustrates the controls required for facing trap points in overlaps.

8. Where restricted approach (delayed yellow aspect) arrangements are required for operating purposes, points within a minimum distance of 50 yards beyond the next signal to be locked to prevent a crossing movement taking place.

It is NOT essential to provide a separate track circuit to prove the 50 yards restricted overlap is clear; if a track circuit has been provided for other reasons this shall be proved clear, provided doing so does not restrict essential traffic movements.

If a separate restricted overlap track circuit is not proved clear in the rear signal controls special care is required to ensure that the signal in rear cannot clear [even momentarily] to an aspect less restrictive than caution [delayed yellow] when a train has passed the signal with the restricted overlap [see SSP 62].

9. When a route with a restricted overlap and delayed aspect clearance is selected this shall be automatically stepped up to a full overlap with the appropriate aspect clearance, provided that :- the signal has not yet cleared; there is no train in the route; a route is set from the exit signal and that signal is not disengaged; and the full overlap is clear. The full overlap shall then be locked until the route which requires the overlap is restored to normal and the route and overlap track circuit locking is released.

If a signal with an individual automatic working facility which applies to a route with a delayed clearance and restricted overlap is set to work in automatic mode for that route then it shall step up to a full overlap subject to the appropriate conditions as specified above. In addition it shall revert to the restricted overlap conditions following the passage of the train for which the full overlap conditions applied.

APPENDIX 4

Interpretation of Hasler Data

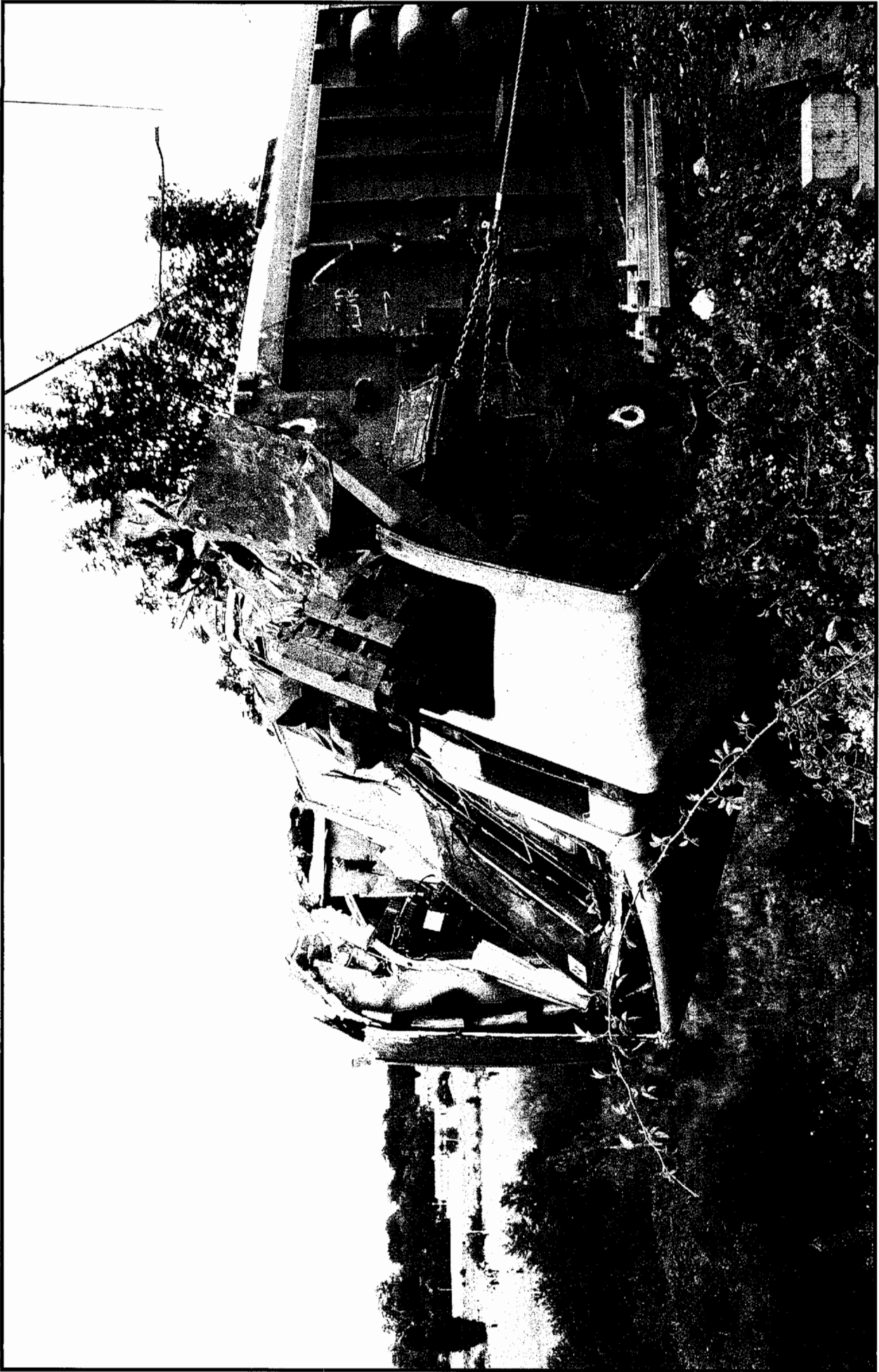
Vehicle 77962 (rear coach of passenger train)

