The Ladbroke Grove Rail Inquiry

Part 1 Report

The Rt Hon Lord Cullen PC

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Front cover: View of crash site taken shortly after midday on 5 October 1999

Those who lost their lives
Ladbroke Grove, 5 October 1999

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Derek Antonowitz
Anthony Beeton
Ola Bratlie
Roger Brown
Jennifer Carmichael
Brian Cooper
Robert Cotton
Sam Di Lieto
Shaun Donoghue
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Juliet Groves
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Acknowledgements

The plates in this report were supplied both by parties to the Inquiry and other photographers as shown below. The Inquiry is particularly grateful to Chris Milner and Marco Deidda for permission to use their photographs.

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Track and driving diagrams	Prepared by W S Atkins based on a diagram provided by Railtrack

Chapter 1
Executive summary

1.1 This Inquiry arises out of the crash at Ladbroke Grove Junction on 5 October 1999 between trains operated by Thames Trains and First Great Western (FGW), which caused considerable loss of life and injuries. Part 1 of the Inquiry is concerned with the investigation of the causes of the crash and the circumstances in which it occurred, lessons which should be drawn from what happened, and recommendations for the improvement of safety in the future.

1.2 In **Chapter 2** I outline my approach to Part 1, the preparations for the Inquiry, and the procedures which were followed.

1.3 **Chapter 3** describes events leading up to the crash. A Turbo of Thames Trains, driven by Michael Hodder, left Paddington Station at about 08:06 bound for Bedwyn in Wiltshire. At about 08:08:25 the Turbo passed signal SN109 on gantry 8 at red for Danger, travelling at 41 mph. It had passed the previous signal, SN87, at single yellow. The state of the points beyond SN109 was such that the Turbo was inevitably carried towards the Up Main line. Meanwhile a High Speed Train (HST) of FGW was approaching on the Up Main on green signals. Shortly before the crash a signaller at the Integrated Electronic Control Centre (IECC) at Slough, who had been monitoring the progress of trains, put signal SN120 back to red in face of the HST. Both train drivers applied their brakes, but this had no significant effect on the impact, which took place at a combined speed of about 130 mph. Both of them were killed.

1.4 In **Chapter 4** I describe what happened in, and as a result of, the crash. The impact was virtually head on. The coaches of the HST absorbed crash energy well, but several of its bogies became detached. On the other hand the Turbo suffered a considerable degree of destruction and failure, with a consequent loss of protection for passengers. The impact was followed by a number of fires which were caused by the dispersal and ignition of diesel fuel. The most horrific was one which engulfed coach H of the HST.

1.5 The chapter indicates where the deceased had been on the trains and where they were found after the crash. It also sets out in some detail the difficulties which were experienced by passengers. There was no organised evacuation. In the case of the HST, the passengers had difficulty in knowing how to open the external doors, and where to find and how to use hammers to break windows. In the case of coaches which had tilted over to a substantial angle, they had difficulty in opening the internal doors which had fallen shut under the force of gravity. As regards the Turbo, a number of passengers were trapped in it. Others could not open the doors between the cars, and found that it was difficult or dangerous to open external doors. There were no emergency hammers. It was fortunate for those who were in the rear car that two Thames Trains employees enabled them to escape through the rear cab.

1.6 The chapter also contains a description of the steps taken for the protection of the crash site and the response of the emergency services, who deserve great praise. The chapter concludes with an account of the site investigation.

1.7 Why did driver Hodder pass SN109 and thereafter not attempt to stop until the crash was imminent? In **Chapter 5** I consider what factors played a part. The evidence of train drivers, supported by that of independent experts, demonstrated that there was persisting difficulty in the sighting of the signals which formed part of the re-signalling scheme between Paddington Station and Ladbroke Grove, and in particular those on gantry 8. SN109 had been passed at Danger on eight occasions since August 1993. Driver Hodder had recently passed out as a driver. He had been a good trainee, but his experience was slender and there were significant shortcomings in his training. It was acknowledged by Thames Trains that he had not been instructed directly about signals which had been passed at Danger (SPADs), and the assessment of his route knowledge did not specifically cover the section between Paddington Station and Ladbroke Grove.

1.8 I examine the evidence in regard to driver Hodder's driving up to the point of impact in four stages:

(i) in relation to SN87;

(ii) at the stage of the initial sighting of the signals on gantry 8;

(iii) over the last 168m before reaching SN109; and

(iv) beyond that signal.

I am satisfied that he believed that he had a proceed aspect at SN109. It is more probable than not that the poor sighting of SN109, both in itself and in comparison with the other signals on and at gantry 8, allied to the effect of bright sunlight at a low angle, were factors which led him to believe that he had a proceed aspect and so that it was appropriate for him to accelerate as he did after passing SN87. After the red aspect of SN109 ceased to be obstructed by the underside of the Portobello Bridge or the overhead line equipment he could have seen it during a period of eight seconds as he approached that signal, but it appears that he either did not see it or did not realise that there was a red aspect. While it might well be expected that if he was concentrating on his duties he would look again at the signal, this depended on his various tasks and the confidence with which he had already identified what he thought that the signal was showing. The unusual configuration of SN109 – a "reverse L" – not only impaired initial sighting of its red aspect, but also might well have misled an inexperienced driver, such as driver Hodder, who was looking at the signal at close range, into thinking that it was not showing a red but a proceed aspect. The fact that he had not been instructed that SN109 was a multi-SPAD signal increased the risk of his making, and not correcting, a mistake as to the aspect shown by that signal.

1.9 In **Chapter 6**, after describing the Integrated Electronic Control Centre (IECC) and the means by which signallers carried out their functions, I narrate the timing of events as they could be seen there. It is clear that for a period of time after being alerted to the fact that the Turbo had passed SN109 at Danger, the signaller did not take action, as he was expecting the driver to stop within the 200 yards overlap beyond SN109. I accept that, in addition to the putting back of SN120 to red, an emergency stop message was sent to the Turbo by means of its cab secure radio. However, owing to the poor quality of the evidence of the signallers, I am unable to determine whether it was received before the crash, let alone how long before it. The evidence of the signaller and other members of the staff at the IECC indicated that there was a serious under-rating of the risks involved in SPADs, a failure to realise the importance of immediate and direct communication with the driver where that was possible, and a dangerously complacent attitude to SPADs as being simply a matter of driver error. The root cause of these deficiencies – which should have been picked up by senior management – lay in the running of the IECC. If management had applied the lessons of past SPADs, and if signallers had been adequately instructed and trained in how to react to a SPAD, it may well be the case that the signaller would have been able to send the emergency message in time to enable the Turbo to be brought to a halt before reaching a point at which it fouled the path of the HST.

1.10 The Inquiry's concern with SN109 and the SPADs which had occurred at that signal led on to an examination of the circumstances which lay behind the events on the day of the crash, against the background of the management by Railtrack of the safety of the infrastructure between Paddington Station and Ladbroke Grove. This is the subject of **Chapter 7**. In the development of the re-signalling scheme there was not an adequate overall consideration of the difficulties which faced drivers, and when those difficulties did emerge, an adequate reconsideration of the scheme. Flank protection by points control required and requires serious consideration. There was a serious and persistent failure to convene signal sighting committees as they should have been, because of the changes to the signals and the fact that signals had been repeatedly passed at Danger. This was due to a combination of incompetent management and inadequate procedures. If a signal sighting committee had viewed SN109 they would have found it was not compliant with Railway Group Standards in a number of respects, and that the sighting was of borderline quality and the signage unusual and inconsistent. There was also a persistent failure to carry out risk assessment by whatever method was available.

1.11 In the years preceding the crash a number of measures, such as uni-directional working, had been mooted for the improvement of safety. Very little had been achieved. A number of measures foundered as a result of objections on the ground that the change would affect performance. Flashing yellow aspects at SN43 and SN63, which appeared to have been factors in previous SPADs at SN109, were removed in early 1999. This was plainly not regarded by management as a complete solution to the risk of SPADs at that signal, but the residual risk was not assessed. This was at a time when the introduction of the Heathrow Express generated additional train movements. The impression given by the evidence was that senior management were content to wait till proposals had been put up to them, and failed to give and maintain the lead in seeking solutions and ensuring a response.

1.12 There was a lamentable failure on the part of Railtrack to respond to recommendations of inquiries into two serious incidents, namely the accident at Royal Oak on 10 November 1995 and the serious SPAD at SN109 on 4 February 1998. The recognition of the problem of SPADs in the Paddington area led to the formation of a number of groups to consider the problem. However, this activity was so disjointed and ineffective that little was achieved. The problem was not dealt with in a prompt, proactive and effective manner. In 1998 Railtrack dispensed with the services of a significant number of senior Great Western Zone personnel or moved them on to other work. In the course of what was correctly described as a "devastating critique" of their deficiencies and other management failures, the incoming Zone Director said: "The culture of the place had gone seriously adrift over many years".

1.13 The chapter concludes with consideration of safeguards for the future. It includes my recommendations as to the need for risk assessments and any actions coming out of these, a safety examination of the layout over 0-2 miles from Paddington Station, and restrictions on any change being made in the running on line 3 or in the current speed limits on any of the lines out to two miles six chains from Paddington Station.

1.14 Since it was highly probable that the crash would not have happened if the Turbo had been fitted with Automatic Train Protection (ATP) in connection with the pilot system which was in operation in the Great Western Zone, the Inquiry examined the basis for the decision of Thames Trains that their trains should not be so fitted. This is the subject of **Chapter 8**. Following the Southall crash in 1997, the company asked W S Atkins to carry out a cost benefit analysis. The conclusion of the analysis was that the fitting of ATP was not justified as the costs outweighed the benefits. I describe the method used by W S Atkins and discuss a number of criticisms that were made of their report. I conclude that, while there was force in some of them, they were not fundamental points and did not materially affect the overall conclusion. In any event it has to be borne in mind that the advice of W S Atkins was not regarded by Thames Trains as the sole basis for their decision. The company also took into account that operating experience with ATP was poor, and that the Train Protection and Warning System (TPWS) was very likely to proceed, as it is now to do. In these circumstances I conclude that the decision not to proceed with ATP but to install TPWS was reasonable.

1.15 **Chapter 9** is concerned with driver management and training in Thames Trains, and, in certain respects, with issues which concern all train operating companies (TOCs). Following the report into the accident at Royal Oak, and in view of the number of SPADs involving Thames Trains drivers, certain initiatives were taken by the company in 1996. While there was some improvement in driver performance, more should have been done to organise management and training in a systematic manner. Driver standards managers conducted their classes as each of them thought best. Training material was not validated. There were gaps in the training. I conclude that the safety culture in regard to training was slack and less than adequate; and that there were significant failures in communication within the organisation. A number of important steps were taken by Mr T Worrall when he became Director and General Manager in May 1999. However, it is evident that there were continuing failures to implement fully the recommendations of the Royal Oak Inquiry. The evidence relating to an audit of the safety management processes in Thames Trains demonstrated failures of communication between the auditors and the company. The chapter also includes my observations on driver licensing, the use of simulators in driver training, the "no blame" culture and human factors as they may affect driver performance.

1.16 The performance of their responsibilities by Her Majesty's Railway Inspectorate (HMRI) is discussed in **Chapter 10**. Neither phase of the re-signalling scheme was approved by the HMRI prior to the crash at Ladbroke Grove. Latterly the HMRI took the view that it was inappropriate for them to do so pending the conclusion of the Inquiry into the Southall crash, which was unfortunately delayed. An internal inquiry within the Health and Safety Executive (HSE) after the crash at Ladbroke Grove questioned whether the approval process for the first phase of the re-signalling had been operated with sufficient urgency, but it was asserted on behalf of the HMRI that they had been overwhelmed with work. In such circumstances they should, in my view, have pressed for increased resources.

1.17 As regards the activities of the HMRI in general, it was candidly accepted by the Director-General of the HSE that they could have done more. I make my observations on the reasons which were given for this deficiency, which were a lack of resources, a lack of vigour in pursuing issues, and the placing of too much trust in duty holders.

1.18 Arising out of Chapters 5 and 7 are a number of lessons in regard to signal sighting, which is the subject of **Chapter 11**. For signals to be effective they should be readable as well as visible. There are a number of ways in which human factors may affect driver performance, including the risk of passing a signal at Danger. Signal sighting requires attention throughout the life of a signalling system. It is important to ensure an adequate supply and range of trained signal sighters. The Group Standard on signal sighting is in need of revision in a number of respects, including the scope for disregarding interruptions "of very short duration" and the meaning of "overhead line equipment".

1.19 As regards SPADs, it is important that the recommendations of signal sighting committees which assist in their investigation are adequately followed up. Those who investigate SPADs and make recommendations should be trained in the identification of human factors and in root cause analysis.

1.20 In the light of what I have described in Chapter 6, I discuss in **Chapter 12** what can be done to assist the work of signallers. I identify the need for the re-drafting of their instructions in regard to SPADs, briefing and dissemination of information about SPADs, and steps to ensure that signallers see themselves as part of a system for the prevention and mitigation of SPADs. Simulators have a part to play in ensuring that training is fully effective. I make a number of observations about the working conditions of signallers, and about changes to assist them in making a prompt response to SPADs. A national system of radio communication between trains and signallers is clearly due.

1.21 In **Chapter 13** I consider the lessons which may be drawn from the crash performance of the trains and the fires which ensued upon the crash, together with the extent to which there is scope for improvement. As regards crashworthiness, I endorse the views of experts that the retro-fitting of certain improvements to HSTs and Turbos should be considered. As regards new vehicles, I note that it is now possible to provide for a greater absorption of energy in a collision. The revision of the Group Standard for crashworthiness should be pursued with particular reference to the design requirements for more realistic accident scenarios, high speed accidents and dynamic verification testing. While use of aluminium in the construction of rail vehicles can meet design standards, consideration should be given to the use of alternative grades and methods of construction, together with the further development of analytical techniques to increase confidence in the crashworthiness of rail vehicles constructed of this material.

1.22 As regards fire mitigation, I endorse expert advice that a number of measures should be considered in order to prevent the recurrence of fires of the type which occurred at Ladbroke Grove. These include the use of anti-misting agents and mechanical means to prevent the dispersion of diesel fuel.

1.23 In **Chapter 14** I consider the lessons for passenger protection, evacuation and escape in the light of the evidence which I set out in Chapter 4. I recommend an extension of the particulars in a railway safety case to cover arrangements for escape explicitly. Among a large number of suggested improvements, I discuss the need for improvements in safety information for passengers, emergency lighting, the operation of internal and external doors, egress through windows, internal and external communications and the training of on-board train staff.

1.24 **Chapter 15** contains a list of my recommendations, together with my views as to the bodies which should be primarily responsible for their implementation, and periods within which they should be implemented.

Chapter 2
The Inquiry

The Terms of Reference

2.1 On 5 October 1999 at Ladbroke Grove junction, about two miles west of Paddington Station, London, there was a head on crash at high speed between trains operated by Thames Trains and First Great Western (FGW). This caused the death of the 31 persons named at the beginning of this report, who include both train drivers, and inflicted injuries, some of them critical, on over 400 other persons.

2.2 As a consequence of that crash I was appointed on 8 October 1999 by the Health and Safety Commission (HSC), with the consent of the Deputy Prime Minister, to conduct a Public Inquiry under section 14(2)(b) of the Health and Safety at Work Act 1974. My terms of reference were as follows:

> "1. To inquire into, and draw lessons from, the accident near Paddington Station on 5.10.99, taking account of the findings of the HSE's investigations into immediate causes.
>
> 2. To consider general experience derived from relevant accidents on the railway since the Hidden Inquiry, with a view to drawing conclusions about:
>
> (a) factors which affect safety management
>
> (b) the appropriateness of the current regulatory regime.
>
> 3. In the light of the above, to make recommendations for improving safety on the future railway".

2.3 In his letter to me of the same date Mr Bill Callaghan, Chair of the HSC, set out a number of factors on which my consideration and recommendations were invited. These related to paragraph 2 of my terms of reference. I decided shortly after I was appointed to hold the Inquiry in two parts, dealing respectively with paragraphs 1 and 2 of my terms of reference, along with, in each case, paragraph 3. This part of my report deals with Part 1 of the Inquiry. It sets out my conclusions about the crash and the circumstances which led up to it. It also indicates the lessons which I have drawn in the light of what happened and which form the basis for my recommendations, which are set out in Chapter 15.

2.4 The crash at Ladbroke Grove happened at a time when the Public Inquiry into the crash at Southall on 19 September 1997, which was conducted by Professor John Uff, QC, was proceeding. It became obvious that there were a number of issues which were of common concern to both Public Inquiries. In these circumstances the HSC, with the consent of the Deputy Prime Minister, appointed Professor Uff and myself to chair a separate Public Inquiry under section 14(2)(b) into these issues, which were:

(i) Train Protection and Warning Systems;

(ii) the future application of Automatic Train Protection Systems; and

(iii) SPAD prevention measures.

These issues accordingly were dealt with exclusively in the latter Inquiry, which was designated as "The Southall and Ladbroke Grove Joint Inquiry into Train Protection Systems Etc". Thus while this report mentions the pilot scheme for Advanced Train Protection which was introduced by British Rail, it does so solely in the context of an investigation into the reasons why Thames Trains decided that this system should not be extended to their trains. Professor Uff and I have presented a separate report on the evidence which we heard in the Joint Inquiry.

The relationship of this Inquiry to other investigations

2.5 The investigations by the Health and Safety Executive (HSE) into the immediate causes of the crash began soon after it occurred. In due course the HSE published a number of interim reports and in December 2000 a final report on their investigations. I am most grateful for the groundwork that was carried out for these reports. While I have taken account of the findings of the HSE's investigations, I have also had regard to the submissions made to me by parties in regard to matters which were in dispute.

2.6 The crash at Ladbroke Grove was also the subject of an investigation by a Formal Inquiry, in accordance with the relevant Railway Group Standard, which was chaired by Mr R Bonham-Carter. That was an entirely separate investigation, and, except to the extent that I was invited to adopt any of its findings, where those were uncontroversial, I have not found it necessary or appropriate to rely upon it.

2.7 The Attorney-General authorised me to undertake in respect of any person who provided evidence to the Inquiry that no evidence he or she might give before the Inquiry, whether orally or by written statement, nor any written statement made preparatory to giving evidence, nor any document produced by that person to the Inquiry, would be used in evidence against him or her in any criminal proceedings, except in proceedings where he or she was charged with having given false evidence in the course of the Inquiry or having conspired with or procured others to do so. The Attorney-General also stated that the effect of the undertaking was to protect from use in any prosecution the actual documents produced to the Inquiry and that it did not extend to any other manifestation of the documents, whether retained originals or any copies, which the police or other investigators were able to obtain.

2.8 Dr Paul Knapman, the Coroner for Inner West London, carried out an inquest in the case of each of the deceased, into the time and place of death and the medical cause of death. In accordance with present legislation each of these inquests was adjourned to await the outcome of this Inquiry. In the circumstances the Inquiry did not receive evidence as to these matters, although it was provided with evidence which, without identifying the deceased, gave the causes of death and where the deceased were at the time of the crash and were found after it.

Preparation for the Inquiry

2.9 Shortly after appointment I chose as Secretary to the Inquiry Mr Andrew Allberry, whose Secretariat arranged for the accommodation and servicing of the Inquiry and managed its documentation. By their hard work and helpfulness the members of the Secretariat (whose names are shown at the back of this report, following the Appendices) assisted in ensuring that the Inquiry was run with efficiency and had a good working relationship with all who came into contact with it. I would like to express my particular gratitude to Mr Allberry for his dedication, support and advice throughout. My thanks are also due to Mrs Dorothy Gordon, of Edinburgh, who cheerfully carried the burden of typing the text of this report and the preliminary drafts and revisals.

2.10 I chose as Counsel to the Inquiry Mr Robert Owen QC, Mr Neil Garnham and Miss Susan Chan. Their roles were to assist me in the investigation, advise on matters of law and evidence, and present evidence to the Inquiry at its hearings. Mr Michael Fitzgerald was appointed Solicitor to the Inquiry and Mr Myles Hothersall was appointed Deputy Solicitor to the Inquiry. All of them amply fulfilled the heavy demands which were made of them. My additional thanks are also due to Miss Chan for assisting me by marshalling evidential material.

2.11 To assist me in my work as Chairman I chose Professor Peter H McKie, CBE, former Chairman of DuPont (UK) Ltd, and Mr Malcolm J Southgate, former Deputy Managing Director of Eurostar (UK) Ltd. Their knowledge, advice and support have been of considerable help to me in conducting the Inquiry and preparing this report. However, for both tasks I bear sole responsibility.

2.12 I visited the scene of the crash at the time of my appointment. In due course I visited the ADtranz premises at West Street, Crewe where I was shown debris which had been removed from the crash site. I also visited the control room at the Slough IECC.

2.13 In order to give the bereaved and injured the opportunity of bringing to my attention any matters which they thought the Inquiry should consider for the improvement of safety I held two meetings with them, in Swindon on 8 April and in London on 15 April 2000. These meetings were held in private, but the representatives of the parties were permitted to attend as observers. I found these meetings to be extremely useful, and the points which were raised were taken into consideration in the lines of questioning which were pursued at the Inquiry. I would like to thank both those who attended and the many people who wrote to me in order to suggest other points which could usefully be pursued.

2.14 In order to provide a focus for Part 1 of the Inquiry, Counsel to the Inquiry drew up, with my approval, a list of issues. This list was thereafter amended as Part 1 proceeded. It was circulated to parties and formed the main structure for the assembling of documents and witness statements and the organisation of the programme for the presentation of evidence at the hearings in Part 1.

2.15 I made a number of orders under Regulation 7 of the Health and Safety Inquiries (Procedure) Regulations 1975 for the production of documents which were likely to be material evidence. From the documents which had been produced core bundles were assembled and copies were printed for the use of the Inquiry and representatives of the parties. Residual documents were kept in a library to which parties' representatives had access. Arrangements were also made for the advance circulation of copies of the written statements and the reports of expert witnesses. Parties' representatives were provided with these documents, statements and reports on the basis of a written undertaking that the material was provided and was to be used exclusively for the purposes of preparation for the Inquiry.

2.16 On 21 December 1999 I held a preliminary hearing in the Inquiry which was concerned with Part 1. One of the purposes of this hearing was to determine, by reference to Regulation 5 of the 1975 Regulations, who should be entitled to appear at Part 1 of the Inquiry. Appendix 1 sets out the parties and their representation. The other main purpose of the hearing was to set the main lines of procedure at and in connection with the Inquiry.

2.17 Although the HSC are empowered under the Health and Safety at Work Act 1974 to pay the expenses of witnesses attending the Inquiry, neither that Act nor the 1975 Regulations make provision for payment of legal costs of representation from public funds. But, in accordance with the normal Government approach in the case of a major accident, the HSC indicated to me that they would consider any recommendation I might make as to the payment of legal costs of persons who were party to the Inquiry. Those representing the bereaved and injured and one of the trade unions, ASLEF, applied to me at the preliminary hearing for payment of such costs in connection with Part 1 from the public purse. In the event, I made recommendations to the HSC in respect of the costs of both the bereaved and injured and ASLEF, in the latter case for part payment of costs. In each case my recommendations were accepted by the HSC.

The proceedings at the Inquiry

2.18 The Inquiry was held at the Central Hall, Westminster. The hearings in Part 1 began on 10 May and finished on 28 September 2000. The evidence was presented in accordance with a programme which was circulated in advance to the parties. The opening and closing submissions were provided to the Inquiry in writing. The parties were given the opportunity of brief oral submissions in supplement.

2.19 Appendix 2 contains a list of the lay witnesses who provided evidence to the Inquiry. Oral evidence was given on oath or affirmation. Evidence was taken from certain witnesses in writing. In that event their statements were read out or summarised at the Inquiry.

2.20 A considerable number of experts provided reports for the purposes of the Inquiry. These are listed in Appendix 3. These reports were either spoken to by the experts when giving oral evidence or incorporated by being summarised at the Inquiry.

2.21 The great majority of witnesses were examined in chief by Counsel to the Inquiry. Parties were asked to submit an advance estimate of the time which they expected to require for the questioning of each witness, and were reminded, where necessary, of the need to adhere to these estimates in order to ensure that the Inquiry could be conducted in an expeditious manner.

2.22 The Inquiry was greatly assisted by the fact that there was a large measure of agreement on matters which called for expert knowledge. On 5 June 2000 Mr Paul Balmer, Railway Consultant, and Mr R Fenton of W S Atkins produced a joint statement about certain events prior to the collision, to which Mr Fenton spoke when giving evidence. Thereafter the Inquiry also received joint statements by experts on the following subjects:

(i) fire, on which Mr C Christie of Geoffrey Hunt & Partners spoke to what had been agreed at a meeting between him and Mr J Hill of Interfleet Technology, Dr R Fletcher of R B Hawkins & Associates, Mr K Moodie of the HSL, Mr P Field of the Fire Research Station, Dr S Jagger of the HSL, and Professor D Drysdale of Edinburgh University;

(ii) crashworthiness, on which Dr Neil Kirk of W S Atkins spoke to what had been agreed at a meeting between him and Mr A Bright of W S Atkins, Professor Sir Bernard Crossland of The Queen's University, Belfast, Mr P Murrell of W S Atkins, Mr M Phillips of Burgoynes, Mr W Rasaiah of AEA Technology, Mr A Scholes, an independent consultant, and Mr C Wilson of the HSL;

(iii) fire and crashworthiness, on which Mr Wilson spoke to what had been agreed at a meeting between him and Dr Kirk, Mr Bright, Mr Scholes, Professor Drysdale, Dr Fletcher, Mr Moodie, Mr Murrell, Mr Rasaiah, Professor Crossland, Mr Christie and Mr Phillips;

(iv) escape, on which Professor E Galea of the University of Greenwich spoke to what had been agreed at a meeting between him and Dr A Weyman of the HSL; and

(v) signal sighting, on which Mr S Wilkins of W S Atkins spoke to what had been agreed at a meeting (chaired by Major C B Holden) between him and Mr R Bell, an independent consultant, Mr W Boddy, an independent consultant, Mr R Fairbrother, an independent consultant, Professor R Watt of the University of Stirling and Mr D Weedon of Amec Rail.

In each case, except to the extent that was stated at the Inquiry, the reports of all the experts who had participated in these meetings were also treated as part of the evidence before the Inquiry, so far as was consistent with the joint statements to which they had contributed.

2.23 The evidence was recorded by means of a computer-assisted transcription system, which enabled the Inquiry and the parties' representatives to have not only a paper copy of the transcript of the proceedings, but also a means of access to the transcript through the use of the software. I would like to pay tribute to the skill and helpfulness of the members of the staff of Harry Counsell & Co, who ensured that this worked smoothly and efficiently. The text of the proceedings was also published through the Inquiry website.

2.24 The parties were given the opportunity of expressing their views in writing as to whether or not the proceedings should be televised. Having considered those views I decided that in the circumstances of this Inquiry televising should be restricted to the proceedings at the time of the opening and closing submissions.

2.25 As the evidence in Part 1 progressed parties were informed that if they wished to criticise anyone, whether or not his or her interests were already represented at the Inquiry, then they should, through the Inquiry, give advance notice of the criticism, in accordance with usual practice. After these notices had been received, the parties who represented the interests of the persons criticised were given the opportunity to state any procedural objection to the Inquiry considering that criticism. Thereafter the procedure provided for substantive replies to such criticism to be contained in closing submissions.

2.26 I concluded the hearing of the main closing submissions for the parties on 28 July 2000, leaving only the hearing of certain further evidence and submissions relating exclusively to the report on cost benefit analysis which Thames Trains had obtained from W S Atkins in 1998. The Inquiry was adjourned for this purpose to 13 September. Shortly before that date it came to my notice that Railtrack had then produced for the Joint Inquiry, which was due to open on 18 September, a report by W S Atkins for Railtrack entitled "Initial Study of Signal Sighting Practice on Railtrack Infrastructure", which had been issued on 6 March 2000. I was advised, and I was wholly satisfied, that it dealt with matters which were pertinent to issues relating to signal sighting which had been the subject of evidence and submission months before. It appeared that the existence of this report had not been known to Railtrack's legal representatives. I was in no doubt that if their legal representatives had been aware of its existence, they would have ensured that it was produced for the purposes of this Inquiry. I took the view that it would be singularly unfortunate if I could not take account of this report and the submissions of parties about it. In the unsatisfactory circumstances I considered that the appropriate course was to have copies of the report circulated to the parties and to give them the opportunity to make submissions to me in writing by 2 October. The final hearing in Part 1 took place on 28 September when I heard oral submissions relating to the report on cost benefit analysis which Thames Trains had obtained from W S Atkins. That hearing also provided an opportunity for the report for Railtrack on signal sighting practice to be placed in the evidence for Part 1 and for me to indicate that after receiving the written submissions from parties on the report I would decide whether any further action was required. In the event I decided that it was sufficient for the parties to have the opportunity to make their submissions to me about it in writing, as they did.

Chapter 3
The journey before the crash

3.1 At about 08:06 on 5 October 1999 a Thames Trains train for Bedwyn in Wiltshire left platform 9 at Paddington Station. The train was a 3-car turbo class 165 diesel unit, to which I will refer as "the Turbo". Its headcode was 1K20, and its driver was Michael Hodder. About 08:09 there was a crash at Ladbroke Grove Junction between the Turbo and the 06:03 First Great Western train from Cheltenham to Paddington. The latter train was a high speed train, comprising eight coaches with a diesel power car at each end, to which I will refer as "the HST". Its headcode was 1A09, and its driver was Brian Cooper. In this chapter I will set out the course of events which led up to the crash. In Chapter 5 I will consider the factors which could have caused or contributed to it.

3.2 Between Paddington Station and Ladbroke Grove Junction, which is about two miles to the west, there were six bi-directional lines, each of which could be used by trains running to and from the station. To enable the tracks to be used in a flexible manner the layout included a number of crossovers so that trains could be routed from one line to another. At Ladbroke Grove Junction there were connections between the lines. To the west of the Junction there were four running lines, namely the Up and Down Main lines and the Up and Down Relief lines, along with two carriage lines and one engine and carriage line.

3.3 The signals which were intended to control the movements of trains travelling on the six bi-directional lines were, for the most part, mounted on gantries which spanned all of the lines. They were referred to with the prefix "SN", which stood for Slough New, following the re-modelling of the Paddington layout in the early 1990s. The signals were of the four-aspect type. The usual arrangement of this type of signal is that the aspects are set out vertically, with the red aspect in the lowest position and above it the two yellows with the green between them.

3.4 In accordance with normal railway practice, entrance to each successive section of line was protected by a signal. The signal would be set at red for Danger until such time as the section was proved to be clear of any other trains, and all junction points and rail crossings affecting that section had been set and locked in their appropriate positions. Each such section extended beyond the signal for a certain distance, normally at least 200 yards, in order to provide an overlap or safe zone in case the train ran past the signal. If a section before a red signal was clear, the signal which protected that section would display a single yellow. This aspect meant, according to the drivers' Rule Book, "caution – the following signal is presently at Danger". If a section before a single yellow was clear, the signal protecting that section, where four aspects were in use, would display a double yellow. The meaning of that signal, according to the Rule Book, was "caution – the following signal is presently at yellow, with the next after that currently at Danger". If the section before the double yellow was clear, the signal protecting that section would display a green aspect. Accordingly as a train progressed along the line its progress would be governed by the signals controlling each section of the line, and the signals would change behind it in accordance with the sequence to which I have referred.

3.5 The routes to be followed by trains such as the Turbo were normally commanded by means of a computerised automatic routing system (the ARS). Under this system the Solid State Interlocking (SSI) system at the Slough Integrated Electronic Control Centre, referred to as "the IECC", set routes for trains in response to the ARS and in accordance with a pre-loaded timetable. This system was used for controlling all signals, points and train movements between Paddington Station and West Drayton. In accordance with that system the ARS would request the SSI to set a route. The SSI would then ascertain whether it could implement that request by checking the track circuits and the points within the circuits. If the way was clear, the SSI would instruct a lineside computer to command the signals and points to adopt the appropriate status. The SSI then conveyed this information back to the IECC for display at the signaller's work station. This system did not prevent the signaller from over-riding the ARS when that was appropriate. In such a case he would control train movements and the operation of equipment himself.

3.6 Trains such as the Turbo and the lines on which they travelled were equipped with the Automatic Warning System (AWS). This system was standard throughout UK railways. It had been introduced in the 1950s, and since the 1970s virtually all tracks had been fitted with it. In accordance with that system an AWS magnet is associated with each signal, and is installed between the rails at a distance before the signal, usually about 200 yards. The effect of the magnet along with the equipment carried on the train is that as the train goes over the magnet an audible signal is triggered in the driver's cab. If the signal is then green, an "all clear" bell sounds in the cab. If the signal is at double yellow, single yellow or red, a warning horn is sounded in the cab. If a bell sounded, the driver did not need to take any action. If, however, a horn sounded, the brakes on the train would be applied automatically to bring the train to a halt, unless the driver cancelled the warning within three seconds of its starting. If he did so an indicator in the cab, which was otherwise all black, would turn to black and yellow, colloquially referred to as "the sunflower", as a reminder to him that the train had passed a signal displaying a restricted aspect. The evidence before me indicated that there was no defect in the functioning of the AWS equipment on board the Turbo.

3.7 The Turbo was also fitted with two systems which could, independently of any external device, restrict the movement of the train. The first was the driver's reminder appliance (DRA). This could be used by a driver when his train was stationary and facing a red signal. The effect of its application was that he could not apply traction power until the appliance had been switched off by him. I will discuss its further possible use in Chapter 5. The second system was the driver's vigilance device (DVD), which would apply the brakes automatically if the driver did not acknowledge an audible warning by depressing a button at regular intervals.

3.8 The course of events after the Turbo drew away from platform 9 can be established with a reasonable degree of certainty. There are two principal sources of information which may be used for this purpose.

3.9 First, there are the contemporary computerised records maintained at the IECC. These comprise a continuous record on tape of:

(i) each instruction from the ARS (or the signaller) to the SSI;

(ii) each instruction by the SSI to the signals and points;

(iii) the response of the signals and points to such an instruction; and

(iv) the progress of each train as detected by successive track circuits when the front of the train reached a length of track to which a particular track circuit related and formed an electrical connection; and likewise when the rear of the train cleared that length of track and so broke that connection.

The ARS also maintained a continuous record of the routes set for trains within the area controlled by the IECC. Analysis of the SSI and ARS tapes has shown that both systems were functioning correctly, and accordingly that reliance could be placed on the information contained on them. The SSI data was marked with time stamps recorded in whole minutes, whereas the ARS data had an internal clock synchronised to a recognised time source and typically correct to within five seconds. Each event recorded by the ARS was within the time stamp of five second intervals. The SSI clock was in fact running 1 minute 15 seconds ahead of the ARS time, but data from each could be readily correlated so as to provide a chronology accurate to within five seconds. In my narrative the times at which track circuits were occupied are times according to the ARS data.

3.10 Secondly, the front and rear of the Turbo were each equipped with On-Train Monitoring and Recording equipment (OTMR) which recorded the speed of the Turbo in a series of quantised speed steps. This information has enabled the distance travelled by the Turbo to be deduced. In addition the front OTMR recorded the starting and ending of the sounding of the AWS bell or, as the case might be, its horn. After the crash it was found that there were a number of apparent discrepancies between the data from the front OTMR and that from the rear. However, detailed analysis of the data by W S Atkins identified a repetitive pattern in the discrepancies. This led to the development of a hypothesis that, independently of the effects of the crash, certain of the data from the front OTMR had been assigned to incorrect time labels. If the hypothesis was correct, which appeared to be highly probable, the data could be put into the correct sequence. This resulted in a complete correlation of data in regard to speed and the application of the throttle or the brake. More importantly it provided a record of the correct functioning of the AWS system at all the signals passed by the Turbo. W S Atkins were also able to relate this data to features on the ground by using as the datum the point at which the Turbo passed over the AWS magnet associated with signal SN43, referred to in para 3.14.

3.11 On leaving Paddington the lines curve to the left and then run straight as far as Royal Oak where a long right hand curve begins. On the approach to Westbourne Park where signal SN87, referred to in para 3.17, is situated, the line straightens briefly before curving again to the right (*see Plate 1*). The line then runs straight until a long left hand curve begins approximately 80m before signal SN109, referred to in para 3.19 (*see Plates 2, 3, 4 and 5*).

3.12 Before the departure of the Turbo from platform 9, signal SN17, which was on gantry 2, just beyond the end of the platform, showed a green aspect. This signal was fitted with a theatre indicator. This type of route indicator consisted of a screen on which a letter or number could be illuminated against a black background. In this instance the theatre indicator showed "4", for line 4.

3.13 At 08:06:20, having been despatched from platform 9, the Turbo occupied track circuit DL thus passing SN17. (Track circuits are denoted with a prefix "(P)", thus: "(P) DL". For brevity the prefix is omitted.) The ARS requested the setting of a route for the Turbo up to SN109 at Ladbroke Grove. The route which was then set for the Turbo was by way of line 4 leading by way of a crossover at points 8051 to line 3. The route was not set beyond SN109, which controlled access to the Down Main line or the Down Relief line by a train which was travelling westwards on line 3. Given the appropriate setting of points, a train which had been signalled to proceed beyond SN109 could reach the Down Main by way of points 8057 and thereafter points 8060. It could reach the Down Relief line either by points 8055 or, further on, by points 8059.

3.14 At 08:07:00 the Turbo, having travelled on to line 4, occupied track circuit CZ on passing SN43 on gantry 3 which was at green. This signal also had a theatre indicator which was showing "4".

3.15 At 08:07:20 the Turbo occupied track circuit GH on passing SN63 on gantry 4 which was at double yellow. The OTMR data showed that the AWS horn sounded and was cancelled. All the other signals on gantry 4 were at red. SN63 did not have a theatre indicator. It was fitted with the type of junction indicator which is colloquially known as a "feather" indicator. This is a means of indicating to a driver which route a train is to follow at a diverging junction. It consists of a row of five white lights against a black background, set at an angle to the vertical depending on the direction of the divergence. The junction indicator for SN63 was not illuminated, consistent with the Turbo continuing to move along line 4.

3.16 At 08:07:40 the Turbo passed over the AWS magnet for SN87 which was on gantry 6. The OTMR data shows that the AWS horn sounded and was cancelled.

3.17 At 08:07:50 the Turbo occupied track circuit GK on passing SN87 which was at single yellow. SN87 was fitted with a feather indicator which displayed position 1, indicating a move from line 4 to line 3. All the other signals on gantry 6 were showing red. Thereafter the Turbo crossed from line 4 to line 3 by way of points 8051 set in reverse. The tips of points 8051B were 320m in advance of SN87 (ie for a train travelling towards the signal, 320m after that signal was reached).

3.18 At 08:08:15 the Turbo passed over the AWS magnet for SN109 on gantry 8, which was 152m in rear of that signal (ie for a train travelling towards the signal, 152m before that signal was reached). The OTMR data shows that the AWS horn sounded and was cancelled.

3.19 At 08:08:25, having passed under the Portobello Bridge which carried Golborne Road over the tracks, the Turbo occupied track circuit GE on passing SN109 which was still at red. SN109 was 637m beyond SN87. In Chapter 5 I will explore the history and layout of this signal in greater detail, but for the present it should be noted that the red aspect was mounted in an unusual "reverse L" shape, and to the left of the lowest of the other lamps. This signal was also fitted with a theatre indicator. It was giving no indication of route, i.e. as to a route by way of the Down Main or the Down Relief. Such an indication would have been given by the showing of an “M” or an “R”, as the case might be. The other signals mounted on gantry 8, which was about 97m from the western side of the bridge, comprised SN107, SN111, SN113 and SN115, applying to lines 2, 4, 5 and 6. Some distance above the signals on gantry 8 were signs which were intended to indicate the particular line to which a signal related. SN105, which applied to line 1, was carried on a signal post at the left of the formation (*see Plate 6*). All of these signals were at red (*see track and driving diagrams inside back cover*).

3.20 At the stage when the Turbo passed SN109 it was travelling at about 41 mph. After leaving platform 9 it had attained the speed of about 46 mph. This was its speed at the stage when it passed SN63. Step 1 braking was applied at that stage, and the Turbo began to coast, its speed dropping back to about 38 mph. It passed SN87 when it was travelling at this speed. It coasted for about 740m. The period of coasting was followed by the engagement of the throttle. Notches 1, 5 and 7 were engaged when the Turbo was 255, 239 and 104m in rear of SN109. In the result the speed of the Turbo had risen to 41 mph as I have stated. It may be noted that the speed limit from platform 9 to Royal Oak which was at the 46 chain post was 40 mph. Thereafter the speed limit was 60 mph to a distance of 1 mile 38 chains. Thereafter the speed limit for trains proceeding from line 3 to the Down Main was 85 mph, and 70 mph for those proceeding to the Down Relief, although the speed limit for approaching SN109 was 60mph. At a distance of two miles six chains, which lay beyond SN109, the speed limit for a Turbo was 100 mph on the Down Main line and 80 mph on the Down Relief.

3.21 When the Turbo passed SN109 the state of the points in advance of that signal was as follows. Points 8055B, 8057D and 8059B lay normal so that a train which continued to move forward would inevitably be carried towards points 8063A, a swing-nose crossing, and the Up Main. Hence there was a risk of head-on collision with any train which was travelling towards Paddington Station on that line.

3.22 Having passed SN109 the speed of the Turbo increased. It was 41 mph when it occupied track circuit GE; 44 mph when it occupied track circuit GF, 135m beyond SN109; 48 mph when it occupied track circuit GG, 396m beyond SN109; and 50 mph when it occupied track circuit FZ, 547m beyond SN109. It was travelling at the last-mentioned speed when it passed the fouling point 563m past SN109.

3.23 Meanwhile the HST had been following an earlier train on the Up Main. After the passage of the earlier train the signals for the HST had progressively been turned from red to single yellow, double yellow and green. In particular twenty seconds before the Turbo passed SN109, SN104 cleared from red to single yellow, with corresponding changes to the signals in its rear, so that SN120 changed from single yellow to a double yellow. At 08:08:40 SN72 cleared to a single yellow, with corresponding changes to the signals in its rear so that SN120 cleared from double yellow to green. SN120 was a short distance to the west of points 8063A, and about 700m from SN109. The speed limit for the HST was 100 mph.

3.24 Shortly before the crash, in circumstances which I will describe in Chapter 6, a signaller at the IECC, who had been monitoring the progress of trains, put SN120 back to red in face of the HST. This took effect at SN120 at about 08:08:50. At that point the front of the HST was 222-251m from SN120, according to the evidence of Mr P Balmer, a railway consultant, or 179-278m, according to Mr R Fenton, of W S Atkins. Adopting different methods for the purpose, they calculated respectively that the speed of the HST just before SN120 was replaced to red was 81-83 mph or 81-84 mph. At about 08:09 the HST cleared track circuit MZ2, having passed SN120.

3.25 About 33 seconds after the Turbo had passed SN109 it ran through points 8063B, and impact between the two trains occurred. Wheel slide of the Turbo started about 33 seconds after it had passed SN109 and at 33.10 seconds control of the doors was lost. The speed of the Turbo was then about 51 mph. A few seconds before impact there were two brake applications by the driver of the Turbo. The first was a service brake 3 (at 30.70 seconds). The second was the start of emergency braking (31.75 seconds), with the throttle slammed shut. There is no record from which any inference can be obtained as to braking on the part of the HST, but from the accounts given by passengers it appears that impact was immediately preceded by heavy braking. In neither case did the braking have any significant effect in lessening the force of the impact or its consequences. The combined speed of impact is likely to have been in the region of 130 mph. The point of impact between the trains was about 58 sleepers east of the tip of blade 8063A. At the time of impact the whole of the Turbo had passed the swing nose crossing west of 8063B points.

3.26 It was clear from the evidence that, faced unexpectedly with the putting back of SN120 to red, there was nothing that the driver of the HST could do to prevent the crash, and that he could not reasonably have been expected to have applied the brakes earlier than he did.

3.27 At the time of the crash the ATP equipment on board the leading power car was not operational. It was not in dispute that this did not have any bearing on the crash. I note, with approval, that since January 2000 First Great Western have applied a policy which requires that ATP equipment in a running train should be operational at all times, and that if ATP equipment ceases to be operational the train to which it is fitted should be taken out of service immediately.

Chapter 4
The crash

Introduction

4.1 This chapter is concerned with:

- what happened to each of the trains in the crash (paras 4.2-4.10);
- the crash performance of each train (paras 4.11-4.29);
- the fires which were caused by the crash (paras 4.30-4.51);
- the fatalities and injuries (paras 4.52-4.59);
- the protection and escape of passengers (paras 4.60-4.94);
- the emergency response (paras 4.95-4.127); and
- investigation (paras 4.128-4.141).

What happened to the trains in the crash

4.2 The initial impact between the trains was marginally offset with the leading end of the Turbo further north than that of the HST. The amount of the offset was variously estimated by experts to be 100-150mm or 300-400mm.

4.3 There was not precise agreement between the expert witnesses as to the sequence of events after the initial contact between the trains, but the differences are not material. For present purposes it is sufficient for me to set out an account which is based on the report prepared by Dr N E Kirk of W S Atkins.

4.4 The initial impact was between the leading coupler of the front car of the Turbo and the drawgear of the power car of the HST. These would have been deflected backwards and also vertically or laterally to one side, allowing the power car buffers to contact the underframe and lower superstructure of the front car of the Turbo. As the leading coupler on the front car deflected, the dragbox behind the coupler was likely to have been forced back and upwards, tearing it away from the leading bolster and opening up the vehicle (*see Plate 7*). The dragbox of the power car may have also been damaged at this stage. The coupler of the front car and the drawgear of the power car became detached. The buffers of the power car may have been torn off as they impacted into the front car of the Turbo allowing the headstock of the power car to come into firm contact at the leading end of that front car. As the power car impacted the cab end of the front car of the Turbo, the cab and leading section of the floor of that car were destroyed. The leading bolster shattered into several pieces and the leading bogie separated from the bolster pivot. The cab end and left hand bodyside were destroyed as the HST penetrated the vehicle. The right hand bodyside of the front car of the Turbo started to fail along the welds to the solebar. The cab of the power car, which was constructed of GRP, shattered, and pieces were scattered over the southern area of the site. The headstock of the power car was severely damaged and separated from the front of the vehicle. The left hand solebar was torn from the power car and the centre longitudinals were bent upwards. The fuel tank from the front car of the Turbo sustained a heavy impact across its leading end and was destroyed. This is likely to have been caused by a large item such as the leading bogie of that car.

4.5 The trailing end of the front car of the Turbo struck the leading end of the middle car. The trailing end of the front car failed and was pushed inside the middle car. The gangway pillars of the middle car were likely to have been torn through the underframe of the front car before failing at floor level (*see Plate 8*). The leading end of the middle car failed along the right hand cantrail welds and the roof was pushed upwards. The left hand side failed along the welds to the solebar, and the floor was pushed down. The trailing underframe of the front car failed and fell into planks. The trailing bolster of the front car failed and its bogie detached. The leading end of coach H (the front coach) of the HST impacted on the trailing end of the power car. The trailing end of the power car was pushed inside the guard's compartment at the front of coach H, and coach H started to override the power car. Coach H lifted up as it overrode the power car. The underframe of coach H started to bend back on itself and the leading bogie fell away. The underframe of the power car was bent up and the superstructure pushed backwards into the vehicle. The superstructure of coach H was torn away from the solebar as the underframe bent back.

4.6 The floor and left hand bodyside of the front car of the Turbo were severely damaged by the HST slicing through the leading sections of the car. The bogies and leading fuel tank from the power car separated from the underframe. A section of floor from the right hand side of the leading door of the front car of the Turbo passed through and became embedded in the trailing fuel tank of the power car. The power car veered off to the right towards the southern side of the track. Coach H started to rotate as it followed the power car and was struck from the rear by the trailing coaches. The trailing fuel tank detached from the power car. So also did the trailing bogie and the underframe equipment on coach H. Debris from the superstructure of the leading end of the front car of the Turbo was scattered over the southern side of the site. To this may be added the account given by an eye witness, Mr G A Burton, who was a passenger in coach C of the HST. He said:

> "I saw the front power car of the train (the HST) rising up and to the right, almost like an aeroplane taking off. I believed that, at that point, there was already smoke and fire coming out of it."

4.7 During the collisions described in the last two paragraphs, the middle and rear cars of the Turbo were pushed back by about 12 metres and to the north of the track by 4.5 metres. As the HST passed the Turbo its coaches scraped along the left hand side of the middle car of the Turbo and struck the left hand side of its rear car. Debris from the trailing underframe of the front car came to rest under the trailing end of the middle car. The leading wheel set from the middle car came to rest underneath the leading end of the rear car. The rear car fell onto its right hand side, rupturing the fuel tank on its right hand side. As the middle car was pushed backwards off the track the right hand side of its fuel tank was ruptured. A heavy item glanced across the left hand side of the tank causing secondary ruptures. Due to the large amount of debris it is difficult to ascertain exactly what caused them.

4.8 The leading bogie of the power car sustained heavy impact across the front of its headstock, coming to rest beyond the top of a gantry girder which had been flattened. The trailing bogie of the power car and the leading bogie of coach H came to rest against the girder on the south side of the track. Coach H jack-knifed, sliding over, and possibly sustaining secondary impact with, the gantry girder on the south side of the track. It came to rest near the power car. The leading fuel tank from the power car came to rest at the trailing end of coach H.

4.9 As coach H jack-knifed, coaches F and G started to topple onto their right hand sides. The bogies were sheared off backwards, possibly due to derailment, embedding in the track or impacting with other equipment. The underframe equipment on coaches F and G was destroyed. Coach F slid along on its right hand side and coach E toppled on to the power car bogie. Some items of debris from the front car of the Turbo were dragged along by the coaches of the HST and were distributed along the length of the scene of the accident. Others were thrown into the air in the initial impact, coming to rest in numerous locations around the site.

4.10 The impact was accompanied by the almost immediate development of fireballs and subsequent fires on and around the trains, in particular coach H of the HST and the middle car of the Thames train. This is dealt with in greater detail in the section on fires.

The crash performance of the trains

4.11 In this section of the chapter I will summarise the evidence as to the crash performance of each of the trains. Whether and to what extent there is scope for improvement in crashworthiness, having regard to the possible speed of collisions, is a matter which I will consider in Chapter 13.

The HST

4.12 The HST was a type of train which had been designed, developed, built and commissioned entirely within British Rail. It was designed to be capable of carrying about 400 passengers at speeds up to 125 mph. It consisted of seven or eight coaches with a diesel power car at each end. The development of the coaches, which were designated as mark III, began in 1968, in succession to the mark II coaches. The trains were constructed in the workshops of British Rail Engineering Ltd (BREL). A total of 91 train sets were put into service between 1976 and 1982, 27 for the main line services of the Western Region of British Rail. The material used in their construction was mainly natural mild steel.

4.13 The HSTs were designed to be capable of meeting the proof loading requirements and fatigue loads which were required at the time of their construction, in accordance with the standards of the Union Internationale des Chemins de Fer. The traditional standard for the structural behaviour of a train was that it should be capable of resisting the imposition of certain static loads, applied at various positions, and that it should meet certain fatigue loads.

4.14 The HSTs were not designed to undergo controlled collapse in specified areas when subject to the forces exerted upon them during an accident. They were not designed to have crumple zones, shear-out couplers or anti-climbers. The significance of crumple zones is that they can assist in preventing structural failure in the rest of the survival space provided by the vehicle. It is only comparatively recently that railway vehicle bodies have been designed to undergo such controlled collapse. Such a requirement is currently contained in Railway Group Standard GM/RT 2100. It requires that a minimum energy of 1 megajoule (MJ) should be absorbed by plastic deformation of the end section of the vehicle when subjected to a collision, within a collapse distance of 1 metre. At the same time it has to be borne in mind that the total energy involved in the crash was considerable. Thus Dr Kirk stated in his report that the leading power car, and each of the mark III coaches of the HST, had a kinetic energy of 72.1 MJ and 31.6 MJ respectively. The kinetic energy of the front car of the Turbo was 9.7 MJ. Thus the total energies involved were 300-400 MJ.

4.15 I had the benefit of a statement setting out what was agreed by a number of experts in crashworthiness, along with the reports of the individual experts, as to the crash performance of the trains.

4.16 The experts found that, despite the apparent lack of intent, the ends of the coaches of the HST had acted like crumple zones and had managed the crash energy well. Dr Kirk observed in his report that there was plentiful evidence of plastic deformation at the ends of coach H. This indicated that the structure had absorbed a significant amount of energy. The main body shell was distorted but remained essentially intact. The experts observed that, in general, the mark III coaches had retained their windows and the structural integrity of the survival space. Passenger protection within the survival space which those coaches provided was good. There was no clear evidence of passengers being ejected from the survival space, and penetration from the outside by missiles was minor. At the same time it has to be borne in mind, as the experts pointed out, that the leading power car had protected the coaches. The general outcome, as Dr Kirk observed, was that, given the severe nature of the crash, crash performance of the mark III body shell had been excellent.

4.17 The experts also noted that several bogies had become detached from these coaches. There are no standards as to the retention of such bogies in high speed collisions.

4.18 As regards the interior of the coaches, the experts advised that they had performed well, although there were some misgivings about the performance of the table fittings.

4.19 In the leading power car of the HST, the driver's survival space was, in the words of the experts, "severely compromised". The cab, which was constructed of GRP, would not meet modern structural requirements. Dr Kirk expressed the view that the cab had no significant structural strength, that it could not resist loads above the underframe, and that it provided minimal protection for the driver in a collision. However, the experts were in agreement that even if the cab had been built to modern crashworthy standards, the driver could not be expected to have survived a collision of this magnitude.

4.20 In contrast, the underframe of the power car was extremely strong, as is typical in the case of all locomotives. Dr Kirk described it as having effectively acted as a battering ram when it impacted on other vehicles. This may have exacerbated the damage to the Turbo. The experts noted that both bogies on the power car had become detached. However, in a crash of this severity it was not practical to prevent this happening.

The Turbo

4.21 Construction of Turbos of the type involved in the crash – referred to as 165 Network Turbo Diesel Multiple Unit Train Sets – followed the awarding of a contract to BREL in 1989 as the outcome of competitive tendering. They were built between 1989 and 1992. Construction was required to be in accordance with a specification which was based largely on a British Rail code of practice as to structural requirements. Design and construction proceeded in consultation with, and with the approval of, the HMRI. The material which was used in the construction of these vehicles was mainly 6000 series aluminium extrusion with 4000 series filler wire.

4.22 The most striking aspect of the crash performance of the Turbo, as was pointed out by Dr Kirk, was the complete destruction of the front car, failure along welded connections and the general absence of significant plastic deformation in the parent material of the body shells. The Turbos were designed to meet the relevant proof loading requirements and fatigue loads of the time. They were not designed to meet the crashworthy design requirements of the standard to which I have referred above. A requirement for energy absorption was originally specified by British Rail. However, it was only for resisting collisions up to 18 metres per second, and the requirement was in any event subsequently withdrawn with the approval of the HMRI. The reason for the withdrawal was the unknown difficulties and duration involved in complying with the then "untried and underdeveloped" standard which imposed energy absorption. (That standard was overtaken by a simplified version in 1992.) Accordingly British Rail instructed BREL not to proceed with providing cab ends which were capable of being retrospectively fitted with means of energy absorption. The design did not feature crumple zones, shear-out couplers or anti-climbers. However, the total kinetic energy involved in the crash far exceeded that for which vehicle collapse regions are currently designed to cope. As was observed by Professor Sir Bernard Crossland in his report, it has to be recognised that it is impractical to design crush zones which are adequate for such very high energy. It may be noted that the weight of the HST was about 435 tonnes in total, of which 70 tonnes was the weight of its leading power car. The entire Turbo weighed about 113 tonnes.

4.23 In his oral evidence Dr Kirk observed that, by the standards of its time, the Turbo was an extremely strong vehicle from the point of proof loading. It would withstand weakening and still meet the requirements of the standard for that loading. In his report he stated that it would be unreasonable to expect the front car of the Turbo to remain totally intact given the high speed impact and the aggressive nature of the leading end of the power car of the HST. What was of particular concern was the fact that the damage was not limited to vehicle ends, that the aluminium extrusions had fractured along weld lines and that there was a lack of plastic deformation. Lack of plastic deformation indicated that the body shell had absorbed relatively little energy in the impact, compared to the mark III coaches and the power car. The structure appeared to have failed along the welds rather than deforming in a controlled manner. The coupler of the Turbo was of particular concern as it provided a robust load path into the dragbox and underframe of the vehicle. This resulted in a concentration of load on the interface between the dragbox and bolster. Failure of this connection opened up the floor of the vehicle behind the cab, increasing the chances of uncontrolled structural failure, ejection of passengers through the holes, injuries on jagged edges which had been formed, and the formation of missiles.

4.24 The Turbo was fabricated by welding together extruded sections of aluminium. The longitudinal welds between these sections were carried out by a continuous welding process. Manual welding was also used for attaching pillars or columns to the floor and roof structures. Due to the nature of welding extrusions, the weld areas were "under matched", i.e. weaker than the parent material. This was largely where it was not practical to reach the other side of the parent material. On the other hand the welded areas still met the required proof and fatigue loads, the parent material exceeding them. It followed, as the experts stated, that failure was bound to occur preferentially along the weld lines. The majority of welds exhibited partial penetration, i.e. they did not penetrate through the full thickness of the parent material. This had been done by design: it was an approach adopted by manufacturers at the time. However, the welds still met the required proof and fatigue loads.

4.25 As a result of the power car overriding the front car of the Turbo, all the survival space in the latter was lost. However, in the circumstances of the high kinetic energy involved in the crash, this was, in the words of the experts, "to be expected". In his report Sir Bernard Crossland remarked that in the light of the combined speeds of the trains, even if the front car of a Turbo had been designed to satisfy the 1 MJ energy absorption requirement specified in Railway Group Standard GM/RT 2100, it would have made little difference as the kinetic energy involved greatly exceeded 1 MJ. The evidence before the Inquiry also included a discussion of what practical difference, if any, it would have made if the Turbo cars had been constructed of steel rather than aluminium. I will consider that matter in the course of the discussion contained in Chapter 13.

4.26 The survival space in part of the middle car of the Turbo was lost when it was impacted by the front car. Once again, the effect was, in the words of the experts, "to be expected". The maintenance of survival space is, of course, the primary aim of a crashworthy design.

4.27 The welding of the aluminium extrusions was generally of reasonable quality. However there were some notable exceptions, particularly some of the welds of the vehicle end pillars to the floor/roof, and some other manual welds. As regards the middle car, the poor welds of the gangway and corner pillars at the intermediate ends reduced the protection that might otherwise have been afforded in lower speed collisions.

4.28 The protection of passengers within the middle and rear cars was considered by the experts to be reasonably good, in the sense of retaining the passengers, since only one passenger was ejected, and that only partially; and in the sense of protecting against penetration by missiles from outside. In the event, given the speed of impact, such penetration was relatively minor. There was some evidence of penetration by large objects in the tapering ends of the cars, but this was not considered to be a major cause for concern, given the high speed of impact.

4.29 The interiors were considered to have performed well, with the exception of some of the seats which were considered to have failed in an undesirable manner, by tracking breaking off at the seat bottom.

The fires which were caused by the crash

4.30 I now return to the narrative of what occurred in order to describe the fires which were caused by the crash. In this account I draw on the agreed statements by fire and crashworthiness experts and their individual reports.

4.31 Within a fraction of a second of impact the fuel tank of the front car of the Turbo disintegrated, after being struck by a bogie. As it did so, diesel fuel escaped under pressure.

4.32 The power car carried two fuel tanks, numbered 2 and 3. (There was no number 1 tank.) Shortly after the initial impact the number 2 tank of the power car became detached. That tank was immediately in-board of the cab-end bogie, and spanned the width of the power car. It carried self-sealing bulk loading valves on each side. The number 3 tank failed as a result of being penetrated by a section of floor from the Turbo, thereby releasing further fuel under pressure. That tank was located in the centre of the power car, immediately behind the number 2 tank, and was sandwiched between two battery boxes. It had no fuel filler, but was connected to tank number 2 by a flexible hose which acted as a balance pipe. Damage to these two tanks was less severe than that to the tank from the Turbo. Tank number 2 was carried forward by the decelerating remains of the HST, spilling fuel from numerous openings as it did so, but probably not so energetically as from the other two tanks. Although it was penetrated it could still hold liquid.

4.33 The fuel tanks on the middle and rear cars of the Turbo were ruptured in the process of those cars being derailed and toppled over. This probably resulted in their coming into contact with the ground or being struck by passing debris. The rupture caused fuel to drain from them. The fuel from the tank of the middle car contributed to local fires.

4.34 All the tanks were fabricated from aluminium. There was no evidence that the welds were "under matched". There was plentiful evidence of a variety of failure modes and plastic deformation of the parent metal.

4.35 I turn now to the effect of the escape of the fuel. At the time of, or almost immediately after, the collision there was a region of rapid turbulent combustion, described by eye witnesses as a fireball, which rose into the air and travelled along the HST, followed by the presence of substantial quantities of thick black smoke. Many passengers on the HST described travelling through a ball of fire that went along the outside length of the train from front to back. A video recording by a camera located in the car park of a supermarket to the north of the crash site showed that the fireball covered a horizontal distance of about 70m.

4.36 It was agreed that the source of fuel for the fireball was finely dispersed diesel fuel. Much of it came from the contents of the fuel tank of the front car of the Turbo which contained 688 litres at the time of the crash. However there was also a contribution, which it was not possible to quantify, from the diesel fuel contained in the two fuel tanks of the HST power car. The total contents at the time of the crash were estimated as 4,130 litres, comprising 2,410 litres in tank number 2 and 1,720 litres in tank number 3.

4.37 The horrific effects of the fire were most pronounced in coach H. Witnesses described seeing, just after the coach had come to a stop, a fireball travelling from near the rear of coach H to about halfway into the carriage; this probably then rolled back again towards the rear. Mrs Pam Warren was sitting at the rear of coach H. She described what happened just after the carriage had come to a halt:

> "I turned my head to the right and I saw a fireball. At this point I was still bracing myself in my seat… I tried to curl up when I saw the fireball coming. I twisted to my right and pulled my right leg up, trying to get into a foetal position and tried to pull the left leg up. I was unsuccessful in pulling my left leg up because it was trapped under the table which had fallen on to it. I clamped my hands over my face and pushed my right side of my head into the back of the seat. I don't recall screaming but I might have done because I managed to burn the inside of my mouth and throat….I remember the fire hitting me. It got incredibly hot and I could hear my hair crackling. There was also a noise like gas igniting. It then went quiet. The heat had died down, so I took my hands away from my face… My right leg that I tried to pull up was actually stuck on the arm rest and was still on fire. I reached down with my right hand and patted my legs and put the flames out".

Mrs Warren sustained severe burn injuries as did many others in coach H.

4.38 The fireball is likely to have been caused by the ignition of airborne fuel within the coach. The fireball originated at the rear end of the coach and propagated through it to, and a little beyond, the partition between the smoking and non-smoking sections. It is difficult to say whether the partition acted as a barrier. It is likely that the fireball did not proceed further due to the lack of airborne fuel which was within the limits required for flammability.

4.39 It is likely that when coach H came to rest there were multiple seats of fire within it, after the fireball had rolled through part of the coach. For example, survivors gave evidence as to seeing trails of fire around its interior. From photographic evidence it could be seen that one significant fire apparently developed at the rear of the coach, venting through the rearmost left hand window, not far from the rear vestibule. It was agreed between the experts that this fire spread through the coach over the course of seven or eight minutes until it fully engulfed it. Of those passengers who remained in coach H after the impact of the crash, all but one managed to escape from the coach before fire engulfed it. The majority of the combustible materials within the coach were then consumed over a period of about 30 minutes (*see Plates 9 and 10*).

4.40 The presence of diesel fuel inside coach H played a significant role in the development of the fire from its early stages. Mr C Christie of Geoffrey Hunt & Partners, who is a specialist in the investigation of fires and explosions, explained that in the early stages the predominant factor was the combustion of diesel fuel. It was inevitable that, when an accelerant was burning on a material, even one which was normally fire-retarded, there would be an eventual stage where the material could no longer resist the fire. The involvement of an accelerant in the early stages of a fire very much increased the onset of that condition. Diesel fuel could have entered the coach by way of broken windows, openings at each end of the coach and areas where the body of the coach had been damaged and penetrated. This was a mixture of burning and unburnt fuel, which had entered the coach during the dynamic stage of the incident rather than after it had come to rest. Mr Christie explained in evidence that this conclusion was based on the evidence of passengers and on the way in which the fire had spread, for example with trails of flame burning round the edges of windows on non-combustible materials. The fact that the initial spread of fire was not necessarily rapid indicated that unburned fuel had entered at a dynamic stage and became involved in the combustion at a later stage.

4.41 It seems that fire may have entered through the floor of the toilet at the rear of coach H; a passenger was in the toilet at the time and described a fireball suddenly coming up from the floor. The next thing he remembered was sitting on the track. The experts agreed that the structural damage to the rear end of coach H and the burning of fuel were consistent with the observations of Mr E P Warmington, another passenger in the coach, who saw the toilet wall at the rear end being pushed forward and a huge orange glow around the area. Mr D J Boddy, who was standing in the vestibule area between coaches G and H, was engulfed in flames almost immediately following the collision.

4.42 It was also agreed that fire had momentarily entered into the front vestibule of coach G of the HST while it was still upright.

4.43 The spillage of diesel fuel from the tank in the middle car of the Turbo propagated a trackside fire at the front end of that car. It is likely that dispersed fuels from other sources were also involved. Ignition was a natural aftermath of the initial fireball. This fire involved materials in the field of debris from the front end of the middle car of the Turbo. There was also an isolated fire in the middle car. Either burning fuel or burning material passed through the point of its side which had been penetrated, at or very shortly after the time of penetration.

4.44 In addition there were widespread and numerous trackside fires, mainly to the south of the crash site. These were caused by the dispersion of burning items and diesel fuel.

4.45 The diesel fuel in the tanks of the HST power car was a “summer” mix, whereas the fuel in the case of the Turbo was probably a “winter” mix. It was agreed between the experts that both fuels complied with BS2869:1998, and that the variation in properties as between summer and winter mixes was not relevant to the dispersion process, the possible sources of ignition or the subsequent development of the fire.

4.46 There were many potential sources of ignition. The most likely were the overhead line equipment, the onboard electrical systems and thermite sparking. Almost certainly all three were present and were particularly potent sources.

4.47 It was agreed by the experts that the coach materials in the HST performed as expected and in accordance with their design criteria. The establishment, and rapid spread, of fire within coach H were a consequence of the contamination of the interior materials by diesel fuel. The circumstances which prevailed were outside the design criteria. It was also agreed that the materials in the Turbo performed in accordance with their design criteria.

4.48 The only Railway Group Standards which are relevant to fuel tanks are GM/TT 0179, "Structural Requirements for Body Mounted Equipment on Rail Vehicles" (1993) dealing with general requirements, extreme body accelerations, proof load cases, ultimate load cases and fatigue load cases; and GM/TT 0402, "Internal Combustion Engines in Rail Vehicles", which requires that the engine fuel system and its fuel storage system must not present a hazard when in normal use. As was stated by Mr P J Howarth, Controller, Technical Services, Safety and Standards Directorate of Railtrack, there is relatively little guidance in Railway Group Standards, now or in the past, as to the design or location of fuel tanks on diesel powered trains. The general practice of BREL was to locate them under the floor of the vehicle between the bogies, and towards the end of the vehicle opposite to that occupied by the engine and the transmission, in order to reduce fire risk but at the same time avoid long pipe runs. As to the size of the tanks, this was clearly a compromise between the operator's interest in maximising the amount of fuel which could be carried and the extreme congestion under the vehicle with which the train designer was increasingly confronted.

4.49 On 8 September 1995 at Maidenhead three coaches of an HST which was travelling in excess of 100 mph became engulfed in flames when the rear fuel tank on the front power car became detached. Following recommendations made by an HSE investigation of this accident a number of changes were made to the fuel tank arrangements of HSTs. These included, in the long term, the modification of the fuel tank fixings. The Inquiry was informed that this was being done in conjunction with the carrying out of certain maintenance. At the time of the Ladbroke Grove crash this work had been done on both power cars of the HST. As at 5 July 2000, modifications had been made to all but seven of the First Great Western fleet of HST trains and it was anticipated that all but one of them would have been modified by September of that year. Following another recommendation of the HSE investigation, the toilet and sink waste pipes were to be replaced with ones which were more fire resistant. There had been problems with progress in implementing this recommendation. However, all of the fleet had been modified in this way by 31 March 2000.

4.50 In the 1970s rail vehicles were constructed in accordance with standards relating to building materials, such as BS476. In 1983 a code of practice, CP/DDE/101 ("Code of Practice to Improve the Safety of Passengers and Crew in the event of a Fire in Railway Traction and Rolling Stock Vehicles"), which related to the fire performance of the whole vehicle, was issued. This underwent continuous development. In 1987 BS6853 ("Code of Practice for Fire Precautions in the Design and Construction of Passenger carrying Trains") was issued. Its requirements were invoked by the British Rail code of practice. According to the evidence of Mr Howarth, all the HSTs which were operated by First Great Western were built to BS476 and were extensively refurbished in 1996/97 in order to comply with BS6853. The Turbos were built to conform to CP/DDE/101 and BS6853.

4.51 Since it is relevant to the protection of the Turbo against fire, it is convenient to refer forward at this point to the evidence given by Mr S Dicker, a trainee train driver, who was travelling in the rear cab of the Turbo. He said that following the crash he was unable to get sufficient purchase on the manual discharge handle to operate the engine fire suppressant system in the rear car of the Turbo. This system was designed to protect the engine in the event of a fire. It comprised two fire bottles. One was intended to be capable of being operated automatically from the driver's cab. The other was intended for manual operation. The contract and modern standards required the system to be manually operable from the trackside. The requirement for operability dictated the location of the manual discharge handle, which was just below the vehicle solebar. The pull handle was situated behind a protective cover. It was T-shaped and attached by means of a cable to the valve for releasing the aqueous foam contained in the fire bottle. Mr Dicker was standing on the train as the side wall had now become the roof. There is no suggestion that his inability to operate the handle contributed to any spread of the fire. He tried to activate the system and failed to do so, but by then the fire which he was attempting to extinguish had died down and did not seem to be posing any further danger. He did not attempt to operate the system a second time. It is also to be noted that the surface of the train had become slippery due to diesel fuel. The force required to operate the handle equated to that required to lift a 5.5 kg weight. I am satisfied that, as was contended by ADtranz, the force required to operate the system was low and that there was nothing which the designer could do in order to anticipate a situation in which diesel fuel had made the surface of the train become slippery, apart, that is, from protecting the handle itself, which was done. In these circumstances I am satisfied that the inability of Mr Dicker to operate the system was due entirely to the difficulty created by the position in which he sought to operate the handle and the fact that his footing was slippery due to the presence of diesel fuel.

The fatalities and injuries

4.52 31 people died as a result of the crash; 24 were on the Turbo and seven were on the HST.

4.53 422 persons were travelling on the HST, including the driver, Brian Cooper. He was instantly killed by the impact. His body was thrown from the power car and was later found to the south of coach D.

4.54 Coach H contained 36 passengers, six of whom were killed. The bodies of three of them were found in the rear part of the leading power car. They had apparently been thrown forward into it through the area between it and the coach. The bodies of two other passengers were found to the south of coach D and in the wreckage outside the front of coach H. All of these passengers died from injuries which they suffered as a direct result of the impact and secondary impacts which occurred during the crash. They all had been in the front end of coach H. The remaining passenger, who had died as the result of inhaling fire fumes, and was also found to have sustained significant head injuries, was found in the rear of the coach. All of the remaining 30 passengers suffered injuries, some of them being very serious burns.

4.55 Coach G contained 42 passengers, all but two of whom were injured. Coach F, which was the buffet coach, contained 30 passengers and two catering staff. All these persons, with the exception of four passengers, were injured. Coach E contained 85 passengers, of whom 56 were injured. Coach D contained 74 passengers, of whom 52 were injured. Coach C contained 64 passengers, of whom 41 were injured. Coach B contained 40 passengers, of whom 23 were injured. In coach A, which included the senior conductor's compartment, there were 47 passengers and, at the time of the crash, the senior conductor. All of these persons, with the exception of 19 passengers, were injured.

4.56 In the Turbo 148 persons were travelling, including the driver Michael Hodder.

4.57 In the front car of the Turbo there were 25 passengers and the driver. He and 19 passengers were killed. Of those persons, three were found in wreckage at the front of the middle car, seven were found between the front and middle cars, one was found outside the rear doors of the middle car, and one was found between the middle car and coach C of the HST. The remainder of the dead were found as follows: two to the south of coach E, two under the front bogies of coach E, two to the south of coach D and two to the south of coach C. One of these persons died from the effect of burns some weeks after the crash. That passenger, who was the only victim of the crash to die solely from the effects of burns, is likely to have been caught up in the fires which started in and around the leading car of the Turbo after the collision. The other persons died as a result of the injuries which they sustained in the impact or secondary impacts, subject to the qualification that in the case of one of them the inhalation of fire fumes was an additional cause of death. Of the surviving six passengers, all of them sustained injuries, in many instances of a very serious character.

4.58 In the middle car there were 60 passengers, of whom three were killed. These three had been seated in the front of that car, and their bodies were found in it. They had died as a result of impact-related injuries. Of the survivors, all but two sustained injuries.

4.59 In the rear car there were 62 passengers, of whom one was killed. That passenger had been seated near the middle of the car, and her body was found under it. Death had resulted from traumatic asphyxiation. Of the surviving passengers all but four had sustained injuries.

The protection and escape of passengers

The HST

4.60 Immediately after the crash the senior conductor, Mr C Paton, who had recently returned to his compartment at the rear of coach A, made an announcement over the public address system asking passengers to remain calm, and appealing for the assistance of persons who had medical training or were fire fighters, service personnel or railway staff. It appears that he also advised passengers to remain where they were until they were advised that it was safe for them to leave the train. He also said that passengers should make their way to the rear of the train. At that stage he was understandably unaware of the scale of what had happened. It may be noted that, according to the code of practice "Competence and Training of Personnel in Dealing with Train Emergency and Evacuation Procedures", in most cases it is safer for passengers to remain on the train. The general good sense of this statement is obvious. Immediately following the accident at Maidenhead in 1995 a passenger had been killed when he jumped out and was struck by a passing train. The code also states that complete evacuation of a train should be undertaken only "as a last resort, if absolutely necessary".

4.61 The conductor promptly used his mobile phone to call the emergency services manager of First Great Western to inform him of the location of the crash, and request the protection of the lines and the cutting off of the electricity supply to the overhead lines in the area. He had been issued with his mobile phone only two weeks before. The Inquiry was told that such phones had also been issued to First Great Western drivers on a trial basis. In evidence Mr Paton explained that his actions were in accordance with a new rule. Prior to that it was the responsibility of the guard, such as himself, to inform the signalman.

4.62 The conductor also attempted to get into contact with the driver by means of the on-train intercom. When he obtained no reply he got out of the train and walked forwards in order to make contact with him. In evidence he explained that he did so because of the new rule, which had been introduced a few days before, that the driver was in charge of the train, while the guard was in charge of the passengers. He said that he had not been trained for this splitting of responsibility. Prior to it the guard had been responsible for the protection of the train and for seeing to the safety of the passengers. While he was walking forward two members of Virgin Trains railway staff, who fortuitously had been travelling in his compartment, assessed the situation in coach A. One of them, Mr M Thomas, put down track circuit clips behind the train to ensure that the signals in rear of it were at red, and in due course assisted passengers to dismount from the train through the senior conductor's compartment with the use of a ladder which he had obtained from there. The other members of the train crew of the HST were the two persons who were serving in the buffet car. The only means by which the senior conductor could communicate with them was by way of the public address system or by using his mobile telephone. On his way forwards the conductor realised a disaster had happened. He was delayed by requests for assistance to deal with the injured. He became progressively overwhelmed by the magnitude of what was happening about him, and realised that the protection of the passengers was an impossible task for him to discharge. His predicament was aggravated by the fact that he had apparently sustained some concussion as a result of the impact. Given the death of the driver, he was technically in charge of not only the safety of the passengers but also the protection of the train. It may be noted that he was the only surviving member of the train crew who had had training in emergency evacuation procedures. At about 08:30 he telephoned the IECC to advise them that he had been unable to find the driver, and asked whether the overhead power had been cut off.

4.63 Following the conductor's initial announcement to the passengers, no further advice was given to them over the address system.

4.64 There were no emergency exits, as such, on the HST. In normal circumstances passengers could walk from one coach to another by means of the corridor which connected them. The door to the guard's compartment was normally locked, since it gave access to a bodyside door which was not fitted with central door locking. There was, however, a break glass in this door which could be used in order to gain access to the compartment in an emergency.

4.65 The main means of escape from a mark III coach were as follows. Each coach had four external doors, two on either side of each end of the coach. Each of these doors was a slam door and, apart from the senior conductor's compartment doors, could be locked and unlocked centrally. Central door locking enabled a bolt to be held in place by pneumatic pressure while the train was in motion. It was controlled by the senior conductor. When he released it the bolt retracted as air vented from the system, so that the passengers could open doors in the normal manner, namely by lowering the window in the door and opening it by means of the handle on the outside. The door had no internal handle. However, in an emergency it was possible for a passenger to unlock any door – and the door on the opposite side of the coach – by pulling an emergency door release lever above the frame of the door. In order to do so the passenger had to break the cover which protected it. On the face of the cover were the words "Emergency door release: To use break cover". The breaking of the cover exposed the instructions: "Pull here (with an arrow): then open door in normal way". The Inquiry was informed that the lever had been located above the door, in a modification of an original arrangement, because this was the most practical location and also because there might have been a risk of the cover being broken and the lever operated accidentally if it had been located at a lower level.

4.66 In order to reach an external door, or for that matter, to walk into an adjoining coach, a passenger had to get past an internal sliding door between the saloon and the vestibule at the end of the coach. This door was intended to open automatically when triggered by a sensor. All the doors were designed to slide in the same direction. It may be noted that, according to the guidance provided by Railway Group Standard GO/OTS 220 (1993), to assist in emergency egress from overturned vehicles, internal doors should slide in opposite directions or be hinged from opposite sides at each end of the passenger saloon. However, that standard was not retrospective. Its requirements applied only to new railway stock, and to existing vehicles undergoing refurbishment "insofar as it is opportune and practicable to incorporate them".

4.67 Each of the coaches contained a number of emergency hammers to enable the windows of the coach to be broken in an emergency. There were intended to be four of such hammers in each coach, except for coach F in which there were 2. They were located towards each end, and on both sides, of the coach, and behind a sugar glass cover which could be broken in order to obtain access. On the outside of the cover it was stated: "Emergency only". When the glass had been broken and the hammer removed a pictogram in the panel could be seen which instructed the user to strike the window in the corner to break glass. The windows were of toughened glass. The Inquiry was informed that, following the Maidenhead accident in 1995, First Great Western had provided a new type of hammer. According to the evidence given by Mr C Burrows, their Director of Engineering, this type of hammer was very sharp. It was strong and gave some protection to the user. It required, he said, relatively minor force to break the glass, although the force would have to be applied in the corner of the window.

4.68 First Great Western did not at the time provide any further written or verbal advice on board to passengers about what could be done for their safety in an emergency. However, they had produced a leaflet, and incorporated it in their current timetable. Under the heading of "Safety Information", it stated:

> "Keeping safe in an emergency. In any emergency, it is usually safest to remain on board the train. Move along the train to distance yourself from any hazard. Do not get off the train until instructed to do so by a member of staff unless you find yourself in immediate danger and you cannot move to another part of the train. If leaving the train in an emergency situation, disembark on the side away from the track: if there is a track on both sides of the train, do not get out until you have checked that there is no other train coming and then move off the track immediately. Follow these instructions if you are instructed to leave the train via an emergency window or by unlocking a door."

This was accompanied by pictograms relating to evacuation by each of these routes. The text relating to door evacuation stated:

> "Strike panel above door to break seal. Remove panel to expose handle. Pull handle to unlock door. Open door in usual way".

As regards window evacuation it stated:

> "Smash glass in panel to retrieve hammer".

4.69 Mark III coaches were equipped with portable fire extinguishers. It appears that these were principally intended to enable trained staff to fight small fires inside the train. The normal complement was as follows. There was one aqueous foam fire extinguisher in each power car cab and in the conductor's compartment. There were two carbon dioxide fire extinguishers in coach F, and one aqueous foam fire extinguisher in one of the vestibules of each of the other coaches. The senior conductor's compartment also contained a crowbar, hammer, axe, saw, rope, ladder and two sets of track circuit clips. It also contained the first aid kit. There was a further first aid box in coach F.

Escape from coaches A-E

4.70 After the HST had come to rest coaches A-E were still upright. The means of escape which were used by passengers in these coaches were as follows.

4.71 Just under half of the passengers in coach A left the train through the door in the senior conductor's compartment on the south side of the train. As I have already stated they used a ladder which had been put in place by Mr Thomas. Others left the train by way of the external doors at the front of the coach on both sides of the train.

4.72 About half of the passengers in coach B left the train by the rear door on the south side. This was after some delay during which efforts were made to break a window with a hammer. Passengers got down from the train by sitting on the edge of the floor and dropping down to the track. A door on the north side of the train was used after it had been opened in due course. Some passengers from coach B also got out by way of a door at the rear of coach C.

4.73 The great majority of passengers in coach C left the train by way of a door at the rear of the coach on the south side. Others used doors at either end of the north side.

4.74 About four-fifths of the passengers in coach D exited by the front external door on the north side. Most of the remainder did so by using the rear door on the south side.

4.75 About a third of the passengers in coach E left the train by way of a window on the north side of the front of the coach. This had been smashed by two passengers. The door to the front of the north side of the coach appeared to be jammed, and one of those on the south side could not be used because it was close to a fire. Some passengers were later able to get out by the jammed front door on the north side, after the glass in it had been broken. Just under half of the passengers left the train by way of the rear door on the north side. A small number of passengers escaped through a small gap which had opened up between the coach and coach F. The door which gave access to coach D could not be opened.

4.76 The Inquiry heard evidence of the difficulties experienced by passengers from these coaches in making their escape. Apart from the efforts of Mr Thomas and his colleague, who fortuitously had been able to assist passengers at the rear of the train, passengers had not received any further advice or instruction. The conditions in and around the train were deteriorating. Several coaches, and in particular coaches D and E, began to fill with smoke. The firemen later found that the fans which formed part of the air conditioning were still drawing in air despite what had happened in the crash. However, it does not appear that this made a significant difference to the conditions in the coaches. There had also been a total failure in the lighting. The coaches were equipped with a battery-powered system of emergency lighting, but it is likely that the effect of the crash was such as to disable the system by breaking the circuits which were necessary for its operation. In the deteriorating conditions groups of passengers, and individual passengers, acted on their own initiative.

4.77 It is clear that the release of the central door locking system was not effected or attempted. It may be noted that Miss Ursula Querino, a passenger in coach C who was employed by First Great Western as a dispatch supervisor, chose not to use her key to release the central door locking system because at the time she rightly judged that to do so would expose passengers to a greater risk than if they did not dismount there, even though the coach was becoming hot. Later examination showed that there was no fault in that system which might have impeded the escape of passengers. However, a number of them gave evidence that there was inadequate information as to how to get out of the train in an emergency. It is plain that the means of opening the external doors in such a situation was poorly understood. Passengers did not know about the location and use of the emergency release handle. There was criticism of the level at which the handle was located. Some did not appreciate that even after the emergency release handle had been operated, the external door handle had to be operated for the door to open; they did not see the further instruction located behind the glass cover. As a result of all these difficulties many passengers tried to open doors without success. Others waited for something to happen or turned in search of another door, especially when there was word that it could be opened. Later examination showed that all of the emergency release handles in coaches A, B and C had been pulled, none in coach D, and in coach E only those at its rear.

4.78 In evidence passengers also complained about the relative narrowness of the doors, in the sense that only one passenger could disembark from the train at a time, and the difficulty which they experienced in getting down from the train when there was no ladder or an equivalent.

4.79 Dr A M Wray of the Health and Safety Laboratory in his examination of the coaches found that, with the exception of a door at the front of coach C, all of the automatic sliding doors in coaches A-E had been damaged, possibly as a result of deceleration or passengers pressing against the doors during deceleration.

4.80 A number of passengers also gave evidence that they did not know where to find a hammer with which to break a window, or how such a hammer should be used for the purpose. Instructions appear to have been overlooked, probably because of the smoke from fires and the stress of the situation. There was evidence that two hammers were broken in use, although one of them was used thereafter to break a window (a drop-light window on the north side of coach E). Mr Burrows stated that hammers may have been broken because they were being used on the middle, rather than on the corner, of the window. Some passengers complained of a shortage of hammers. This may have been due to the fact that some hammers had already been taken for use. A number of passengers attempted to break windows with their hands or feet or with implements such as pieces of train furniture. Despite the evidence as to the shortage of hammers, there were, as Dr Wray reported, a number of hammers still in place when the coaches were examined some time after the crash.

Escape from coaches F-H

4.81 Coaches F and G ended up at about 70 and 90 degrees respectively from the vertical. Coach H, which had been spun round so as to face in the direction opposite to its original direction of travel, was resting at a considerable angle to the vertical *(see Plates 11, 12 and 13*).

4.82 Just over half of the passengers in coach F got out of the train by going through the front of the coach which, apart from the sliding door, was now open. But a sixth of the passengers got out through the rear of the coach, which had separated from coach E, although they first had to negotiate their way past a panel door used on occasion to close the carriage off. One panel had closed, restricting the doorway access by half. The passengers then jumped to the ground.

4.83 About 40% of the passengers in coach G got out of the train by way of a window in the middle of the north side of the coach, which by then had become part of the "roof". It appears that passengers had managed to smash this window despite its height above them. Those who escaped by this means slid down the side of the coach and across its underside until they reached the ground. About the same proportion of passengers exited through the front of the coach which, apart from the sliding door, was now open. A smaller number left through the rear of the coach which had separated from coach F.

4.84 Although hampered by restriction in visibility caused by smoke from the fires, virtually all of the 30 passengers in coach H who had survived the impact managed to escape. It appears that six passengers escaped from the front end of coach H, which had been crushed with the front seats and vestibule area ripped away. A number of passengers also got out of this coach by climbing through a window towards the front of the coach on the left hand side (by reference to the original direction of travel) which had been broken by a passenger with a table leg. Others managed to clamber out of another window about two-thirds down the left hand side of the coach, which had smashed in the impact. The passenger who had gone to the toilet at the rear of coach H found that after the crash he was sitting on the ground, having sustained severe injuries. Mr K Stiles and Mrs Warren, both of whom had sustained serious burning injuries while at the rear of the coach, acted with great courage in extricating themselves and getting out of a window on the right hand side of the coach which appears to have been broken in the crash. Mr Boddy, who had been standing in the rear vestibule, managed, despite burning injuries, to roll himself out of what had become the open end of the coach. All of those who escaped from the coach did so before it became, in the words of a passenger eye-witness, “a complete inferno”.

4.85 Lighting in these coaches – as in the case of the others – had failed as the result of the crash. Passengers in these coaches experienced dangerous and debilitating conditions. In coaches F and G the presence of dust and smoke inhibited breathing and further reduced visibility. In coach H there were a number of fires, as I have already narrated. These were accompanied by smoke which was thick and black. Escape from these coaches by their external doors was not practicable. The internal doors such as those in coaches F and G had shut under the influence of gravity. Passengers had to wrench them open by force. Once open, a door had to be held in an open position otherwise it would fall back again. This was a substantial hindrance to passengers and delayed their escape. It was particularly difficult for female passengers who required assistance. Dr Wray estimated that the force required to open a sliding door at the front of coach F was of the order of 28 kgf. The position in regard to the door at the rear of coach G was even worse. In that case the force was found to be 66 kgf, largely the result of the door binding, possibly because of the frame of the coach having become distorted. This force, he reported, corresponded approximately to the force required to lift an adult person. He also observed that to escape, assuming that the door was in the closed position following the collision, the force would have had to be applied through the fingertips from an awkward and cramped position. Dr A K Weyman of the Health and Safety Laboratory observed in his report that when a carriage was overturned and the vestibule doors were closed in a horizontal orientation the force required to open them was likely to be beyond the capability of more than 10% of adult males and most females. The Inquiry was informed that each door weighed about 18 kg. It contained a clear panel of GRP which was not readily breakable. It should be added that escape from these coaches by way of the windows was once more said to have been hampered by inadequacy of signage and difficulty in locating hammers, let alone gaining access to windows which had become part of the “roof”.