1. Data starts at departure from Harrow and Wealdstone station at 39.642 miles. (All figures are rounded to 3 decimal places, one thousandth of a mile being 1.76 yds)
2. Total distance travelled from Harrow and Wealdstone Station to point of impact is 45.307 - 39.642 = 5.665 miles.
The actual distance from the mid point of Harrow and Wealdstone station (11 miles 30 chains = 11.375 miles) to signal WJ759 located at 16m 1551 yds(16.88 miles) is 5.505 miles.
3. The distance past WJ 759 at point of impact is therefore recorded as 5.665 - 5.505 = 0.16 miles = 281 yards.
4. The actual point of impact measured on site was 222 yards beyond signal WJ 759, a difference of 59 yards from that shown on the data recorder.
5. The difference between the actual and recorded impact points is within acceptable limits and can be accounted for by the fact that the diameter of the wheelset from which the Hasler recorder took its data was not exact ,as the data recorder had not been recalibrated at the previous service in Bletchley TMD.
6. However given that the difference of 59 yards (.033 miles) in a distance travelled of 5.505 miles is a an error of 0.6%, the mileage data can be considered acceptable.
7. For the purposes of data interpretation, 45.307 miles is reckoned to be actual point of impact, i.e. at 17m 13yds - 222 yards past the location of signal WJ 759.
8. Locations of signals etc are therefore calculated as:

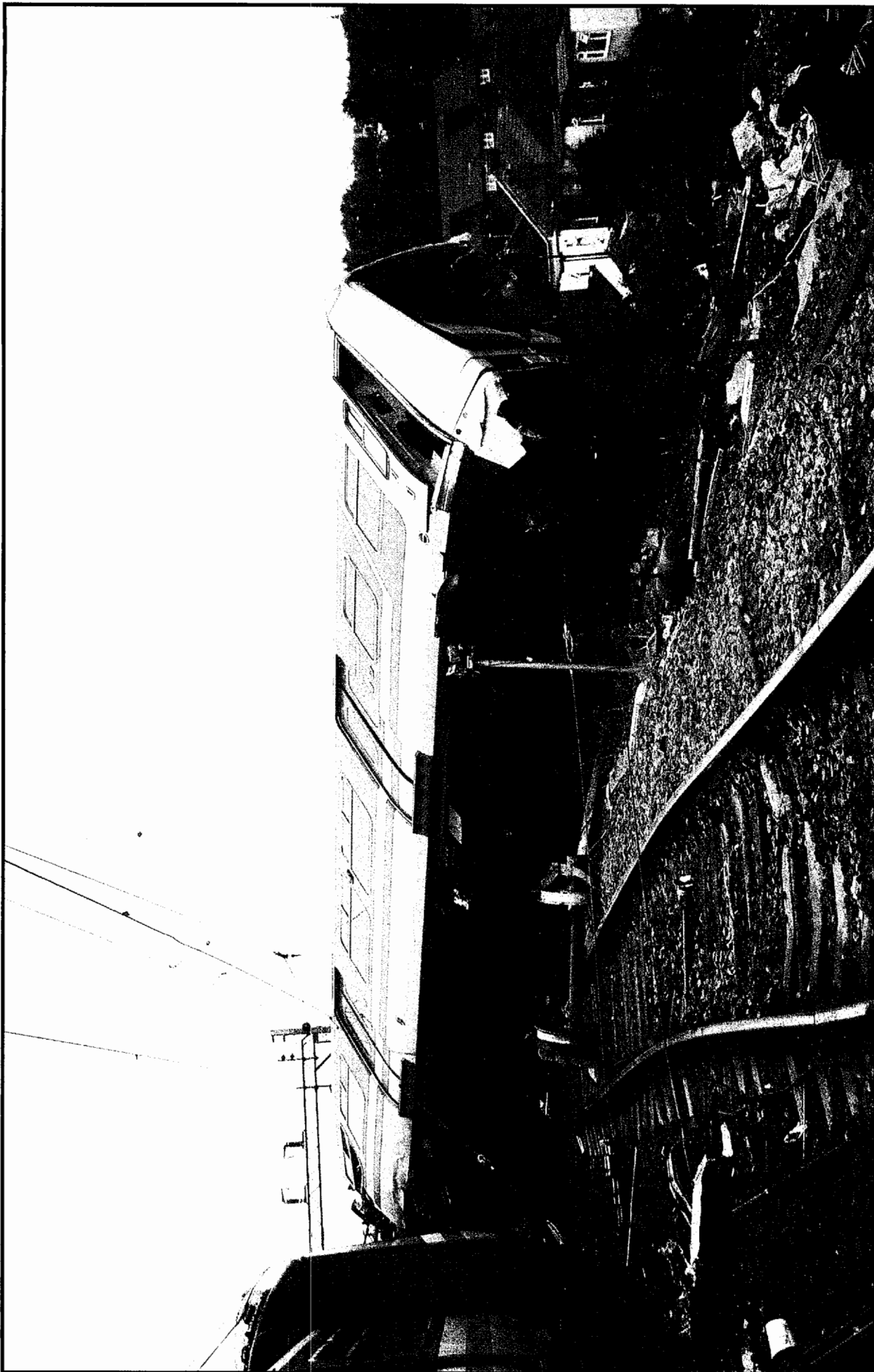
	<u>Hasler data</u>	<u>Mileage from Euston</u>	<u>Distance from impact</u>
Impact position	45.307 miles	(17m 13yds)	zero
Signal WJ 759	45.181 miles	(16m 1551yds)	222yds
Signal WJ 755	44.654 miles	(16m 624yds)	1149yds
Bushey Station(mid point)	44.257 miles	(15m 1668yds)	1m 105yds
60mile/h PSR board	44.058 miles	(15m 1318yds)	1m 455yds
Signal WJ 751	43.863 miles	(15m 974yds)	1m 799yds
Signal WJ 167	43.031 miles	(14m 1270yds)	2m 503yds



PHOTOGRAPH 1
Aerial view of collision scene
 (Courtesy of Hertfordshire Constabulary)