The Turbo

4.86 The Turbo was equipped with an address system which enabled the driver, in normal circumstances, to give messages and advice to the passengers. However, the driver was the sole train employee who was routinely on board. According to the evidence of Mr R Pamment, Fleet Manager, Thames Trains, it was possible for the signalman to address the passengers if the driver was not available, provided that the driver had opened up the radio link with the Control Centre, as he would at the start of the journey. No announcements were made to the passengers on the Turbo. Fortuitously, however, two Thames Trains employees, Mr Dicker and Mr A Barrell, his driver instructor, were travelling in the rear driver's cab. Mr Barrell phoned Railtrack at Slough to ensure that steps were taken to protect the train. He and Mr Dicker gave great help in unlocking the door which gave access from the rear car to the cab. This was not an emergency exit and was normally kept locked. They then assisted numerous passengers from the rear car, which had fallen 90 degrees on to its right side, to dismount from the train through the cab and a window in the driver's door. This was because the driver's door itself could not be opened.

4.87 The Turbo had no emergency exit, as such. Each of the cars of the Turbo had two external doors on each of its sides, situated at one-third and two-thirds along its length. These were automatic bi-parting doors. They were designed to be operated from a central control point. They were also designed to be capable of being opened from inside in an emergency when the train was at rest by means of the use of an emergency door release. This required access to a handle behind a sugar-glass cover above the doors. If the handle was pulled – which, in the absence of the supply of air, relied wholly on physical effort – the pressure which held the doors together was released; the doors would open a little and could then be pushed apart by hand. A notice below the handle gave information about this means of opening the doors in an emergency.

4.88 When the HST was constructed there were no mandatory standards applying to emergency access and egress. The practice at that time was for such matters to be covered by the technical specification in accordance with which the coaches were to be constructed. By the time that the Turbo was constructed it was possible for British Rail to draw on the Code of Practice CP/DDE/101 to which I referred in para 4.50. It had been developed in the early 1980s and, following its publication in 1983, it underwent continuous development up to 1990. It dealt with notices and signs, passenger communication systems, emergency door release, passenger emergency hammers, operation of passenger doors in an emergency, emergency operation of driver's cab-saloon door, and bodyside windows. In the 1990s the provisions of this code were formalised in a series of Railway Group Standards. However, in recent years, the scope for such standards has been narrowed. In accordance with Railtrack's responsibilities under the safety case regime and the Railway Group Standards Code matters which were entirely within the control of one operator and did not affect the safety of staff or passengers of any other operator or the general public were excluded from the scope of Group Standards. Accordingly, in regard to such matters, Group Standards came to fulfil the function of being only a guide to good practice.

4.89 Emergency hammers were originally fitted in Turbos such as the one which was involved in this crash, although it was not a requirement of the code of practice. This was because the greatest distance between a seat in the car and the nearest external door was 7.2m, and hence less than the distance of 12m which was prescribed in para 4 of the code at which provision of hammers was mandatory. However, according to the evidence of Mr Pamment, vehicles suffered from the theft of hammers on an enormous scale. He stated in evidence that 7,000 had been stolen from a total fleet of 300 vehicles. In one Thames Trains vehicle every window and piece of glass had been smashed from within the car. Vandalism and the risk of injury to other passengers, staff and the general public had been of great concern to the company. In 1996, following a risk assessment by Engineering Link, a subsidiary of the Railway Technical Centre, and with the approval of the HMRI, the hammers were removed from the Turbos. This was subject to a condition that the internal doors connecting one car with the adjacent one were modified so that they could be opened manually.

4.90 The Turbo had a total of six aqueous foam fire extinguishers of different sizes. There was one in each cab and in the middle and rear cars. In the case of the front car there were two fire extinguishers, because in order to gain access to the first class compartment at the front of that car, a set of bi-parting doors required to be opened. The front car also contained a cupboard with emergency equipment on either side of a toilet. The cupboard was locked, but could be opened by operating a lever behind a break-glass cover.

Escape from the Turbo

4.91 Survivors from the front car of the Turbo who were able to free themselves from the wreckage found that the car was open to the south side. Mr W M Levy, who was sitting towards the middle of the front car, described the scene after impact:

> "The carriage was completely devastated. The floor had come up. There were seats and debris and metal all over the place, and a few pockets of flame around the carriage and the right hand side of carriage (left hand side when facing the direction of travel) was completely gone. It was completely missing."

He described how his clothes were ripped and he was covered all over in black, sticky diesel. Mr K B Badu, another passenger, had been sitting on the rear right hand side of the car. After the crash he could not move as he was trapped in the wreckage with fires burning around his legs. Fortunately, two or three people helped to pull him free of the wreckage and fires on to the side of the track. However he still sustained severe burns.

4.92 As regards the middle car, a number of passengers were trapped in the crushed front end of it, and remained there until they were released by the fire brigade. One of those trapped was Majella Lyons, who gave moving evidence to the Inquiry of her experience. She was thrown out of her seat on impact, landing on the floor on her back. Her legs were elevated in the air trapped in twisted metal, glass and foam above her. She was covered in shattered glass. She could hear flames roaring nearby and felt an intense heat from the fire; she was scared that she would be burnt whilst trapped. The fire was put out and over the next four hours, the firemen and paramedics reassured her and provided medical assistance whilst the firemen carefully removed the debris from around her in order to free her. This was an extremely hazardous situation as the wreckage was precariously balanced. The lighting on the Turbo train also failed as a result of the crash. Once again, the failure of emergency lighting which would have been provided by batteries appears to have been due to the effect of deceleration on the circuits which were required for the operation of this system. Passengers had to rely on natural light. In the case of the middle car the external doors on the "high" side of the car could not be used. The front door on the other side of the car had apparently been damaged by the impact and was unusable. It was not possible for passengers to use the sliding doors which gave access to the rear car as they also had been damaged and were jammed in a partially shut position. Accordingly the rear door on the "low" side, the north side, was the only means of egress for those able to make their own way out of the car. This door was opened with difficulty, probably due to impact damage or the inertia in the door opening mechanism. The evidence disclosed that near that door was a bicycle, which required to be pushed aside.

4.93 The rear car fell to the right on to its side, blocking all exits to the north side. Passengers in the rear car were unable to open the external doors apart from one set, on the south side, which was opened using the emergency handle, but in that case they had difficulty in gaining access to this exit as it was now the roof, and they were in any event reluctant to use it through fear of coming into contact with live overhead electric cables. Some attempted without success to break windows without the use of hammers, although it is to be noted that one of the deceased had fallen through a broken window on the north side, before the car hit the ground. Exit through the window in the driver's cab door was not easy for the passengers. As I have already noted, it was only because of the presence and assistance of Mr Dicker and Mr Barrell that they were able to use this means of escape at all. Mr Dicker and others helped to pull up fellow passengers who were then lowered towards the ground and caught, again by fellow passengers.

4.94 In the initial impact a number of seated passengers in each of the trains were thrown out of their seats, and, it appears, were injured thereby. There was also evidence that luggage was thrown around. This was at least a potential cause of obstruction to egress, but there was no evidence that it caused any injury.

The emergency response

Electrical isolation

4.95 At the Slough IECC it was noted that at about 08:09 an interference with overhead line equipment had occurred. Mr T Siddell, who was the electrical control room operator, observed that circuit breakers for the Main lines and Down Relief lines had tripped out. He telephoned Railtrack Control to advise them of a major emergency incident. He opened the circuit breakers for the Up Relief line in order to shut off the power for that area also, and put a lock on the breakers so that they could not be put back in. Mr Siddell and Mr C D Neale, a technician with Amey Rail, were not in agreement as to which of them had telephoned the other as a result of what had been observed. However, it is clear that thereafter Mr Neale took prompt action in setting out with a number of teams of technicians to earth the lines, so as to deal with any possibility of residual current in them and prevent any accidental re-energisation. This was done by clipping aluminium earth strips to the overhead lines. Authority was given to Mr Neale for this purpose at 08:34. The earths were up by 08:36. After that work had been done Mr David Feltham, Railtrack Mobile Operations Manager, who had been appointed to be the Rail Incident Officer, issued a number of forms permitting work to be done on or near the overhead lines between defined limits.

Mr C D D Burchell, Railtrack Area Operations Manager, was appointed to be the investigation officer.

The Fire Brigade

4.96 Following an emergency call at about 08:10, the first fire engines of the London Fire and Civil Defence Authority arrived at the site very shortly before 08:15. They came from North Kensington fire station, which was about half a mile away. When he arrived Station Officer Hodson was able to observe a large mushroom cloud of smoke rising 150-200m into the air. At about 08:15 further appliances were called for. The natural means of access to the site was from the south where a Eurostar complex adjoined the railway tracks. At first there was some delay in opening an electronically controlled security gate, because the keys of the gate had to be fetched from the control room. However, this did not prevent five officers from scaling the gate by means of a ladder. Initially the security gate could be only partially opened, due to the interruption of the electronic infra-red beam which operated the motor. Therefore crews had to proceed on foot laying hoses. The gate was not fully opened for some minutes. After entering the grounds of the depot, firemen climbed over the trackside perimeter fence using extension ladders. Access was also gained through the hole which the HST had made in the trackside fence. Arrangements were made to cut a further hole in the fence by means of hydraulic equipment so as to allow access by medical personnel and removal of live casualties. Personnel from the depot and builders who had been working in a nearby street helped to cut down the trackside fence at another point. In due course a large number of pumps and appliances attended from fire stations including Hammersmith, Battersea, Willesden, Kentish Town and Paddington, and the major incident procedure was instituted.

4.97 When fire officers first gained access to the crash site it was not immediately obvious that there was a fire near the middle of the Turbo since they were approaching the site from the south side and vision was obscured by smoke and twisted metal. However, very quickly steps were taken to lay hose to that side of the site and extinguish the fire.

4.98 The fire brigade were assisted by members of an emergency response unit from London Underground, in particular in jacking up the roof of the middle car, so as to enable the firemen to extricate those who were trapped there. The evidence disclosed that there had been some initial confusion as to what was required, and it was suggested that there was a need for improvements in the arrangements between London Underground and Railtrack. The rescue of trapped passengers from the middle car of the Turbo was hampered by the dangers posed by the suspended roof and the fraying of the overhead electric lines. It was made more difficult by the presence of smoke. A number of firemen displayed great courage and endurance in not only extricating those who were trapped but also comforting and supporting them during the long drawn out process of this delicate operation.

4.99 By the time that members of the fire brigade attended, the situation in regard to coach H was such that no one who was in it at that time could have survived the inferno. Flames could be seen rising about 100 feet into the air from it. Accordingly, the primary effort of the fire brigade was directed to the Turbo. In due course hoses were laid to extinguish the fire in coach H. At one stage the supply of water was temporarily interrupted, because a fire engine which was taking water from the hydrant outside the Eurostar depot had to be moved in order to allow another engine to be driven into the complex.

4.100 Mr Feltham, the Rail Incident Officer, gave evidence of receiving a request from the fire brigade to cut back some of the overhead wires which were snagged around the Turbo. He said he spoke to Mr Neale of Amey Rail that evening, but Mr Neale had no recollection of any such request that day. Certainly, by the next morning Mr Neale was aware of the request. He said that it was not possible to perform this operation on 6 October as it was unsafe to do so, because a large piece of the roof of the Turbo was hanging on the equipment. This was eventually removed by the Fire Brigade with the assistance of Amey Rail on 7 and 8 October, after which the wires were cut back from the two trains.

The Police

4.101 Following the emergency call officers of the Metropolitan Police Service arrived on the scene no later than about 08:15. The first of the officers of the British Transport Police (BTP) arrived at about 08:22. To facilitate access to the crash site, Detective Inspector Colin Lee of the Metropolitan Police commandeered a builder's lorry and with the driver's assistance put ladders down the side of the bank. He organised the evacuation of uninjured passengers to a safe area and asked officers to assist in evacuating injured passengers from the site to waiting ambulances. He also organised the distribution of first aid equipment. In total, about 500-600 personnel from all emergency services were involved on the site during the period of 12 hours from 08:45. During that time they were engaged in a number of activities, both in response to the disaster and in regard to setting in motion the necessary site investigation.

4.102 Officers of the Metropolitan Police arranged for the closing of Ladbroke Grove and Harrow Road, and for hospitals to be alerted. Barlby Road School was opened for reception of passengers who were in need of medical attention, and for the interviewing of witnesses. At 08:28 the incident was declared a major disaster. In a major disaster the co-ordination of the activities of the emergency services in London is provided for under the London Emergency Services Liaison Panel Major Incident Procedure. This is a protocol which directs that three levels of command should be set up, namely, Gold, Silver and Bronze, dealing with strategic, tactical and operational decisions respectively. The BTP established an inner cordon in liaison with the Metropolitan Police who maintained an outer one. The establishing of an inner cordon, in accordance with procedures recommended by the London Emergency Services Liaison Panel, enabled the activities and resources of all the emergency services to be co-ordinated. The Metropolitan Police also made arrangements with the two train companies involved for the setting up of family reception centres within the police force areas covering the train routes. Centres were set up at Gloucester, Swindon and Reading, staffed jointly by representatives of the train operating companies (TOCs), the BTP and the local police forces.

4.103 At about 13:00 on 5 October the BTP started a fingertip search of the crash site, with the assistance of Railtrack, First Great Western, the HMRI and Thames Trains. It was rightly described by Counsel for the BTP in his submissions as having been performed "in arduous, distressing and sometimes dangerous conditions". This search lasted for nine days. The site was handed back to Railtrack at 17:25 on 13 October.

4.104 Given the precarious position of the coaches, and in particular coach H, it was decided by Assistant Chief Constable Nicholas of the BTP, who was Gold Commander in the Major Incident Procedure, that the search should be suspended during the night between 5 and 6 October.

4.105 On 6 October there was a report in the national press that the police feared that 60 passengers remained in the burnt-out wreckage of coach H. I understand that later in the week the figure had risen to well over 100. However, on 11 October the press were able to report, as I have already narrated, that only one body had actually been found in that coach. There can be no doubt, as was put to me, that the exaggerated figures increased the anguish of many of those who were caught up in the events, waiting for news of friends or loved ones who were believed to have been on the HST. This was highly regrettable. How this came to happen was not established in the evidence. However, it is most important for the future that in any incident involving multiple casualties the greatest care should be taken to avoid the giving of any impression that the scale of loss of life may be greater than is certain.

The Ambulance Service

4.106 The first ambulance arrived on the scene at 08:19. At about that time Dr Gareth Davies, an Accident and Emergency Consultant of the Royal London Hospital, also arrived and became the Medical Incident Officer. Dr Matthew Neal of the Helicopter Emergency Medical Service based at the Royal London Hospital received a call at 08:15 and went by road to the crash scene. He arrived at about 08:20 and made an initial assessment of the scene to assess what medical resources were needed. Mr Ashley Barratt arrived at 08:35 and became the Ambulance Incident Officer. At least 11 doctors and registrars attended the scene, as well as a mobile medical team from University College Hospital. Four hospitals, St Mary's, Chelsea & Westminster, Charing Cross and the Central Middlesex Hospitals, were told to activate their major incident plans. The Royal Free Hospital and University College Hospital also received injured people. Regular contact was made with all receiving hospitals by mobile phone.

4.107 Between 08:35 and 08:50 the medical services assessed the size of the incident and the number of casualties. Initial figures suggested 200 patients. Approximately 20 people were believed to be trapped. Dr Davies emphasised the need for early aerial photography to take place as a useful tool to establish exactly where reported casualties were. Final records show that 227 people were admitted to hospital. It was unfortunately not possible to use the air ambulance to transport those with severe burns to specialist burns units throughout the south-east of England because the helicopter was undergoing mechanical repair. This placed an extra load on the Ambulance Service who had to transfer patients with severe burns to burns units by road some hours later.

4.108 By 13:00 on 5 October the last three remaining trapped casualties had been released, leaving only bodies in the wreckage. The London Ambulance Service remained on site with a crew to ensure an immediate response if further survivors were found or rescue personnel were injured. A St John mobile medical unit was also on site for 24 hours a day during this time. The London Ambulance Service stood down at 09:30 on 13 October.

Tributes to passengers and the emergency services

4.109 Many of those travelling on the trains showed acts of great courage and humanity in the aftermath of the crash. Under appalling conditions and, in many cases, with injuries of their own, they helped their fellow travellers to safety and looked after them until the emergency services were able to take over. Their outstanding efforts, and those of the many members of the public who responded so readily and effectively to the crisis, were clear from the evidence presented to the Inquiry, and it is right that this report should pay full tribute to them.

4.110 The work of the fire brigade, the police and the ambulance services also deserves the highest praise. They brought great comfort to those who were distressed and confused, many of whom were in great pain and had suffered very serious injuries. I wholeheartedly endorse the tribute which Mr Hamer expressed in the Inquiry on behalf of the bereaved and injured whom he represented:

> "I am especially instructed, and I do so willingly, to express the deep feelings of gratitude and appreciation to the Fire Brigade, the Police and the Ambulance Service for the painstaking way they carried out their tasks, and the comfort they brought to the distressed and confused passengers, many of whom were in great pain and suffered appalling injuries".

4.111 At a ceremony on 7 February 2001, HRH The Prince of Wales presented Certificates of Commendation from the British Transport Police to 47 passengers, members of the public, organisations and BTP police officers for the outstanding courage and skill which they displayed in response to the crash.

The recovery of bodies

4.112 Following the removal of live casualties, operations within the inner cordon moved into the recovery of bodies. Dr Neal was appointed mortuary officer on the day of the crash. He was responsible for pronouncing that life was extinct and producing tags for the bodies which were outside the carriages. The location of each body was noted by him on the tag, which he signed. The bodies were then left for the police to take further action. Dr P Knapman, HM Coroner, visited the site at about 11:00 on the day of the crash. He helped to direct the process of body recovery, which started at 17:45 on 5 October and took place over the next nine days. On two occasions the process had to be interrupted; once on 8 October because a fractured gas pipe under the tracks was discovered, and once on 11 October, because an underground electrical cable was discovered to be exposed. It had not been possible to isolate this from the Slough IECC. Body recovery was stopped until the Fire Brigade assured the police that the site was safe.

The removal of the carriages

4.113 The removal of the crashed carriages proved to be a somewhat difficult and long drawn out process. Two 1,000 tonne cranes were provided by a heavy crane contractor, arriving at 12:30 on 5 October. No lifting was carried out that day since the police were not yet satisfied that the search had been adequate. Other support cranes also arrived the same day. The first lift did not take place until 21:00 on

8 October when a section of the middle Turbo car was removed. In order to enable one crane to get into the site certain cabins had to be demolished. The first lift of a coach took place on 9 October. Coach H was lifted and removed on 11 October. Thereafter the removal of the remaining coaches took place until 13 October.

The support of the bereaved and injured

4.114 In general the way in which the bereaved and injured were looked after by the police and social services was greatly appreciated. In particular the work of family liaison officers for the bereaved was highly valued. Unprecedented use of police family liaison officers was made, in order to assist with identification of those injured and killed. They provided a means of contact to pass information between the Casualty Bureau and the families. They also provided support services to bereaved relatives and advised the police on how to help families who had suffered bereavements. There were, however, two matters to which criticism was directed.

4.115 A number of the passengers who had been taken to adjoining premises after leaving the crash site pointed out that no steps had been taken to assist them on their onward journey from there. There is some force in that criticism. No doubt this is a matter on which useful lessons can be learned. TOCs should understand that they have a responsibility for attending to passengers who do not require to receive medical attention, and accordingly they should have arrangements for their after-care.

4.116 A number of the bereaved were highly critical of the way in which the Casualty Bureau of the Metropolitan Police Service had been organised. This seems to have arisen from the inadequate systems which were in place to collate enquiries and to inform those anxiously awaiting information about relatives or friends. The Casualty Bureau was completed in 1983 as part of the Central Command Complex. Since that time there have been some 27 major incidents with which the Bureau has been concerned, a third of them being railway crashes. Railway incidents place a particular strain on any information system that is in place, because of the absence of passenger lists and because of the lack of information about the numbers of people who may have been involved. The system which was in place at the time of the disaster was not computerised but instead was based on the recording of the details of missing persons on forms. These forms were sent to a collation unit. A separate part of the unit dealt with incoming calls from hospitals and officers based at survivor centres. This was all fed into a paper exercise resulting in a card index.

4.117 On the first day 3,868 calls were received, reporting nearly 2,000 missing persons. By the beginning of the second day the card index of the collation unit contained over 5,000 reports of missing persons, casualties, survivors or cancellation reports. By this time, the Bureau was overwhelmed by the sheer volume of material which had been coming in. The difficulties arose from the volume of missing person reports, and the logistics of going through a paper cross-referencing exercise with all the labour and imprecision which that inevitably involved. There were difficulties associated with trying to contact those who had reported persons missing, as they frequently moved around. Further difficulty was caused by the fact that other organisations had issued different telephone numbers for the use of members of the public. The problems were compounded by the fact that a number of false reports were received from mischief-makers.

4.118 Although an IT system is now in place in the London Metropolitan Police area (the Holmes 2 system), it appears that some other police forces still rely on the old paper-based system. There is also doubt as to the degree of automation which the Holmes 2 system offers. It is understood that there is a lacuna between the receipt of a telephone call and the logging of information onto a computer. The call details are recorded on paper and subsequently transferred by another operator to the computer. Telephone operators are not trained in the inputting and collection of data. This does not permit the instant feeding back or clarification of details that may be already in existence in regard to the person about whom the enquiries are being made. It was pointed out that in the airline industry volunteer telephone operators in the Emergency Planning Incident Centre can enter information straight into the computer.

4.119 It is highly desirable that the system used in the Casualty Bureau and other police forces for the reception of information about missing persons, casualties and survivors in the event of a major incident should be computerised in order to avoid delay and distress. So far as is practicable, a person who receives a call should be able to enter the information received directly into the computer, and, to the extent appropriate, provide information from it to the caller. There should be a set procedure for the returning of a call where information cannot meantime be provided to the caller. This should include the logging of incoming and outgoing calls. It should be understood that, wherever possible, an assurance should be given that the call will be returned in the given period of time, and this assurance honoured.

4.120 Steps should be taken to extend computerisation to all police forces and to ensure that the information collated by each police force is readily available to all others. For this purpose it may desirable, in the interest of economy and efficiency, for these facilities to be provided on call from one or more central locations.

4.121 The police service, in co-operation with the other emergency services, should use their best endeavours to ensure that, in order to avoid confusion, common telephone numbers are issued for the use of members of the public who are seeking to give or obtain information about persons who have, or may have, been involved in a major incident.

4.122 On behalf of the Rail Users' Committees it was suggested that the Railway Group should review emergency planning, including liaison with emergency services, arrangements for the after-care of survivors and the provision of support and facilities for the bereaved and injured. I agree with that suggestion, and so recommend.

Debriefing

4.123 All the emergency services held debriefing sessions within weeks after the crash. The police debriefing highlighted areas within which they concluded there was room for improvement and the recognition of good practice. It was considered that there had been weaknesses in communication, both to the scene and at the scene itself.

4.124 The fire brigade debriefing recognised that lessons should be learned from instances of lack of liaison and co-ordination at North Kensington Fire Station. Comments were also made about the lack of communication in general.

4.125 The emergency services (including the ambulance service) held a joint debriefing session on 11 November 1999. Railtrack co-ordinated an industry debriefing session on 27 October 1999, and an internal site management debriefing on 13 March 2000. At the latter the view was expressed that site safety could have been handled better, and that there was a need for a single point of contact for site management. On 22 March 2000 a multi-party debriefing was held, following discussions between the BTP and Railtrack. It was attended by representatives of First Great Western and Thames Trains. It was followed by a further session on 3 May 2000, which was attended by the BTP and representatives of the rail industry. It may be noted that no single body is responsible for the organisation of multi-agency debriefing. I fully endorse the recommendation of Professor Uff in his report on the Southall Rail Accident Inquiry that post-accident debriefing procedures should be reviewed to ensure that combined debriefings are held between all involved railway industry and emergency services groups (paras 2.25 and 17.16).

4.126 On behalf of the Rail Users' Committees Mr Cartledge invited me to recommend that the BTP, the fire brigade, the ambulance service and the London Emergency Services Liaison Panel and equivalent bodies elsewhere should each address the issues identified in their post-incident review of their response to the crash. I do not consider that there is a suitable basis for such a recommendation. It should be left to the good sense of each of these bodies to digest the lessons from what happened and to ensure that these are disseminated to the extent that is appropriate.

4.127 Mr Cartledge also invited me to recommend that the Railway Group should review all relevant rules, standards and procedures in regard to a large number of topics under the general heading of "emergency planning for serious train accidents". Save to the extent which I indicate in this chapter and Chapter 14, I do not consider that there is a suitable basis for such a recommendation.

Investigation

The police and the HMRI

4.128 In the case of major incidents on the railway, responsibilities for police functions are shared between the BTP and the relevant Home Department force, in this case the Metropolitan Police. In accordance with an agreement, the BTP has a responsibility for investigating most railway incidents. In the case of this crash, the division of responsibilities between the BTP and the Metropolitan Police was agreed on the morning of 5 October by Assistant Chief Constable Nicholas, the Gold Commander of the BTP and Commander Currie, the Gold Commander of the Metropolitan Police. Gold Command liaison officers for both forces were set up at New Scotland Yard. The BTP investigation was headed by Detective Chief Superintendent Cardew, assisted by Detective Superintendent Nicholas Bracken. The BTP set up a Major Incident Room at Hammersmith, from which the police investigation was co-ordinated.

4.129 The HMRI also have the responsibility for investigating railway accidents, which may lead to the bringing of prosecutions by the HSE under the Health and Safety at Work Act 1974. The respective responsibilities of the police and the HMRI are defined in a protocol. This provides that in all cases of death a police investigation will take place. It further provides that the police will lead in the investigation of serious offences (where there is evidence of deliberate intent or gross recklessness), and the HMRI will lead in investigations where the evidence suggests that human error or carelessness is involved, with working environment, equipment, or operating procedures playing a significant part. In the case of an investigation led by the BTP, of which Ladbroke Grove was an example, the police were assisted by the HMRI in providing technical advice and expertise. Once the site of the crash had been declared to be a scene of crime on the morning of 5 October, the BTP were in overall control, apart from where rescue of the injured or recovery of the bodies of the deceased was involved. Assistant Chief Constable Nicholas told the Inquiry that in practice the HMRI took over the technical direction of the experts, although there had been some initial confusion as to who was directing them at the crash site. This confusion appears to have come about because the arrangements had not yet been reduced to writing at that stage. The BTP and the HMRI were in agreement that the arrangements between them appeared to have worked well. Mr Nicholas described the working relationship between them as “excellent”. He explained that the HMRI were not represented at Gold level meetings because they were operating at the investigative level.

The position of Railtrack

4.130 On the morning of 5 October it was decided at the first Emergency Services Gold Co-ordinating Group meeting that Railtrack should be excluded from the strategic decision-making process of that group as they might be subject to prosecution. Immediately after this meeting the BTP met Railtrack to discuss the use by the BTP of specialist railway technical experts. Railtrack offered the services of AEA Technology Rail and W S Atkins, who normally provided services to Railtrack under standing contracts. This offer was accepted, and it was agreed that technical reports would be shared with Railtrack to enable them to complete their own industry inquiry and that any safety-critical reports would be immediately passed to Railtrack. This agreement was reduced to writing in a protocol between the BTP and Railtrack dated 23 November 1999, which was approved by the HMRI. The general principle was that, after consultation with the Crown Prosecution Service and the HMRI, evidence would be disclosed to Railtrack promptly unless it was thought that its disclosure would have a significant prejudicial effect on the continuing police investigation. In practice it was the HMRI who decided whether information was of that character.

The securing and preservation of evidence

4.131 Shortly after their arrival on the scene the police took steps to safeguard locations where evidence required to be secured. Inspector W D Baker of the BTP, who became Incident Officer, directed officers to secure the drivers’ cabs, along with relevant signals and points. He also directed that all rail personnel who were working on the site should be accompanied by police officers. At about 10:33 data was downloaded from the rear OTMR on the Turbo. The BTP also instructed officers to go to the IECC at Slough to secure evidence. Two BTP officers and Mr Alan Cooksey, Deputy Chief Inspector of Railways, HMRI, there took possession of the voice tapes for the signal post telephones, the cab secure radio and the electric control office, along with the SSI tape logs. However, as I will explain in Chapter 6, they were unaware of the existence of the logger which recorded data relating to the use of the cab secure radio. On the same morning the BTP organised a group of representatives from the BTP, the HMRI, First Great Western, Thames Trains and Railtrack who walked through the site from SN120 to SN109. SN109 was visually inspected at this time, and two days later the signalhead was opened by W S Atkins in the presence of representatives of the BTP, the HMRI and Railtrack. Mr Burchell, Railtrack's investigation officer, commented that, while the BTP investigation was clearly thorough, he would have preferred to look earlier at the parts of the infrastructure that might have been the causes of the crash. Instead the investigation proceeded under the timetable set by the BTP and the HMRI.

4.132 As I stated earlier a detailed fingertip search of the crash site started about 13:00 on 5 October. This was for the dual purpose of recovering body parts and searching for evidence. Officers of the BTP were accompanied by investigation officers from Railtrack, First Great Western and Thames Trains who pointed out items of evidential value. The search had to be suspended at 19:00 because of the lack of natural light and concerns about the precarious position of coaches and the overhanging power cables. At that time there was also a concern that evidence might be disrupted by the bringing in of heavy lifting vehicles.

4.133 On the following day three separate search teams were organised, for body recovery, property recovery and evidence recovery. The search lasted for the next nine days, during which the AWS equipment from both trains, the ATP system from the HST and both data recorders from the Turbo were recovered. One of the reasons why the search lasted for so long was related to coach H. This was the last coach to be searched as it had been subjected to such temperatures in the fire which engulfed it that it needed to be the subject of a special search under the direction of a pathologist. This in turn depended on the design and building of a complex scaffolding support structure to stabilise the coach and to protect it from the weather and the consequent destruction of evidence. Search, clearance, removal and recovery of that coach lasted until 17:25 on 14 October 1999. At that stage Silver Control handed the site back to Railtrack.

Railtrack's involvement

4.134 Having arrived on the site at 08:56 on 5 October Railtrack personnel quickly established the railway Silver Control point in Barlby Road, which was adjacent to the Silver Control points for the emergency services. The Rail Incident Officer, to whom I have already referred, was responsible for co-ordinating and controlling the representatives of Railtrack, TOCs and Rolling Stock Companies (ROSCOs) involved and for keeping in liaison with the emergency services. He operated at the level of Silver Command.

4.135 Although Railtrack were excluded from Gold Command level meetings they were very much involved at the Silver level, and in particular in the collection of evidence. The policy operated by the BTP was that Railtrack and the other rail companies had supervised access to the crash site, provided that this did not interfere with the work of the emergency services. Railtrack and the other rail companies were able to gather evidence but only under the supervision of a scenes of crime officer. Any removal of evidence by any of these companies was recorded by photographs or a video camera. This arrangement appears on the whole to have worked very well. Mr Feltham, the

Rail Incident Officer, told the Inquiry that "the working relationship between all parties was brilliant. Everybody helped each other and we worked as one team".

4.136 One concern which Inspectors of the HMRI reported was that "no one was in overall control of site safety until eight days after the accident. This resulted in a lack of adequate communication, co-operation, and co-ordination between the various organisations on site". This prompted them to recommend that in future Railtrack should have suitable consultation procedures for the provision of adequate site health and safety management. The eight days mentioned roughly coincided with the time during which the crash site was a scene of crime under the control of the BTP. Dr R J Smallwood, Deputy Chief Inspector of Railways, HMRI, accepted that there might be a practical problem with this when the police were in control of a site including the cordons.

The Formal Inquiry

4.137 Under Group Standard GO/RT 3434/3 Railtrack are required to set up an industry inquiry – known as a Formal Inquiry – in all cases of accidental death on the railway. Such an inquiry is normally expected to report within eight weeks of the incident. Mr Richard Bonham-Carter, the independent chairman of the Formal Inquiry in the case of the crash, emphasised in his evidence the importance of having the Inquiry at an early date. This would usually be well in advance of any investigation by the HMRI. It was important because of the effect of the passing of time on the recollections of witnesses. In that connection I note that Professor Uff in his report on the Southall Rail Accident Inquiry said: "Nothing should be permitted to delay the opening of a railway internal inquiry or investigation, nor the completion of their report and recommendations" (Recommendation 80).

4.138 Mr Bonham-Carter explained that in the normal course of events, technical experts are instructed by the Formal Inquiry to produce evidence. However, in the case of Ladbroke Grove the Inquiry had no access to consultants for about six weeks. Even then, information could not be disclosed to the Inquiry until after it had been verified. This led to experts attending the hearings and saying they were not permitted to give any opinions. On 22 October 1999 AEA Technology Rail had refused a request for information from a member of the Formal Inquiry panel, pending authorisation from the BTP and the HMRI. This Inquiry was informed by the BTP that this was entirely consistent with the protocol although it had not then been reduced to writing. Railtrack might have been misled by the previous inconsistencies in the treatment of evidence, since prior to this stage evidence had been passed directly from the experts to Railtrack. AEA Technology Rail were subsequently reminded of the contents of the protocol. Mr Bonham-Carter indicated that, following production of the protocol on 22 November 1999, the flow of information did improve, though even then his impression was that "the process was not perhaps working".

4.139 Initially there appeared to be some conflict between the BTP and the HMRI about when expert evidence should be released to the Formal Inquiry. In April 2000 the BTP replied to a concern which had been expressed by Railtrack, implying that the HMRI had been responsible for any delay in disclosing evidence. However, this was due to a misapprehension on the part of Assistant Chief Constable Nicholas who was not aware of the agreement between Detective Superintendent Bracken and

Mr S Walker of the HMRI as to when evidence would be disclosed. With the benefit of that information Assistant Chief Constable Nicholas confirmed to this Inquiry that in fact there had been complete agreement between the HMRI and the BTP as to when reports should be disclosed to Railtrack.

4.140 Mr Bonham-Carter said that he could not understand why experts were not directed by Railtrack as would be common in the case of Formal Inquiries. The Group Standard simply provided that where expert investigations were involved, a plan for testing might need to be agreed with the HMRI and/or other organisations such as the BTP. Mr Bonham-Carter saw no difficulty in the Formal Inquiry directing the investigation by experts which might be used in criminal proceedings, particularly in view of the independence of the chairman and other members of the panel. In connection with the matter of independence it may be noted that, in accordance with normal practice, Railtrack managers provided their comments on the draft of the report of the Formal Inquiry. These were under various categories, one of which was "Material comment", which was described as "Items which the reviewers believed, in their professional judgment, were fundamentally material to the descriptions of the events, consideration and gathering of evidence, discussion and evaluation of factors, and the conclusions. These, is (sic) our view must be addressed before completion of the Inquiry". Another was "Direction or recommendation", which was described as "Reviewers believe the content, purpose or ownership of the Recommendation needs to be re-considered or is misdirected". Despite these descriptions, Mr Bonham-Carter told this Inquiry that the panel did not pay much attention to the category in which comment was placed. He considered that it was only polite to consider each of the comments. It was for the panel to decide what would be done about it. He described the contribution of comments as "extremely unusual".

4.141 Since the matters with which I have been dealing were also discussed in Part 2 of this Inquiry, I will express my observations about them in my report on Part 2.

Chapter 5
The actions of driver Hodder

Introduction

5.1 The immediate cause of the collision was that driver Hodder did not stop at signal SN109 or attempt to stop thereafter until the crash was imminent. He passed SN109 when it was at red and when, consistent with this, no route was indicated for his train. He had, as I have also narrated, passed SN63 (1117m before) at double yellow and SN87 (637m before) at single yellow. In the case of each of those three signals he cancelled the AWS horn which sounded before he reached the signal.

5.2 The Turbo was not equipped with a train protection system for the application of the brakes as a safeguard against signals passed at Danger (SPADs). Accordingly the safety of those on board the Turbo and any other train depended on the vigilance, observation and actions of driver Hodder.

5.3 This chapter is concerned with the following questions:

(i) why did driver Hodder pass SN109 at red?; and

(ii) why did he not attempt to stop thereafter until the crash was imminent?

The fact that driver Hodder died in the crash makes the task of attempting to answer those questions far from straightforward. I must avoid mere speculation. I must ask myself what inferences, if any, can and should be drawn from the circumstances.

5.4 Certain matters can be put aside at the outset. From the evidence I am satisfied that there was no malfunction of the Turbo, the track, the signalling, or the AWS system, which could have contributed to what happened (I will refer later to the misalignment of SN109). Expert examination of the braking equipment demonstrated the absence of any material deficiency. There was nothing to indicate that the wheel slide protection system was deficient in any way.

5.5 I consider that I can also put aside any idea that, for whatever reason, driver Hodder passed SN109 at red in the knowledge that this aspect was being displayed. On the contrary I have no difficulty in accepting that he believed that he was driving in reliance on having received, at some stage, a proceed aspect, that is to say, an aspect other than red.

5.6 In their approaches to the evidence parties concentrated on two possible solutions. The first was that at some stage driver Hodder formed the mistaken belief that he had or would have a proceed aspect at gantry 8. The second is that he did not believe that there was any signal on gantry 8 which applied to him. If the latter was the case, he must have been acting on the basis of a proceed aspect which he had received at an earlier stage.

5.7 Either way, I will require to consider whether, and to what extent, what happened resulted from factors which were particular to driver Hodder, such as his training, the extent of his experience and his attention to signals, or were due, on the other hand, to factors relating to features of the infrastructure, such as the track and signalling.

5.8 The nature of these questions involves the consideration of a considerable number of subjects. I will deal in turn with

- the origin of the signals on and at gantry 8 (paras 5.9-5.18);
- experience with the track and signalling system (paras 5.19-5.21);
- previous SPADs at SN109 (paras 5.22-5.24);
- driver Hodder's recruitment and training (paras 5.25-5.48);
- the experience of driver Hodder (paras 5.49-5.55);
- possible explanations for the manner in which driver Hodder drove the Turbo (paras 5.56-5.103);
- conclusions (paras 5.104-5.112); and
- final observations (paras 5.113-5.115).

The origin of the signals at gantry 8

5.9 A scheme for the modernisation of the infrastructure between Paddington Station and Ladbroke Grove was approved by the British Railways Board in 1989. The prime drivers for the changes were the needs of the InterCity mainline services and Network South-East suburban services for increased service frequencies; the proposed construction of a link between the main line to Reading and Heathrow Airport with new services between Paddington and Heathrow; and the construction of a new maintenance and service depot at Old Oak Common for Eurostar International Services using the Channel Tunnel. Because of the problems of electrical interference, the last of these entailed that the existing signalling would have to be heavily modified or replaced.

5.10 It appears that the design of the permanent way was governed by the desire to use high running speeds as close to Paddington as possible. This was described by Mr R J Poynter, former Regional Operations Manager of the Western Region of British Rail, as "unique". High speed connections and crossovers were worked into the design with the intention that speeds of 100 mph could be attained at two miles from Paddington Station, and trains could cross from one line to another at speeds of up to 90 mph. The result was a completely revised layout, consisting of six lines out of Paddington, each intended for running in each direction, which converged at Ladbroke Grove to the four lines of way, i.e. the Up and Down Main and Up and Down Relief lines. The layout between Paddington and Ladbroke Grove provided for access from, and egress to, either Main or Relief line from any of the platforms at the station.

5.11 The designing of the track layout was followed, in accordance with the normal method of British Rail, by the designing of the signalling. Because of the considerable number of connections between the six running lines and the fact that they were intended to be used at high speeds and in both directions, the signalling layout was one of the most complicated in the United Kingdom.

5.12 It appears that, for reasons that were not clear, the spacing between signals was designed to comply with the requirements of the composite curve for multi-traffic lines. While the use of this braking curve permitted the running of freight trains at higher speeds, it had the effect of requiring a significant increase in the signal spacing distances. This made it necessary for gantry 8 to be positioned 97m to the west of Portobello Bridge which carried the Golborne Road over the tracks. If a reduced signal spacing distance had been adopted, such as would have been permitted by the use of the passenger train or W curve, there would have been scope for siting gantry 8 to the east of the bridge, according to the third report of Mr S J Wilkins, senior engineer, W S Atkins. The bridge was almost 100 years old. It was of a massive steel lattice construction, with the deck carried by under-slung transverse girders. The effective clearance beneath the girders represented the line of sight between the gantry and the sighting points of its signals.

5.13 Because of the limited width between the six bi-directional lines, a considerable number of signals had to be designed to be placed on gantries over the tracks, such as gantry 8. That gantry carried both Up and Down signals. The Down signals were the last signals which controlled movements to the Down Main and Down Relief lines.

5.14 When it was brought into use on 4 January 1993, as part of Phase 1 of the scheme, SN109 was a standard four-aspect signal with position light junction indicators mounted on top. According to the signal sighting form dated 20 June 1990, the red aspect, which was the lowest, was then to stand at a height of 5,750mm above the rail level, and it was envisaged that the permitted speed on the approach to that signal, i.e. by line 3, would be 95 mph.

5.15 The extent to which the bridge obstructed the approach view of the signals on gantry 8 from the Paddington direction was apparently not realised until the new signalling was brought into use. As a temporary expedient, permitted speeds on all the lines approaching that gantry from Paddington were lowered to 40 mph. The cages from gantry 8 were lowered and the height of the red aspect of SN109 was reduced to 5,085mm above the rail level. On 26 April 1994 revised signal sighting forms for all the signals on that gantry were produced, and on 7 August 1994 a revised arrangement was brought into use. All the position light junction indicators had been removed and their function replaced by standard alpha-numeric route indicators. All four-aspect signal heads had been removed and replaced by a “reverse L” shape, in which the red aspect was to the left of the lower yellow. The alpha-numeric route indicators were placed alongside the main aspects of the signals. The permitted speed on the approach to gantry 8 from Paddington was set at 60 mph, in accordance with the permitted use of route indicators under the relevant Group Standard.

5.16 The erection of the steel-work for the overhead line equipment (OHLE), which took the form of 25 kv electrification, began. Energisation took place on 24 November 1996. The effect of the OHLE was to reduce further the visibility of the signals, especially those on gantries 3 and 8. The OHLE took the form of a portal-boom and drop-tube system. This used horizontal booms carried between stanchions on either side of the formation. Substantial vertical drop tubes were attached to the booms, and the insulators which supported the registration arms were attached to the lower end of the drop-tubes (*see Plate 14*). The insulators were larger, and the effect of the drop-tubes on signal visibility was very much greater, than in the case of the components of the alternative headspan system. It should be added that, in order to resist vandalism, the insulators were very much larger and more robust than those used in other OHLE schemes.

5.17 Rectangular line identification signs were set on the walkway handrails across some of the gantries including gantry 8. The signs on that gantry were mounted at a height of 9,390mm above rail level, and were offset to the right hand side of the centre of their respective lines. As a consequence, they were closer to the signal to the right hand side than to the signal for the line to which they related.

5.18 On 24 May 1998 the operation of the Heathrow Express between Paddington and Heathrow Airport began. Part of the Heathrow project was the extension of a pilot scheme for ATP. It covered, inter alia, both Main and Relief lines and all six bi-directional lines, as well as the link between the Airport and the Main line. Both InterCity Great Western (later First Great Western) HSTs and Heathrow Express trains were equipped to use ATP, but Network South East (later Thames Trains) rail vehicles were not.

Experience with the new track and signalling system

5.19 Drivers found that the use of the ARS in conjunction with the new track system meant that there was a multiplicity of routes which they required to follow. Mr Steven Gollop, a senior driver standards manager with Thames Trains, explained that owing to the fact that there were six lines, all of which were bi-directional, the drivers would not be aware of which route would be set by the ARS. There was a multitude of combinations, depending on what service the particular driver was working. Mr Victor Belcher, a train driver with Thames Trains, said: “You can never exactly say which route you’re going to take because there are so many, you know, and you have to go signal to signal as you are going in and out”. In his report which was prepared for the purposes of this Inquiry, Mr P G Rayner, former operations manager with British Rail, drew attention to the problems created for the drivers by the operation of the ARS in the context of such a track and signalling layout, in which trains would be repeatedly swung left and right. He expressed the view that “in over 45 years in the industry I have never seen such a confusing set of options to a driver”. One consequence of this was that the driver’s view of the signals ahead would be liable to change as he changed from line to line. The effect of the curvature of the lines was that a signal would not remain in the same place from the driver’s point of view but would become offset to one side or the other.

5.20 Many drivers gave evidence that the sighting of the numerous signals when going into and out of Paddington on the bi-directional lines was difficult and confusing. This was due to their being intermittently obscured by bridges and OHLE. Thus, Mr Graham Robinson, a train driver with Thames Trains, said that with the gantry signals at Paddington “there is just so many you have to keep working out which one is yours all the time”. Mr Philip Wells, a driver instructor with Thames Trains, said that “with the electrification you cannot see most of the signals at all until you are on top of them now”. He went on to say:

> "I take signal to signal, you have to take it really slowly and you need to know which line you are actually on and you need to count from left to right and right to left. You need to double check again and again and you have to be certain. If you are not certain, you need to stop and you won't proceed".

Mr Raymond Adams, a driver instructor with Thames Trains, described how, as a result of the view being obstructed by the OHLE, signals would disappear temporarily and then reappear. He and Mr David Relf, a driver standards manager with that company, gave evidence that drivers had complained, at least among themselves, about the poor sighting of signals in the stretch between Paddington and Ladbroke Grove. In his third report Mr Wilkins observed:

> "The general signal viewing conditions in the Paddington area present the drivers with an exceptionally difficult signal reading task. The complexity of the layout and signal gantries, the range of approaches, and the obscuration of signal aspects by OHLE presents most difficult visual and interpretative challenges to drivers, particularly on the approaches to gantries 3 and 8".

5.21 The sighting of signals on gantry 8, and in particular SN109, was described by drivers as being very poor owing to the obstruction presented by the bridge and the OHLE. Miss Kirstine Brookes, a driver trainer with the Heathrow Express, gave evidence that in her experience the view of the red aspect of SN109 was obstructed by an insulator in front of it, although the position changed slightly with the movement of the train. She always approached that signal with extreme caution, at a speed of about 15 mph, in accordance with defensive driving. This was if a red signal was expected. If on the other hand a single yellow was expected, the speed would be about 30 mph, but it depended on the driver. Mr Robinson said that it was difficult to see signals on the way into and out of Paddington. He had to move his head to see things better. He would dip his head as he approached gantry 8 in order to get a better view of his signal. Mr David Bunney, a former driver with First Great Western, said that gantry 8 could not be seen until the train came under the bridge. As was pointed out by Counsel for ASLEF, under reference to a report for the national SPAD Reduction and Mitigation Group (SPADRAM) in 1996 entitled "Driver Distraction: Factors which influence driver performance and safety", well-recognised examples of poor signal sighting are where signals are positioned on bends, or are close to each other or are obscured. It should also be noted that Mr R J Fairbrother, a signal engineering consultant, observed in his report for the Inquiry that there were three different approaches to SN109, two of which originated from lines 2 and 4. This was based on operational requirements, but did nothing to assist in the sighting of that signal. He said: "Colour light signals have a narrow angled beam, and approach curves make sighting alignment difficult. When there is a choice of approach, as in this case, alignment will necessarily be a compromise".

Previous SPADs at SN109

5.22 The Inquiry heard evidence from the drivers who had previously passed SN109 when it was at red and those who had investigated the circumstances of these SPADs. The first of these SPADs was on 2 August 1993, i.e. some seven months after the new track and signalling system had been brought into operation. The eighth and last before the crash occurred on 22 August 1998. A summary of the evidence relating to these SPADs is contained in Appendix 4. Dr Ian Murphy, a lecturer in mathematics at Glasgow University, who has made a study of various aspects of risk in the railway system over the last nine years, provided a report for the Inquiry in which, on the basis of past experience in the years 1996, 1997 and 1998 and the evidence of an underlying annual frequency of two SPADs at SN109, he estimated that there was an 86% chance in a given year of at least one SPAD at that signal. Having regard to the collision opportunities, there was also a 7.2 % chance of a collision in any given year, or in other words one collision in about 14 years. It not surprising that in these circumstances Counsel for Railtrack put it to a witness in the course of the evidence: "One could say SN109 was a black spot". At the time of the crash, SN109 was one of the 22 signals on the Railtrack network at which the greatest number of SPADs had occurred.

5.23 What actions were, or should have been, taken in the light of this record of SPADs is a subject with which I will deal in Chapter 7. So far as the present chapter is concerned, I am interested in whether any of the factors which played a part in any of these incidents may throw light on what happened in the case of driver Hodder on 5 October 1999. SPADs plainly occurred in a variety of circumstances, but it can be seen from Appendix 4 that they all took place between 08:00 and 09:30 or between 17:00 and 19:00, which are times of peak traffic, at which red signals may be more likely to occur. Four of the SPADs involved short over-runs, i.e. less than 15 yards. The most serious over-runs were on 15 March 1996 (146 yards) and 4 February 1998 (over 432 yards). The drivers involved were of various ages and experience.

5.24 It should not be assumed that the track and signalling system was precisely the same at the time of each of these incidents. For example, a factor which appears to have played a part in the SPADs on 3 April 1997 and on 4 February and 22 August 1998 was that the driver had been led by the existence of a double flashing yellow at SN43, followed by a single flashing yellow at SN63, to expect that he could proceed through the Ladbroke Grove Junction. The same may possibly apply in the case of the SPAD on 23 June 1996 with respect to the flashing yellows at SN37 and SN57. The signalling system had originally been designed so that signals which protected junctions incorporating swing-nose crossings were fitted with flashing yellow aspects as a means of giving advance warning to a driver that a diversion was ahead and that he would require to reduce speed accordingly (see Group Standard GK/RT 0035). However, it appears that the showing of such aspects tended to lead drivers to assume that they could proceed across the junction. These aspects were in fact unnecessary, owing to the reduction in linespeeds to which I have already referred. The removal of the flashing yellows was undertaken in January 1999 as a result of the investigation of the SPAD which occurred on 4 February 1998. Whether the removal of those aspects was an adequate response to what had happened is a matter which I will consider in Chapter 7.

Driver Hodder's recruitment and training

Thames Trains' recruitment procedures

5.25 Thames Trains had an established recruitment procedure requiring the applicant to fill in a form which gave details appropriate to the job and required two independent referees. In the case of Mr Hodder this process was not followed. Mr Hodder replied to an advertisement in a local newspaper; he did not fill in an application form. The fact that he did not fill in an application form also meant that he was not asked to, and did not, disclose that he had had a conviction for a minor offence in respect of which he had been given a conditional discharge. Whilst the administrative procedures were not followed the Inquiry was told that nevertheless it is very likely that Mr Hodder would have been employed had he filled in his form. Thames Trains told the Inquiry that the conviction would have been spent by the relevant time.

5.26 Prior to November 1998 Thames Trains recruited drivers internally. As the supply of candidates diminished it was necessary to recruit potential drivers from outside the industry. In November 1998 the first person external to Thames Trains entered the system. Mr Hodder entered in the second phase of recruitment in February 1999. In the campaign in which Mr Hodder was recruited Thames Trains had 420 applicants of whom 132 were invited for interview. Mr Hodder was interviewed on 27 November 1998 by Mr Jonathan Lyford and Miss L R Hall. He was assessed to be in the top two of the 132 interviewed in the batch. Mr Hodder passed through further assessments and medical tests, and was offered a job, subject to six months' probation and satisfactory reference checks. In fact, one of these references was not followed up and the other was from a relative, although this was not known at the time.

5.27 It is not suggested that Mr Hodder was in any way unsatisfactory as an applicant. However the fact that Thames Trains were prepared to bypass their own procedures, due to the need to recruit drivers quickly because of an increase in traffic, suggests that they had set a production requirement ahead of following procedures appropriately.

5.28 It may also be significant that Mr Hodder's preference for his work location was to work out of Reading, as this would be close to home. In the event he was trained for and assigned to the routes out of Paddington. This meant that his journey to work was in excess of an hour.

Thames Trains' driver training programme

5.29 Train operators such as Thames Trains were subject to the duty to comply with Group Standard GO/RT 3251 (October 1998) for train driving. This standard required each TOC to ensure that processes were in place for persons to acquire the necessary skills and knowledge for competent train driving, and for supervision by competent persons for this purpose. The assessment of competence was the subject of Code of Practice GO/RC 3560 (August 1998), which defined the recommended components of a system for the assessment of competence which satisfied the Group Standard. Each TOC individually certifies its drivers when they are judged to be competent.

5.30 In the handover from British Rail in 1994, Thames Trains received the driver training package known as Driver 2000. However, there were a number of years following the takeover when Thames Trains did no recruitment. Recruitment of drivers started in the middle of 1998 and Thames Trains started driver training with a modified version of Driver 2000. This was set up by one of Thames Trains' driver team leaders, Mr Ron Baird. Two groups of training courses were run. These were based mainly on the Baird package, one starting in November 1998 and the other in February 1999. Mr Jon Chilton joined Thames Trains in February 1999 in the post of Operations Manager. He recognised that the training which was being given was not strictly following the Baird package, and that the package itself had not been validated. Perhaps the clearest description of the lack of structure in the Thames Trains driver training process comes from Mr Chilton's own words describing the state of affairs on his arrival in February 1999:

> "I couldn't find out any reason why, or any documentation as to why, that had happened and there wasn't anybody else to sort of ask at that point… I couldn't put my finger on what was happening".

Mr Chilton commissioned Halcrow Transmark to examine the Thames Trains driver training package.

5.31 It is instructive to consider the final Halcrow report in May 1999. It stated:

> "The trainers did not appear to be following the training course syllabus and supporting notes as they considered these to be 'not fit for purpose' with inappropriate time allowances for some sessions. The traction and introduction to driving section of the course has been extended and the six week route learning session is being used as additional practical handling".

At another passage it stated:

> "Separate theoretical route instruction does not appear to be provided. However, it should be emphasised that route knowledge is a key area of competence and some time should be programmed to ensure trainees are made aware of potential risk areas. Signalling maps and plans are available for some routes but these have not been updated with essential information such as high risk (eg multi-SPADed) signals etc. A risk assessment does not appear to have been undertaken to determine the criteria for route learning. Route learning 'norms' viewed (for link 5 at Reading) do not appear to recognise the risk of inexperience, particularly for newly qualified drivers with no previous operating experience over the route".

5.32 This is of particular concern in view of the fact that the inquiry into the collision on 10 November 1995 at Royal Oak, 46 chains outside Paddington Station, concluded in its report dated 6 March 1996 that "the methods of route learning into and out of Paddington appear very informal".

5.33 Recommendation 1 of the Royal Oak inquiry was that TOCs should review the methods of route learning at complex junctions.

5.34 Recommendation 2 of the Royal Oak inquiry directed attention to SPAD briefings to drivers. It was recommended that TOCs should consider the use of videos to help in the driver training process. There is no evidence that such a video was in use by Thames Trains at the time of driver Hodder's training and it certainly was not used in his training.

5.35 It is also surprising that Thames Trains had not taken note of the comments of Mr M Holmes of the HMRI, who told Mr D R Franks of Thames Trains on 20 August 1996 that he was "very concerned about driver training". His concern extended particularly towards driver leaders who were too young or too inexperienced to deal with "at risk" drivers. Driver leaders are responsible for the training of a group of drivers and their subsequent supervision.

5.36 There can be no doubt that the corporate memory of Thames Trains was weak in that it failed to take note of these early warnings. It did not pass them on to Mr Chilton when he arrived at Thames Trains in February 1999, and he was not made aware of the recent correspondence with Halcrow about deficiencies in driver training. It would have been expected that Thames Trains would have paid particular attention to the question of SPADs since from 1990 to 1998 SN109 was the fifteenth most SPADed signal on the Railtrack-controlled infrastructure. Of the eight SPADs that occurred at that signal in that period, six were by Thames Trains drivers, one was from the days of British Rail and one was by a First Great Western driver. Even allowing for the fact that Thames Trains used that route very frequently, the high percentage of SPADs involving Thames Trains drivers should have made them more alert to that signal.

5.37 It is all the more surprising that the question of SPADs was not covered with drivers since Thames Trains had reassured the HMRI on 25 September 1996 that "all drivers on Thames Trains have had or are receiving briefings on SPADs as part of the SPAD strategy".

5.38 Driver Hodder was a member of the February 1999 recruitment group, and therefore did not have the benefit of the upgraded training package being developed by Thames Trains at the time, on the basis of the work of Mr Chilton. It is significant that he was among the first of the employees who came from outside the rail industry to be trained. The driver training package gave no special attention to trainees who came from that source.

5.39 All the evidence presented to the Inquiry suggests that the instructors in Thames Trains were perfectly adequate for their teaching task, but there was concern about the length of the course, its content and its disjointed nature. Driver Hodder's training occurred during this disjointed phase, when Thames Trains were "in between courses". In Mr Chilton's words the driver training managers were "conducting their own classes as they thought best, based loosely on what had been the practice in British Rail days." Mr Chilton decided to review and change the training process but this took effect after driver Hodder's training.

Driver Hodder's practical training

5.40 Driver Hodder began his training on 1 February 1999, starting with general introductory training on railways, followed by two weeks of observing a driver standards manager at work. He then spent five weeks of training on rules and regulations which was delivered by Mr Lyford. Following his rules and regulations training he was assessed as satisfactory by Mr Relf on 5 April. Thereafter he had two weeks' introduction to train driving with a driver instructor. Then on 26 April he began four weeks' traction training with Mr R S Cox. Following his traction training he was assessed again, this time by Mr K W Ball. On 31 May he began his 16 weeks practical handling training with Mr Adams. Due to a vacation commitment of Mr Adams, his last week's training in practical handling (the week ending 11 September) was with Mr D P Jacobs. The assessment of his practical handling was conducted by Mr Relf.

5.41 During all of his training activities and assessments, driver Hodder's trainers warmly praised his cheerful attitude and the rate at which he applied himself to, and learned, the task. There is no question but that driver Hodder was a good pupil and attended the training courses as described.

5.42 However, it must be said that the training course was deficient in several aspects. The course was based on the previous British Rail sessions but modified by the driver standards managers in "whatever way they felt appropriate". Driver Hodder's training incorporated some elements of the Halcrow report but in a relatively unstructured way. In his witness statement and at the Inquiry Mr Terence Worrall, Director and General Manager of Thames Trains, accepted that the company's management of driver Hodder's training had failed to achieve:

"(a) instructing him directly about the risks of SPADs at particular signals, such as SN109;

(b) arranging for him to attend a SPAD awareness day;

(c) ensuring that his route learning assessment questions specifically covered the area between Paddington and Ladbroke Grove".

5.43 Driver Hodder was not taught to pay particular attention to signals at which there had been multiple SPADs. This information had not been given by any of the instructors to any of the driver trainees. This was contrary to Group Standard GO/RT 3252 which required details of multi-SPADed signals to be supplied to training instructors and passed on to drivers.

5.44 Due to the lack of structure within Thames Trains regarding the training process at the time when driver Hodder was being trained, there is no real detail as to driver Hodder's progress other than that he attended on each day, and that he answered questions devised by Messrs Baird, Cox and Lyford. They used questions and processes that they had based on their own experiences and there is no evidence that these questions had been adequately validated.

5.45 In regard to route learning and the assessment of this process, many questions remain unanswered. Mr M P Winkworth, a Thames Trains driver standards manager, described his examination process, which consisted of asking a number of questions. He told the Inquiry there was no pass or fail mark. The training process was assessed by Professor J A Groeger, of the Chair of Cognitive Psychology at the University of Surrey, who prepared a report on this and other subjects for the Inquiry. He expressed three specific concerns, namely that:

(i) there were no specific criteria being used by the observer to determine whether the driver had competently handled a situation;

(ii) there was a lack of definition as to how frequently the driver should have to perform in similar situations before being assessed as competent; and

(iii) the frequency or level of deviation from textbook driving which was tolerated was not defined anywhere.

5.46 It must be concluded therefore that driver Hodder's training was not adequate for the task for which he was being prepared. The very favourable comments made as to his progress by his various teachers have to be viewed against the background that his teachers were working with a less than perfect training programme.

5.47 Thames Trains had a defensive driving policy. At the date of the crash about half of the TOCs had such a policy. Mr Adams confirmed that driver Hodder was taught to follow the elements of defensive driving. Mr Worrall confirmed that it was company policy to be "among the leaders in defensive driving techniques". In accordance with the Thames Trains driving manual, driver Hodder would have been told that when he was proceeding under restricted signal aspects he should stay focused, concentrate, avoid distraction and be prepared to stop. The policy clearly stated that when approaching signals at which a driver had never stopped before, he should "brake early, kill your speed and don't wait until you see the signal". He was also taught that if in doubt at any signal either because of his lack of confidence, or because of the masking of the signal due to sunlight, he should stop and ask the signalman. It was emphasised in the training that he should not take a chance. Thames Trains' defensive driving techniques included a rule requiring drivers expecting a signal at Danger to drive "15 mph at AWS magnet and stop 20 yds from signal".

5.48 No record exists of any specific training given to driver Hodder regarding the signals between Paddington and Ladbroke Grove, other than a comment from Mr Adams to say that Paddington was "tricky", and that he should pay particular attention in that area and drive from one signal to the next. Mr Adams could not recall giving driver Hodder any guidance as to when a signal on gantry 8 could first be interpreted properly. He said that he taught him to identify which signal on a multi-signal gantry was applicable to his line by counting across the gantry from left to right. This was in contrast to some other driver trainers, who taught to count from right to left. He reminded him that that one of the signals at gantry 8 (SN105) was on a post, and told him "the whole saga of the wires". He mentioned to him that there had been problems with gantry 8, and that was why the signals were mounted in a strange format on the gantry. However, he said "I was not there to teach Michael the routes. I was totally to teach Michael how to drive a Turbo". He would subsequently pick up his route knowledge when he was further trained. In regard to the use of route maps for training and driving, Mr Adams said Thames Trains did not make maps officially available but that drivers shared maps that they themselves had made. When Mr Adams was questioned about training in route learning for driver Hodder in regard to the Paddington area, he said: “ I have grown up with the system. I have taken it as it has evolved, but someone like Mick is just thrown in at the deep end and said well, this is Paddington and sort of make the best of it really”. Mr Adams was not aware at the time that SN109 was a multi-SPADed signal. Since then Thames Trains have a notice case for drivers which contains information about SPADs which have occurred. Until the day he gave evidence Mr Chilton was unaware that Mr Adams did not consider that it was not for him to teach driver Hodder the routes.

The experience of driver Hodder

5.49 Driver Hodder accumulated a total of 230 hours training with Mr Adams and 20 hours with Mr Jacobs, giving a total of 250 practical hours under instruction. Thames Trains’ minimum training period is 200 hours.

5.50 The Formal Inquiry found (at para 6.1.4) that when driver Hodder drove under the guidance of a driver instructor, he mainly worked over the relief lines from high-numbered platforms (perhaps 85% of total departures); he departed from platform 9 on an estimated nine occasions, and probably never from there to the Down Main; he made an estimated four trips to Bedwyn, always on the same train, which was one of the few Bedwyn trains which used the Down Main and was booked to leave platform 11; of 17 departures to the Down Main, perhaps 13 were via SN109, at least two of which were slowed significantly or stopped before reaching SN109; and no estimate could be made of the number of times when the approach to SN109 was by line 4 and then line 3, but it is likely to have been rare. In this Inquiry Mr Adams said that he thought that Michael Hodder would have driven from Paddington to Bedwyn about ten times, at least once by line 4 and on to line 3, but could not say how often he passed SN109.

5.51 Michael Hodder passed out as a driver on 22 September 1999. According to a report prepared by Mr D McKenzie of W S Atkins, he drove out of Paddington on 20 occasions after 22 September and prior to 5 October. These occasions comprised:

(i) 16 occasions on which he drove down line 5, passing SN113 (on gantry 8) at green;

(ii) two occasions on which he drove down line 4, passing SN111 (on gantry 8) at green;

(iii) one occasion on which he drove down line 6, crossing to line 5, on which he passed SN113 at green; and

(iv) on 2 October, he passed SN43 at double yellow and SN63 and SN87 at single yellow. SN109 was showing red, but this aspect cleared directly to a green aspect when his train was fully on the berth track circuit in rear of SN109.

5.52 On this last occasion he was destined for the Down Main line. On all the other occasions, he was destined for the Down Relief line, which was the line normally used by Thames Trains services. That was also the sole occasion on which he departed from platform 9. Accordingly during this period he did not require to stop at any signal at gantry 8.

5.53 On 23 September he had worked from 22:53 to 08:12, and on 24 September from 22:53 to 05:44. The following day, which was a Saturday, was a rest day off. He was off thereafter until 28 September. On that date and the two following days he worked from 00:43 to 13:24. On 1 October he worked from 06:11 to 14:45. On 2 October he worked from 08:03 to 15:57. He was off work on Sunday 3 October. He had worked on 4 October from 06:43 to 13:24.

5.54 On 5 October 1999 driver Hodder rose soon after 03:00. He came on duty at Paddington at 05:28. He drove the Thames Trains service from Paddington to Reading, departing from platform 13 at 05:43. He returned to Paddington driving the 07:06 from Reading, which arrived at Paddington at 07:57.

5.55 His behaviour and spirits on 5 October when he left Paddington driving the Turbo to Bedwyn leaving at 08:06 appeared to be entirely normal. The rail operator supervisor who dispatched the train described him as always smiling when he saw him, and this occasion was no different.

Possible explanations for the manner in which driver Hodder drove the Turbo

5.56 The interpretation of driver Hodder's actions requires a consideration of his driving on this occasion as a whole, along with a number of other factors which may be relevant. However, it is convenient to deal with the course of events in four main stages.

His driving in relation to SN87

5.57 On any view his driving prior to SN87 was unexceptional. Mr Gollop, who had examined the OTMR record, explained that his interpretation was that after setting out from Paddington driver Hodder had shut off power and performed a running brake test. After that he had allowed the train to coast for some considerable distance. Mr Gollop regarded that as quite significant. It indicated to him that at that time he realised that he was not running on green signals. He contrasted this with driver Hodder's journeys to and from Reading earlier in the day, in which, after carrying out a running brake test, he retook power. That is what he would expect a driver to do if he was driving on green aspects. SN87 was displaying a single yellow aspect, which, as I stated in Chapter 3, meant "caution – the following signal is presently at Danger". According to the report of the Committee of Experts on Signal Sighting, that signal was visible from a point 461m before it. The signal was not obscured in any way, and its identification was assisted by the fact that signals on its gantry were grouped in pairs. It appears that SN87 had never been passed at Danger.

5.58 Counsel for Railtrack submitted that, having passed SN87 and having coasted at a slightly reduced speed for about ten seconds, driver Hodder should have begun braking, as a careful driver would have done, in order to stop at an appropriate distance before reaching SN109. Counsel relied on evidence about defensive driving which was intended to be practised by Thames Trains' drivers. According to that driving technique, a driver who receives a single yellow aspect should drive in such a way as to stop about 20 yards in rear of the next signal. In the present case, for example, in order to use step 1 braking to bring the Turbo to a stop at that distance in rear of SN109, driver Hodder would have had to start such braking 466m in rear of SN109. To do so by means of step 2 braking (which is the next harder) he would have had to start at 284m, while he was still on line 4. However, driver Hodder did not brake but engaged notch 1 of the accelerator at 255m in rear of SN109, and, about a second later, notch 5 at 239m. When he was at these points the red aspect of SN109 was not yet visible. Counsel submitted that, through inattention, driver Hodder had not seen the single yellow aspect at SN87. He acted as if he had not seen that signal. Counsel compared this with the SPAD at SN109 on 3 April 1997, after which driver Hussain said that he had no recollection of having seen SN87 at all. It was not as if driver Hodder's driving might be explained by the existence of flashing yellows, since they had been removed by this time.

5.59 Counsel for Railtrack also founded on the fact that when passing SN87 driver Hodder had not put in the DRA. Evidence had been given by Mr Adams that "from day 1" he had taught driver Hodder to use the DRA. Mr Adams understood that it could be used not only when the train was stationary at a platform, but also when it was passing a single yellow, the next signal being at red. According to a report by Mr Balmer, a study of OTMR records showed that on his journey to Paddington that morning driver Hodder had used the DRA at three different signals, all of which showed single yellow aspects. In one case it had originally been a red aspect. There had been no application of DRA which did not correspond with a yellow, and vice versa. Counsel submitted that the fact that driver Hodder did not use the DRA at SN87, although there was nothing to prevent him from doing so, raised the real possibility that this had played an important part in the disaster. If he had put in the DRA this would have illuminated a light in the cab about eye level and to his left. This would have reminded him that he had to halt before the next signal. If after a lapse in attention he became alert, he might have thought that the fact that the DRA button was not lit indicated that the coast was clear for him to drive on to the Down Main or the Down Relief. In Counsel's submission, this provided the most plausible explanation for his driving in a way which was inconsistent with basic and defensive driving principles. It also showed the undesirability of his practice of using the DRA on his approach to a single yellow aspect.

5.60 However, this is not the only interpretation which can be placed on driver Hodder's actions. Mr Wilkins, who has extensive experience in the investigation of SPADs, observed in his third report on signal sighting that it was unlikely that driver Hodder had mistaken what signal aspect was shown at SN87. However, the spacing between that signal and SN109, which was 637m, was such that driver Hodder needed to take no immediate action as he passed SN87 and no further action was required by him in respect of the aspect shown by SN87 for about another 20 seconds. Mr Wilkins observed:

> "There remains the possibility that in this interval, Hodder forgot or mis-remembered the message given by SN87. Errors of this type have been

> determined as common causes of SPADs and the risk is controlled through the Railway Group Standards by limits placed on the spacing between caution and stop signals. The provision of excessive distance for braking passenger trains between SN63 and SN109 was largely concentrated in the section between SN87 and SN109 and does constitute a possible risk factor"

(see para 5.12 and Group Standard GK/RT 0034). In his oral evidence Mr Wilkins said that "where that situation arises experience shows that it dramatically increases the risk of SPADs at the forward signal". However, he accepted that this was not a factor to which he could attribute Mr Hodder's accelerating as he approached the red signal.

5.61 In this connection it may be useful to consider the facts relating to the SPADs at SN109 on 6 and 22 August 1998. They appear to involve a failure on the part of the driver to react appropriately to SN87. In these SPADs and in the SPAD on 23 June 1996 the driver appears to have forgotten that the signal was at single yellow or remembered its aspect incorrectly, and hence failed to appreciate that SN109 would be at red.

5.62 Another explanation, which was advanced by Counsel for First Great Western, was that driver Hodder believed that SN87 was displaying, not a single yellow aspect, but a double yellow. This was said to be supported by the evidence given by Mr Robinson, the Thames Trains' driver, who had driven an empty stock train out from platform 8 at Paddington shortly after 07:50. He had travelled out on line 5 on green signals. As he was approaching gantry 6, on which were mounted SN87 and other signals, he received an AWS bell indicating that his signal was at green. However, he immediately saw "all the signals right the way across all lit up like a Christmas tree". This was mostly to his left. He could not remember looking at the ones to his right. He remarked how bright and low was the sun behind him. He could not have told which was the correct aspect. In this way it was maintained that driver Hodder could have been led to believe that there was a double yellow aspect at SN87, and hence would expect a proceed aspect at SN109.

5.63 I have also to bear in mind the assessment by Mr Gollop of driver Hodder's driving. He stated in evidence that how a driver should conduct his train would depend on the distance between the single yellow and the stop signal. Given a speed of slightly under 40 mph he would expect the train to be coasted for some time, and that was exactly what happened. This would be followed by braking to come to a stop at SN109, but he would not expect a driver to take power unless he believed that he had a proceed aspect at SN109. It would, on the other hand, be inconsistent with defensive driving for a driver to accelerate if he could not see a proceed aspect, and believed that the signal was at Danger.

5.64 As regards the non-use of the DRA, there may be more than one possible explanation. Thus, as Counsel for Thames Trains pointed out, driver Hodder might have felt that it was unnecessary for him to use it when he had already been coasting for about 740m by the time that he arrived at SN87. Moreover, Counsel for the bereaved and injured maintained that little could be inferred from driver Hodder's use of the DRA on a single journey into Paddington. Its use was non-compulsory, and the practice of drivers using the DRA on the move as they left Paddington had not been explored.

Moreover, an audit by Railtrack in May 2000 found that Thames Trains' drivers had not received face to face briefing on the operational requirements of the DRA.

The initial sighting of SN109 and the other signals on gantry 8

5.65 The report of the Committee of Experts on Signal Sighting, taken together with Mr Wilkins' second report, enables the following to be stated in regard to the sighting of SN109, as it would be perceived by the driver of a Turbo approaching from line 4 and then line 3:

(a) at 433m from SN109, the first part of that signal, namely the lower yellow aspect, came into view, very heavily obscured by the underside of the bridge;

(b) at 299m, this aspect became only heavily obscured by the underside of the bridge;

(c) at 282m, this aspect became only partially obscured by the underside of the bridge. There was a brief and heavily obscured glimpse of the red aspect;

(d) at 258m, the lower yellow aspect became clear and the upper yellow aspect was visible but heavily obscured by the OHLE;

(e) at 219m, the red aspect became visible, heavily obscured by the OHLE. The upper yellow aspect was now partially obscured by the OHLE;

(f) at 188m, the red aspect was visible but was partially obscured by the OHLE; and the upper yellow aspect remained partially obscured by it; and

(g) at 168m, the red aspect became fully free of obscuration. So also did the upper yellow aspect.

5.66 As regards the route indicator, it was heavily obscured by the OHLE at 219m, and at closer range it was partially obscured. At distances less than 140m, no obscuration of any aspect of SN109 or its route indicator was evident.

5.67 In his report Mr Wilkins defined very heavy obscuration as typically the obscuration of 80-90% of the aspect. A very heavily obscured aspect would generally be invisible in all daylight conditions. He defined heavy obscuration as typically the obscuration of 40-70% of the aspect. A heavily obscured aspect would generally be invisible during bright sunlight and barely visible during dull conditions. For all practical purposes, a heavily obscured aspect should generally be regarded as unreadable in all daylight conditions. He described partial obscuration as meaning the obscuration of typically 10-30% of the aspect. A partially obscured aspect was generally readable in daylight, although during conditions of high ambient light, its readability would be significantly inferior to that of an aspect in clear view. His evidence drew a clear distinction between the visibility of a signal and its readability. He said:

"Visibility is considering physical factors as to whether or not a signal aspect can be seen. Now, it may be possible to see with reasonable ease three or four aspects in the distance, but it may not be possible to read them because it may be unclear as to which signal applies to which line. Readability is taking into account a number of human factors as well, such as the interpretation of those signals; whereas visibility is simply asking can you see it or can you not".

I also note that the Committee of Experts expressed the view that the vertical and lateral positioning of the driver's eye were extremely critical in determining his approach view. Later in this chapter I will refer to the unusual configuration of SN109 in which the red aspect was alongside, and to the left of, the lower yellow. The effect of that configuration was that, at the stage when the lower yellow was becoming more visible, the red was hidden behind a large strut on the underside of the bridge. In his third report Mr Wilkins observed that aspect reading errors were more likely, particularly under conditions where visibility was marginal, when aspects appeared in non-standard positions or relationships.

5.68 In connection with these observations it should be noted that driver Hodder engaged notch 1 and then, for more power, notch 5 of the accelerator at 255m and 239m from SN109 respectively.

5.69 The Committee of Experts on Signal Sighting were agreed that SN109 was not compliant, in regard to class 165 trains, with the requirement of the current Railway Group Standard (GK/RT 0037), in respect that the whole signal could not be seen for at least seven seconds' sighting time (that is, at linespeed) from the cab of such a train. Mr Wilkins gave evidence that, in order to accord with the standard, gantry 8 would have to be on the east side of the Portobello Bridge. Similarly SN109 was not compliant with the code of practice (JDP C005) which was in force when the signalling scheme was being designed and which was in due course replaced by the Group Standard. It may be noted that the red aspect of SN109 did not become fully visible until the train was 168m from SN109. At linespeed (60 mph), this would give an approach view for 6.25 seconds.

5.70 At a later stage in this report I will discuss the adequacy of the Group Standard. For present purposes it is sufficient to say that, in the case of driver Hodder, the time which he had to sight SN109 is not, of itself, an explanation for his failing to stop at that signal. The Turbo was travelling at two-thirds of linespeed, and if he had applied the brakes on seeing the red aspect at 168m, he could have brought the Turbo to a halt at the signal. It is also clear that he did not at any stage react to seeing the red aspect of SN109 by applying the brakes. In this respect this case is unlike that of the previous SPADs including the one on 4 February 1998.

5.71 It is plain that the quality of signal sighting, on which vital decisions may turn, depends not only on the visibility but also on the readability of those signals.

5.72 In his third report Mr Wilkins emphasised that there is a fundamental difference between the reading of a signal which is standing on its own and the reading of one which forms part of a group of signals. He said:

> "A solitary signal can usually be read as soon as it becomes visible; a signal forming part of a group cannot. When one signal of a group is visible at long range, that signal is meaningless. Any attempt to read one signal of a group in isolation is dangerous since there can be no certainty as to which signal is being read. The safe reading of a group of signals requires the whole of the group to be visible to allow the driver to differentiate between the individual signals. In the case of very large gantries carrying four, five or more signals, it is usually sufficient for a large proportion of the signals to be visible to allow counting in from one end, or from a suitably distinguishing feature, to enable a specific signal to be identified reliably. If any of the signals in a group are either deficient in approach view, or have an approach view that is significantly shorter than other signals in the group, not only is that signal more likely to be misread, other signals in the group are more likely to be misread as a result of the obscured signal or signals affecting the relationship between the other signals in the group… The approach view of all the signals in a group is therefore of paramount importance, and it is essential that the visibility of all signals is maximised by good design of the signalling installation".

He went on to say:

> "When all the running lines are bi-directional, the lateral separation between signals is reduced, signal identification becomes complex, and a greater tendency for misreading results".

By "misreading" Mr Wilkins clearly meant incorrectly reading. It may be noted in that connection that in the relevant Group Standard (GK/RT 0037) no allowance is made for the fact that signals are in a group, beyond the advice that care must be taken to ensure that confusion does not arise. Since the signals on gantry 8 relate to bi-directional lines, they are on that account sited closer together than they otherwise would have been.

5.73 The Committee of Experts on Signal Sighting were agreed as follows:

> "From the initial sighting of any of the signals on gantry 8, up to the point where they all achieve full, uninterrupted sighting, there is a changing pattern of visibility such that the number of signals visible varies and the view of any one signal can be interrupted. This presents a confusing picture to a driver. From the driving position of a class 165, the red aspect of signal SN109 comes into view last".

5.74 According to Mr Wilkins' first report, the various signals on and at gantry 8 became visible in the following order, and at the following distances from SN109, although this was "subject to partial obscuration and not necessarily of satisfactory readability":

- SN105 (line 1) at 496m
- SN107 (line 2) at 349m
- SN115 (line 6) at 327m
- SN113 (line 5) at 263m
- SN111 (line 4) at 248m
- SN109 (line 3) at 219m

The last is, of course, subject to the observations which I have set out in para 5.65. Also it can be seen from Mr Wilkins' report that each of SN111, SN113 and SN115 was found to revert intermittently to being obscured after becoming clear.

5.75 What I have stated in the last few paragraphs provides powerful support for the accounts given by drivers as to the difficulties which they experienced in making out the aspects shown by the signals on gantry 8, and by SN109 in particular. Mr Wilkins said that he tended to agree with the view that a mixture of good and bad sighting could make matters worse. He said:

> "Good signals do tend perhaps to increase a driver's confidence of the approach view of signals, which tends to lead to his being wrong-footed when he comes across a badly sighted signal".

In this context Counsel to the Inquiry pointed out that, while SN109 was fully visible for 6.25 seconds at linespeed, SN43, SN63 and SN87 were visible for 10, 12.5 and 17 seconds respectively.

<u>Could driver Hodder have believed that he had or would have a proceed aspect from a signal on gantry 8?</u>

5.76 It can be seen straight away that the present case is not one in which it can be said that the driver could have thought that he had a proceed aspect by incorrectly reading an adjacent signal as being one which applied to his train, since at all material times all of the signals, including SN105, were at red. If, therefore, he believed that he had a proceed aspect, the basis for that belief must have arisen from some other factor.

5.77 In his third report Mr Wilkins stated that, bearing in mind that the signals on gantry 8 came into view from beneath a low bridge:

> "… there is a tendency to assume, entirely without justification, that any signal whose red aspect is not visible has cleared to a 'higher' aspect, and in particular to a green aspect… Unfortunately, this rather precarious assumption is proved true each time signals showing 'higher' aspects are encountered beyond low bridges. Every driver knows that the absence of a red aspect should not be taken to imply a higher aspect, but the habitual presentation of such evidence may be subconsciously compelling. The non-appearance of the red aspect of SN109 for some distance after all other red aspects on gantry 8 have come into view therefore has the potential to create the impression in a driver's mind that SN109 is not only showing a proceed aspect, but is probably showing a green aspect".

Counsel for Railtrack contended that this could not apply in the case of driver Hodder as he was inexperienced and had only recently undergone induction as a driver. There had not been enough time for such a habit to be acquired.

5.78 Dr Weyman of the Human Factors Group of the Health and Safety Laboratory (HSL) spoke to a report which he and other members of the Group had prepared on the subject of the potential for driver error. Dr Weyman had previous experience in the areas of risk perception, risk-taking behaviour and risk-decision making. In the course of his evidence he advanced the view that it was a plausible hypothesis that driver Hodder, who had mainly encountered proceed aspects in the past, had decided to increase power in the expectation that his signal on gantry 8 would "step up" to a proceed aspect, and that he believed that he had confirmation of this from his initial sighting of the other signals on the gantry. It is stated in the report that "human beings have a tendency to be more receptive to perceptual information which confirms their initial hypotheses than that which conflicts with them". In giving evidence Dr Weyman said that he had had discussions with drivers which led him to think that some considered the absence of a red aspect to be a sufficient criterion for proceeding through the junction, given the obstruction provided by the bridge.

5.79 Dr Weyman accepted that this hypothesis would not provide a sufficient explanation for the driver's apparent failure to observe and react to SN109 after it had ceased to be obstructed, although it could, in his view, be reasonably considered to have the potential to reduce his motivation to attend to the signal thereafter.

5.80 Counsel for ASLEF submitted that on this basis a driver could have been lulled into a false sense of security. It was a fact that signalling had such high reliability that it was inconceivable to a driver that a signal which could not be seen might not be working. Counsel for Railtrack, on the other hand, castigated the hypothesis as illogical, counter-intuitive and counter to a basic rule which had been inculcated into driver Hodder that he should proceed taking one signal at a time, and hence with due caution.

5.81 Another explanation of a different character was offered by Professor R J Watt of the Department of Psychology, University of Stirling. He had carried out an observation of the signals on gantry 8. He pointed out that on 5 October sunlight was striking the signal head of SN109 at an angle of incidence of only 11°. It was unusual for sunlight to do so: the mean total hours per year when the signal was directly illuminated by the sun at such an angle or less was 0.52% of all sunlight hours at most. Moreover the sunlight might not always be very strong. On this occasion it was a cloudless morning and the sun was unusually bright; visibility was 15 km and there was no evidence of any visible cloud. He had also examined a photograph of SN109 which had been taken from the driver's position in a class 165 on line 3 at a distance of 17m on the following day at about 08:14 in broadly similar illumination conditions. This showed, in his opinion, that the effect of direct sunlight on SN109 was to cause its image to be less easy for a driver to read. This was because:

(i) the unlit yellow lamps generated enough internal reflection to produce a brighter and more saturated (coloured) image than they would normally do when unlit; and

(ii) the red lamp was reduced in its saturation.

He referred in particular to the stage at which driver Hodder was between about 280m and 186m from SN109. Some of the sunlight would have been reflected on the internal surfaces of the lower yellow lamp as a yellow colour. The driver's perception of the brightness and colour would have tended to be enhanced while this reflected light was seen against the dark underside of the bridge. Thus the driver would see something like a weak single yellow, replaced later at about 219m by a weak double yellow (as the upper yellow lamp became less obscured). The most likely place for such a view was at the crossover from line 4 to line 3. This would be followed very soon afterwards by a red aspect, which was presumably brighter than either of the yellow lamps. However, the appearance of a red aspect at that stage would not be accompanied by any diminution in the intensity of the other aspects. The coming of the red into view might cause him to re-assess, but that would depend on the degree of certainty with which he felt he had identified the signal before he reached that point. It was possible that as SN109 was being approached the driver did not question his first perception of that signal, and that this misperception was not discovered. At this stage SN109 would no longer be as conspicuous as it had been when it first came into sight. This was because of the complexity created by a number of features, including electrification gantries, competing for visual attention.

5.82 Counsel for Thames Trains submitted that Professor Watt's explanation was the only one that had been offered for what prompted driver Hodder to take power after coasting, and to do so when he did. There was, as Mr Wilkins said in evidence, a natural desire to read signals at the earliest opportunity.

5.83 Counsel for Railtrack submitted a number of criticisms of the evidence given by Professor Watt. Firstly, his assessment of any quantitative difference between the luminance of the red and that of the yellow could be of no assistance when considering the position at more than 188m from the signal, or materially more than 17m. Moreover Professor Watt was clearly wrong in stating, with reference to the red aspect, that at 17m there was still "in excess of 50% of the luminance". Mr Wilkins had given unchallenged evidence that the train left the beam of the signal 90m before it, and that it was within the spread of the beam that the luminance was in excess of 50% of its luminance at the centre. Counsel maintained that in these circumstances the luminance at 17m would have dropped well below 50%. As regards this point I am not satisfied that reference by Counsel to the evidence of Professor Watt was accurate. Professor Watt stated that outside the beam there was "only a reduction in power of the lamp around 50% and that is not a great deal". Furthermore it was not put to him that he had been in error in giving that evidence and accordingly he was not provided with the opportunity to respond to any challenge in this respect.

5.84 Counsel for Railtrack also founded on the evidence given by Mr Wilkins as to the possibility that driver Hodder might have interpreted any reflected light from the yellow lamp on SN109 as a lit signal aspect which applied to him. In his third report Mr Wilkins stated that, although the dark underside of the bridge tended to assist the reading of aspects displayed by the signals on gantry 8, reflected light from the yellow aspect was not perceptible to him throughout the approach to SN109 when viewed from the test train on 6 October. He stated that while it was not possible to eliminate the possibility that driver Hodder's perception of the equivalent conditions on 5 October may have differed, it appeared that this was an improbable explanation. In his oral evidence Mr Wilkins accepted that in bright sunlight the unlit yellow aspect of SN109 reflected some yellow light. However, it was very small compared with the specular (white) reflection of the sunlight; he described it as an ashen shade of yellow; and it was visible only at close range, and was not readable in any sense at a distance of 200m or 250m, according to his qualitative assessment. Counsel for Railtrack also emphasised that Professor Watt had not gone so far as to express the opinion that it was likely that driver Hodder had read SN109 as displaying a yellow aspect. He had merely advanced this as a possibility. In any event, in accordance with the Rule Book, on which he should have been trained, driver Hodder should have treated any signal which was uncertain or difficult to see as though it was displaying a red aspect.

5.85 At the same time it is necessary for me to take into account a number of points which were put to me by Counsel for Thames Trains. The observations of Mr Wilkins, as Professor Watt pointed out, had been made from a position where the somewhat brighter and much more saturated red was visible. This offered him a reference against which to judge the yellows. He was also seeing the signal against the bright background of the sky, which would produce a quite different perception of the brightness of the yellows, as compared with the position some hundreds of metres back when they were seen against a black background. Counsel for Thames Trains also reminded me that Mr Wilkins' evidence was based on steady observation over a period of two or three minutes, whereas driver Hodder would have had only seconds. His observations were essentially static, whereas those of driver Hodder were in motion. It was possible that driver Hodder's seat position might have been different, and in this connection it was important to bear in mind that the Committee of Experts had stated: "The vertical and lateral positioning of the driver's eye was extremely critical in determining the approach view". Mr Wilkins had accepted that driver Hodder's position might have been slightly different from his own. His perception of colour might also have been different and the sunlight might have been brighter on the day of the crash.