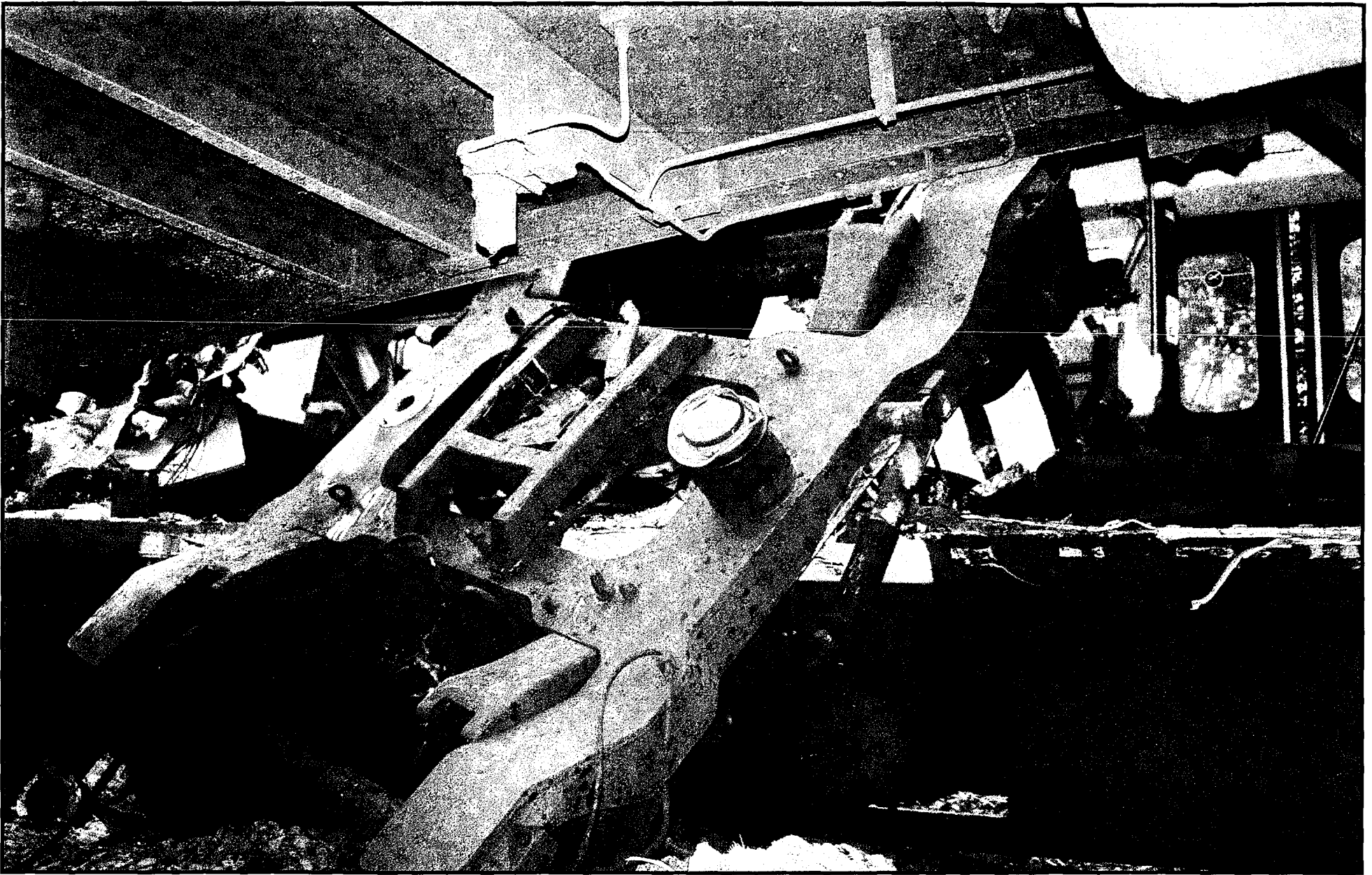
PHOTOGRAPH 2
Leading coach of passenger train, after collision.
(Courtesy of North London Railways)



PHOTOGRAPH 3
Leading coach of empty coaching stock train.
(Courtesy of North London Railways)



PHOTOGRAPH 4
Second coach of empty coaching stock train, after collision showing result of overriding with first coach at left of photograph.
(Courtesy of North London Railways)



PHOTOGRAPH 5

**Displaced bogie from empty coaching stock train at rest within
passenger space of second coach of passenger train**

(Courtesy of North London Railways)