5.86 Do any of these explanations fit in with the timing of driver Hodder's taking of power? Counsel for Thames Trains submitted that it was striking that, first, his application of notch 1, and then notch 5, was virtually coincident with the point at which all the red aspects on gantry 8, with the exception of SN109, were visible; and, secondly, that the application of power correlated also with the possible misperception of a weak yellow. However, the first of these points is not straightforward. As can be seen from para 5.74, at the time when driver Hodder applied notch 1 (namely when he was at 255m) not all of the signals on gantry 8, other than SN109, were visible, and his application of the accelerator must have been preceded by a period of time in which he interpreted that he could see and decided to apply power.

<u>Could driver Hodder have believed that there was no signal on gantry 8 which applied to him?</u>

5.87 In his third report Mr Wilkins referred to the provision of para 4.1.4 of Railway Group Standard GK/RT 0037 that "when lines running parallel to each other are signalled in the same direction, the signals for each line shall generally be placed opposite each other". This general rule as to the "parallel positioning of signals" was also specified in the code of practice for signal sighting (CP8) which was current at the time of the resignalling scheme. Mr Wilkins drew attention to a number of cases of non-parallel positioning of signals at Paddington, namely SN37 in the Down direction and SN14 in the Up direction. Mr Fairbrother also referred to further examples in the relationship between SN125 and SN127 in the Down direction; and between SN102 and SN104, on the one hand, and SN98 and SN100, on the other hand, in the Up direction.

5.88 Counsel for ASLEF founded on the opinion expressed by Mr Wilkins in his third report that such non-parallel positioning had the potential to be very misleading since it in effect taught drivers "to expect signals to be missed out when weaving between running lines". If a driver was familiar with the idea of not receiving any Up direction signal at Ladbroke Grove Junction for routes from SN114 to lines 1 and 2, which a driver might regard as crossing from the Relief line side to the Main line side, there was a danger that a driver might expect no signal to exist at gantry 8 for moves from the Relief line side to the Main line side in the Down direction. That was the move made by driver Hodder on the day of the crash, and by driver Bunney in the SPAD on 4 February 1998. A similar view was expressed by Mr Fairbrother. Counsel for ASLEF also pointed out that in his report Mr Rayner observed that most of driver Hodder's previous journeys were down the Relief line; and that driver Hodder could have been under the impression that SN109 was not there, or that the gantry containing it was the point at which non-paralleling had begun. On this basis Counsel for ASLEF submitted that, having received a single yellow with a junction indicator at position 1, driver Hodder may have thought that he had been routed all the way across to the main line, and therefore that there would be no signal for him on gantry 8.

5.89 Counsel for Railtrack, on the other hand, submitted that this was a far-fetched, if not untenable, explanation of Mr Hodder's driving. Gantry 8 was plainly a landmark, and there was an important difference between a route by way of the Down Main line and one by way of the Down Relief. There should be no difficulty in a driver being taught, and understanding, that on his way out from Paddington Station there were signals at each of the gantries.

The last 168m before SN109

5.90 I turn next to the stage after the red aspect of SN109 had become clear of obstruction. It is, of course, necessary for me to consider all of the stages through with driver Hodder passed, since what happened in one of them they may have implications for another. However, for the present I am concerned with factors that are particular to this stage, which I will endeavour to set out in the order in which they would or might have arisen. At 152m before SN109 the front of the Turbo passed over the AWS magnet for that signal. The AWS horn sounded at 129m, and its cancellation was completed when the Turbo was 111m from it. At 104m driver Hodder engaged notch 7. Mr Gollop's interpretation of the OTMR record of driver Hodder's driving was that it was consistent with his believing that he had a proceed aspect, most likely to have been a double yellow, as he took power "just at SN109". It also should be noted that an AWS horn does not relate uniquely to a red aspect: it may give warning of any restrictive aspect. It is widely accepted that there is a danger that drivers may become accustomed to cancelling the horn as an automatic reaction.

5.91 Shortly to the west of the AWS magnet for SN109 was a speed restriction sign. It was suggested by Mr Wilkins in his third report that the sounding of an AWS horn at 129m might have been misconstrued by driver Hodder as a warning relating to the speed restriction rather than to the restrictive aspect of SN109. However, he accepted that there was no such use of an AWS magnet on the Down line from Paddington as far out as the North Pole depot, and that an experienced driver would be expected to know that. Counsel for Railtrack also pointed out that AWS magnets are used in case of speeds of 60 mph or more being restricted by one third or more. It was, he said, improbable that it would be used in connection with a limited increase of speed coming out from Paddington Station.

5.92 Mr Wilkins gave evidence that it was essential that signals were positioned as close as possible to the driver's eye and no higher than 5,030mm above rail level. Group Standard GK/RT 0037 states that "when mounted on a gantry the most restrictive aspect is normally to be at 5.03m above rail level and 914mm from the left hand running edge". He explained that the lower that a signal was positioned the closer it was to the driver's eye level, and the greater was its readability during his approach under conditions of bright sunlight. SN109 was positioned at a height of 5,085mm above rail level. Mr Wilkins also said that the alignment of SN109 was not accurate. To accord with the Group Standard the centre of the beam required to be aligned towards a point three metres above the left hand running rail at a distance of 183m from the signal. It appears that, owing to some failure of communication between Railtrack and Amey Rail, this was not covered by the latter's maintenance work. SN109 was aligned short, although this was partially corrected by an upwards misalignment of the red aspect. In the result the centre of the beam of the red aspect was aligned at 108m in rear of SN109. The driver of a Turbo would enter the top edge of the beam of the red aspect at 240m (although it was in fact obscured by the OHLE at that stage), and leave the bottom edge at 90m. Accordingly the driver would be within the actual beam from the point where red aspect became visible at 219m until he reached a point which was 90m from SN109. As Mr Wilkins accepted, this was well focused to coincide with the sounding of the AWS horn.

5.93 As was pointed out by the experts to whom I have referred above, the "reverse L" configuration of SN109 (along with the other signals on gantry 8) did not comply with Railway Group Standard GR/RT 0031 which states: "The normal order of proximity to the axis of the driver's eye shall be that the red aspect is closest". Mr Wilkins commented: "The driver's expectation is that… the red aspect will be the nearest aspect to him on a signal. If he were to glance at a signal as he goes past it at speed, his assumption will be that the red will be the closest and that the signals will be positioned in the standard sequence". Mr Rayner described the "reverse L" as a rare, if not unique, feature. Gantry 8 was the only gantry which carried signals with that configuration. It is arguable that its unusual configuration would take longer for a driver to interpret.

5.94 As I stated in para 5.84, Mr Wilkins gave evidence that, in certain conditions of bright sunlight, at a distance of 30m or less to SN109 the driver would see an "ashen yellow" reflection from the yellow aspect of SN109. However, he also stated that "at no time was any reflection of yellow light significant relative to the readability of the red aspect". The tendency of bright sunlight to swamp a lit aspect and cause it to be "washed out" is an accepted phenomenon. An example of this was given by Miss Fay Beever, a train driver with Heathrow Express, in what she saw at SN81 or SN105 when she was driving the 07:55 train from Paddington to Heathrow. There was uncertainty as to the date, but it is likely to have been the day before the crash. On the morning of 6 October Mr Wilkins noticed that at a distance of 17m from SN109 (where the test train had stopped) the sunlight was swamping the red aspect to the extent that the lit aspect was identifiable only when compared to unlit aspects. According to his third report, this would have reduced the readability of the red aspect, especially at close range, which he defined as 30m or less in round terms. However, the swamping did not prevent the red aspect from remaining the dominant aspect as perceived by an experienced driver.

5.95 Counsel for Railtrack pointed out that from the time when the red aspect of SN109 became unobstructed, driver Hodder could see it for about eight seconds, given the speed at which the Turbo was travelling, before he reached the last 30m before that signal. He was warned by the AWS horn and the "sunflower" device in the cab after he had cancelled it. He should have been alert not only to the aspect of SN109, but also to see whether his route lay by way of the Down Main or the Down Relief line. The absence of any indication of a route should have been taken by him as confirming that he was approaching a red aspect. He had plainly been inattentive. Although the luminance of the red aspect was below 50% after he had come within 90m of the signal, the aspect remained visible and readable at least until the last 30m. It was, he said, more probable than not that he was not looking at SN109. He drove as if gantry 8 and SN109 did not exist.

5.96 At the same time I have to bear in mind that the Inquiry heard evidence that a train driver who believed that he had read a signal would be unlikely to seek to review that reading. In his third report Mr Wilkins said:

> "The fact that Hodder's eyes apparently did not revisit SN109 should not be regarded as unusual; unlike road traffic lights, railway signals are not in the habit of reverting to red as a driver approaches. There is therefore a tendency for a driver to mentally 'put a tick in the box' for a signal once it has been read and not to review the signal thereafter".

As I have already noted, Professor Watt accepted that when the red aspect came into view, it might cause a train driver to reassess what he believed that he had perceived, but he said that this depended on "the degree of certainty with which the driver in question felt he had identified the signal as being what he thought it was before he reached that point". In the course of his evidence Professor Groeger spoke of the phenomenon of "inhibition of return": when a person has searched an area visually and then passed on to another one, the former area is much less likely to be looked at again until other areas have been looked at. The Inquiry also heard evidence from Professor N Moray, of the Department of Psychology of the University of Surrey, about the distribution of visual attention between several tasks. A train driver required not only to look out for signals but also to monitor his speed, observe the track, look for speed restrictions and look at his documentation. Assuming that a driver could switch his visual attention every second, and using a well established statistical analytical technique, Professor Moray said that on about half of the occasions when he was carrying out these tasks he would return to any point of observation in about four seconds. On a quarter of the occasions more than 7½ seconds would elapse. He pointed out that since those times were averages, on occasions the time interval could be considerably longer.

5.97 Counsel for Railtrack submitted that it was well known that distraction was a significant cause of SPADs. It seemed possible that something had made driver Hodder disregard SN109. Distraction should not be discounted merely because of the absence of positive evidence that he was distracted. The most probable causes of his inattention were a build up of fatigue after his early start and the stage in his shift when it occurred. Dr Deborah Lucas, a principal psychologist employed by the HSE, pointed out that it was a well known phenomenon that errors seemed to be concentrated between the second and the fourth hour of duty.

5.98 As regards possible distractions, there was no evidence before the Inquiry that there was any unusual feature or occurrence within the cab of the Turbo. At one stage there was a suggestion that driver Hodder may have been using a mobile phone. There was, however, no evidence to substantiate this, and it should be positively ruled out. As regards any external source of distraction, there was positive evidence before the Inquiry that no maintenance personnel were working on the permanent way, the OHLE or the signalling system at the time of the crash. In his third report Mr Wilkins was critical of the yellow reflective line identification signs which were mounted on the gantry. As he pointed out, during bright sunlight there was a tendency for the signs to reflect sunlight towards the driver and thus produce a distracting glare during his approach to the gantry. In any event, they were much too high to be of any practical value. It was much easier to correlate signals to running lines than to correlate signs which were nearly 10m above rail level.

Driver Hodder's driving beyond SN109

5.99 After the application of notch 7 104m before SN109 the speed of the Turbo climbed steadily from about 38 mph until shortly before impact when it was travelling at about 51 mph. The overlap beyond the signal is the zone which is intended to enable trains which have overrun signals to come to a halt without fouling the path of any other train. The overlap is normally about 200 yards (183m). In the case of gantry 8 the overlap for any train which was not diverted towards the Down Main or the Down Relief line was unusually long. It was 563m to the fouling point. At 615m after SN109 driver Hodder engaged notch 6. This was followed by a number of events, each within a fraction of a second of the last, namely notch 6-notch 2; notch 2-coast; coast-brake 2; brake 2-brake 3. The last was a full service brake at 636m (30.70 seconds after passing SN109), followed by the start of emergency braking, apparently as a result of a separate decision, at 660m (31.75 seconds). Wheel slide started at 688m, and the control of doors was lost at 690m.

5.100 As I have already noted, this incident, unlike the previous SPADs, was not one in which there appears to have been any realisation that SN109 was being, or had been, passed at red. Thus whatever led driver Hodder to pass SN109 led him also to continue until the point where the crash was imminent.

5.101 Two questions arise in relation to this stage. First, was there anything during the period up to the point where he applied level 3 braking that could have confirmed a belief that he could rely on a proceed aspect? Secondly, and conversely, was there anything which should have alerted him to the fact that he was on a wrong route?

5.102 In the course of the Inquiry it was suggested that he might have been confirmed in thinking that all was well by having the sight of a proceed signal, either on the Down Main (SN125, which was about 850m beyond SN109), or on the Down Relief line (SN127, which was about 780m beyond SN109). Counsel for Railtrack said that both aspects of this "luring" theory were unfounded. He pointed out that, according to Mr Wilkins' first report, SN125 was invisible at SN109. It became intermittently visible 230m after SN109 and visible without interruption after 476m. By the time that SN125 became visible, driver Hodder had already passed points 8057C/D and he had not been diverted towards the Down Main. By then, Counsel submitted, he should have realised that there was only one available route, namely points 8059B to the

Down Relief. Consequently the luring theory should have no foundation. As regards SN127 it also was wholly invisible as driver Hodder passed SN109. At that time it was in fact displaying a red aspect. It was not possible to exclude the possibility that over 100 or more metres thereafter when the signal had stepped up to yellow driver Hodder might have taken the yellow aspect as identifying a clear and set line of route, assuming that he then focused upon it. However, the problem with this theory was that when the belief proved to be erroneous as the train was taken to the left, there was no prompt reduction in power or move to brake the train at or in track circuit GG. Reduction in power and braking did not begin for a further ten seconds or so in track circuit FZ.

5.103 As regards the second of these questions, Mr Gollop said that, after the second set of points which would have led the Turbo to the Down Relief line, he would have expected a competent driver "to understand that this was a perverse route he was taking", adding "that is very close to the collision, mind". He went on to say: "Even an experienced driver probably would take a second or two before the reality of what was taking place sank in". He would expect such a driver to double check to make absolutely sure he was on the wrong route, and then apply the brakes. It would not be uncommon to apply the full service brake followed by the emergency brakes in such a situation. He said that if he were in that situation himself, he probably would have reacted about the same time as driver Hodder had done.

Conclusions

5.104 The evidence and the submissions submitted to me clearly demonstrate the difficulty of reaching definite conclusions as to what led driver Hodder to pass SN109 at red and thereafter to make no attempt to stop until a crash was inevitable. Whatever conclusions might be correct in the case of another driver are not necessarily appropriate in the case of driver Hodder. His experience was slender, his training had significant shortcomings, and little can be known about his thought processes and habits.

5.105 At this point it is convenient to deal with the argument that driver Hodder believed that there was no signal for him at gantry 8. As was brought out clearly in the evidence, that gantry was a landmark, being the place where the six bi-directional lines converged. The theory that the non-parallel positioning of other signals might have led him to think that there was no signal for him at gantry 8 has some attractions. However, the difficulty is that of seeing a close enough connection between the spacing of other signals and those at gantry 8. In my view this is too speculative an explanation to account for the actions of the driver.

5.106 In my view it is more probable than not that at the time when he passed gantry 8 driver Hodder believed that he had a proceed aspect, and that until the collision was imminent he continued in that belief. Is it possible to determine what factor or factors played a part in this, and, if so, what were those factors?

5.107 I will begin by considering his driving in relation to SN87. There is no suggestion that driver Hodder deliberately ignored what was shown by that signal, and I can no more accept that he did so than I can in the case of SN109. As I have already narrated, the submission by Railtrack was that, through inattention, he failed to see that signal and the fact that he did not put in the DRA misled him thereafter into thinking that he had a clear way through to the Down Main or the Down Relief. I am not persuaded that the evidence indicates that there was any inattention on the part of driver Hodder in regard to what was shown by SN87. The fact that he did not begin to brake does not, in my view, show that he had not seen SN87, or, for that matter, that it had not registered with him. The calculations made by Railtrack as to the point at which he would have had to start braking if he was to use level 1 or 2 braking in order to stop 20 yards before reaching SN109 were no doubt correct as a matter of arithmetic, but the way in which Railtrack sought to use them seems to me to be highly artificial. They presuppose that, despite his slender experience, he had a sufficiently exact knowledge of the distance to know when to start using a certain level of braking to come to a stop at a particular point before he reached SN109. Further, it seems to me that, in view of the good sighting of SN87 and the fact that the signals on its gantry were grouped in pairs, there is a very low probability that he did not see SN87 or that it did not register with him. In any event, there are other possible explanations for driver Hodder not beginning to brake. One is that he had forgotten the aspect which had been shown by SN87. The other is that he incorrectly read SN87 as showing a double yellow aspect. Each of these explanations has some support for it. For the first it is the unusually long gap between SN87 and SN109. For the second it is the effect of bright sunlight at a low angle. For these reasons I do not infer from the evidence that driver Hodder did not see SN87 or that it did not register with him.

5.108 I am also not persuaded that any significance attaches to the fact that driver Hodder did not put in the DRA. Counsel for Railtrack came to rely on this at a fairly advanced stage of the evidence, and did not put it to any expert. The practice of train drivers travelling in the Down direction was not explored. The inference which Railtrack sought to draw was based on what driver Hodder had done in the course of one journey in the Up direction. In any event the facts are equally consistent with driver Hodder considering that it was not necessary for him to put in the DRA in view of the fact that he had been coasting for 740m. I should add that if he had thought that he had seen a double yellow aspect at SN87 the question of using the DRA would not have arisen, since where DRA was used on the move by drivers it was only at a single yellow aspect.

5.109 On any view it is to be expected that a driver such as driver Hodder would be alert to look out for the aspect which was being shown by his signal on gantry 8. I have set out in some detail the difficulties with the sighting of signals on that gantry, and in particular the sighting of SN109, which was particularly poor. Of all the red aspects on that gantry it would have been the last to appear. I am not impressed with the theory advanced by Dr Weyman that driver Hodder may have expected, in reliance on what was shown by the other signals on the gantry, that his signal would step up to a proceed aspect. This theory involved, in my view, too much speculation and had a dubious basis. On the other hand, in the context of the confusing pattern of signal visibility, there is, in my view, considerable merit in the explanation suggested by Professor Watt that driver Hodder, at a time when the red aspect of SN109 was masked, saw what appeared to be a single yellow, perhaps followed by a double yellow. He could not at this stage compare them with the red aspect. In the case of an inexperienced driver such as driver Hodder, it cannot be safely assumed that he would be aware that the bridge and the OHLE were obstructing his view of the signal or that what he saw were not lit aspects. Had he been instructed that SN109 was a multi-SPAD signal it might be expected that he would have been more on his guard. Professor Watt provided a convincing explanation for driver Hodder applying power to the Turbo at the stage when he did. In saying that I take the view that the relationship in time between this and the sighting of the other signals on gantry 8 should not be looked at too narrowly. Mr Wilkins in his third report said that "the unsatisfactory positioning of gantry 8, and all that followed from that decision, is a major factor in most of the more probable explanations" of the SPAD that led to the crash. In my view it is more probable than not that the poor sighting of SN109, both in itself and in comparison with the other signals on gantry 8, allied to the effect of bright sunlight at a low angle, were factors which led driver Hodder to believe that he had a proceed aspect at SN109.

5.110 I do not doubt that, as Counsel for Railtrack emphasised, there was a period of eight seconds during which driver Hodder could have seen the red aspect of SN109. It is evident that he did not see the red aspect, or at any rate that it did not register with him, since if he had done so he would have reacted by applying the brakes. However, the strength of the submission made by Railtrack is considerably weakened by the evidence to which I have referred in para 5.96. While it might well be expected that if he was concentrating on his duties he would look again at his signal, this was only one of the things which might take his attention, and, if he believed that he had already read a proceed aspect and, in reliance on that, he had begun to accelerate, it is less probable that he would make a point of checking that he had in fact such an aspect. He would be even less likely to check in view of the fact that he had not been instructed on the SPAD record of signals such as SN109. The AWS horn sounded and was cancelled, but that would not have distinguished between a red and some other restrictive aspect such as a single yellow. (The latter, I note, would have been consistent with a double yellow aspect at SN87.) It is possible, but it is no more than speculation, that he could have mistakenly linked the horn to the speed restriction sign. I do not attach significance to the misalignment of SN109. However, the unusual configuration of that signal – the "reverse L" – seems to me to be a different matter. In the light of the evidence I consider that if an inexperienced driver such as driver Hodder was looking at SN109, especially when he was relatively close to it, he might well be misled, through the red aspect not being in its usual position, into not realising at that stage that he had a red aspect and continuing to think that he had a proceed aspect. I doubt whether the fact that driver Hodder engaged notch 7 of the accelerator when he was 104m away from SN109 indicates that he made any fresh assessment at that stage. It seems to me to be more likely to have been one of a number of actions on his part which followed from a belief which he had formed at the initial sighting of SN109 that he had a proceed aspect and so it was appropriate for him to accelerate. The line indication boards were potentially misleading and distracting. In view of the strong sunlight which was shining on the route indicator I doubt whether any significance can be attached to the fact that it was not showing a route to the Down Main or one to the Down Relief. In any event it is uncertain whether a driver who was as inexperienced as driver Hodder would have appreciated that the absence of a route indication was of some significance as regards whether or not he was signalled to proceed at all.

5.111 For the reasons which I have given it is not possible for me to arrive at a full explanation of driver Hodder's actions. However, I have reached certain conclusions which I have set out above. These may be summarised as follows:

(i) driver Hodder believed that he had a proceed aspect at SN109;

(ii) it is more probable than not that the poor sighting of SN109, both in itself and in comparison with the other signals on and at gantry 8, allied to the effect of bright sunlight at a low angle, were factors which led him to believe that he had a proceed aspect and so that it was appropriate for him to accelerate as he did;

(iii) after the red aspect of SN109 ceased to be obstructed he could have seen it during a period of eight seconds as he approached that signal, but it appears that he either did not see it or did not realise that there was a red aspect;

(iv) while it might well be expected that if he was concentrating on his duties he would look again at the signal, this depended on his various tasks and the confidence with which he had already identified what he thought that the signal was showing;

(v) the unusual configuration of SN109 – the "reverse L" – not only impaired initial sighting of its red aspect but also might well mislead an inexperienced driver such as driver Hodder who was looking at the signal at close range into thinking that it was not showing a red but a proceed aspect; and

(vi) the fact that he had not been instructed that SN109 was a multi-SPAD signal increased the risk of his making, and not correcting, a mistake as to the aspect shown by the signal.

5.112 In the course of the Inquiry the previous SPAD at SN109 on 4 February 1998 was referred to as the "dress rehearsal" for the disastrous crash on 5 October 1999. It is true, as I have already pointed out, that this earlier SPAD differs in respect that, when passing SN109, the driver realised that it was showing a red aspect, whereas in the present case the actions of driver Hodder indicate that there was no such realisation. However, it is only that realisation that accounted for driver Bunney pulling up to a halt after SN109 as he did. If he had not seen the true aspect when he was emerging from under the bridge, the consequences might have been entirely different, and have resembled what happened on 5 October 1999.

Final Observations

5.113 The circumstances in which this disaster occurred gave rise to the need to examine the way in which Railtrack had carried out the management of the safety of its infrastructure, with particular reference to the signalling at gantry 8. This is a subject to which I will turn in Chapter 7. As I have already indicated the evidence and submissions in regard to signal sighting raised questions as to the adequacy of the relevant Railway Group Standard. I propose to defer my remarks about this to Chapter 8.

5.114 There are, however, two matters arising out of this chapter with which I will deal at this stage. The first concerns the use of the DRA. Railway Group Standard GR/RT 0091 requires that the DRA should be set on each occasion when a train comes to a stand at a signal at Danger, or at a platform where no platform starting signal is provided and the last signal passed was displaying a single yellow aspect. While the DRA is in operation the driver cannot apply power. A red button shines in the cab until it is taken off. The Group Standard allows for the use of the DRA in other circumstances, provided this has been risk assessed and the risk assessment shows that it is beneficial. The evidence disclosed that it had been the practice in Thames Trains and a number of other operators to encourage the use of the DRA not only on the approach to a red signal but on the approach to a single yellow signal. This latter practice was called in question, in particular after the crash on 5 October 1999. It was recognised that the use of the DRA in those circumstances had the advantage of reminding the driver that the signal ahead of him was displaying a red aspect, and meant that he was required to take positive steps to enable power to be taken. On the other hand there were a number of perceived disadvantages. One was that if a driver developed the habit of setting the DRA when he encountered a single yellow aspect, but failed on one occasion to do so, this failure might "set a trap" for him by making him believe that the aspect ahead was likely to be less restrictive than it was in fact. It was also seen that concentration on the DRA might lead a driver not to look as closely at the signals ahead as he should. Mr Worrall told the Inquiry that, following a risk assessment by W S Atkins, the Rule Book for all drivers which is based on the Group Standards was to be amended by Railtrack as from December 2000 to the effect that the DRA might be used only on approaching a red aspect. Thames Trains had reluctantly accepted that this would be the position. In the circumstances I merely note the position and do not consider that there is a need for me to make a recommendation.

5.115 As I have already noted in this chapter and Chapter 3, the AWS horn, and the associated "sunflower" device in the cab, signify simply that a restrictive aspect is being displayed by the signal ahead. They therefore do not distinguish between a red aspect and a single or double yellow. While this is not satisfactory, I recognise that the creation of a separate set of warnings of a red aspect would involve some technical complexity. I also bear in mind that the Train Protection and Warning System (TPWS) will be installed within the relatively near future, and that this will make a substantial difference to the reliance which otherwise is placed on the driver to act in accordance with his signals. In these circumstances I do not consider that a recommendation for a change to the AWS warning system is justified.

Chapter 6
The actions of the signallers

Introduction

6.1 As I have already stated, SN109 was at red since a route for the Turbo had been set by the ARS only as far as that signal. While the ARS was in operation, which was normally the case, it was the function of signalmen in the Integrated Electronic Control Centre (IECC) at Slough, otherwise known as Slough New, to monitor the operation of the system and to intervene when necessary. Thus, in effect, if a train passed a signal at Danger, the intervention of a signalman, depending on the circumstances, could provide a line of defence to prevent a SPAD leading to a crash or dangerous incident. In the present case the distance from SN109 to the point where line 3 reached the Up Main was substantially longer than the normal overlap of 200 yards (183m), and accordingly the time which would elapse before a possible conflict with a train travelling on the Up Main was longer.

6.2 In this chapter I will set out:

- a description of the IECC and the means by which the signallers carried out their functions (paras 6.3-6.8);
- the timing of events as far as the IECC was concerned (paras 6.9-6.10);
- the evidence of the signallers (paras 6.11-6.26);
- the signallers' instructions (paras 6.27-6.37);
- the training and briefing of signallers (paras 6.38-6.42);
- an assessment of the signallers' actions (paras 6.43-6.48); and
- what else could have been done, and, if anything, with what effect (paras 6.49-6.56).

The IECC and the functions of the signallers

6.3 Stage 1 of the IECC was commissioned in July 1993 at the same time as the signalling which it controlled. The control room at the IECC contained three workstations. Workstation 1 controlled the area from Paddington Station to Acton East. Workstation 2 controlled the area from Acton East to West Drayton. Workstation 3 was the position for signal support. There was a separate desk for the electrical control operator. The premises also included a kitchen, mess room and toilet (*see Diagrams 1a and 1b overleaf*).

6.4 Each of workstations 1 and 2 contained eight segments, which comprised, from left to right as seen by the signaller, control buttons for the telephone concentrator (mainly signal post telephones), the visual display unit (VDU) for the telephone concentrator, the VDU for the IECC alarms, four segments containing VDUs which were capable of displaying schematic diagrams of the layout of the signals, track circuits and points in various sub-areas, and six "emergency all signals on" buttons which were set out in a

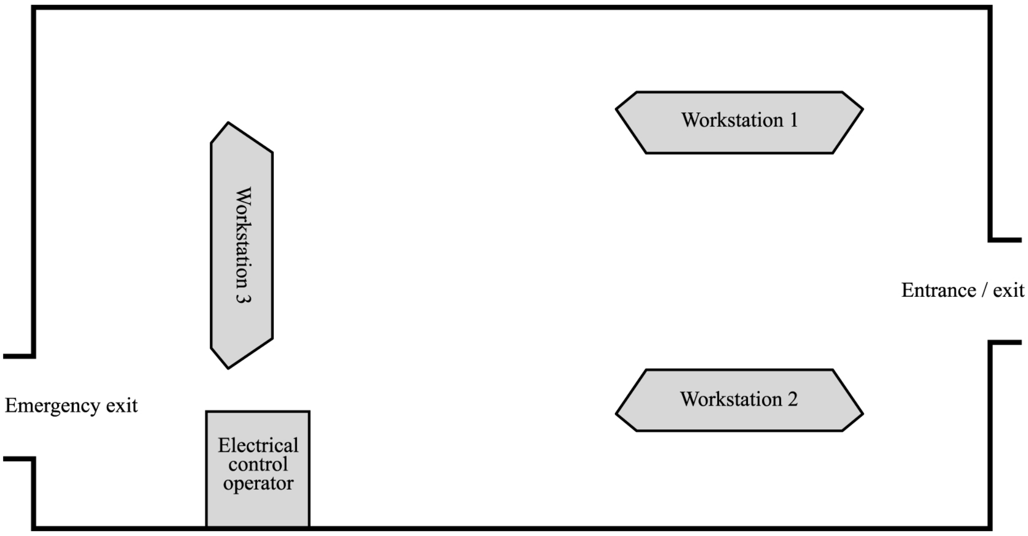

Diagram 1a: Layout of the Slough IECC work room

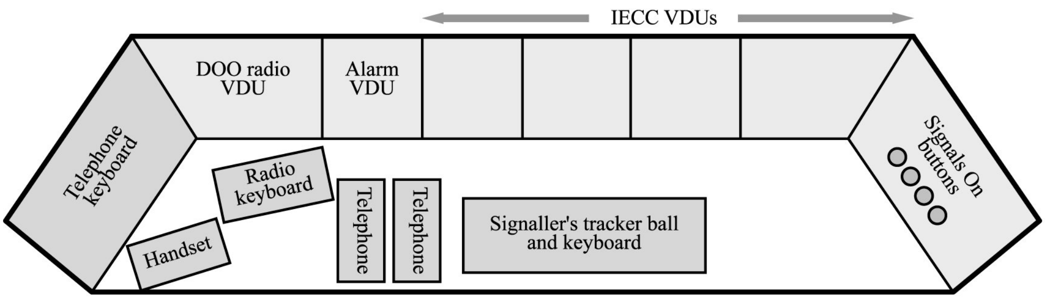

Diagram 1b: Layout of workstation at the Slough IECC

horizontal row. On the desk of each workstation were a radio keyboard and handset, two telephones, and a tracker ball with control buttons and a keyboard (*see Plate 15*).

6.5 The signaller at each of workstations 1 and 2 was able to monitor the operation of the ARS by looking at what was shown on the schematic layouts. He could replace a signal to its most restricted aspect by:

(i) using the tracker ball to move a cursor on the layout to the appropriate signal and pressing a red "cancel" button; or

(ii) typing out the number of the signal on the keyboard and pressing the "cancel" button.

According to the evidence of signallers, (i) was the quicker way of replacing the signal. It was also possible for the signalman to return to red all the signals to which the SSI related by pressing the six "emergency all signals on" buttons. This had the effect of removing the power supply and making it no longer possible to change points. The provision of these buttons was intended to deal with a situation in which the visual display system had "frozen", as indicated by the absence of the so-called "heartbeat" sign which normally appeared in the bottom left hand corner of the screens. In order to prevent damage to the SSI these buttons required to be kept depressed for 15 seconds. A practical disadvantage of using these buttons as a means of replacing signals to Danger in an emergency such as a SPAD was that this might put other trains and their passengers at risk.

6.6 The signaller could also use buttons on his desk to set routes and operate points. In order to perform the latter operation he required to bring up the detailed view, in place of the overview, of the sub-area with which he was concerned and to use the appropriate button for route selection. In some cases points could also be set indirectly by calling a route, but this could only be done if the track circuits in the route were showing clear, and no conflicting route had been set and held by train occupation.

6.7 The VDU for the IECC alarms would, in the event of one being given, identify the nature of the alarm in red. When a train passed a signal at Danger a red alarm would be displayed on the screen, showing the number of the track circuit and the headcode of the train. The track circuit would also be shown as a red line on the schematic display. The alarm was given audibly by a short and not particularly distinctive "tweet". It may be noted that this audible alarm also served to give warning of a number of types of malfunction, the commonest of which was the failure of a track circuit. There were also signalling, points and train describer alarms, as well as alarms for trains which had been a long time in a particular section of track. The signaller had likewise to consult the alarm screen to see the reason for it, and the position to which it referred. According to signaller R G Thoburn, who had previously worked at the Slough IECC, the "tweet" could sound up to 60 times in one hour.

6.8 One or other of two types of radio system was fitted to passenger trains operating over the layout which was controlled by the Slough IECC. In the case of First Great Western and Virgin trains, it was possible to use the National Radio Network (NRN), assuming that the driver was tuned to the appropriate area code which was shown on a board at the trackside. However, this system did not provide a direct means of communication between the IECC and the driver: messages required to be passed to, and relayed by, Swindon control. The trains operated by Heathrow Express and Thames Trains carried Cab Secure Radio (CSR), otherwise known as the Driver-Only Operation (DOO) radio. This enabled direct communication between the IECC and the driver. Thus the signaller could make a telephone call to the driver, waiting for him to respond by picking up the telephone to the cab. He could put out a general call by voice contact to the cabs of all trains which were fitted with the CSR. This would be heard immediately. He could also send an emergency text message to a particular train. This would sound an alarm in the cab, and cause the message to flash up on a screen on the driver's dashboard. The signalman could send such a message by making four strokes on his keyboard for the headcode of the train, followed by pressing a "stop" button.

The timing of events as far as the IECC was concerned

6.9 At this stage it is convenient to set out what could be heard and seen at workstation 1, before coming to the evidence of the signallers. This account of events is based in part in what was recorded by the ARS and the SSI loggers, and in part on the expert evidence of Mr R Fenton of W S Atkins and Mr Balmer. Allowance has been made for the time delay between the occurrence of an event at the scene at Ladbroke Grove and its logging by the equipment.

08:08:29

The occupation of track circuit GE without SN109 being cleared sounded an alarm, and the schematic display showed a red line indicating the occupation of that circuit and hence that a SPAD had taken place at that signal. It may be noted that the Turbo reached that circuit 4m beyond SN109 and 0.25 seconds after passing it.

08:08:34

A second alarm sounded as the schematic diagram showed that the rear of the Turbo had cleared the preceding track circuit GD.

08:08:36

A third alarm sounded as the schematic diagram showed the occupation by the Turbo of track circuit GF.

08:08:41

Track circuit GE showed in the schematic diagram as cleared.

08:08:47-49

The signaller operated controls to replace SN120 to red. At this point track circuit GG, which began 396m beyond SN109, was about to show as occupied.

08:08:49

A fourth alarm sounded as the schematic diagram showed track circuit GG as occupied.

08:08:49.5-50.5

SN120 was replaced to red.

08:08:50

It was indicated that the HST had been removed from the control of the ARS.

From the above it can be seen, as Mr Fenton and Mr Balmer deduced, that from the time when the first alarm sounded (and track circuit GE was shown as occupied), seven seconds elapsed until track circuit GF was shown as occupied, and a total of 18-20 seconds elapsed until the signaller acted to replace SN120 to red.

6.10 At the same time the progress of the HST was shown as follows:

08:08:32

Track circuit NZ was shown as occupied by the HST.

08:08:36

It was recorded that a route was set from SN72 to SN28; and track circuit MX2 was shown as cleared.

08:08:42

Track circuit MY was shown as cleared; and SN72 was changed from red to single yellow.

08:08:44

SN104 was changed from single yellow to double yellow; and SN120 from double yellow to green.

08:08:45

It was recorded that a route was set from SN28 to platform 2 of Paddington Station.

08:08:55

Track circuit FZ was shown as occupied.

Evidence of the signallers

6.11 At the time of the SPAD, workstation 1 was allocated to signaller Dave Allen, and workstations 2 and 3 were allocated to signallers James Hillman and Tom Siddell respectively. Signaller Lee Dhami, who had been relieved by Mr Allen at 07:45, was in the mess room. As was normal practice, out of the four signallers one was on a break at any given time. The arrangements at the IECC did not provide for a supervisor to be on duty, and none of the signalmen was nominated as being in charge. The signalling manager, Mr Heinz Winters, was near the control room. His position was essentially an administrative one. Steven Whatley, a trainee, was in the kitchen.

6.12 Mr Allen had joined British Rail in 1981. He had 11 years' experience as a signaller before becoming a signaller at the Slough IECC in about 1995. He had been a signaller grade 10, the highest grade, for about five years. During a 12 hour shift he would work for an hour at one workstation out of the three, followed by one hour on another and then a further hour on a third. He would then have a break for 20 minutes before resuming. It may be noted that the day of the crash was the seventh successive day on which he had worked a 12 hour shift. Prior to that he had five days off before a period of six days of 12 hour shifts, followed by one day off. In accordance with one of the recommendations of Sir Anthony Hidden in the Clapham Rail Crash Inquiry, it is provided by a Group Standard that a signaller should not work for more than 72 hours in a week. Mr Winters had authorised Mr Allen to exceed that limit. He said in evidence that he did not do so lightly. It had been due to the need to release staff to attend the Southall Inquiry. There were no laid down criteria which governed the extent to which the limit of 72 hours could be exceeded.

6.13 Mr Allen gave evidence at the Inquiry on 30 May 2000 that while he was looking at station worksheets, he heard an alarm. He looked at the alarm screen and the schematic screen which indicated that 1K20 (the Turbo) had passed SN109 at Danger. He said that after that

> "… there was a short period of time when I was expecting the driver to come on the phone and say that he had passed the signal at Danger. It was only then when he progressed over the junction I knew that we not only had a SPAD, that we had a train running away, so to speak, and dealt with that accordingly".

He explained that, although he had very limited experience of SPADs (two or three in all), "99% of the time when I have dealt with SPADs, the driver had always come on the phone within a very short time". By "progressing over the junction" he meant the stage when the train proceeded into track circuit GF. It was then that he realised that it was not stopping. He then put SN120 back to red "as it was going over the junction", meaning as the Turbo progressed over track circuits GF and GG. Train 1A09 (the HST) was seen to be coming up the Main line, approaching SN120.

6.14 Meanwhile, he said, Mr Hillman had come over to help him. As he was fumbling for the keypad, Mr Hillman sent an emergency stop message to the driver of the Turbo (in the manner I have described above). Under questioning he explained that he (Allen) had shouted that 1K20 had passed a signal at Danger, and that Hillman could see the headcode on the screen. He (Allen) changed from the overview screen to the detailed screen for Ladbroke Grove with a view to attempting to move points 8059 to the reverse position and thus divert 1K20 towards the Down Relief. However, as the train entered track circuit GG "I couldn't do it anyway because I was track locked". He (Allen) had never before used the CSR to send an emergency stop message. He was aware that in the last six years there had been eight SPADs at SN109.

6.15 Having regard to the timing of events set out in para 6.9 and his previous statements, Mr Allen's evidence at the Inquiry gives rise to a number of difficulties.

6.16 The first is the relationship of his awareness of the SPAD to his taking steps to have SN120 replaced to red. In a note written by him at 08:25 on the day of the crash he stated:

> "At approx 08:09 I observed 1K20 pass SN109 sig at Danger with 1A09 approaching sig SN120 (green). I then quickly replaced SN120 to Danger to try

> and stop 1A09 entering Ladbrook (sic) junction and sent emergency stop on DOO to 1K20, but it was too late, 1K20 had collided with 1A09 across Ladbrook Junction".

In giving evidence at the Formal Inquiry on 14 October he used the word "immediately" to describe how he slammed back SN120 after 1K20 passed SN109. In a second police statement dated 21 January 2000 he again said that he observed 1K20 pass SN109 at Danger with 1A09 approaching SN120. He stated: "I immediately replaced SN120 to Danger to try to stop 1A09 entering the Ladbroke Grove Junction". In a written statement given in preparation for this Inquiry which was dated 21 January 2000, but, according to Railtrack, was taken on 21 October 1999, he said that on seeing track circuit GE occupied and hearing three alarms "I immediately replaced SN120 to Danger to try and stop 1A09 entering the Ladbroke Grove Junction". In a third police statement dated 7 March he indicated for the first time that he had acted only after he had seen that 1K20 had occupied track circuit GF. He said:

> "In every other SPAD incident I have been involved with the train involved has stopped within the overlap. At the first instant in the situation on 5 October 1999 I monitored the workstation, expecting the train 1K20 to stop. In this case it didn't and I reacted to the situation as soon as I released (sic) that the train 1K20 was still progressing. At this stage it had moved into the next track circuit section – (P)GF. It was at this time I reacted and changed signal SN120 to red by means of the tracker ball method".

Thus it can be seen that over the period up to the time when he gave evidence to the Inquiry on 30 May 2000 Mr Allen progressively moved away from the position which he had described immediately after the crash when he indicated that the steps which he took to have SN120 put back to red followed immediately on his realising that the SPAD had occurred. It may also be noted that the indication that SN120 was showing a green aspect did not appear on the schematic screen on Mr Allen's workstation until 08:08:44, which was 15 seconds after the first alarm had sounded.

6.17 The second difficulty is that at the outset after the crash Mr Allen made no reference to attempting to reverse points 8059. The first time when he claimed to have attempted to reverse them was in his evidence to the Formal Inquiry when he explained how as a train advanced it would lock points. In this case he said that "by the time I tried, I put the signal back to Danger and went to the points here… he beat me to it, he actually started to accelerate… he accelerated by this point it was track locked and there's no way the SSI would have allowed me to move those points". It may be noted that Mr Fenton in one of this reports to the Inquiry stated: "There was no evidence in the SSI log of such a request to 'key' points 8059A and B reverse reaching Interlocking PADDRF 12 or of the points being called reverse. Neither was there any evidence in the ARS log of such a request having changed the state of the points key bits in the memory for these points (which it would have done, even if the points were locked) nor of the points being called reverse. It is extremely unlikely that such a request, successfully generated by the signaller, would not have reached, or have been processed by, the Interlocking".

6.18 The third matter is the question of who sent the emergency stop message to the Turbo. As I have already stated, in the note which he wrote at 08:25 Mr Allen said that he had sent that message. Likewise when giving evidence to the Formal Inquiry on 14 October, after describing how he put SN120 to red, he said:

> "I forgot to tell you that as the train was passing here I also sent to 1K20 emergency stop which is headcode emergency stop and that comes up in the cab and tells the driver to stop wherever he is and he failed to…".

His first reference to Mr Hillman sending that message appeared in his written statement to this Inquiry and in his second police statement. In evidence to this Inquiry Mr Allen said that it was because he was "in a deep shocked state" he had written that he was the person who had sent the message. As to his evidence to the Formal Inquiry, he said that at the time he was confused, under emotional stress and did not know why he had said this when he knew that it was in fact Mr Hillman.

6.19 Mr Hillman had been a signaller for four or five years. He had worked in the Old Box at Slough, Old Oak Common and Greenford before coming to Slough New where he had worked for 18 months. He told the Inquiry that he went over to workstation 1 to assist Mr Allen if he needed it. He asked him if he wanted help, to which Mr Allen said: "You can do that for me". He then sent the emergency stop message to 1K20 which took no longer than two seconds. He could see the headcode on the screen.

6.20 Once again there are difficulties with the account of what happened. First, when Mr Hillman gave evidence to the Formal Inquiry on 14 October he made no reference to sending such a message. When he was asked whether, in the event of something going wrong, such as happened on this occasion, he could contribute in any way he said: "Yeah I can. When he said there had been a SPAD I went over to see if I could assist him in the aftermath because there are so many questions that need to be addressed". He was then asked: "And can you tell us what you were able to do?". He replied: "At the time when I went over there I was expecting just a SPAD. After the collision I went back to my workstation to deal with trains over there stopping them from going any further past Acton". It is true, as was pointed out by Counsel for Railtrack, that Mr Hillman did not answer the second question one way or the other. However, he was, according to his account, trying to assist "in the aftermath", and if he had sent a message in order to endeavour to bring the Turbo to a halt it is remarkable that he did not mention this. In the written statement which he gave for the purposes of the Inquiry he said that he went over immediately to assist when Mr Allen started shouting something like "We've got a SPAD". He then went on to say that he sent the stop message.