APPENDIX 6

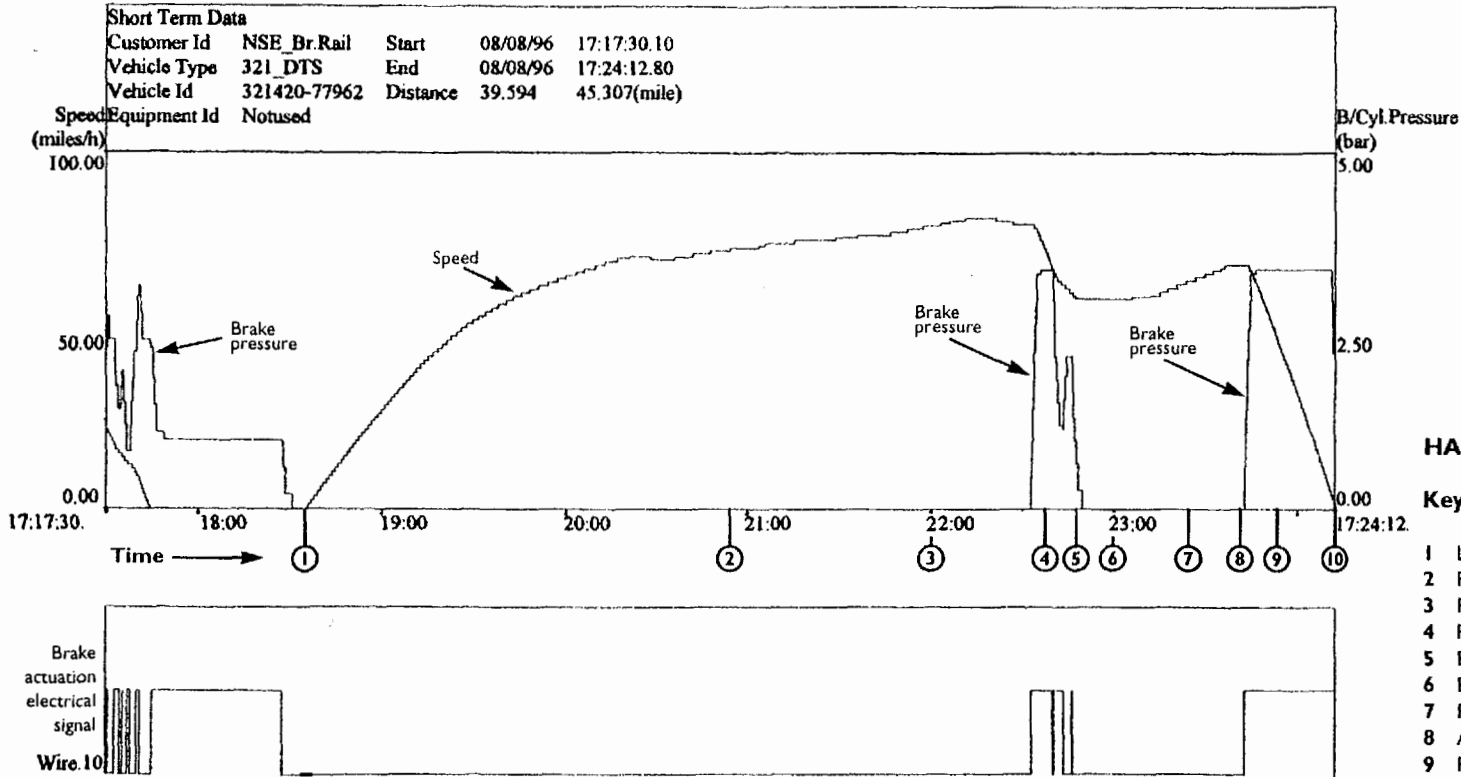
Sécheron Hasler

Journey Output Graphical

TELOC-AS V 2.10

12/09/96 16:05:30

Page 1