6.21 Secondly, Mr Hillman's evidence at the Inquiry as to what Mr Allen was doing at the time when he arrived at workstation 1 was extremely confused. He said that at the time Mr Allen was trying to get the details screen up, in order to move the points, but that while he (Hillman) was sending the stop message to the Turbo, Mr Allen put SN120 back. However, in his written statement, and when pressed on this point at the Inquiry, he said that when he arrived at the workstation Mr Allen was putting SN120 back.

6.22 Mr Siddell said in evidence to the Inquiry that he suggested to Mr Hillman, as he was "legging it across" to workstation 1, that he should ring the driver, although Mr Hillman was already starting to do so. He was not in fact able to see Mr Hillman doing this, although in his written statement for the Inquiry he said that he observed it. He also said that he knew Mr Allen had attempted to turn the points. However, this was not because he saw him doing so but because Mr Allen had told him that. It is quite plain that a great deal of Mr Siddell's evidence was in fact based on assumption or on what he had heard from others.

6.23 Mr Whatley, when he was told of the crash, went to workstation 1 where Mr Allen was sitting. Mr Allen told him that Mr Hillman had sent the emergency stop message and that he (Allen) had attempted to move the points and had put SN120 to danger.

6.24 It is unfortunately impossible to have recourse to independent evidence as to whether the stop message was sent to and received by 1K20, and, if so, when. The use of the CSR was recorded on a radio data logger disk at the IECC. However, the existence of this disk was unknown to Railtrack staff at the IECC at the time of the crash or when various SSI and ARS records were later removed from the premises for the purpose of investigating the circumstances which led up to the crash. Its existence was also unknown to Mr Cooksey and the police officers who took possession of these records. It may be noted that Recommendation 13 of the Formal Inquiry into the accident at Royal Oak on 10 November 1995 was that all managers should be briefed as to the need, in the event of an accident, to recover data disks where there was a CSR. Mr J A Robson, Safety and Standards Manager, to whom the implementation of this recommendation was allocated, gave evidence that he verbally briefed area managers about this and provided them with a written amendment to the written procedure to this effect. However, Mr Burchell, production manager for the Reading area, was unaware of the existence of the logger or of the amendment. Mr Winters also was unaware of the existence of the logger and said that he had not received any instructions about it. The failure to ensure that staff at the Slough IECC were aware of the existence and significance of the logger was thus due to a failure in communication for which Railtrack were solely responsible. The logger was a specialised piece of equipment. The knowledge which was necessary for the removal of, and the downloading of data from, this disk belonged to Racal who were the sub-contractors who had been nominated for this purpose. In these circumstances the data was not obtained from the logger, and after a few days elapsed it was automatically overwritten. However, the Inquiry heard evidence from signaller Keith Andrews who had a period of duty beginning at about 16:00 on the day of the crash. He said that he saw on the monitor for the CSR an entry stating "1K20 stop" on the right hand corner of the screen. He said that this indicated that the stop message had been sent and received. If the message had been only sent it would have appeared in the bottom left. He erased this information in the course of his work.

6.25 The inconsistencies of the evidence of the signallers raise questions as to the reliability, and even the credibility, of some of that evidence. No doubt, as Counsel for Railtrack submitted, it is right to allow for the stress to which Mr Allen had been subjected. However, it is clear that in writing the note immediately after the crash and in giving evidence to the Formal Inquiry, he was at pains to put his actions in the most favourable light. Hence his repeated statement that he had acted "immediately", which, in the context to which it referred, was plainly wrong. He also tried, it appears, to bolster his account claiming that he sent a stop message to 1K20. Whether or not he needed to fortify his position in either respect is not the point. What is clear, in my view, is that he believed that he needed to do so. The effect on the quality of his evidence as a whole is singularly unfortunate. As I have already pointed out the evidence of Mr Hillman and Mr Siddell presents further difficulties. In the circumstances I consider that it is difficult to make any finding except where the evidence for it is clear and unmistakable.

6.26 I am satisfied that a stop message was sent. However, owing to the poor quality of the evidence, it is unsafe to determine whether it was received before the collision, let alone how long before it. While it is possible that the throttling back of the Turbo can be explained as a reaction to driver Hodder becoming aware of the stop message, this appears to me to remain in the realm of speculation. I am not satisfied that there was any actual attempt to change the points, since the technical evidence rules out any such attempt. The time at which Mr Allen instructed the replacing of SN120 to red is otherwise established. As to his reasons for not giving that instruction until the time when he did, I accept the truthfulness of the generality of what he said at the Inquiry, without being prepared to go so far as to accept it in every detail.

The signallers' instructions

6.27 Before making any assessment of the actions of the signallers it is convenient to set out the terms of a number of instructions to which reference was made at the Inquiry. Under the heading: "Drivers Passing Signals at Danger without Authority (SPAD)", Regulation 47 of the Signalling General Instructions (SGI) of August 1999 states:

> "47.1 If a train passes a signal at Danger without authority, the Signaller must immediately arrange for the movement to be stopped by the most appropriate means and take any other emergency action.
>
> 47.2 The Signaller must then make sure the Driver is advised of the circumstances, arranging for the Driver to contact him immediately".

6.28 Under the heading "Obstruction of the Line" and the sub-heading "Trains to be Stopped", Regulation 4.1.1 of the Track Circuit Block Regulations (TCBR) of August 1999 states:

> "If it is necessary to stop trains because of an obstruction on the line or other emergency, the Signaller must place or maintain the necessary signals at Danger to protect the line affected".

Under the heading "Signaller unable to stop train", Regulation 4.3 of the TCBR states:

> "If the Signaller is unable to stop a train proceeding into an affected section, he must comply with Regulation 6".

6.29 Under the heading "Train Divided, or Train or Vehicle Running Away" Regulation 6 of the TCBR states:

> "6.1 If the signaller becomes aware or suspects that a train is running in two or more portions, or that a train or vehicle is running away or proceeding without authority, he must:

(a) place or maintain at Danger the signals for any line which may be affected in order to stop any other train which may be endangered

(b) place or maintain the signals at Danger against the divided train or runaway train or vehicle except as shown below

(c) take all practicable steps to avoid a collision, such as allowing the front portion to proceed on a line which is clear, or divert either portion of a divided train or a runaway train or vehicle to a siding or another line which is clear".

6.30 Section 1 of the "The Instructions to Signallers at Slough New", where it deals with "Driver Only Operation of Passenger Trains 'Cab Secure Radio' System", states:

> "Should you require to stop a D.O.O.(P) train in emergency you must immediately carry out the procedure for sending a STOP message. This is in addition to the placing/maintaining of signals at Danger, and the carrying out of any local instructions… When you have stopped a train using this facility, you must advise the driver of the circumstances when he has brought his train to a stand and has acknowledged your STOP message".

Section 2 of those instructions where it deals with "Use of 'Cab Fixed Radio' to Stop Trains in Emergency: Track Circuit Block Regulation 4.3" states:

> "In the event of it becoming necessary to stop any train or trains in emergency you must carry out the provisions of Regulation 4. If you are unable to stop a train or trains you must, IN ADDITION to carrying out the provisions of Regulation 6, immediately contact Railtrack Customer Service Centre at Swindon…"

Contact was to be by a certain telephone number, stating that it was an emergency and asking that an "all trains stop" message should be broadcast within the area affected.

6.31 In his evidence to the Inquiry Mr Allen was referred to his third police statement in which he said that his instructions when a SPAD occurred were "at first to monitor and determine an overview of the situation. At that point I had to consider the overall situation and observe what's around at the time". He said that these instructions were his interpretation of SGI 47. Initially that instruction had priority. However, after the train proceeded beyond the 200 yard overlap, Regulation 6 of the TCBR took priority. As I have already narrated, he said that he accepted that while the train was still on the overlap he did not do anything as he was expecting the driver to come on the phone. He denied that it was "a wait and see situation".

6.32 Mr Winters stoutly defended Mr Allen's actions. He had, he said, "carried out the rules and regulations applicable to that incident". These were SGI 47, then Regulation 4 of the TCBR, followed by Regulation 6. The following is a passage from his questioning by Counsel to the Inquiry:

> "Q: Do you regard waiting to see if the train was going to stop or move into the next circuit of the track as compliance with instruction 47?

A: Yes.
Q: Is that what you train your signallers?
A: Yes.
Q: You have trained your signallers to see if the train stops of its own accord?
A: 99% of the time the train usually stops within the overlap of the signal".

Mr Winters pointed out that the initial alarm could have been due to a module failure. He trained the signallers that "their first responsibility is to protect the site. Secondary, then use the driver only system". He explained that a signaller communicated with a driver primarily through signals: the DOO system was there as a secondary system for contacting the driver. "The first priority of a signaller is to put a signal back to red. That prevents and protects the site of the incident". For this he pointed to the instructions for Slough New which, he said, took precedence over SGI 47. He did not criticise Mr Allen for waiting till the train occupied track circuit GF. As far as he was concerned his signallers had acted immediately and carried out their instructions: "We don't sit around and wait."

6.33 This evidence may be usefully compared with that given by other signallers. As I have already noted, Mr Hillman said to the Formal Inquiry that when he went over to Mr Allen he was "expecting just a SPAD". In evidence to this Inquiry, when he was pressed as to what required to be done in regard to a train which had passed a signal at Danger he said: "I am not sure I understand what you mean. We can't do anything. We are not allowed to contact drivers when they are on the move, so we have to wait until they come to a stand before we can talk to them unless they carry on". In his previous experience of SPADs (which was of two or three), the drivers had all stopped within 20 seconds and phoned up.

6.34 Mr Siddell said that, after seeing the SPAD on the overview at workstation 3, "we were hoping the train would come to a stand". He was then asked by Counsel to the Inquiry:

"Q. You do not rely on hope do you?
A. Well, the driver is supposed to stop at a red signal".

Later, when he was cross-examined by Counsel for First Great Western there was the following passage:

"Q: What about the near miss in February of 1998? Was there talk between you and your colleagues about what had happened that day and how matters could have been improved?
A: Generalisations, but it was still basically down to the driver to stop at a red signal.
Q: Was that the overall feeling? If a SPAD happens, that is essentially a driver problem?
A: Well how can it not be? If a person at a traffic light goes through a red light, is it not his fault?
Q: What about the problems that there had been in the Paddington area of drivers going through, not just SN109 but other signals, on a number of occasions when they were red against them?

A: Yes.
Q: Was it still felt that the problem was exclusively the driver's ?
A: Well, if a driver fails to stop at a red signal, he is at fault".

6.35 Mr Dhami, when being asked about what the regulations provided for in the event of a SPAD, said: "I think one is if it is a runaway train or passing a signal it is basically stop another train heading towards it". He said that the relevant regulation would be Regulation 6 of the TCBR. When he was asked about SG I47 he could not recall what it stated. However, on being asked what was the first thing he would do if there was a SPAD he said that "one can try and get the train to stop", and if there were any conflicting routes, one could try and make sure other trains that might conflict were stopped. He then did recognise SGI 47. He had never been present at the time of a SPAD.

6.36 Lastly, Mr Whatley did not regard SGI 47 as having priority over Regulations 4 and 6 of the TCBR. His action after a SPAD would be, not to stop the train, but to set signals to Danger as it was the most reliable form of communication.

6.37 Counsel for Railtrack submitted that in SG I47 the word "immediately" fixed on "arranging for the movement to be stopped" rather than "stopping the train immediately": in many, if not most, instances, arranging for the movement to be stopped might best be achieved by setting signals back. Counsel also submitted that Regulation 6 of the TCBR was a free-standing requirement which meant that the first step was "to place or maintain all signals at Danger against any train likely to be affected, including the runaway, and then to consider taking all other practical steps to avoid the collision". However, the use by Counsel of the words "and then" seems to me to read in an order of priority which is not there.

The training and briefing of signallers at the Slough IECC

6.38 At this point is convenient to refer, by way of background, to the training and briefing which was given to signallers at the IECC. Evidence was given that there was a rostered weekly team briefing for signallers at which staff had the opportunity of making suggestions. There were also 8-weekly rostered briefings of signallers at which there were discussions about safety, performance and general issues. Individual signallers were assessed over a 2-year period. The assessment either took place during the course of observation of the signaller while he was on duty or would be covered by a simulated situation with questions and answers. Mr Winters informed the Inquiry that SPADs were one of the main topics which were discussed frequently at briefings and assessments.

6.39 On the other hand there was virtually no formal or informal de-briefing on the lessons of SPADs. There was no training in the management of them, either by way of rehearsal or by checking responses. This should be seen against the background of the fact that in the Paddington area there had been numerous SPADs. There were 46 in the area covered by the Slough IECC in the period from 1993 to 1999. Mr Allen could not recall any discussion, after the SPAD which took place on 4 February 1998, of what should be done in such circumstances. Mr Andrews had no recollection of any discussion of any lesson from any of the previous SPADs. Counsel for First Great

Western rightly emphasised that the fact that a discretion was entrusted to signallers made it all the more important that the signaller was properly trained and rehearsed as to what to do in the event of a SPAD. From the evidence of Mr Winters it appeared that the only thing which had emerged for the signallers from the previous SPADs in the area between Paddington and Ladbroke Grove was a written instruction in regard to the routing of empty coaching stock trains from Paddington to Old Oak Common. He could not say if anything could have been learnt from the previous SPAD on 4 February 1998. There had been some discussion of it, but no specific instructions were given to signallers as a result. He had never at any time had concerns as to the reactions of his signalling staff to SPADs. Documents from the inquiry into the incident were issued to signalling locations. It was up to the individual whether he read them. Following the crash he had not personally briefed his signallers and did not appear to think that, arising out of its circumstances, there was any need to brief them as to what they should or should not do in the event of a SPAD.

6.40 It was also notable that no signaller had received any training in the use of the CSR in the event of an emergency. None of the signallers had used it in connection with any previous SPAD. Mr W G Boddy, an independent railway consultant, observed in the course of his evidence:

> "I think that the traditional way of trying to deal with an emergency has been to try and put signals back to Danger, and that seems to have carried on through even though other methods such as Cab Secure Radio have become available and may be more appropriate. I do not really think that that has sunk into the culture of signallers as to how they should deal with emergency situations".

6.41 The general picture which emerged was of a slack and complacent regime, which was not alive to the potentially dire consequences of a SPAD or of the way in which signallers could take action to deal with such situations.

6.42 Finally, a further illustration of the deficient briefing of the signallers was provided by evidence in regard to the "signals on" buttons, to which I referred in para 6.5. There was uncertainty as to the extent to which signallers were aware of the effect of pressing these buttons, and the circumstances in which they could be so used. The Inquiry was informed that one of the recommendations of the inquiry into the incident at Royal Oak was that the sign on each workstation that the buttons should be held down for 15 seconds should be removed. That inquiry noted:

> "The importance of these buttons should be briefed to the Slough IECC signalmen as the fastest method of putting all signals to Danger in the Slough IECC area".

However, Railtrack decided not to proceed with the removal whilst there was a risk that, if the buttons were released before the 15 second period, this could cause unexpected behaviour of adjacent SSI interlockings. Railtrack later issued two instructions relating to the use of the buttons. The first, dated 4 April 1998, related to the use of buttons in the event that the "heartbeat" ceased to flash. In that situation the buttons were to be operated and held down for a minimum of 15 seconds for the SSI area concerned as this would be the quickest way to replace large numbers of signals to danger. The second, dated 28 July 1999, stated that a button was provided for each

SSI area on each workstation. When the button was pushed in an emergency, all controlled signals (and automatic signals with emergency replacement facility) within the interlocking area concerned would instantaneously be placed to danger. Should it be necessary to operate the “emergency signals on” button, the button must be held down for a minimum of 15 seconds since to release it earlier could cause the SSI system to become inoperable from that workstation and replace signals to Danger in other interlocking areas unexpectedly. Mr Winters informed the Inquiry that although Railtrack had decided to give clearer instructions to the signallers this had never taken place, and he had never been asked to give further instructions to them. According to Mr Allen’s second police statement, which was dated 21 January 2000, he did not appear to be aware that the buttons were effective instantaneously. However, when he came to give evidence at the Inquiry and was asked what would be the effect when a button was pressed, he said: “It is more or less immediate”.

An assessment of the actions of the signallers

6.43 It is clear from his evidence that Mr Allen was aware from the outset that 1K20 had passed a signal at Danger and that 1A09 was approaching from the west along the Up Main. As he made clear, these were the only train movements in the area at the time. He took no action before 1K20 reached track circuit GF, not because he was needing time to ascertain what was displayed at his workstation or to decide what course of action he should adopt, but because he was expecting that train to stop within 200 yards of SN109. In the course of his evidence Mr Balmer was asked to comment on his report in which he stated: “When presented with the alarms and indications, the signaller reacted promptly to replace signal 120 to red…”. He said that this was still his view, adding:

> “He had a very limited time from the first indication of anything happening at all untoward, which was the time track GE was displayed as occupied on his panel. From that time to the time he actually managed to click the button he has got to go through the process of looking at the screens, digesting the information, evaluating a variety of options, and then physically moving his hand on the tracker ball to operate the controls”.

As was pointed out by Counsel to the Inquiry, Mr Balmer accepted that he was not in a position to give expert evidence about signallers. More specifically in regard to the period of time before track circuit GF came to be occupied, Mr Allen’s evidence does not lend any support for the view that he was preoccupied with evaluating his options. If the train had stopped within 200 yards of SN109 it would have been, in the words of Mr Hillman, “just a SPAD”. It is, to my mind, highly significant that in this respect he was backed up by Mr Winters, and that his actions were consistent with what was taught to, and followed by, other signallers at the IECC at Slough. I should also mention the evidence of Dr Weyman that in crisis situations there was a very low probability of an effective response in less than 30 seconds after confirmation of an incident. However, this was not based on any research relating to the responses of signallers, and it does not appear to me to be a reliable guide in the present case.

6.44 The approach taken by Mr Allen and others to SPADs seems to me to reveal a serious under-rating of the risks which these may involve. What Dr Murphy described as “a collision opportunity" was turning into an actuality. It could not be safely assumed that the train was going to halt within 200 yards of the signal, let alone beyond it. Moreover, the time which was allowed to pass before it reached track circuit GF was time lost in regard to any action which was directed to bringing it to a halt or diverting it onto another line.

6.45 Underlying that serious shortcoming was a failure to understand and apply instructions and SGI 47 in particular. As was submitted by Counsel to the Inquiry, SGI 47 applied the moment a train passed the signal at Danger. The first obligations on the signalmen were immediately to take such steps as were available to them to stop the SPADing train and to take any other emergency action necessary to deal with the situation. If a SPADing train is fitted with CSR, the most obvious and effective means of seeking to stop it in accordance with SGI 47 is to send an emergency message by radio. I fully accept, as was submitted by Counsel for Railtrack, that such an instruction should not be regarded as a recipe for unthinking action. But what happened in the present case was that Mr Allen consciously waited to see what would happen. The evidence from witnesses from elsewhere who were experienced in the work of signalling was all to the same effect that it was not acceptable or justifiable for a signaller simply to wait and see what happened before he took one of three courses, namely replacing a signal on a converging line to red, arranging to stop the SPADing train or taking steps to divert it. Mr G Brooker, Acting Area Signalling Manager for Kent, said that he had no doubt that whatever course the signaller chose to take, it was unacceptable to wait before taking action. The evidence of Mr Thoburn was that 99% of the time the signaller should react immediately. The exception was when the signaller concluded that it might cause more problems to bring other trains to a halt when there was no need to do so. However, that exception, I would observe, is itself an example of giving effect to a decision, and has no bearing on the present type of case. I should not be understood as meaning that in all circumstances there is a preferable course of action, such as the use of the CSR, where it is available. As Counsel for Railtrack brought out in evidence, there may be circumstances in which the safer course is to take some alternative action. Counsel to the Inquiry correctly observed that there was merit in the signaller having discretion because what was appropriate might depend on the circumstances facing him. "On many occasions", it was submitted, "prudence will dictate that the signalman should first contact the SPADing train before turning the signals on conflicting routes to danger. On other occasions, the position of other trains in the vicinity may dictate the reverse order of actions".

6.46 Two other matters seem to me to be important and to call for comment at this stage. First, while I can well understand that traditionally signallers have relied on signals as the means of communicating with drivers, there seems to me to have been a failure to realise the importance of direct radio communication with the driver where that is possible, as it was in the present case. It is plain that Mr Allen was not adequately prepared, by training or instruction, for this approach. And yet, in the circumstances, it was the only means by which he could arrange for the stopping of the Turbo. Furthermore he could do so without creating any countervailing risk.

6.47 Secondly, the evidence strongly indicated that, despite all the written instructions, SPADs were regarded by signallers as a matter of driver error. That showed not only a dangerous complacency but a lack of collaboration in the management of safety. The evidence of Mr Winters and Mr Siddell in particular suggested that signallers at the Slough IECC did not fully regard themselves as a line of defence against the consequences of a SPAD, which could be fatal.

6.48 While I have expressed criticisms of the reaction to the SPAD on 5 October 1999 the root causes of the approach which Mr Allen took, and of his understanding of what he was expected to do, lay in the way in which the operation of the control centre was managed including the instruction and training of signallers. It is surprising that the deficiencies to which I have referred were not picked up by senior management.

What else could have been done in the control room, and, if anything, with what effect?

6.49 The complexity of the new track and signalling system, along with the expected speed and frequency of train movements, made an automatic routing system necessary. At the same time intervention had to be possible, in particular where a movement took place without authority. In approaching the first part of this question I have to bear in mind that it relates to what, at least initially, was an interface between automation and human assessment and decision-making. Dr Lucas said that:

> "When the time comes for a person controlling an automatic system to intervene, it takes them some time to get a mental picture of what actually is going on, because that is harder to do when you are paying attention to something, for example, on a VDU screen, than when you are actually physically controlling it. So there is a time dimension there in order to switch over into the manual mode and understand what it is that is actually going on".

In the same context, Counsel for ASLEF drew my attention to the evidence of Mr Rayner that automation carried with it the danger of de-skilling signallers. Counsel reminded me that an experienced signaller such as Mr Thoburn who had been on duty at the Slough IECC at the time of the SPAD on 4 February 1998 told the Inquiry that he had then been working the signal system manually in order to keep his hand in.

6.50 I should therefore bear in mind that when the first alarm sounded Mr Allen was not watching any of the screens but looking at station worksheets. He had to identify the nature of the alarm and what had occasioned it; to take account of other train movements; to assess what courses of action were open to him; and to decide what he should do and in what order. In his evidence Mr Allen made it clear that he was immediately aware that the Turbo had passed SN109 at Danger and that the only other train movement in the area was that of the HST which was approaching the Ladbroke Grove Junction from the west. He knew that the Turbo was equipped with CSR. I have already referred to the fact that, in line with the approach which was generally adopted at the Slough IECC, Mr Allen waited till the Turbo reached track circuit GF.

Earlier replacement of SN120 to Danger

6.51 It was clear from the evidence that, even if Mr Allen had acted earlier in replacing SN120 to Danger than he did, which was 18-20 seconds after the first alarm had sounded, this could not have prevented the crash. Having regard in particular to the sighting distance of SN120, which was 395m, Dr Murphy concluded that the effect of

Mr Allen taking up to 20.06 seconds after the SPAD itself to replace SN120 to Danger would have been "neutral", i.e. taking any earlier steps would not have had any practical effect. The best that earlier replacement could have achieved, given that sighting distance of 395m, a speed of 82.5 mph on the part of the HST and the immediate application of brakes by its driver, would have been a reduction of speed of the HST to about 62 mph at the point of collision. In the event, with the replacement of SN120 to Danger when it happened on the day, the speed could have been reduced at best to about 72 mph at that point. Thus the only effect that the earlier replacement of SN120 to Danger could have had was to bring about a relatively small reduction in the speed at the point of collision. Any reduction in speed would, however, have had a relatively significant effect on the force involved. As Dr Murphy explained, the force varied according to the square of the alteration in speed. The above figures for speed at the point of collision proceed on the basis, it should be noted, that driver Cooper immediately reacted on first seeing SN120. How realistic this is, given the fact that he was faced with a highly unusual reversion from green to red and without any previous warning, is open to serious question.

Earlier sending of an emergency stop message to the Turbo

6.52 Dr Murphy calculated that, if the emergency braking of the Turbo had been applied up to 17.55 seconds after it had passed SN109 at Danger, the train would have stopped by about 562.78m beyond SN109 and hence short of the fouling point. He said that a figure of 17 seconds was a safe one on which the Inquiry could work. This may be compared with the passage in para 4.5 of the report of the Formal Inquiry in which it was stated:

> "To avoid a collision the DMU (the Turbo) would have had to stop about 65 yd (59m) short of the 8063 swing-nose crossing. To have done so would have meant that the driver had to have engaged the emergency brake about 18 seconds after passing signal SN109".

6.53 Was there enough time for a signaller to assess the situation and decide to send an emergency stop message to the Turbo? In seeing whether this question can be answered, it is necessary to make allowance for a number of matters. First is the time which would have elapsed after the SPAD before the first alarm sounded at the workstation. The time taken by the Turbo to travel from SN109 to the start of track circuit GE would have been 0.25 seconds. Thereafter time would have elapsed between the occupation of that track circuit and the ARS adding the event so that it was displayed at the workstation. This was between 0.5 and 2.4 seconds (made up of a fixed calculated delay of 0.5 and up to 1.9 seconds variable delay). Secondly, it is necessary to allow for the time which would have elapsed between the start of the action of sending the message and the point at which driver Hodder applied the emergency braking. Signaller Hillman in his evidence told the Inquiry that it took him no more than two seconds to send the message. Counsel for Railtrack submitted that four seconds should be allowed for driver Hodder to react, and a further 1.95 seconds for the time for the controls to be moved. However, the figure of four seconds was taken from a passage in the submission of Counsel to the Inquiry where it was used as a hypothesis for the purpose of argument. For my part I consider that it would be realistic to take five seconds as the overall time for the reaction of the driver and the controls to be moved. Accordingly, if one starts with Dr Murphy's figure of 17 seconds, it is necessary to deduce a total of between 7.75 and 9.65 seconds for these factors.

6.54 In the result between 9.25 and 7.35 seconds elapsed between the sounding of the alarm and the time when it ceased to be possible for a signaller to begin sending an emergency stop message in time to enable the Turbo to be brought to a halt. I do not suggest that signaller Allen was at fault in not seeing that the message was sent within that period of time. However, if management had applied the lessons of past SPADs and if he had been adequately instructed and trained in how to react to a SPAD, and in particular that he should act immediately and should be alert to the use of the CSR where that was available, it may well be the case that he would have been able to send the emergency message in time, and would have done so. To that extent I am disposed to agree with the submission by Counsel to the Inquiry that there seems to be no good reason why the message could not have been sent out earlier than it was, and in time to enable driver Hodder to pull up before the fouling point, or at any rate to reduce his speed to such an extent that the force of the crash was substantially lessened.

Keying points 8059A and B reverse

6.55 The time from the first alarm during which a signalman could take steps to key points 8059A and B reverse was 10.9 seconds (according to Mr Balmer), or 12.8 seconds (according to Mr Fenton). In evidence at the Inquiry Mr Fenton said these figures made allowance for time for the points to move to full reverse before the Turbo arrived at them. Counsel for ASLEF submitted that in principle the diversion of the Turbo was the appropriate course. However, the design of the IECC made this difficult, if not impossible. Counsel pointed out the separate actions which Mr Allen would have required to take in order to key the points reverse. Furthermore, he maintained, management had failed to impart a lesson of the SPAD on 4 February 1998, which was that putting back a signal to Danger in the face of a train which was "almost on top of it" was ineffective. Counsel for Railtrack submitted that the diversion of a train to another line was not obviously preferable to replacing SN120 to red or sending a STOP message to the Turbo. A signaller would naturally be reluctant to run the risk of causing the derailment of the train which he was attempting to divert, or a collision between it and another train.

6.56 In the circumstances the sending of the emergency stop message was, in my view, the preferable course. If so, it is doubtful whether the signaller would also have had adequate time to key the points reverse.

Chapter 7
Railtrack and the infrastructure

Introduction

7.1 The Inquiry's concern with SN109 and the SPADs which had occurred at that signal led on to examination of the circumstances which led up to the events on 5 October 1999, against the background of the management by Railtrack of the safety of the infrastructure between Paddington and Ladbroke Grove.

7.2 In this chapter I will consider a number of aspects of the management of safety by Railtrack, but without attempting to set out every detail of the extensive evidence on this subject. The topics which I will deal with are as follows:

- signal sighting difficulties (paras 7.3-7.17);
- flank protection by points control (paras 7.18-7.24);
- the history of SPADs (paras 7.25-7.29);
- signal sighting exercises (paras 7.30-7.45);
- risk assessment (paras 7.46-7.59);
- improvements previously suggested (paras 7.60-7.91);
- empty coaching stock movements and flashing yellow aspects (paras 7.92-7.93);
- the response to recommendations of Formal Inquiries (paras 7.94-7.106);
- SPAD management (paras 7.107-7.113);
- the actions of senior management (paras 7.114-7.118); and
- safeguards for the future (paras 7.119-7.129).

Signal sighting difficulties

7.3 Railtrack assumed responsibility for the safety of their infrastructure on 1 April 1994. It is instructive, however, to examine what preceded this handover.

7.4 As I have narrated in Chapter 5, the design of the new track layout preceded that of the new signalling. It appears to have been assumed that the layout could be safely signalled, and the layout was finalised without reference to the location of signals. During the design of the signalling it was recognised that signal sighting would be difficult. This was because of the numerous overbridges, the curves in the track and, above all, the speeds at which bi-directional running was to take place. Despite these factors, there appears to have been a resistance to re-considering the track layout or the manner in which it was to be used. One reason which was given for that resistance was the anticipated introduction of ATP which at that time was seen as likely to be introduced on a nation-wide basis. When Phase 1 of the re-signalling scheme was commissioned in July 1993 the linespeed was temporarily restricted to 40 mph. When signal SN109 was brought into commission the cages which held it and the other signals on gantry 8 had been made lower than had been originally designed. A working group which had been set up to review the problem of signal sighting reported in July 1993 in regard to all the signals in the scheme. The group referred to the need for the urgent resolution of the issues "to reassure drivers that their comments are being taken on board". It was noted at a re-signalling meeting on 5 August 1993 that the "inadequate sighting of certain signals" was "the subject of criticism of train crews".

The location of gantry 8

7.5 The location of this gantry was determined by reference to the requirements for running freight trains at high speeds so as to allow for the greater braking distance which that type of traffic required. In August 1993 Mr A Hares, the Project Manager, sent a memorandum to the Director of InterCity Great Western, referring to complaints which had been made about the sighting of Paddington signals, and to the fact that a signal sighting committee had found deficiencies at 16 signals. He said that by far the most severe deficiencies affected gantries 3 and 8, and that "in the light of the above the only practical solution is seen as providing a new gantry, immediately to the east of Golborne Road overbridge and transferring the whole of the Down line signals to this new location rather than providing repeaters". The minutes of a meeting of a re-signalling committee on 17 August 1993 record that this proposal was being examined with a view to its feasibility being confirmed by 24 August of that year. Reference was also made to the manufacture of a new gantry.

7.6 However, on 25 August 1993 Mr Ian Harman, the Project Signal Engineer, responded that the signalling projects group were now committed to carrying out improvements which included the lowering of signal cages on gantry 8 by 400mm. This had been agreed at a meeting on 27 July. Mr Harman told the Inquiry that the concerns about moving gantry 8 were that it would cause a similar problem for trains in the Up direction; a problem with reading through for signals on gantry 6; and the need to change pointwork. Mr Richard Spencer, a project assistant, expressed the view that the objection was because it would have involved extensive work on the permanent way, resulting in delay to the project as well as considerable cost. Another possible reason which was suggested by the evidence was the difficulty of finding a site which was clear of underground connections. There does not appear to be any documentary evidence of further examination of the idea of changing the location of the gantry. In due course the further lowering of the signals on gantry 8 was completed by 23 November 1993.

The non-compliance of SN109

7.7 At a re-signalling meeting on 15 April 1994 it was agreed that the signals on gantry 8 should be re-configured so as to take the form of a "reverse L". It was recognised that this did not comply with the then standard, SSP 4. On 20 May 1994 Mr Colin Bray, Signalling Standards Engineer, wrote to Mr R McCulloch, Signal Engineer, noting that the proposed arrangement of aspects would have the effect of allowing the linespeed to be increased to 70 mph. He recommended that the non-compliance of the signals on gantry 8 should be accepted provided that their operating colleagues accepted that there was "no significant risk of non-reading of the non-standard signals". He also recommended that the non-compliance with SSP 6 in regard to signal sighting time should be accepted. Mr Harman stated in evidence that the reconfiguration had been peer reviewed by senior signalmen and "it seemed to be the consensus of those that had contributed that it was probably about the only reasonably practical arrangement that we could arrive at".

7.8 Mr McCulloch issued a derogation in regard to SSP 4, but not SSP 6. It appears that, in issuing the derogation, he was following an existing convention or practice. The procedure for derogations was not adequately set out until it was the subject of a Group Standard in October 1998. Mr McCulloch accepted in evidence that he had acted in the mistaken belief that he had authority to grant such a derogation.

7.9 The alterations to gantry 8 signals were carried out between 21 May and 7 August 1994. Thereafter the linespeed was increased in early 1995 to a maximum speed of 60 mph which was consistent with SSP 6.

7.10 Before leaving the matter of non-compliance, it is right that I should record that Counsel for Railtrack emphasised that there was no direct evidence that drivers found that the "reverse L" configuration was more difficult to read. Driver A W Bailey said in evidence that it was "no more difficult than other signals". When Driver Adams was asked whether it made any difference to him whether the red light was to the left or to the right of the stack of signals, he replied: "Well, it doesn't now but it did at the time. I had never seen a signal like that in my life". When he was asked what effect that had on him, he said: "As I said before, we just took it on board. There was nothing anybody was going to do". Railtrack also emphasised that SN109 had not been criticised by the HMRI when they carried out their inspection in January 1995, when they declined approval of Phase 1 of the re-signalling scheme and pointed out that there were 27 items which required to be attended to.

The effect of electrification

7.11 The erection of OHLE as part of the scheme took place in 1995. On 17 May of that year the Safety Review Group for the Zone approved a Safety Plan. This was at a time when construction had already started. Mr R L Wilkinson, who chaired the group, gave evidence that approval would not have been given if the group had taken the view that the OHLE had a significant effect on signal sighting.

7.12 In July 1995 Mr Stephen Dapre, a signalling works assistant, whose function was to ensure that there was no impact on signal sighting, wrote to the Major Projects Division of Railtrack, stating that the overhead line structures would have a negligible effect on the sighting of a number of signals, including those on gantry 8. However, at that point the OHLE had not yet been erected.

7.13 On 25 August 1995 Mr Bray wrote to Mr Harman after a site visit. He said that the signal sighting at particular signals would be significantly restricted by the OHLE structures, in particular the masts on left hand curves. This would mean virtually continuous interruption of sighting. Mr Harman had mentioned that the Major Projects Division had told him that they would proceed to erect the OHLE structures despite the objections and would "wait and see how many drivers complained; any that complained would be taken to Euston and shown what problems the west coast drivers face". They were not prepared to be stopped by Group Standard GK/RT 0037 and would seek a derogation. Mr Bray described this as unacceptable. He said that the cost of re-positioning the bases for the OHLE masts should not be used as a reason for unsatisfactory signal sighting. He did not receive a reply to his letter. At the same time the view was entertained by the Resident Engineer that interruptions of sighting caused by the masts could be ignored on the ground that they were of "very short duration". Mr Bray, who had drafted the predecessor to the Group Standard, told the Inquiry that it was intended to refer only to interruptions by wires.

7.14 In the same year it became apparent that, through an error in the positioning of masts, the sighting of SN105 was substantially restricted. In 1994 this signal had been moved to a post in the trackside to enable its sighting to be improved for the linespeed which was then intended. Mr Robson took the view that only one option was acceptable, namely to have the masts re-positioned. In evidence to the Inquiry he said that he never changed his mind. However, Mr A P Hancock, Production Manager, indicated that "moving the masts at a rumoured cost of £200k cannot be contemplated". He said that he was far from convinced that they required to commit significant amounts of time and money to find a way out of a theoretical problem, when the difficulty could be resolved by restricting the linespeed to 75 mph, for which the sighting was compliant. This was duly done, and the masts were also moved slightly. In a letter to Mr Wilkinson dated 24 November 1995 Mr Bray said that this involved an embarrassing change of position on the part of the Zone. He suggested that the offer by the Major Projects Division of a banner signal at SN109 should be accepted because:

> "… whilst the requirements for signal sighting at 75 mph may be achieved by the current position of SN105 and the OHLE the Standard GK/RT 0037 sets down the *absolute minimum acceptable arrangement* these (sic) may not be acceptable in an area with the intense train service that Paddington has. SN105 has (like the signals on gantry 8) much poorer sighting than the other Down direction signals… The provision of further electrical equipment (e.g. struts and insulators) may further reduce the available sighting and hence reduce the allowable speed below 70 mph".

While in one sense that letter was about the effect of these problems on performance, it also highlighted the marginal nature of the sighting available. It is clear that the matter of performance was an influential factor, and there was no assessment of what was reasonably practicable. Mr Bray also expressed a concern, which was shared by Mr McCulloch, that the addition of the wires would further reduce the sighting of the signals on gantry 8. In the event a banner signal was not provided, apparently on the ground that the linespeed would be restricted to 75 mph.

7.15 While it is clear that complaints were made by drivers, it appears that they were made verbally and at the time, rather than in writing. Many drivers grumbled among themselves or to their employer rather than to Railtrack. Mr Harman said that his section were not made aware of any complaints arising out of the electrification phase. As far as he was concerned, the OHLE did not remain a major problem for signal sighting in the Paddington area "to any degree in excess of any other overhead line scheme". However, Railtrack did not dispute in the Inquiry that the OHLE did cause additional sighting difficulties; and that this made it necessary for drivers to exercise especial care.

The consideration of safety concerns

7.16 Two points stand out in regard to the development of the scheme. First, from the outset there was not an adequate overall consideration of the difficulties which would face drivers, in particular in signal sighting, on which the safety of travellers critically depended. Secondly, when difficulties did emerge, there was not an adequate reconsideration of the scheme. There was a resistance to questioning what had already been done. Cost, delay and interference with the performance objectives underlay that resistance. Adjustments were made to the location and configuration of signalling but without, as I will narrate later in this chapter, the required viewing by a signal sighting committee. The residual risk was never assessed by whatever methods were available.

7.17 I consider that there is merit in the suggestion by Counsel for the bereaved and injured that, where a material change to track or signalling or both is proposed, there should be an express consideration of all relevant safety issues by an analysis of the material factors, if necessary by means of a risk assessment. This should be done on a holistic basis at the design concept stage and repeated at defined stages up to and including full implementation. It should cover an express consideration of all human factors which could apply in the use of the new track or signalling, taking account of the instructions and training of drivers and signallers. This is in order to ensure not only that these factors are taken into account, but also that the demands of the new scheme are adequately complemented by what competent and well trained personnel are able to do.

Flank protection by points control

7.18 The concept of this type of protection is to ensure that points are set so as to divert a train which has passed a red signal without authority from a higher to a lower risk of collision. In the context of the crash on 5 October 1999 flank protection for the HST would have involved the Turbo being diverted to the Down Relief line, either by way of points 8055 or, more probably, points 8059.

7.19 Railway Standard SSP 49, which appeared in its first version in June 1988, provided for this as follows:

> "Set and lock points in the converging route in a position to divert an unauthorised movement away from the legitimate route where this can be achieved without restricting other permissible movements".

The standard stated that this should be used "only where the application is both simple and effective. Each case must be decided on its merits". This last sentence was deleted in the revised version of the standard which was issued in November 1990.

7.20 In the late 1980s and early 1990s when the scheme for the new layout was being devised it would have been relatively simple and practicable to include this. According to the evidence of Mr D L Scholes, who was the Infrastructure Development Manager, it was the responsibility of three departments, namely Operational Safety, Civil Engineering and Signalling and Track Engineering, to consider flank protection. Other evidence indicated that the person who would have been principally involved in this would have been Mr Roger Ferris, Project Assistant in Design at Reading. However, owing to his death, it is not known what view was taken at that stage. The evidence given by Mr P Woodbridge, who was a Principles Tester for the Slough SSI from April 1992, suggests that the reasons why such flank protection was not incorporated in the case of SN109 were:

(i) the fact that without such flank protection there was a greater distance in which the overrunning train could come to a halt; and

(ii) the fact that the introduction of automatic train protection was seen as imminent.

Another factor was the concern that such flank protection would give rise to substituting one risk for another. Once the layout was installed the introduction of flank protection would have involved the changing of the SSI data. This clearly would have been seen as expensive and involving technical risk.

7.21 Group Standard GK/RT 0078, in the version of February 1998, provided for "basic overrun protection". In terms of the standard that type of protection was as follows:

> "Flank points, where available, may be set to divert an unauthorised movement away from an authorised route, subject to their being a net reduction in risk by so doing. The line on to which an unauthorised movement is diverted should preferably be either:
>
> - used predominantly for trains in the same direction, or
> - a siding".

7.22 Mr Harman told the Inquiry that flank protection should have been considered by engineers at the development stage of the layout. It could have been provided "relatively simply" but "at some operational disbenefit". All that he could say was that at the time the designers thought flank protection pursuant to SSP 49 was "not necessary" or "inappropriate". It appears that when he took up his post in May 1992 he did not see reason to investigate this.

7.23 Mr Fairbrother gave evidence that flank protection could have been provided to SN120 by splitting points 8059, 8059B being redesignated with a separate number unlinked to any other points. The purpose of this would be to prevent the points "freezing" the Down Relief line whenever SN109 was at red. The alternative was to keep points 8059 together and to accept a restriction on the signalling of trains to the Down Relief line.

7.24 It is, of course, necessary to make a comprehensive assessment of not only the need for flank protection but also the risks to which its use may give rise. For that reason it is not possible for me to determine that it should have been provided or should not be provided. However, I am equally clear that it is a measure which required and requires serious consideration within the context of an assessment of the whole risks and benefits which would be involved.

The history of SPADs

7.25 Between 1 February 1993 and 2 July 1999 there were 67 SPADs in the Paddington area. They were set out in a list appended to Mr Fairbrother's report. These included the SPAD of SN74 at Royal Oak on 10 November 1995. On that occasion a Thames Trains driver passed that signal at Danger, thinking that his signal was SN72, which was on the same gantry 5. Although his train stopped at SN30, this was too late to avoid a collision with a Great Western train from Swansea which was also approaching Paddington. The evidence before the Formal Inquiry into that collision demonstrated the high level of SPADs in the Paddington area. At that time SN63 had been passed at Danger four times, and SN109 had been passed twice. Of a total of 37 SPADs which had already occurred, 21 had occurred at gantries, including 12 where the driver had mistaken the correct signal. Comparison of the SPAD rates before and after the installation of the new layout showed a marked change.

7.26 As far back as June 1993 Mr Wilkinson had suspected that the SPAD rate in the Paddington area was "extraordinarily high". Mr Bray wrote a report to the Formal Inquiry in which he pointed out the serious nature of the problem with SPADs (see para 7.61).

7.27 On 22 January 1996 Mr S Hudson, writing to Mr Hancock on behalf of the Director of Safety, set out a critique of the report on the Royal Oak collision. He pointed out that no reference had been made to the signal sighting problems which witnesses had mentioned. Of the 16 SPADs within 1½ miles of Paddington, ten were "misreads" of the signal passed or of the previous signal.

7.28 The list of 67 SPADs includes, of course, the SPAD at SN109 on 4 February 1998, which is described in Appendix 4. At the time of that incident Mr Bray wrote to Mr Spencer repeating his analysis. He said: "People have asked why Paddington has so many SPADs? I think the problem is very simple. Drivers have to choose one signal from six rather than the normal chose (sic) one from two or three". He attributed the difference between SPADs in the Up direction, as compared with the Down, to the poor sighting in the Down direction.