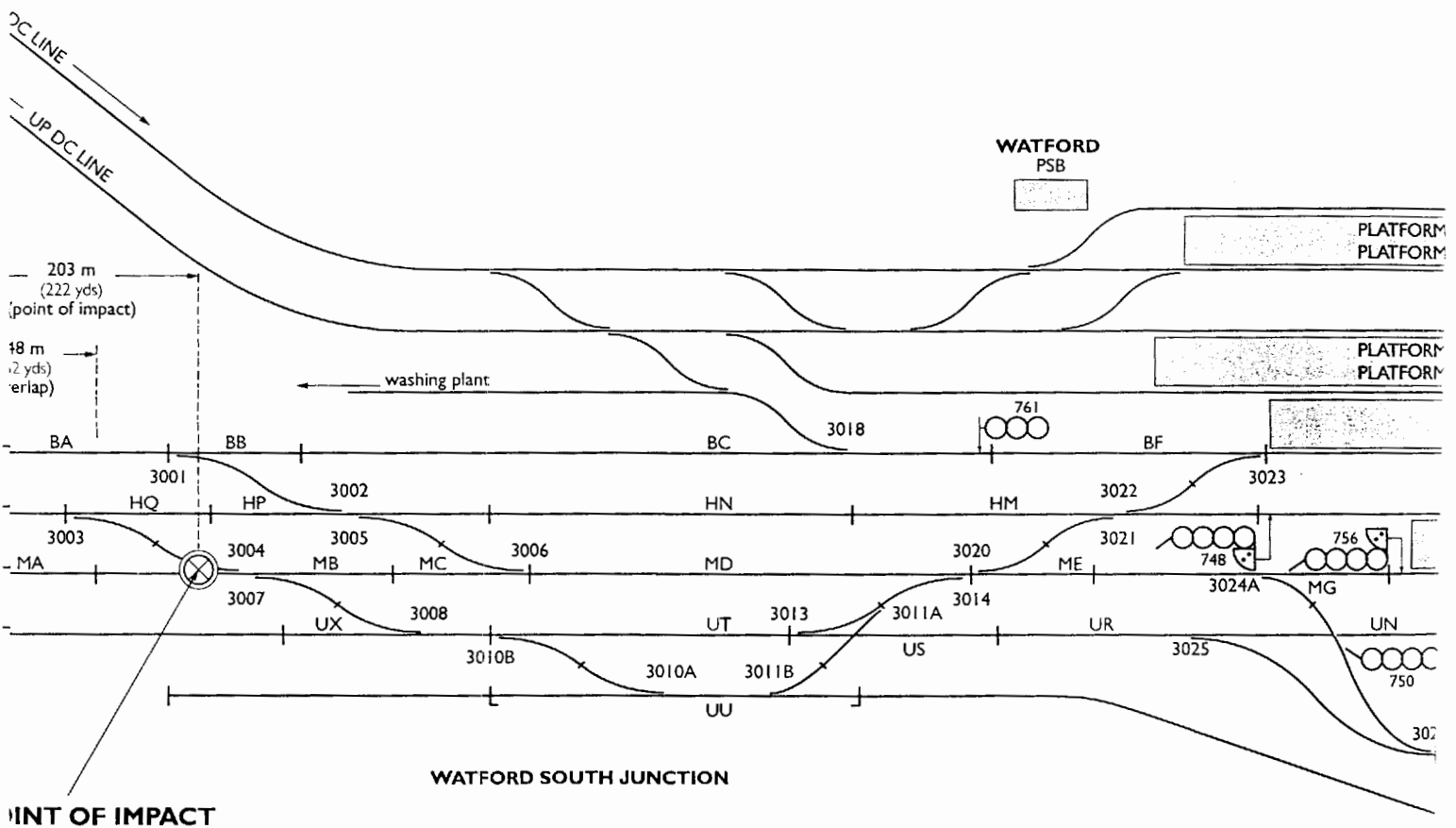


Note: Times are shown on Hasler recorder digital print out, but are not guaranteed to be accurate to BST owing to calibration.