7.29 In his report Mr Fairbrother showed that the high rate of SPADs continued, although the rate varied from year to year. Whether or not this record was worse than in the case of other major termini, it is clear that it remained the cause for considerable concern. Counsel for the bereaved and injured pointed out that the frequency which multi-SPADs occurred at individual signals was irregular, and founded on the evidence of Dr Murphy that after May 1998 there was the additional factor of Heathrow Express trains. Dr Murphy observed such trains accounted for 44.7% of arrivals into Paddington. Hence there was an increased risk of collisions, especially at peak periods.

Signal sighting exercises

7.30 The importance of signal sighting should not be underestimated. In a system where the safe movement of trains is dependent on the proper observation of and response to signal aspects, signals with poor visibility constitute a clear danger. The requirement for signal sighting by committees who are appointed for the purpose is an extremely important safeguard against such a danger. A signal sighting committee provides an official record of the visibility of a signal, so that, where appropriate, improvements can be made. The requirement to convene signal sighting committees for this purpose arises both from new or altered signalling and from the multi-SPADing of signals. I will deal with each of these aspects in turn.

New or altered signalling

7.31 Group Standard GK/RT 0037 on Signal Sighting, which came into force in October 1994, states that:

> "The position and form of all new and altered signals and indicators will be considered by a Signal sighting committee convened for that purpose… A Signal sighting committee will also be convened at the request of the Train Operator or Infrastructure Controller to consider problems (or alleged problems) arising from the position or sighting of an existing lineside signal, indicator or notice board".

The standard also provides:

> "Note must be taken of any foreseeable change likely to obstruct the view of the signal, such as building developments… Where a potential obstruction is identified action must either be taken to ensure that the sighting is not impaired or the signal must be repositioned".

The standard also makes provision as to the composition of signal sighting committees, the manner in which their decisions are to be recorded and a number of sighting considerations.

7.32 Following the modification of the signals on gantry 8 in 1994 which I have mentioned above, no signal sighting committee viewed them. SN109 was last viewed by such a committee on 20 February 1994. This was despite the fact that Mr D Timothy of the HMRI noted after the inspection on 31 January 1995: "Since construction work was done during the period when reference levels were not stable a complete review of signals to sighting form should be carried out by the sighting committee".

7.33 The Project Safety Plan to which I have already referred stated: "It is proposed to validate the interface between signal sighting and the structures by a specially convened sighting committee concentrating solely on this issue… The remit covers the general requirements to assess each signal". This group was to be made up of "experienced staff representing Powertrack, Interlogic and Zonal production". It is noteworthy that when the Safety Review Group gave an interim certificate on 17 May 1995 for the installation of the overhead lines – which included the "steelwork, registration arms and overhead line catenary and associated hardware" – it was a condition that, inter alia, the "signal sighting review takes place". At no time was the effect of the OHLE equipment considered by a signal sighting committee.

7.34 In July 1995 Mr Dapre made the report to which I have already referred. On 24 August 1995 Mr Bray, along with representatives of Interlogic and Powertrack, viewed a number of signals, not including SN109, which had been identified as "problem signals". This was at a time when the steel masts were in place. It was not a signal sighting committee but a meeting to consider signals. Accordingly they did not complete signal sighting forms. This exercise followed a letter from Mr Hancock to the Director of Engineering and Production dated 18 August by which he increased the linespeed in the Down direction to 60 mph on lines 1-6 but "on the strict understanding that erection of OHLE headspans and other structures over the coming months does not affect approach sighting of any signals. Someone qualified to sight signals would have to be satisfied on this point before the lines concerned are handed back to traffic after each OHLE possession". In October 1995 there was a similar exercise in which representatives of Railtrack and Interlogic viewed SN105 in order to assess the obstruction caused by the masts.

7.35 None of these groups visited all the Paddington signals which had been envisaged in the safety plan, and in particular any of the signals on gantry 8.

7.36 However, a letter from Mr M Southwell, Heathrow Express Project Manager, dated 24 November 1995, informed Mr Bray that from a "study" undertaken by the Major Projects Division "gantry 8 signals were found to satisfy the sight surveys and graphical problems. With particular reference to wiring, the study has not identified any specific problems". On 17 May 1996 Mr Southwell wrote to Mr A Harvey of the HMRI, saying: "With the introduction of the electrification works a detailed signal sighting exercise has been completed and the effect of electrification equipment has resulted in negligible effect to signalling". It may be noted that in the period between these two letters Mr Hudson wrote the letter to Mr Hancock to which I referred earlier. In that letter he asked whether signal sighting committees had been convened. About two weeks after Mr Southwell's second letter a representative of ASLEF raised concerns about the signal sighting at Paddington at a Joint Safety Council Meeting, with particular reference to the overhead line masts which were being erected. While the Group Standard does not explicitly include the installation of OHLE as one of the events giving rise to the need to convene a signal sighting committee, it is plain that its installation gives rise to a risk of signals being obscured.

7.37 When he was asked at the Inquiry whether signal sighting committees had looked at the signals after 1994, Mr Harman said that there were "supplementary committees, where we had difficulty with the electrification structures". As to the absence of either a signal sighting committee or any other form of sighting exercise, he said that any possible impacts had been mitigated during the installation of the steelworks or were covered by the exception for interruptions of short duration; and that Railtrack were not aware of any complaints from drivers. However, there is no evidence of such mitigation. As I have pointed out earlier, Mr Bray took the view that the exception applied only to wires. In view of the events which I have narrated Railtrack can hardly have failed to be aware of complaints.

Multi-SPADs

7.38 Group Standard GO/RT 3252, first issued in March 1995, required the convening of a signal sighting committee following the passing of signals at Danger. Issue 1 states: "As a minimum requirement a signal sighting committee must be convened as soon as is practicable where a signal has been passed at Danger more than once in 12 months or three or more times in any three year period".

7.39 Of the eight previous SPADs which are listed in Appendix 4 to this report, six of them should have led to the convening of a signal sighting committee, namely those on 15 March and 23 June 1996, 3 April 1997 and 4 February, 6 August and 22 August, 1998. In none of these cases was a signal sighting committee convened. The failure to do so is particularly difficult to understand in the light of the decision of the SPAD Action Group on 5 February 1998 (i.e. on the day after the SPAD of 4 February) that signal sighting committees for SN63 and SN109 should be convened within a month. Furthermore, on 20 April 1998 Railtrack received from First Great Western a hazard ranking form in regard to that SPAD. The section for recommendations was as follows: "The sighting of SN109 is to be reviewed". Mr G R Tribe, the Formal Inquiries Process Manager at Railtrack headquarters, asked Mr M H Sutton, Safety Performance Manager, in October 1998 why the Inquiry into that SPAD had not asked whether a signal sighting committee had been convened following the SPAD on 15 March 1996. His letter was passed on to the chairman of the Inquiry, but nothing further appears to have happened.

7.40 Whose responsibility was it to see that a signal sighting committee was convened after a SPAD? A number of Railtrack witnesses, including Mr Robson, said that they were certain that it was the responsibility of Mr S Murrant, who was Train Operations Liaison Manager from June 1996 to August 1999. However, his job description merely stated that he was to "act as advisor and panel member for the Zone's signal sighting committee requirements". Mr Murrant, who was the chairman of the SPAD Action Group at their meeting on 5 February 1998, said to the Inquiry that he had asked for signal sighting committees to be convened, not because it was his job, but because he wanted the TOCs to feel that as a representative of Railtrack he was trying to do something. Mr Wilkinson, who was Production Manager from May 1996 to September 1998, gave evidence of having discussed with Mr Murrant the progress with signal sighting in connection with line reminder boards in September 1996. He accepted that it was "very bad management" for a manager to be unaware of an obligation which had been placed on him. It appears that Mr Robson and Mr R Atkins, Mr Murrant's line manager, failed to realise that signal sighting committees were not being convened in accordance with the standard or that Mr Murrant was not fulfilling his responsibilities. Mr Robson assumed that Mr Sutton was ensuring this. It is clear that there was no, or no adequate, system in place to check that such committees were being convened, and that there were in any event persistent failures on the part of Mr Robson and Mr Atkins. Beyond them Mr Wilkinson, the Production Manager, was responsible at a higher level still. In the result there was a long-standing non-compliance with the standard.

7.41 Why were signal sighting committees not convened by Mr Murrant when he had undertaken to have this done? In evidence he gave three explanations, namely, difficulty in obtaining safety permits for possession of track, the lack of qualified persons, and the lack of a clear direction on Paddington from senior management. However, as to the first, he accepted that neither he nor anyone else on his behalf had taken steps to get possession of the track. As to the second, he said that he made efforts to contact suitably qualified persons to make up the committee, but was unable to find a date on which they were all available. The Group Standard prescribes that records should be kept of those who are competent to make up such committees, but he said that there were no such records. Neither Mr Robson nor Mr Wilkinson was aware of such a problem. In passing it may be noted that a report by W S Atkins in March 2000 on signal sighting practice indicated that signal sighting had been generally undervalued in the past and that those who were available to Railtrack for this purpose were grossly overstretched and, in some cases, had inadequate resources in terms of training and equipment. As to the third reason given by Mr Murrant, this does not bear examination. The terms of the Group Standard were mandatory. The decision of the Safety Review Group was clear. Nothing happened to justify deferral of signal sighting pending some positive direction from senior management. Mr Murrant asserted that because "the sighting conditions were well known… there was no benefit in further signal sighting committees being convened". This is a feeble justification for inaction and betrays a culture of apathy and lack of will to follow up promised actions.

7.42 In March 1999 the Zone was audited by Railtrack Assurance and Safety as part of a national review to determine whether there was compliance with GO/RT 3252. This followed a report by the HMRI on a SPAD-related accident at Watford on 8 August 1996. The audit examined, on a sampling basis, SPADs which had occurred at SN109 and SN63. The audit report in April 1999 revealed that in both cases the Zone had not convened a signal sighting committee following the SPAD. The Zone scored as the lowest of all zones. Auditors commented that the two signals which had been chosen had been the scene of six and four SPADs respectively. However, they observed that "both were located on the line from Paddington to the two mile post where a generic exercise is underway to examine all the signals along this corridor. This and other initiatives tabled by Great Western Zone demonstrated a pro-active stance on this issue but did not constitute a signal sighting committee". It appears that the exercise mentioned by the auditors refers to the stated intention of Mr B T Melanophy, the then Operations Manager, to commission W S Atkins to review the signalling between Paddington and Ladbroke Grove. That being the case, the auditors were under a mistaken impression, since Mr Melanophy did not in fact commission W S Atkins or anyone else to review the signalling. The audit report recommended "that Great Western Zone hold signal sighting committees as soon as possible, in accordance with the Railway Group Standard GO/RT 3252". However, a follow-up audit carried out in September 1999 could find no evidence of any action being taken by the Zone. Mr Murrant agreed he would have been "the man to be asked" about compliance with the standard, but he had no knowledge of either the audit or any action taken to follow up its recommendation.

7.43 Mr D Holmes, who became Production Manager in March 1999, disputed that nothing had been done. He told the Inquiry that he drew up and implemented an action plan to address the corrective action requests that arose. This included the convening of signal sighting committees from May of that year. It is true that at the meeting of the Senior Management Group on 14 April it was stated that a draft strategy would be in place by 31 May to facilitate "preventative visits". However, Mr Holmes accepted that any signal sighting at that stage was not of that nature. Asked why signal sighting committees had not then been convened to view SN109 and SN63, Mr Holmes said that "there had never actually been an occasion which required a signal sighting committee to be convened with regards to these two signals", i.e. there had not been a SPAD after May 1999. This disregards the substantial SPAD history of these signals prior to that time. It was singularly regrettable that when giving evidence on 14 December 1999 before an employment tribunal which was dealing with Railtrack's appeal against a prohibition notice relating to SN109, Mr C R Leah, the Director, Operations, incorrectly said that a signal sighting committee had been convened after the SPAD at SN109 on 4 February 1998.

7.44 If a signal sighting committee had viewed SN109 they would have found that, as I have already stated in Chapter 5, it was not compliant with GK/RT 0037 (or its predecessor JTP C005) as to signal sighting time, or with GK/RT 0031 (or its predecessor SSP4) in regard to its configuration. They would have been able to note the effect of the bridge, the OHLE and the yellow reflective line indicator signs and the speed restriction board. They would also have been able to assess the effect of the borderline quality of the signal sighting and the unusual and inconsistent signage. It is also to be borne in mind that Mr Wilkins of W S Atkins reported that in any event SN109 was placed at too great a height above rail level. After the crash on 5 October 1999, a signal sighting committee recommended that:

> "(a) Railtrack undertakes a complete review of size and positioning of the Overhead Line Equipment (e.g. insulators, dropper/support pipes and registration arms etc) within the Paddington area to see if a smaller gauge of equipment can be used and installed, and if registration arms can be moved away from the view of the signal aspect.
>
> (b) Railtrack undertakes a complete review of line ID signage within the Paddington area, with a view to standardising it…
>
> (c) The sighting committee is re-convened when the outcome of (a) above is known so that a full review of the signal sighting in the Paddington area can be carried out…"

7.45 The failure to have signal sighting committees convened was persistent and serious. It was due, as Counsel to the Inquiry submitted, to a combination of incompetent management and inadequate process, the latter consisting in the absence of a process at a higher level for identifying whether those who were responsible for convening such committees were or were not doing so. If a signal sighting committee had been convened, they would have found that SN109 was unacceptable, not merely because of its non-compliance with the relevant Group Standards, but also because of the inferior quality of its visibility. There would have been changes, although it is not possible for me to specify what they would have been. It might well have led to the replacement of gantry 8 and its Down signals.

Risk assessment

7.46 At the stage when the new layout was being designed there was no requirement under a Group Standard for a risk assessment of the layout. However, as early as the inquiry into the collision at Newton on 21 July 1991, British Rail referred to the development of a system of risk analysis in the context of proposed schemes for single track working. The report by the HSE "Ensuring Safety on Britain's Railways" in 1993 regarded risk assessment as fundamental to the management of safety. Since 1992 all employers have been required by regulations to assess the risks to workers and any other persons who may be affected by their undertaking (Management of Health and Safety at Work Regulations 1992, succeeded by similar provisions in regulations of 1999). In addition the Railways (Safety Case) Regulations 1994 require a railway duty-holder to make a statement in its safety case of the findings of any risk assessment which has been carried out under the Health and Safety Regulations. A risk assessment may be carried out by the use of a computer or through discussion and analysis by experts.

7.47 The documents before the Inquiry demonstrated that there had been over the years a number of proposals or recommendations for the risk assessment of the signalling in the Paddington area. However, none of them was carried into effect.

7.48 On 5 January 1996 Mr McCulloch, Signal Engineer, wrote to Mr Hancock, Production Manager, as he had become aware of a computer simulation programme which he believed could be used to carry out a risk analysis in the Paddington area. He asked Mr Hancock for funding to develop the programme but received no response. At the same time it should be noted that Mr McCulloch pointed out in evidence that the programme was untried and untested, and its use would have had to be validated by Railtrack Headquarters. But he felt that it was perhaps "a lost opportunity".

7.49 Recommendation 8 of the Formal Inquiry into the collision at Royal Oak on 10 November 1995 was that there should be a feasibility study into a range of options to reduce the possibility of a misread. This would, it appears, have resembled a limited risk assessment. However, Mr Robson, Safety and Standards Manager, who was to take this matter forward, told the Inquiry that he did nothing about it and could give no reason for this. Mr McCulloch gave evidence that Mr Robson and/or the Head of Production at Railtrack Headquarters had taken the view that it was not of benefit, but he could not explain why it was for the Head of Production to make a decision of that kind. At Railtrack Headquarters, Mr Tribe, who was responsible for monitoring recommendations on a national level, asked Mr Sutton, the Zone Safety Performance Manager, about what was being done to follow up this recommendation. On 6 August 1996 Mr Sutton replied saying that Mr Robson had been charged with this matter but "as yet there have been no definite proposals". Mr Sutton gave evidence that he had taken no further steps, explaining that the Zone were dealing with 400-500 recommendations. The evidence given by other Railtrack witnesses satisfies me that this was a substantial exaggeration. As for Mr Tribe, after consulting with his managers, he took no further action.

7.50 In November 1996 Mr Timothy of the HMRI wrote to Railtrack asking them to confirm that the whole of the Paddington to West Drayton re-signalling had been subject to a layout risk analysis and that the provision of ARS had been fully taken into account. He referred to a risk assessment model which was being developed by the consultants Arthur D Little. In the completion certificate sent to the HMRI in January 1997 Railtrack stated: "Formal layout risk assessment has not been carried out, as the scheme was designed and implemented prior to Railtrack". They formally responded to the HMRI in March 1997 indicating that they were unaware of any requirement for a risk analysis to be applied retrospectively, and asking to be informed of any view to the contrary. Mr Cooksey told the Inquiry that a retrospective risk assessment could not be carried out in 1997 because of the limitations to the then available layout risk model. This accords with the view of Mr Timothy who informed the Inquiry that the model was only of value in the initial design stages when a comparison was being made between different options. It had no value as a retrospective tool. In the result Railtrack's response was regarded by the HMRI as acceptable.

7.51 At the meeting of the Safety Management Group for the Zone on 18 June 1997 it was agreed that signals in the Paddington area "would be assessed using the A D Little risk model which was being developed". The group expected this would provide a numeric method of assessing risks and measures to mitigate them. It appears that no further action was taken on this decision.

7.52 Recommendation 5 of the Formal Inquiry into the SPAD at SN109 on 4 February 1998, which was published on 1 July 1998, was that "there should be an appropriate risk assessment of bi-directional signalling on the six track high speed lines between Paddington and Ladbroke Grove". At their meeting on 2 July 1998 the Safety Review Group allocated this recommendation for action by Mr P Wiseman, Business Development Manager. It is remarkable that, according to his evidence, he was unaware of this fact until over 18 months later. It appears that it was arranged later that Mr Bray should explore this matter. However, Mr Bray gave evidence that the risk assessment was "put on hold" while he went to do work on signalling problems at Filton. In the result the recommendation was of no practical effect. However, the Inquiry heard some evidence that there was an occasion in early 1998 when Mr Bray, Mr Melanophy and Mr T M Mayo, Production Standards Manager, placed pennies on a plan of the layout in order to discuss alternative signalling patterns.

7.53 In may be noted that at a meeting of the SPAD Action Group on 17 April 1998 it was recorded that banner repeater signals were the preferred option for the signals which were at highest risk. The Group went on to say that a review of all signals would prioritise the work. However, Mr Murrant, who was to take this matter forward, did not do so. He told the Inquiry this was because he was waiting for a clear direction from his superiors as to what was to be done, and because there was a movement towards other options such as the use of countdown markers.

7.54 In June 1998 Group Standard GK/RT 0078 Issue 5 came into effect. It provided for "enhanced overrun protection". It required a risk assessment in regard to signals "presenting high risk". It stated:

> "A risk assessment shall be undertaken (and consequential action taken as necessary), when
>
> - more than one SPAD occurs within a 12 month period;
> - a major change of traffic pattern occurs which is qualitatively assessed as likely to increase the risk of SPADs;
> - other factors become relevant which are qualitatively assessed as likely to increase the risk of SPADs".

The standard listed a number of factors which might require to be considered in order to assess the risk consequent upon such a signal being passed at Danger, and required Railtrack to consult with train operating companies to determine the appropriate mitigation measures, of which examples were given. These included "layout alterations", which included flank protection. The risk assessment was defined as the layout risk model or any other system acceptable to Railtrack. The requirement of this standard plainly applied to SN109 after the two SPADs which occurred in August 1998. Mr Spencer gave evidence that he became aware of the requirement of the standard only "indirectly". He said that it was not applied to the re-signalling project because the layout risk model of A D Little was not available, and he was unaware of any other risk assessment tool which was regarded as acceptable for the purposes of the standard. Mr Fairbrother gave evidence that an outcome of risk assessment could have been the adoption of flank protection in the form of splitting points 8059. If this had been done it would have avoided the disaster on 5 October 1999. Mr Bray gave evidence that flank protection would have flowed from a risk assessment of bi-directional running.

7.55 In July 1998 Mr Wilkinson set up the SPAD Technical Solutions Group (STSG). The remit of this group was that they should identify solutions to the SPAD problem with their quantified risk values, and that these should be reported to Mr Wilkinson within a month's time. In a letter dated 26 August 1998, following the SPAD at SN109 on 6 August, Miss A Forster, Operations and Safety Director, First Great Western, asked Mr Wilkinson what action was to be taken "to mitigate against this high risk signal". In reply Mr Wilkinson said: "I have commissioned a special study to determine what causes can be identified which contribute to the number of SPADs which have occurred. I expect a report in the near future and this will ensure that effective solutions are identified for early implementation. The views of train operating companies will be taken into account within this study". It appears that the report to which he referred was the report which he had instructed the STSG to produce. In fact no such report was ever produced. In September 1998 Mr Wilkinson moved out of the Zone.

7.56 On 22 December 1998 Miss Forster wrote to Mr Melanophy referring to "a serious problem with drivers misreading signals" in the Paddington area. She referred to the working group which Mr Melanophy proposed to set up, which was named the Golden Two Miles Group (GTMG). She said, "I do not believe the timescales for this working group are sufficient to mitigate against the very obvious risks". In her evidence at the Inquiry Miss Forster said that she later met Mr Melanophy who promised her "a full risk assessment". At the meeting of the Safety Management Group on 16 December 1998 Mr Melanophy had said that he intended to employ W S Atkins "to look at signal sighting between Paddington and Ladbroke Grove". In a letter to Miss Forster dated 23 February 1999 Mr Melanophy, after referring to the recent removal of the flashing yellow aspects, said: "I have commissioned W S Atkins to review the signalling Paddington to Ladbroke on the Zone's behalf and this review will take place over the next few months". This was not the case. Mr Melanophy had approached someone in W S Atkins whom he had in mind but he was working on another contract. No review was commissioned from W S Atkins before or after Mr Melanophy left the Zone on 4 May 1999. Mr A McNaughton, the Production Manager, who had been present at the meeting on 16 December and had agreed to this review, failed to realise that there had been no outcome. He explained in evidence that his discussions were almost exclusively concerned with the alteration in the arrangements for the routing of empty coaching stock. "I did not pick up with him the W S Atkins thing." Mr Holmes, who succeeded Mr McNaughton in March 1999, told the Inquiry that he was unaware at any time that Mr Melanophy had intended to employ W S Atkins to look at signal sighting in the Paddington area. Miss Forster was never given an explanation as to why such a review did not take place. On 9 June 1999 she wrote a letter to Mr Holmes in which, after referring to an alteration of instructions relating to movement of empty coaching stock, she said:

> "It is almost 12 months since FGW had a SPAD or an ECS train leaving Paddington following which Railtrack Zone promised a major review of the signalling in the 0-4 mile post area. I remain seriously concerned that after all this time (a number of meetings to discuss SPAD mitigation methods) that I am being asked to consider a solution to a problem in isolation and as a result of an event(s). If we carry on in this way we will continue to solve one problem but its solution will create another hazard. This is clearly not the manner in which to manage risk and an approach to which I am strongly opposed. Therefore, I suggest that an holistic approach is taken to SPAD management in the Paddington area and all changes to infrastructure or methods of working are properly risk assessed".

She did not receive a reply to this letter. Mr Holmes said he was not aware of the remit which had been given to the STSG, but many of the issues would have been picked up by the SPADRAM Group and the STSG was still continuing for the best part of 1999, "so I would not have seen that the issues would have been lost".

7.57 The layout risk model of A D Little became available during the course of 1999. It was only then that the signal engineers were trained to use that model. Mr Bray explained to the Inquiry that limitations to the model still exist. It is far more able to give figures comparing risks of adopting particular measures than to give an absolute figure for the risks of the layout in terms of likely fatalities. He claimed that owing to its non-availability it was not possible to apply Group Standard GK/RT 0078. "Its application to a layout of the complexity of Paddington was daunting, to say the least". He was not aware of any attempt to apply the standard to multi-SPAD signals at Paddington before the crash. Mr Leah told the Inquiry that a limited application of the model to Paddington had been carried out later. It showed that SN109 and SN120 were signals with a higher risk than others. Railtrack were working closely with A D Little to try to resolve its limitations. The Inquiry was informed that Railtrack had instructed train contractors to liaise with Dr Ian Murphy in order to develop ideas on layout risk method. On 21 July 2000 Railtrack Line and the HMRI signed off the layout risk model for indefinite use, it having originally only been certified for one year. Railtrack's view is that, whatever its deficiencies, it is the best model available within the current state of knowledge and expertise. Mr Gerald Corbett, Chief Executive of Railtrack, informed the Inquiry that Railtrack were engaged in the review and risk assessment of a considerable number of complex bi-directional layouts to determine whether suitable additional mitigation measures were required at such locations. He also said that a full risk assessment had been carried out in respect of over 200 signals which had been passed at Danger twice or more since 1 April 1994, with a view to SPAD prevention and mitigation.

7.58 It may be noted that the Formal Inquiry into the crash on 5 October 1999 observed in regard to Recommendation 5 of the Formal Inquiry into the SPAD on 4 February 1998: "The Panel considers that the alternative of using a group of experts to carry out a 'structured professional judgment' assessment should at least have been considered". The Chairman explained in evidence to this Inquiry that this referred to a group of experts sitting down and reviewing the layout, as an alternative to a computer-based system. This may be compared with the type of exercise which, as I mentioned in para 7.56, Mr Melanophy had mentioned. As Mr Cooksey pointed out, a risk assessment can be a "professional judgment made by competent and experienced engineers".

7.59 Once again - prior to recent work - there was a failure of a persistent and serious kind. No attempt was made to carry out the required risk assessment by whatever methods were available. As was pointed out in the course of evidence, it did not require to be of a sophisticated computer-based kind. Even signal sighting involves in some degree an assessment of risk. It is not possible to state what would have been the outcome of the assessment, and in particular whether flank protection as a form of enhanced overrun protection would have been installed. However, as can be seen from a later section of this chapter, the idea of flank protection is still, after all, under consideration.

Improvements previously suggested

7.60 In the years preceding the crash on 5 October 1999 a number of measures had been suggested for dealing with the recognised problems of SPADs in the area between Paddington and Ladbroke Grove. As will be seen very little had been implemented.

Uni-directional working, double blocking and speed restriction

7.61 Following the Royal Oak accident Mr Bray submitted a report on 16 November 1995 to the Formal Inquiry. This included analysis of reasons for SPADs in the Paddington area, and suggested possible improvements. He was concerned about the signalling and was encouraged by Mr McCulloch to express those concerns. His report drew attention to the high number of SPADs in the six track section and to the fact that 75% of the SPADs in the area had been on the middle lines, 3 and 4. Mr Bray pointed out four factors which he believed were contributing to drivers mistaking signals at Paddington: the fact that drivers had to choose one signal from six; the great height of the signals above the line; the signals being on curved sections of line; and the high speeds in the area. He suggested 11 possible improvements including the reduction of the linespeed (to give drivers more opportunity to realise their mistakes and also reduce any consequences); removal of one signal from each gantry making one of the middle lines uni-directional (to improve the pattern recognition of the signals); and, his preferred option, at least in the short term, not allowing trains to approach signals with high SPAD risk unless the signal was showing a "proceed" aspect.

7.62 Mr McCulloch, who was a member of the panel for that inquiry, said in evidence that Mr Bray's suggestions were not considered in any depth because the inquiry heard evidence from the driver that he had been significantly distracted at the time of the SPAD. In other words, the accident was considered to be primarily due to driver error. This was a view which was shared by Mr Hancock who chaired the inquiry. Mr Bray in this Inquiry said that Mr McCulloch had told him:

"… that whilst it was a useful guide that I had written of suggestions for infrastructure changes, they found so many significant problems with that driver – he had only been driving for three weeks – that the justification for doing any infrastructure alterations to a reasonable man was more difficult to make".

7.63 Following the SPAD at SN109 on 4 February 1998 one of the recommendations of the Formal Inquiry, of which Mr Bray was a member, was that there should be a risk assessment of bi-directional signalling. Mr Robson, who chaired that inquiry, considered that that was "over the top", and took no action upon it.

7.64 Thereafter Mr Bray wrote a paper dated 21 July 1998 in which he proposed the discussion of the advantages and disadvantages of making both of the middle lines (3 and 4) uni-directional. He indicated that he felt that the reason why Paddington had so many SPADs was because drivers had to choose one signal from six rather than the normal choice of one from two or three. He referred to the proposal to remove flashing yellow signals, stating that this might reduce the number of SPADs at SN109 but was "unlikely to affect the overall pattern significantly". He went on to say: "I consider that it is our duty to try to reduce the number of SPADs now of our own choosing before others impose their own possibly more draconian solutions".

7.65 Mr Bray's proposal received a variety of responses, including the views of the Operational Planning Department that it would "make the station unworkable at certain times of the day", and would involve a major re-working of the timetable. When the subject was mentioned at the Zone Executive Quarterly Review meeting on 12 August 1998, Mr R Middleton, Railtrack's Commercial Director, said that he was not happy with the suggestion because of the implications for capacity. Mr Wilkinson later summarised Mr Middleton's reaction as being that it would be "serious bad news for Railtrack". It was evident that the views of Operational Planning were the biggest obstacle to Mr Bray's proposal.

7.66 Mr Melanophy, who became Operations Manager in September 1998, seemed initially to be in favour of the idea of uni-directional running. This was one of the layouts which featured in the table-top exercise to which I have referred earlier. He stressed to Mr Bray that, since safety was paramount, he would insist on the change even over strong objection from the operational planners. When Mr Wilkinson was briefing the incoming Zone Director, Mr N Josephy, in a memorandum dated 11 September 1998 he referred to four current actions, one of which was the remitting to the STSG of a thorough review of the signalling arrangements. In that connection he stated that one option, as he had suggested at the quarterly review meeting in August, was to make two lines uni-directional. He said: "Clearly this would have performance and capacity implications. I note, and here record, Richard Middleton's direction that such a decision would be serious bad news for Railtrack". Concluding the letter he remarked that the risk associated with SPADs had reappeared "and it would be negligent, in my view, not to progress all four items with vigour".

7.67 At this time the STSG were pursuing the feasibility of the option of uni-directional running. In October 1998 the STSG approached Operational Planning with a request that a study be done into the effect of making the middle two lines uni-directional, with an indication that their strong preference was for line 3 to be uni-directional in the Down direction and line 4 in the Up. The response from Mr A Wilson, Operational Planning Manager, was that if the bi-directional capability of lines 3 and 4 was removed,"we shall be unable to honour existing TOC contracts. I recognise that safety is paramount but believe there must be ways of mitigating this risk without crippling the Zone's major revenue generating terminus". The attached observations repeated the view that the proposition was "quite unworkable". In addition Mr Stuart Hendry, the Zone's Safety Auditor, expressed deep concerns about the operational effect of uni-directional running. It may be noted that an unfortunate consequence of the fact that more than one group was considering a particular SPAD solution was that while the STSG were pursuing this option, the SPAD Reduction Group on 9 September recorded that this was not a good proposal, because of the risk of causing confusion to drivers.

7.68 At their meeting on 14 December 1998 the STSG decided that the Operational Planning Manager, the Area Production Manager at Reading and Mr Hendry should be invited to attend the next meeting on 15 February 1999 to discuss the issues further. In the event only Mr Hendry attended. It appears that the Area Production Manager did not attend because the GTMG had been set up. The subject was not discussed at that meeting or by any of the other groups which had been set up to discuss the problems in the Paddington area. Some witnesses, such as Mr Bray and Mr Spencer, did not regard the matter as abandoned. However, Mr Mayo said that "it was quite clear that it was… a non-starter in the circumstances". Perhaps the most influential factor was a meeting on 15 December 1998 which had been prompted by a SPAD at SN85. It was attended by Mr Atkins, Mr Spencer and Mr Melanophy who discussed uni-directional working, along with approach release and the imposition of a speed restriction on non-ATP services. In the light of an assessment of each option, they agreed that the disbenefits of uni-directional working were that it was effective over only a limited area, it was likely to have a significant impact on line capacity, and would increase the opportunity for drivers to encounter red signals, which would in turn lead to an increased likelihood of SPADs and the need to use signal post telephones. A provisional decision was made to reject it, but a final decision was to be made in conjunction with train operators and the Production Manager. Railtrack witnesses agreed that a decision on such an important issue would ultimately have gone to the Zone Director, probably through the Production Manager, or possibly the Operations Manager. Both Mr Holmes and Mr McNaughton said they would have expected a firm proposal to be put forward, on which a definite decision would have been taken. There does not appear to have been any clear procedure by which a conflict of views relating to performance and safety could have been readily resolved. Plainly the issue should have been resolved by the Zone Director. Instead it ran into the sand.

7.69 As regards the holding of trains at all signals up to the relevant signal unless the latter is showing a proceed aspect or a route is set from it (which is commonly referred to as "double blocking"), Mr Bray renewed this suggestion in his analysis of the SPADs in the Paddington area which he submitted to Mr Spencer on 21 July 1998. This followed a double SPAD at SN41 and at SN61 two days before. The following day Mr R Cole, Operational Planning Manager, responded that double block working was "unworkable with the current level of services operating on headways of two minutes".

7.70 The idea of double blocking was rejected as not reasonably practicable by the panel which sat in August to inquire into the double SPAD. However, it was considered at the meeting on 15 December 1998 to which I have referred above. Although it was seen that there were some disadvantages, it was regarded as the preferred choice, subject to consultation with the TOCs and the Production Manager. In this case also it appears that this did not happen.

7.71 The need for immediate speed restrictions was another matter which Mr Wilkinson drew to the attention of Mr Josephy in his memorandum of 11 September 1998. Mr Wilkinson said in evidence that he did not know what response there was to his suggestions.

7.72 Following a number of SPADs in 1998 Mr Spencer proposed a 40 mph speed restriction in the 0-2 mile area for non-ATP fitted trains, so as to give drivers and signallers more time. However, the panels which investigated these SPADs rejected the idea as commercially unfair to Thames Trains since their stock was not fitted with ATP, unlike First Great Western which had inherited ATP-fitted trains from British Rail. Mr Spencer, who chaired the STSG meeting on 17 August 1998, claimed that his group could not make a decision on it as it did not involve any technical issue. At the SPAD Reduction Group meeting on 9 September 1998 this suggestion evoked mixed feelings.

7.73 Lastly, at the meeting on 15 December 1998 this idea was rejected in favour of approach release arrangements. Mr Melanophy told the Inquiry that "one would look to find the solutions that had the least commercial impact on the travelling public". He expected the matter would be taken forward by the STSG or the GTMG. It was not.

7.74 Counsel for Railtrack submitted that none of the three suggestions represented a simple answer, having regard to the increase in the demand for paths for trains and the danger of creating other risks. At the same time it is plain that in each case the suggestion was rebuffed by Operational Planning and thereafter was allowed to peter out without any systematic evaluation of its reasonable practicability. Once again the issue was never submitted to the Zone Director.

Co-acting signals and a second AWS magnet

7.75 In April 1994, following a re-signalling meeting to discuss the non-compliance of some signals in the Paddington area, Mr Bray suggested co-acting signals for gantry 8. This meant installing track level signals which would replicate the main signals above. He included co-acting signals in his list of improvements which he submitted to the Royal Oak Inquiry. He also suggested a second AWS magnet which a train would reach prior to the normal one.

7.76 On 23 July 1998 Mr Mayo referred to co-acting signals in a memorandum to Mr Bray. The subject was also suggested at the first meeting of the STSG on 17 August of that year. At the meeting of the SPAD Reduction Group on 9 September it was agreed that SN109 would be fitted with a co-acting signal to improve sighting. However, Mr Spencer apparently took the view that all that was agreed was that there should be a feasibility study. This was commissioned from Michael Hamlyn Associates (MHA), and was expanded to include all the signals on gantry 8.

7.77 It appears that Mr Spencer had reservations about co-acting signals. His concerns were that, with the limited visibility on the approach to SN109, a single co-acting signal there was liable to be misread. However, he thought that co-acting signals on all lines were likely to overwhelm drivers with information. He was also concerned that there was insufficient space between the tracks for co-acting signals, a concern which had been shared by the panel which carried out the Royal Oak Inquiry. On 26 January 1999 Mr Spencer submitted a proposal to Mr McCulloch for an additional AWS magnet for each of SN63 and SN109. He said: "Although this proposal is not strictly in accordance with current standards, an innovative solution is required to reduce SPADs at these signals. Therefore it is not acceptable that the proposal be rejected as non-compliant. It enjoys significant support arising from an innovative meeting of minds called by the Production Manager".

7.78 The first draft report by MHA in March 1999 concluded that "it can be seen that the lowest risk options are to provide co-acting signals to either SN109 alone or all of the five signals without any position light and route information". MHA stated that the "biggest risk would be to invoke the No-Change option". However, they said that if five co-actors were placed on the ground, they should not have position light or routing information as they would create confusion for a driver and make the position more unsafe than before. This appeared to conflict with Group Standard GR/RT 0031 on lineside signals and indicators, which stated that "the main aspects and associated indications of the co-acting signal shall be the same as those of the primary signal". Mr Spencer disagreed with MHA's view that co-acting signals should only be installed if position light and routing information was omitted from them. His view was that this would increase the potential for an incorrect routing not being recognised by a driver.

7.79 MHA were then asked to consider the feasibility of providing additional magnets for SN109 and SN63. In their further draft report of April 1999 they urged caution in respect of this measure, pointing out that there was "no known precedent for providing additional AWS magnets in the circumstances described", that Group Standard GK/RT 0078 did not specifically refer to the provision of additional AWS magnets on the approaches to signals, and that consideration should be given to what would happen if a signal changed from red after a driver had passed the first magnet but before the second.

7.80 From this time onwards, a difference of view between Mr Bray and Mr Spencer as to the respective merits of co-acting signals and second AWS magnets became apparent. In April and May 1999 each of them advocated his competing proposal to the Business and Development Department. However, the issue in May 1999 of the Anti-SPAD Toolkit caused Mr Spencer to reassess his initial enthusiasm for a second AWS magnet. He told the Inquiry that "the Toolkit specifically noted that AWS deployments should not include double magnets. A novel proposal for the two magnet solution clearly fell within this". However, the Toolkit merely states: "Over-provision of AWS magnets on approaches to signals causes distraction… ensure provision… does not become over provision", and it is notable that GK/RT 0078 states that a possible risk mitigation measure is an additional AWS.

7.81 It is strange that at the SPADRAM Group meeting on 7 July 1999, which was attended by Mr Spencer and Mr Bray, the latter reported that a feasibility study was being undertaken for co-acting signals, which would be in conjunction with an additional AWS magnet. This was despite the fact that Mr Spencer had received the final report from MHA on 24 June, which reported that a second AWS magnet for SN109, situated 65 yards in rear of that signal, was feasible. Mr Spencer did not correct Mr Bray's impression that there was still a case for a study of co-acting signals, nor did he seek to resolve the apparent difficulty imposed by the Anti-SPAD Toolkit in consultation with the representatives of the TOCs. Although First Great Western had indicated that they were in favour of co-acting signals, Mr Spencer could not remember this. His recollection was that the TOCs did not appear to be in favour of them. Mr Spencer told the Inquiry that he wanted to raise the issue at a meeting of the STSG, but that group had not met since 29 April 1999.

7.82 For the next two months nothing was done to progress either of these measures. However, on 9 September 1999 Mr McNaughton remarked to Mr Bray that, if he had a solution for Paddington, he should implement it in six months or "heads will roll". That same day Mr Bray sent a micro-mail to Mr McNaughton confirming that co-actors would be provided for all the gantry 8 signals, and that a cost of £250k was authorised. The technical endorsement of the TOCs would be sought at a SPADRAM group meeting later that day. While Mr McNaughton replied confirming his understanding of the conversation, Mr Spencer informed Mr Bray that it was inappropriate for this matter to be raised with the TOCs before Railtrack had sorted out their own position. In an e-mail to him on the same day Mr Spencer claimed that the proposal was contrary to a ruling by Mr Melanophy at the STSG meeting on 29 April 1999. He added: "If I see a scheme plan depicting such a change I will veto it". It is to be noted that Mr Melanophy was not at the meeting on 29 April 1999, and gave evidence that no final ruling had been made at any time. Mr Bray and Mr Spencer gave conflicting evidence as to whether the latter was prepared thereafter to discuss their difference of opinion. Mr Spencer said in evidence that he wished that he had driven ahead with the second AWS magnet option, even though it was apparently at variance with the Anti-SPAD Toolkit. In any event the crash on 5 October 1999 intervened before the views of the TOCs could be obtained at SPADRAM Group meeting which was due to take place on 25 October. Mr McNaughton did not follow up the matter. In the result, Counsel for the bereaved and injured submitted, with some justification, that this was a case of "institutional paralysis", or at any rate an example of Railtrack's inability to achieve anything with speed.

Banner repeaters

7.83 A banner repeater signal is used to give a simple indication of what the relevant signal ahead is showing. It consists of a disk which shows either a horizontal bar when the signal ahead is showing a "Stop" aspect, or a bar at an angle of 45 degrees to the horizontal when the signal is showing a "Proceed" aspect. It is used in practice to give advance warning of a signal where its visibility is restricted.

7.84 In August 1993 the Scheme Project Group considered the use of banner repeaters either on a new gantry to the east of Portobello Bridge or attached to the bridge itself. The Group agreed that this could be confusing, as the banner repeaters would be unable to show the relevant signal indications for both the routes straight ahead and any diverging routes. The idea was abandoned in favour of the suggestion that a new gantry be provided to the east of the bridge, but this was itself abandoned later.

7.85 In November 1995 Mr Bray suggested miniature ground level banner repeaters in his submission to the Royal Oak Inquiry. They were also discussed three years later at a SPAD Action Group meeting on 17 April 1998. It was then agreed they would be the best option at the signals which were most at risk, and that a review of all signals would determine which needed to be fitted first. Mr Murrant, who chaired the Group, did not draw up an action plan, on the ground that he was waiting for directions from others on the most effective way in which to deal with the Paddington problem.

Boards, markers and indicators

7.86 In August 1998 it was suggested at a meeting of the STSG that a chequered backing board would provide a more distinct background to SN63. Mr Spencer, who was to arrange for its provision, did not do so. He said this was because the signal which was thought to have a comparable background at Waterloo Station did not have such a board. He was also worried that the blue and white edging was not mentioned in the Anti-SPAD Toolkit. However, it was pointed out to him that the May and November 1999 versions of the Toolkit advised that a distinct surround to a signal backing board should be provided where a signal was difficult to identify.

7.87 At a Safety Liaison meeting with Thames Trains on 3 April 1996 there was discussion of countdown markers which could be placed 300, 200 and 100 yards before a signal in order to warn a driver of the need to start braking. They are used elsewhere on gradients where a driver may misjudge the braking distance. Mr Robson told the Inquiry that their installation at SN109 and SN63 was not considered to be feasible as there was very little space to fix the markers between running lines. They were discussed again at the meeting of the STSG on 17 August 1998, where the proposal was rejected as it was thought that the number of markers which would be required for the four routes approaching SN109 would lead to greater confusion and possible distraction.

7.88 Recommendation 7a of the Royal Oak Inquiry was that there be a trial to consider the effectiveness of placing reflectorised line reminder boards in the "4 foot" (i.e. between the rails), with matching boards showing corresponding shapes on the gantries. In the event such boards were fitted only to gantries 3 and 6 because there was insufficient track possession time for gantry 8 to be sighted. They were not fitted until Christmas 1996 and only after the Joint Safety Council in September had noted that they had not been fitted, and Miss Forster had queried the delay. Her query prompted Mr Wilkinson to respond: "I can only say that I am totally embarrassed". The trial was never assessed for effectiveness. Mr McCulloch, who had accepted the responsibility for closing out the recommendation, had intended to assess the boards by reviewing the SPAD frequency at a later date, but did not do so. Mr Wilkinson and Mr Spencer had not even appreciated that there was a trial. The failure to assess effectiveness is significant because the views which were expressed about these boards were not uniform. Mr Bray thought that the reaction from drivers was not positive, while Mr McCulloch thought that the drivers welcomed them. It is not clear why there was no further fitment to other signals. In June 1998, at the prompting of First Great Western, Mr Murrant agreed to submit a paper to the STSG with a proposal to fit reminder boards on all multi-SPAD signals. The paper appears to have been presented, but nothing further was done. Three months later a representative of First Great Western requested Mr Murrant that he should be advised of plans to fit reminder boards at other locations, but he received no reply to his letter.