DIAGRAM 2: HASLER RECORDER TRACE FOR JOURNEY FROM HARROW AND WEALDSTONE STATION UP TO POINT OF COLLISION

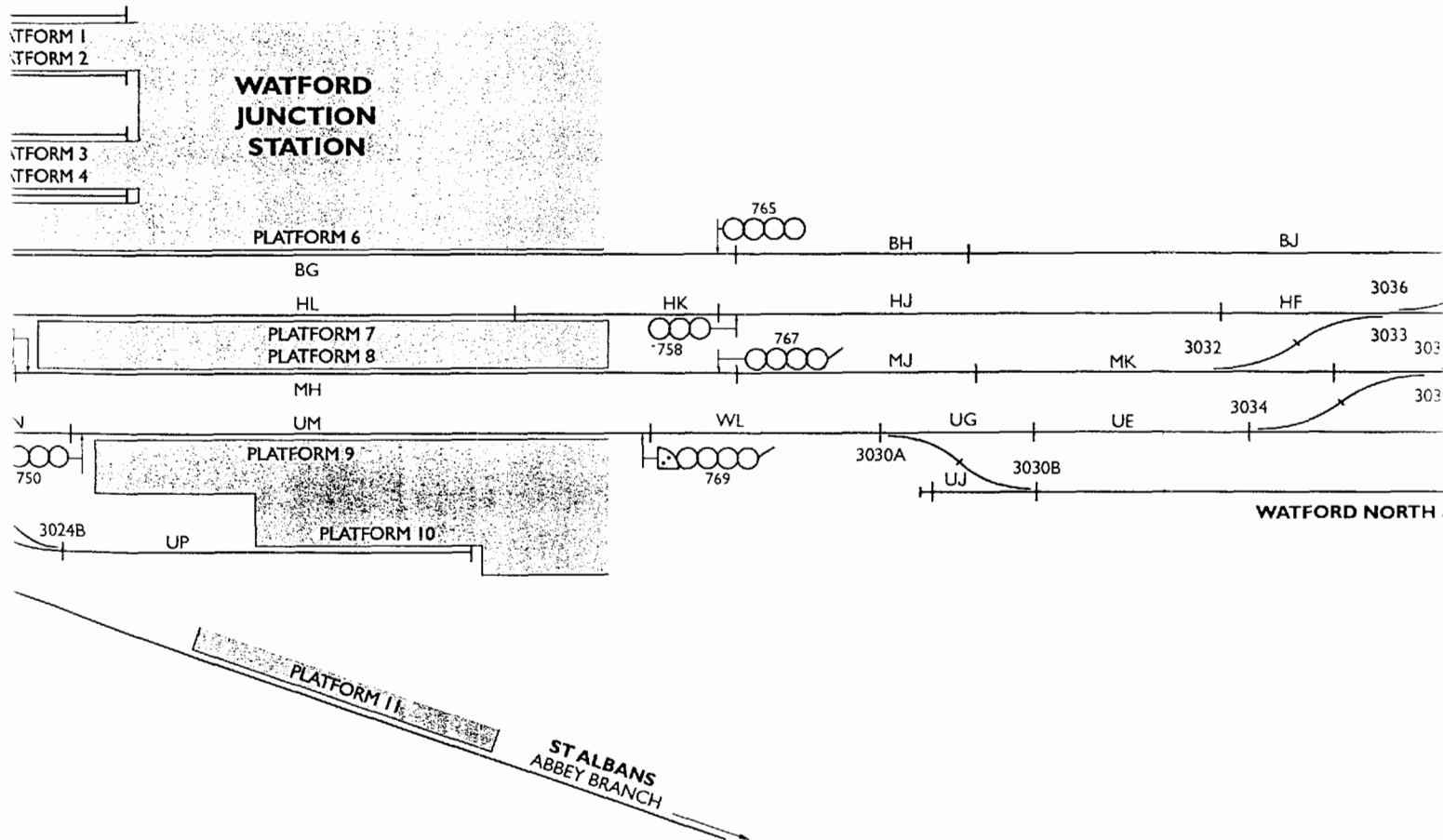
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C12 4/98

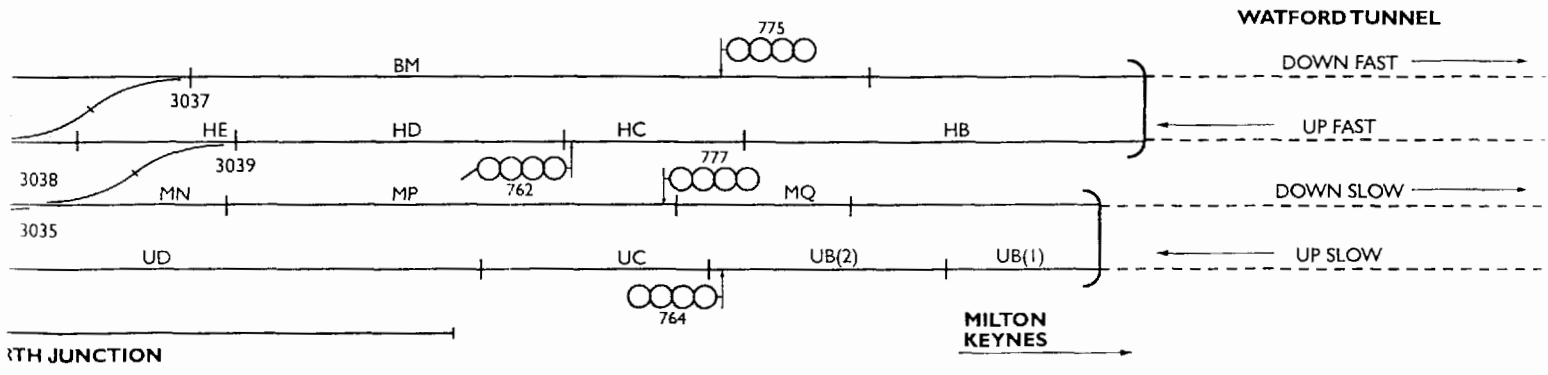
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POINT OF IMPACT

WATFORD SOUTH JUNCTION





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RAILWAY ACCIDENT AT WATFORD

A report of the investigation into the collision that occurred on 8 August 1996 at Watford South Junction on the line from Euston to Crewe in the Railtrack Midlands Zone



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