7.89 The Royal Oak Inquiry recommended the installation of SPAD indicators, which are lineside alarms giving off an audible warning if a signal is passed at Danger. Mr Robson stated in evidence that this was overtaken by the recommendation of the inquiry into the rail accident at Newton on 21 July 1991. The risk assessment which was carried out on the basis of the latter recommendation showed that only two signals in the Zone, neither of which was in the Paddington area, should be fitted with such indicators.

7.90 The inquiry into the double SPAD on 19 July 1998 recommended that consideration be given to such indicators. Mr Spencer, to whom this matter was allocated, decided after discussion with Mr Bray that they were practicable but expensive. They felt that it was better to prevent SPADs occurring at all. Mr Spencer was concerned that their provision would require substantial reconfiguration of the signalling system and new structures to carry the indicators. A further consideration was the long-term prospect of a train protection and warning system. In these circumstances SPAD indicators were not provided at Paddington.

7.91 The Inquiry into the double SPAD also recommended aircraft taxiway-style indicators, which are networks of small white lights located between the rails of the tracks showing the route that is set. Mr Spencer agreed to take this matter forward. He consulted with Mr Bray, who considered that while they could be provided, they were not practicable. It was thought that adding lights at ground level would create distraction and confusion, and could lead to additional SPADs. There were also doubts about how they could be maintained. For these reasons it was decided not to proceed with them.

Empty coaching stock movements and flashing yellow aspects

7.92 As I have already narrated in Chapter 5, flashing yellow aspects were removed from SN43 and SN63 in January 1999. At the end of the previous year new arrangements for the control of empty coach movements had been put into operation, with a view to reducing the risk of SPADs at SN63. Mr Holmes, who became Production Manager in March 1999, said that his discussion with Mr Melanophy gave him to understand that the problem with SN63 and SN109 had been largely resolved. The evidence of Mr McNaughton was substantially to the same effect. Mr Corbett told the Inquiry:

> "I think what may have happened, and this is hypothesis rather than fact, is that between the removal of the flashing yellows and the actions that were taken on the empty coaching stock there had not been any SPADs at all in the Ladbroke Grove layout, compared with ten the year before. So I think what may have happened is that there may have been a sense that although there is always more things that can be done, the risk had been mitigated and that, to a large extent, the problem had been solved".

In the case of SN109, Counsel for Railtrack maintained that the SPADs on 23 June 1996 and 22 August 1998 showed similar features in that the driver had encountered flashing aspects before approaching SN109 on a line other than line 3. It was also submitted that the SPAD on 4 February 1998 was instructive in showing the beneficial effect of the long overrun at SN109. Had the points been set towards the Down Relief line, this would have led to a fouling of that line and the possible derailment of the train.

7.93 On the other hand, there was considerable force in the submission by Counsel for the bereaved and injured that the actions of Railtrack personnel and the discussions of the various groups which were concerned with SPADs demonstrated that it was recognised that there was a continuing problem with SPADs which required further solutions. Further, Counsel maintained that on a true analysis the evidence of the driver in the SPAD on 4 February 1998 showed he had forgotten that gantry 8 preceded, and did not follow, the junction. Accordingly he was surprised by the sudden appearance of SN109 beneath Portobello Bridge while he was still on line 3. The static yellow aspect at SN87 had prepared him for a red aspect, but without indicating where that red aspect would be encountered. Counsel also stressed the limited benefit of the changes which had been made. They did not address SPADs at other signals. Having regard to the irregularity of the occurrence of SPADs, and multi-SPADs in particular, not enough time had elapsed to enable a conclusion to be formed as to the effectiveness of the changes. Counsel also relied on the evidence of Dr Murphy who said that the introduction of the Heathrow Express trains had increased the collision opportunities. Dr Murphy also pointed out that the inquiry into the SPAD on 4 February 1998 had concentrated on the SPAD itself and not on the collision opportunity beyond SN109, which was of major significance. Counsel submitted that even where there were flashing yellow aspects, it was difficult to see why they might have been thought to contribute to a SPAD beyond them. No driver should have been in doubt that a static yellow might be followed by a red aspect, and that once he had reached a static yellow he had gone beyond any "protection" thought to be given by flashing yellows. The comment of Mr Fairbrother was: "I still find it hard to believe how they (flashing yellows) could be cited as a cause of SPADs when SN87, which is a good signal, is clearly there at yellow saying 'Stop at the next signal'. The only reason I can find is that 109 was not a suitable signal for them to see and stop at".

The response to recommendations of Formal Inquiries

7.94 The response to recommendations of inquiries into serious accidents is a test of whether there is a true determination to address the underlying causes and apply the lessons. The evidence in this Inquiry demonstrated that there had been a lamentable failure on the part of Railtrack to implement the recommendations of two Formal Inquiries and to take steps to see that such recommendations were tracked and the persons responsible for implementation were monitored.

The Royal Oak collision on 10 November 1995

7.95 That inquiry made 14 recommendations, all but one of which was accepted by the Safety Review Group on 20 March 1996. Nine were directed at Railtrack, and allocated to particular individuals. Mr Wilkinson accepted that he was responsible for ensuring that they were pursued.

7.96 The following recommendations were not put into effect:

(i) Recommendation 4 (a risk assessment of a more urgent alarm for SPADs). Mr Spencer raised the matter at a meeting of the Programmable Electronic Systems Group in mid-1996. The group indicated that it would be considered as part of the next upgrade of IECC software. However, it was not incorporated in two subsequent revisions. Mr Spencer did not know why. The change was conceded by Mr Corbett to be technically possible. Counsel for Railtrack accepted that no risk assessment had been carried out. Three possible solutions to the technical difficulties were under consideration.

(ii) Recommendation 6a (a study and risk benefit assessment of a single emergency button at the Slough IECC to put all signals to danger). Mr Robson said that he passed this matter on to the Head of Production at Railtrack Headquarters. As far as the Zone was concerned that was the end of the matter. Counsel for Railtrack stated that a review was being undertaken. In regard to both this recommendation and Recommendation 4 there appears to have been confusion as to whether the recommendation was a matter for the Zone or for national implementation.

(iii) Recommendation 6b as amended by the Safety Review Group, (a study and risk benefit assessment of the "signals on" button automatically sending the emergency "all trains stop" message on the CSR). Mr Tribe said that the Head of Controls System Engineering had written to him about this matter, but he had never heard anything more and did not expect to be told the result. Counsel for Railtrack informed me that a study was in its early stages.

(iv) Recommendation 7a (a trial of the effectiveness of reflectorised line reminder boards). See para 7.88 above.

(v) Recommendation 7b (a trial of the effectiveness of moving the existing line reminder boards on the gantries above or next to the relevant signals). This recommendation was not implemented, despite the fact that it was recommended by MHA in March 1999.

(vi) Recommendation 8 (a feasibility study of a range of options to reduce the possibility of a misread). As already stated above in para 7.49, this recommendation was not implemented. Counsel for Railtrack reiterated the view of Headquarters that it was of no safety benefit.

(vii) Recommendation 9 (a risk analysis of fitting a lineside SPAD alarm). As I have already stated in para 7.89 this matter was overtaken by the recommendation of the inquiry into the rail accident at Newton.

(viii) Recommendation 12 (a review of the minimum acceptable sighting times for gantry signals). It appears that after a discussion by the Signal Subject Committee the outcome was limited to adding advice in the second issue of Group Standard GK/RT 0037 that when gantry-mounted signals were being considered care should be taken to avoid confusion as to which line a signal applies to and to avoid confusion arising from inconsistencies in signal positioning along the route.

(ix) Recommendation 13 (a briefing of all managers of the need, in the event of an accident, to recover data disks where there was a CSR). A written amendment to the procedure was circulated, but apparently to no effect. Mr Winters, Signalling Manager at the Slough IECC, said that he had never been briefed as to its existence.

The SPAD at SN109 on 4 February 1998

7.97 The above may compared with the fate of a number of the recommendations of this Formal Inquiry. Recommendation 3 was a review of all flashing yellow aspects, initially in the Paddington to Ladbroke Grove area, and ultimately in the Zone as a whole. Recommendation 4 was for the training and practice of manual routing of trains for signallers. Recommendation 5 was a risk assessment of bi-directional signalling. Recommendation 6 was a review of the software applicable to the signalling and ARS. Recommendation 7 was the adoption of a process of timetable change risk assessment prior to each timetable change.

7.98 None of these recommendations was implemented, apart from Recommendation 3 which was put into effect to the extent of the Paddington to Ladbroke Grove area. Recommendations 3, 5 and 6 were allocated for action by Mr Wiseman. He was unaware of this fact until over 18 months later, apparently as a result of the failure of Mr Sutton to notify him. Recommendations 4 and 7 were allocated to Mr Wilkinson. It appears that nothing was done. He said in evidence that they were referred to Headquarters and that a layout risk model would have assisted. He was not aware how either recommendation on the layout risk model was progressing at the time when he left the Zone in September 1998.

Tracking by the Zone

7.99 At the time of the Royal Oak inquiry there was no Zone procedure for the tracking of recommendations. Mr Robson said that Mr Sutton was responsible, apparently on the basis that this had been delegated to him. Mr Sutton said that once a recommendation had been passed on to Railtrack Headquarters, that was the end of any tracking of that recommendation by the Zone, but Mr Robson thought otherwise. In August 1996 Mr Tribe asked Mr Sutton what had happened to Recommendation 8. Mr Sutton replied that the Safety and Standards Manager was charged with the duty of undertaking it, but "as yet there have been no definite proposals". This matter was not pursued. Mr Sutton gave as the reason for this that the Zone was swamped with 400-500 recommendations. As I have already said this was an exaggeration. Mr Hancock did not think that there were a large number of outstanding recommendations which had not been actioned, and did not believe that there were 400 outstanding when he was Production Manager (until May 1996). However, if it was the case that many recommendations were allowed to become outstanding, that clearly indicated a failure in the system. Mr Robson accepted that it was bad management that he failed to see that the recommendations of the Royal Oak inquiry were implemented.

7.100 At the time of the inquiry into the SPAD on 4 February 1998 there was a written Zone procedure for the reporting and investigation of accidents and incidents, which had been introduced in 1997. This was GWP/P5.2. It is to the credit of Mr Sutton that he drafted this procedure and appears to have effected some improvements. The procedure stated that, if a recommendation was accepted by the Safety Review Group, "the responsible manager will be notified and the fact recorded in a tracking system". That system was to note the date and nature of the decision and the person charged with implementing it. No provision was made for a timescale despite the terms of Group Standard GK/RT 3434 which required members of the Railway Group to have in place procedures for "monitoring the implementation of appropriate changes to a defined timescale and reviewing impact" as well as "recording the decision making process involved in those considerations". The system which was in operation in the Zone did not pick up the fact that Mr Wiseman was to take responsibility for the implementation of Recommendations 3, 5 and 6. Mr Sutton claimed that Mr Wiseman's name would have appeared in the quarterly safety intelligence reports together with the progress of the recommendations. However, none of the reports which were produced included his name, and no check made on the fact that Mr Wiseman did not report back to Mr Sutton as he should have done. Counsel for the bereaved and injured drew my attention to a letter which Mr Sutton wrote to the HMRI on 27 January 1999. He stated in that letter:

> "The SPAD Technical Group is now empowered to make decisions and carry recommendations forward and revised procedures have ensured that all remedial actions are implemented where necessary. All relevant parties are now notified if recommendations are progressed or declined".

Counsel submitted with justification that this was not an accurate reflection of what happened in fact. The same comment was made about a letter which Mr Wilkinson wrote to Miss Forster on 11 September 1998 to the effect that the SPAD Focus Group would "monitor progress" with recommendations arising from SPADs and thus ensure timely close-out.

7.101 At a meeting of the GTMG on 10 May 1999 it was agreed that action should be taken to review all past SPAD and inquiry recommendations in the Paddington throat "to ensure that all issues have been addressed". It appears that this matter was not pursued.

7.102 As to recommendations which were directed at TOCs, it appears that in many cases Railtrack simply passed the matter on. Little, if anything, was done to monitor them.

Tracking by Railtrack Line

7.103 The Railtrack Line procedure for the tracking of recommendations, RT/D/P006, March 1995, states: "The HQ Production Directorate shall maintain records showing for each Inquiry the current state of implementation of recommendations arising, and for which Railtrack has accepted responsibility for implementation. When implementation is complete, the appropriate record shall be closed". Mr Tribe, who was Formal Inquiries Process Manager from 1996, was responsible for following up recommendations directed to Railtrack Headquarters. His job description included the following: "Allocate as appropriate responsibilities for the progression of recommendations by Railtrack Line HQ Professional Heads, and others, and monitor progress, taking action as necessary". However, while this clearly envisaged that the progress of recommendations would be tracked after their allocation to individuals, Mr Tribe told the Inquiry that he was given guidance by his managers to the effect that he was not responsible for ensuring that a recommendation was acted upon, but simply that someone had accepted responsibility for it. As a result no one appears to have been responsible for monitoring recommendations. In the words of Mr Leah, Mr Tribe became "more of a register and not a chaser and closer down of recommendations". Furthermore, Mr Tribe was not aware of it being anyone's responsibility to set timescales for the implementation of recommendations, despite the terms of Group Standard GK/RT 3434 to which I have referred above. Railtrack Line did not monitor recommendations which were addressed to Zones, and there was no system for central monitoring.

7.104 Mr Leah accepted that the evidence given by Mr Tribe disclosed a flawed system. Mr Corbett's evidence was to the same effect. Mr Leah acknowledged that, had it not been for the evidence given in the Inquiry, the shortcomings in the system for tracking recommendations might not have been discovered.

Improvements

7.105 The Inquiry was told that Railtrack had recently doubled the resource available to Mr Tribe. Mr Leah, who gave evidence on 11 July 2000, said:

> "We are overhauling the whole of the recommendation process to initiate a system such as a clearing house where all recommendations from Inquiries will come to a central point, they will be prioritised, they will be monitored, they will be controlled and they will be reported. They will be reported to the Board on a four-weekly basis of where each of the recommendations, on a priority basis, has reached. That will be in place within about three or four months' time. Meanwhile we have instituted a process whereby the Board, through its safety report, sees every four weeks the number of Inquiries and where they are in status terms".

Mr Corbett said in evidence that the number of outstanding recommendations was now the subject of a key performance indicator reported to the regular meetings of a special committee known as SAFEX, focussing exclusively on safety and environmental issues, which he chaired and which were attended by Executive Board Directors and Zone Directors. The Inquiry was also informed that the following up of recommendations was now reviewed at the level of Zone Directors.

7.106 In my view, Railtrack procedures, and the actions of management to enforce them, should be directed to ensuring that:

(i) a recommendation which is accepted is implemented according to a defined timescale;

(ii) the person to whom a recommendation is allocated for implementation is required to report periodically the action which has been taken, the state of progress and the reasons for any delay;

(iii) the monitoring of the implementation of a recommendation is assigned to an identified individual whose duties are clearly defined, whether by job description, formal instruction, or training or a combination of these methods;

(iv) the person to whom monitoring is assigned is required to ensure that the recommendation is implemented according to a defined timescale;

(v) a recommendation should not be abandoned unless, exceptionally, this is shown to be fully justified to the person to whom monitoring is assigned;

(vi) any management system to which the recommendation relates is altered to align it with the recommendation;

(vii) the effectiveness of a recommendation is audited after its implementation;

(viii) full records are kept of all recommendations and their state of progress; and

(ix) there is a system for the central tracking of recommendations which are directed to Railtrack Line and those which, either immediately or thereafter, are directed to one or more of the Zones.

Consideration should be given to extending sub-para (ix) to recommendations which are directed to one or more of the TOCs and others. No evidence was before the Inquiry about the follow up of recommendations by TOCs. However, it is desirable that they reassure themselves that the systems which they have in place for this are strong and effective. I should add that I consider that it is very important that each TOC should pass to other members of the Railway Group what it has learned as a result of the investigation of an accident or incident on the railway whether or not it has been the subject of an inquiry or investigation under a Group Standard or the Health and Safety at Work Act 1974.

SPAD management

7.107 The evidence before the Inquiry clearly demonstrated that it was widely recognised that there was a problem with SPADs in the Paddington area. In preceding sections of this chapter I have sought to describe the extent to which any action was taken with a view to addressing this problem. A factor which appeared from time to time in the course of the discussion of this subject was the view that SPADs could be regarded as simply a "driver issue". Mr Robson agreed that his perception of SPADs in the Paddington area was coloured by his view that they were essentially a problem of driver error. That belief can be seen to have influenced the decision by the Royal Oak inquiry not to follow suggestions which Mr Bray had put forward for alterations to the infrastructure. More recently, at a meeting of the STSG in October 1998, the possibility of analysing in greater detail the moves and routing patterns within the six track section was dismissed, as "this was felt to be of little value or relevance… Drivers are expected to observe and correctly act on lineside signal aspects at all times". Counsel for Railtrack rightly conceded that there had been a lack of a holistic approach to the root cause analysis and a historic tendency to regard SPADs as driver problems. There had been unacceptably slow progress in dealing with SPADs. On the face of it there was a considerable amount of activity on the part of groups which had been set up at Zonal level to seek solutions to the problem of SPADs. Their names have already been mentioned earlier in this chapter. They comprised:

(i) the SPAD Action Group, otherwise known as the SPAD Reduction Group, which met from February to September 1998;

(ii) the SPAD Technical Solutions Group (STSG) which met from August 1998. It is unclear whether it met after April 1999. Its remit was as follows: "The SPAD Technical Group will consider signals that have been referred to it by the SPAD Reduction Group where technical or signalling design may be a factor and produce plans that will lead to a reduction in risk at that signal…". The group was originally comprised of the Signalling Engineer, as Chairman, the Signalling Development Engineer and the Production Standards Manager. It was described by Mr Bray as a "can do" group. Mr McNaughton regarded it as empowered to make decisions and carry forward projects. Mr Wilkinson gave the group a further remit dated 22 July 1998 with particular reference to SPADs in the Paddington area, which "feature heavily in our multi-SPAD top 25". According to this remit the group was to investigate the "level of SPAD incident" and length of overrun, along with cause and categorisation. They were to identify possible reasons for the current level of SPADs, and examine the contribution made by various factors including 6-track bi-directional signalling and the sighting and identification of signals. The group was asked to identify solutions for immediate and medium term implementation. Their proposals were to be clearly linked to the factors considered and to quantified risk values. The remit also stated: "You should involve train operating company staff in seeking solutions. You should consider the effectiveness of actions taken elsewhere. You should report progress to me within one month by which time you should be in a position to present a clear quantification of risk together with a suite of proposals";

(iii) the Golden Two Miles Group (GTMG), which was set up by Mr Melanophy "to get things moving", was originally intended by him to be a "one-off" brainstorming session in January 1999 on the Paddington problem, but it met until May of that year; and

(iv) the SPAD Reduction and Mitigation (SPADRAM) Group. This group was set up as a consequence of a national initiative and met from June 1999 onwards. It involved representatives of the TOCs. Its remit was to understand the causes of SPADs and to decide on corrective and mitigatory action. It reported to the Zone Senior Management Group which discussed safety performance.

Apart from the above there was the Safety Review Group which was responsible for reviewing and approving any significant changes to the organisation, infrastructure, operations or processes. A Joint Safety Council, on which Unions were represented, discussed the implementation of health and safety legislation. Safety liaison meetings also took place between Railtrack and individual TOCs.

7.108 The proliferation of groups dealing with similar issues caused confusion. Members of a group incorrectly believed that certain issues would be considered by another. For example, Mr Mayo who was a member of the STSG thought that uni-directional running would be considered by the GTMG, but it was not. Mr Bray, who was much involved in the consideration of preventive and mitigatory measures, said that he was barely aware of the existence of the GTMG, even though it had been expressly set up with the aim of bringing together a team of experienced people to examine issues relating to the SPADs in the Paddington area. As a continuing group the GTMG was never properly co-ordinated with the STSG. Mr Holmes told the Inquiry that when he arrived in the Zone in March 1999 he wanted to rationalise the groups which were dedicated to SPAD Management, with the ultimate aim of having one group to provide a single focus. With that in mind he established the SPADRAM Group, intending to wind up the others. The GTMG did not meet after Mr Melanophy left the Zone in May 1999, and the SPAD Action Group had not met since the autumn of 1998. After discussion with Mr Spencer he initially allowed the STSG to continue, provided that it was closely linked to the SPADRAM Group. However, there was uncertainty over whether or not the STSG had been overtaken. Mr Bray and Mr Mayo attended for a meeting of the STSG in June 1999 but discovered that no one else had appeared. The meeting was aborted and no minutes were taken. Mr Holmes said that it was clearly understood by everyone that the STSG was winding down, and that the SPADRAM Group would encompass all activities. He could not comprehend how Mr Bray or Mr Mayo could have thought otherwise. As I have already narrated, Miss Forster of First Great Western wrote a letter to Mr Holmes in July 1999 in which she asked for clarification of the SPAD groups and their respective remits.

7.109 Along with confusion there were also difficulties in achieving continuity and communication. Mr Murrant, who was supposed to attend the STSG meetings in order to provide the interface between the train operators and the technical experts, attended only the first STSG meeting. There was evidence of concern that one group would not know of the decisions of others. In April 1998 the Great Western Zone Safety Management Group (SMG), which discussed safety performance, asked that the minutes from the SPAD Reduction Group be attached to their minutes. In October 1998 the SMG minuted that "the actions arising from the SPAD Technical Group were not being conveyed to the relevant operators, and a process was required that enabled them to be aware of the decisions". Even those who were in key safety management posts appeared to have had limited knowledge of what was going on in the groups. For example, Mr Robson was unaware of matters being discussed in the SPAD Action Group, despite being the Project Safety Manager at the time. Mr Wilkinson's aim of involving TOCs through the work of the STSG does not appear to have been achieved. When the SPADRAM Group was set up it met on three occasions prior to 5 October 1999. However, on each occasion it had a different chairman. Following the crash there was a further meeting which had yet again a different chairman.

7.110 Despite the discussion of a large number of preventive and mitigatory measures considered in the Zone, only three changes were ever implemented: the installation in December 1996 of reflectorised line reminder boards on gantries 3 and 6, the amendment of instructions for the movement of empty coaching stock and the removal of flashing yellow aspects. It is, in my view, significant that only the second of these three changes came about as a result of a suggestion made in any of the groups. Miss Forster told the Inquiry that although actions were agreed by the SPAD Action Group, such as the provision of route packs, seminars and tapes on good communications between drivers and signallers, and the development of a Railtrack procedure for speedy investigation of SPADs, these were never effectively implemented. At the third meeting of the SPADRAM Group on 9 September 1999 the Chairman, at the request of Mr Holmes, expressed his concern, which was shared by the group, that it appeared to be delivering little in terms of a cohesive plan to manage the reduction of SPADs across the Zone. Mr Holmes had noted that the meetings were not being held monthly as he had requested. The group further noted that the Chairman would forward his comments and views to the new Operations Manager, so that the group could become more proactive in future. When asked to explain why so little had been achieved by the SPADRAM Group before the crash, Mr Holmes indicated that it had taken on a much wider scope, and breadth of responsibility, than the two mile area on which the GTMG had focussed. It was difficult to make that change and to have good quality outputs in such a short time. He also pointed out that some of the TOCs were becoming involved for the first time. He said that, with hindsight, he could perhaps have ensured that timescales for actions were imposed on the group and that he should perhaps have chaired the first two meetings himself. Whatever may be the reasons, the reality is that each of the SPAD management groups, including the SPADRAM Group, actually achieved very little by way of implementing specific actions to address SPADS in the Paddington area. In the course of her evidence Miss Forster said:

> "It was a huge frustration. There were a lot of meetings held on different issues, but signals passed at Danger specifically, where lots of ideas were created but no action then was taken with all those ideas. And then we had another group set up discussing ideas and it seems that Railtrack became overwhelmed with those ideas and actually just did not appear to us, though they may well have been taking things forward within their organisation, they did not communicate that with us".

In his witness statement Mr Corbett accepted that criticism, at least to some extent, when he said:

> "There were probably too many groups and their functions overlapped. While a number of good ideas were formulated and debated there was a lack of a single person or body to ensure that prompt and appropriate action was taken. The organisation, in this respect, was diffuse".

7.111 The evidence clearly demonstrated the lack of a comprehensive approach to the SPAD problem. Individual measures were proposed and considered frequently in reaction to events rather than seeking to forestall them.

7.112 Miss Forster also told the Inquiry that she had past and present concerns about the quality of communications between Railtrack and her company. She said: "I find Railtrack Zone unresponsive to our requests for information, for action, and that unresponsiveness is not only between me and Railtrack, it is often between the signallers and the drivers, and the response to the drivers' reports is actually sometimes non-existent, sometimes ineffective". That criticism may be illustrated by the fact that she wrote to Mr Sutton on 24 August 1998 pointing out that her company had not received information about the SPAD which had occurred at SN109 on 6 August, despite the fact that it had been agreed some months before that when a SPAD occurred at a multi-SPAD signal Railtrack would advise TOCs rather than waiting for a Safety Management Group meeting. She wrote to Mr Wilkinson about SN109 on 22 August, asking "as a matter of urgency what action you intend to mitigate against this high risk signal". She received only a holding response. On 21 October 1998 her company wrote to Mr Sutton expressing concern that Railtrack appeared to have no record of a large number of instances in which there had been signalling irregularities. Ms Orla Fitzgerald, Safety Performance Analyst, said: "Considering Railtrack are safety custodians of the line, this is not satisfactory… please can you investigate this situation and establish whether there is a problem with the communication chain which needs to be addressed". Mr Sutton told the Inquiry that the cause of the non-reporting could not be established, but signallers were briefed on the need for comprehensive reporting. Similar concerns were expressed by other train operators. The common objective put forward by the TOCs at the meeting of the Senior Management Group in April 1998 was "Quicker response by Railtrack". In October 1998 the Group noted that "TOCs required a faster notification of multi-SPAD signals and asked if the list could be made available at more frequent intervals… Railtrack to agree with each operator their preferred means of receiving multi-SPAD information and to provide the SPAD list every two weeks". A further example of the failure to communicate important information was the delay in sending copies of the reports of Formal Inquiries to the TOCs. First Great Western were concerned that they did not receive the report of the Formal Inquiry into the double SPAD at SN41 and SN61 on 19 July 1998 until January 2000. In partial explanation Mr McNaughton said that the manager who was responsible had taken a very long time to produce the report, having left the Zone shortly after the investigation. Although Mr McNaughton said that the output of the report was known to the TOCs at the time of the investigation, this did not excuse the slowness in producing the report. Hearing of the delay had "appalled" him.

7.113 The lessons from this disjointed and ineffective activity in SPAD management are clear, and do not need to be the subject of a recommendation. It is for management to ensure that safety responsibilities and accountabilities are well understood. The commitment to safety should be communicated throughout the organisation. The purpose for which a safety group is established should be clearly defined in writing. Its work should be designed to achieve a conclusion within a stated timescale, and should be subject to monitoring by an identified manager. The criteria in virtue of which decisions are taken or advice given should be spelt out and recorded. The communication of information about safety proposals to TOCs, and their involvement in discussions of such proposals, are extremely important.

The actions of senior management

7.114 What I have described in this chapter provides evidence of a serious and persistent failure to deal with the recognised problems of SPADs in the Paddington area in a prompt, proactive and effective manner. A number of these deficiencies were acknowledged by Railtrack from the outset of the Inquiry. As Counsel for First Great Western submitted, the evidence showed a lack of appreciation within Railtrack that deficiencies in the infrastructure could play a significant part in SPADs. There was over-reliance on conformity with Group Standards as being sufficient. There was an inability to consider the problems of the Paddington area and the potential solutions as a whole. There was a reluctance to carry out risk assessments, and a deep-seated laissez faire culture within the Zone. There was a reluctance to consider solutions which might impact on capacity and performance, and there were a number of management deficiencies, of which I have given examples. To what extent was this perceived by senior management, and what did they do to correct it?

7.115 During the course of the evidence of a number of Railtrack witnesses whom I have mentioned in this chapter, it emerged that their services had been dispensed with or that they had been moved on to other work. When Mr McNaughton, who came to Great Western Zone in September 1998, came to give evidence, he presented a much darker picture of events, delivering what Counsel to the Inquiry correctly described as a "devastating critique" of the way in which the Zone had been managed. By implication this included the management of safety. He said that the Zone had been declining for at least a decade. People had been moved in and out of posts, the Zone had been allowed by British Rail to deteriorate, and as a result every indicator, such as maintenance and track quality, had been on a downward trend over this time. He told the Inquiry of how he struggled on his arrival in the Zone to understand how "so many apparently good people could produce so little action". He detailed some of the problems of the Zone: people had burdens that were too complex; they were not prioritising; people were not doing jobs to which they were well suited – "square pegs in round holes"; some were not competent; and, in summary, "the culture of the place had gone seriously adrift over many years". What Mr McNaughton said created the clear impression that he was anxious to distance himself and those who had been appointed under him, such as Mr Holmes, from what had gone before. This unexpected development in the evidence also created the unfortunate impression that, had it not been for the progressive revelation of the shortcomings which I have described earlier in this chapter, the true picture might not have emerged. Mr Corbett later gave evidence much to the same effect as Mr McNaughton. He acknowledged that there had been management deficiencies in the Zone, resulting in "lots of meetings, a lot of discussions, but not much action". He told the Inquiry that, upon taking up his post in 1997, he had been struck by the seemingly endemic culture of complacency and inaction in the Zone. He felt this was rooted in an industry culture that had been inherited, and that was relatively unresponsive and slow-moving. He commented that this had its origin in the hierarchical and rigid culture of the old railway. "The culture is one in which decisions are delegated upwards. There has been little empowerment. People have tended to manage reactively, not proactively. The basic management discipline of 'plan-do-review' are (sic) absent the further down the organisation one goes". This would take many years to change. It required leadership, an injection of outside management, the clarification of accountability and the "ownership" of problems at the most local level. He said that as a result of his increasing concern at the strength of the Zone's operational management from March 1998, a "clean sweep at the top of the Great Western Zone's management" was made. The people in key posts, namely the Infrastructure Contracts Manager, Area Manager, Production Manager and Zone Director, were all changed during the year. Mr Corbett stressed that the cultural problem would take some years to remedy, even if short-term problems could be put right in six to nine months. I note that at the quarterly business review of the Zone in July 1999 Mr McNaughton reported that the "new safety team is now fully in place and has exposed the shortcomings of the previous arrangement very much as expected".

7.116 As regards the problems in the Paddington area, Mr Corbett said that as a result of attending the quarterly zone review meetings he was aware of the number of SPADs, and that the number was increasing and the situation needed to be addressed. The Zone had reported the Paddington SPAD issue as one of their key safety risks. He acknowledged to the Inquiry that no London terminus had problems as serious as Paddington. In these circumstances I find it extraordinary that he said to the Transport Sub-Committee of the Environment, Transport and Regional Affairs Committee of the House of Commons on 15 July 1998, that Railtrack believed Paddington "to be the best protected major terminal station anywhere in the world". Mr Corbett went on to explain to the Inquiry that this remark was prompted by the fact that the Paddington routes were fitted with ATP, but he agreed that in retrospect it was an unfortunate statement for him to have made. It was, in my view, not only ill-considered, but it demonstrated either a degree of complacency on the part of senior management or a desire to encourage an undeserved confidence in what Railtrack had actually achieved.

7.117 Mr McNaughton was well aware, since the correspondence had been copied to him, that a number of the proposals for SPAD management had been opposed by Operational Planning. He said in evidence that there was no such thing as a balance between train performance and safety. However, it is a matter of fact whether effects on performance are used in order to resist a proposed safety measure (or vice versa). Railtrack should ensure that safety is not subjugated to performance, let alone commercial considerations, and that the full implications of a proposed safety measure are adequately assessed according to what is reasonably practicable. Mr McNaughton said that he expected proposals such as uni-directional working to be subjected to an assessment of their reasonable practicability, but he did not ask for this to be done. The impression which senior management witnesses created was that they would wait to deal with a problem until a proposition was put before them by someone else. Thus, in regard to reflective boards, Mr Holmes said: "If a situation had been highlighted to me where it would seem that, or it would be of value to add lineside identification boards, then I would have, of course, made sure it was followed through". If that approach was reproduced at each level of management, it would carry the risk of proposals for improvements being stultified or lost. In my view senior management should have given and maintained the lead in seeking solutions and ensuring a response. Within the Zone this meant the Zone Director and those under him in the management hierarchy.

7.118 It seems to me to have been too readily assumed that the new instructions in regard to empty coaching movements and the removal of the flashing yellow aspects meant that there was no longer an urgent need to assess the risks which were inherent in the infrastructure and the way in which it was used. Management do not appear to have taken an overall view, not only of individual SPADs, but also their potential for serious consequences. I observe that in a letter dated 9 February 1999 to Mr Leah, Dr Smallwood, referring to Railtrack's attitude to SPAD issues in general, said:

> " What concerns me… is the lack of urgency and the attention given to sorting out the problems. I have to question therefore whether enough Senior Management effort is being devoted to SPAD issues… Our own position is that it is simply not acceptable on a properly run railway to have SPAD incidents. There may very well be a temptation within the industry to wait for TPWS to solve the problem but that should not be looked at as the possible solution".

Safeguards for the future

7.119 The Inquiry was informed that the Board of Railtrack had approved the creation of a Ladbroke Grove Response Programme Team to organise the necessary changes arising from work done after the crash. This involved a substantial number of projects. Among those projects was a programme to re-examine Railtrack's management of catastrophic risk. Mr Leah was appointed to be Board Director for Safety and Environment.

7.120 In the aftermath of the crash a number of temporary measures were taken: SN109 was taken out of action and bi-directional running on line 3 was suspended. Thus lines 2 and 3 became uni-directional in the Down and the Up directions respectively, whereas line 4 remained bi-directional. A speed limit of 40 mph for all trains in the Down direction was imposed out to two miles six chains from Paddington Station. Thereafter the speed limit was increased on 12 December 1999 to 50 mph on lines 3-6 as from 0 miles 78 chains, and on line 2 as from one mile 12 chains. A signal sighting committee viewed and reported on a number of signals, and made recommendations, as I have stated in para 7.44. Counsel for Railtrack in opening and closing submissions made it clear to the Inquiry that Railtrack did not intend to bring the route past SN109 into service until after I had reported, TPWS had been installed on the track and reached an appropriate level on trains, and the HMRI had given their approval. It was also stated that whether at that time additional measures should be incorporated would be carefully considered and risk assessed.

7.121 The Inquiry heard evidence as to the steps which Railtrack had taken or intended to take to mitigate or prevent SPADs in the Paddington area in the light of what happened in the crash. Since this report is necessarily limited to the evidence which was available in time to be given in public before the close of Part 1 of the Inquiry, it does not reflect any subsequent developments.

7.122 Mr Bray told the Inquiry that flank protection by points was "likely" to be a measure that would be applied at signal SN109, although this had not yet gone through Railtrack's internal approvals process or been considered by the HMRI. Mr Leah, who gave evidence to the Inquiry on 11 July 2000, spoke to a letter from Railtrack to the HMRI dated 27 June 2000 which was in response to a statutory notice. Counsel for Railtrack indicated that, while Railtrack did not accept that there was any obligation on the HMRI to impose a condition in that notice whereby Railtrack were to provide a plan for the permanent layout arrangements and a programme for the implementation of the works for the track and signalling for Phases 1 and 2 of the Paddington new works scheme to be agreed with HMRI by a certain date, they had not challenged, and would not challenge, the perception of the HMRI that there was a need for Railtrack to produce such a final plan.

7.123 In that letter, Mr Leah stated:

> "The permanent arrangements at Paddington are the subject of a number of initiatives currently being undertaken by Railtrack and the final solution will be a combination of all or some of the following:
>
> - early fitment of TPWS to all main signals from Paddington out as far as the 2mp;
> - provision of additional flank protection;
> - four-aspect signals converted to three-aspect;
> - improvements to the optical characteristics of signals;
> - amended linespeeds;
> - provision of Signal Group Replacement Control; and
> - IECC 01 upgrade."

In regard to flank protection he went on to state:

> "In the event of TPWS failing to stop a train overrunning signals SN107 or SN109 within their overlaps, controls will be amended to minimise the consequences of any such overrun".

As to the conversion of aspects, he said:

> "It is proposed to convert selected signals from four to three-aspect so that with the amended linespeeds proposed the signal spacing is compliant with the provisions of Clause 6.4 of Group Standard GK/RT 0034. This conversion may also have the beneficial effect of 'freeing up' SSI outputs for TPWS use".

Under the heading of "Improvement of Optical Characteristics of Signals" Mr Leah stated:

> "Railtrack expect to approve a fibre optic main signal head by September. It is anticipated that this will reduce the size of the cages where signals are mounted on a gantry. This may allow signals to be mounted nearer to drivers' eye level whilst still maintaining clearances to overhead lines and to stagger the height of signals on gantries to assist drivers in identifying their signal. Once revised cage designs are available Railtrack will commission a visual simulation, of the type undertaken successfully as part of the Leeds Scheme, to assess the drivers' view of any proposed amendments to gantry signals".

Under the heading of "Amended linespeeds" Mr Leah stated:

> "It is proposed to amend linespeeds so that in the event of a train overrunning a signal at red TPWS will bring it to a stand within the overlap of the signal".

As regards aspects of the letter which dealt with the IECC at Slough, I will refer to them in Chapter 12.

7.124 Mr Leah also stated that a draft scheme plan had been completed incorporating the above features and would be subjected to a layout risk model assessment and to a structured expert judgement exercise. He also indicated that the ultimate solution to the present arrangements at Paddington would integrate these initiatives, many of which were currently being evaluated by specialist consultants who would advise on the timescales. An attempt had been made to quantify risk using the A D Little layout risk model, which showed a higher risk for SN109 and SN120 than for elsewhere on the layout. However its limitations meant that it did not provide an appropriate risk assessment on which decisions could be based. He could not confirm which, if any, of the measures under consideration would be implemented save that the fitment of TPWS had been brought forward. Railtrack expected to have the infrastructure fitted from Paddington to the two mile post by October 2001. Because of the limitations of the layout risk model, a working group of railway experts, led by Mr Holmes, would be carrying out risk analyses of various options, in consultation with consultants from A D Little. While noting what was said on behalf of Railtrack I would like to commend the work of Dr Murphy in assessing the risks posed by individual signals. This should be invaluable in determining the priority for improvement.

7.125 Having regard to the evidence which I have considered and outlined in this chapter, and taking account of the stated intentions of Railtrack, I am in no doubt that Railtrack should ensure that the risk assessments and any consequent actions required under Group Standard GK/RT 0078 in respect of the signals in the Paddington area are carried out as soon as possible.

7.126 The evidence which I have heard leaves me in doubt as to the safety of the track and signalling layout over 0-2 miles from Paddington Station. In my view Railtrack should conduct a safety examination of the layout so as to satisfy the HMRI, if necessary by a risk assessment and additional measures, that it is safe for operation at current speed limits and to current traffic arrangements. Such a safety examination should be repeated before the implementation of any change which is or may constitute, in the opinion of the HMRI, a material change of circumstances.

7.127 I am also satisfied that no change should be made in the direction of running on line 3 or in the current speed limits on any of the lines out to two miles six chains from Paddington Station unless and until the following have been done to the satisfaction of the HMRI, namely:

(i) a risk assessment has demonstrated that the change can be implemented in safety, and, if this can be achieved only if certain measures are taken, what these measures are; and

(ii) such measures have been implemented and shown to be effective.

7.128 The risk assessment to which I have referred in the last paragraph should take account of the following possible measures, inter alia:

(i) the conversion of four-aspect to three-aspect signals;

(ii) the addition of flank protection at SN109 and elsewhere if appropriate;

(iii) the installation of standard, simple, non-distracting and consistent means of line identification;

(iv) the alteration of the height, configuration and mounting of signals; and

(v) the installation of an additional gantry to the east of Portobello Bridge for carrying Down signals previously carried on gantry 8.

The risk assessment should be carried out by persons independent of Railtrack and in accordance with usual standards and the best available methods. It should take account of human factors which may affect the actions of drivers and signallers, and any risks which the carrying out of any of these measures might create.

7.129 Underpinning my approach to these matters is the following. On the one hand the public quite rightly expects that there should be no SPADs which run the risk of causing injury. On the other hand human nature is fallible: no matter the training and experience - and they are extremely important – it is impossible to exclude the possibility of such an event. Hence the need for TPWS, and, beyond it, the European Train Control System (ETCS), which have been the subject of the Joint Inquiry. I am concerned with the residual risk which should be assessed. It is some years since one man (or woman) operation of trains has become accepted. I do not suggest a departure from that, but if and to the extent that the safe operation of a train is dependent on one person it is essential that the demands which the railway system makes on him or her take adequate account of human factors.

Chapter 8
Thames Trains and Automatic Train Protection

Introduction

8.1 If the Turbo had been fitted with Automatic Train Protection (ATP), and if that had been operational, it is highly probable that the crash would not have happened. The ATP system is designed by means of a combination of on-train and signalling equipment to control a train, should a train driver act outside the correct parameters of responding to signals received. The system provides for automatic halting of the train prior to overrunning a red signal. The management of Thames Trains had decided that their trains should not be fitted with ATP. In view of the effect which the fitting of ATP would have had, it was important for the Inquiry to consider the basis for that decision.

8.2 In this chapter I will examine:

- the background (paras 8.3-8.6);
- the earlier steps taken by Thames Trains (paras 8.7-8.9);
- the cost benefit analysis by W S Atkins (paras 8.10-8.21);
- the decision of the management of Thames Trains (paras 8.22-8.24);
- review of W S Atkins' cost benefit analysis (para 8.25);
- criticisms of W S Atkins' cost benefit analysis (paras 8.26-8.49); and
- overall conclusions and observations (paras 8.50-8.54).

The background

8.3 In the late 1980s British Rail approved plans for the development of an ATP system. These plans were reinforced by a recommendation by Sir Anthony Hidden, who conducted the Inquiry into the crash at Clapham Junction.

8.4 British Rail decided to run two trial installations of ATP with an objective of having both trials operational by 1991. These trials were initiated in Great Western Zone and on the Chiltern line during 1991. By 1994, just prior to privatisation, the installations were almost complete in both test areas except for the final 12 miles into Paddington. On 31 March 1994, the Chairman of British Rail wrote to the Secretary of State for Transport, reporting on ATP and giving British Rail's conclusions on its economic viability (the "BR-ATP Report"). The report concluded that the cost of ATP far exceeded the normal safety investment criteria as measured by cost per equivalent fatality avoided. The report was referred by the Secretary of State to the HSC which later expressed qualified support for these conclusions.

8.5 As from the time of a statement by the Secretary of State on 29 November 1995 ATP ceased to be viewed as a national solution and was replaced by the SPAD reduction and mitigation programme (SPADRAM), including TPWS. The pilot schemes for ATP were still to proceed. The operational experience with the ATP pilots was initially poor. Equipment problems combined with deficiencies in driver training and, seemingly, a less than committed management drive, meant that the system was operational for at best less than 30% of the time in the period up to August 1997.

8.6 During the period of uncertainty regarding the development of ATP, the collision occurred at Royal Oak on 10 November 1995 involving a Thames Trains Turbo passing a signal at Danger. Recommendation 10 of the Formal Inquiry into this collision was that Thames Trains should carry out a risk benefit analysis into the fitting of all Thames Trains Turbos with ATP. On 19 September 1997 a collision occurred at Southall between a Great Western train and a freight train operated by English, Welsh and Scottish Railways. The ATP system on the Great Western train was not in service (although it was serviceable) at the time of the collision. Had it been in action, in all likelihood the accident would have been prevented. In May 1998 the HSE published draft regulations requiring the use of a train protection system on passenger lines. Following consultation the Railway Safety Regulations 1999 were laid before Parliament in August 1999.

The earlier steps taken by Thames Trains

8.7 Mr Franks, who was Production Director of Thames Trains and the manager with responsibility for safety, said that the response of Thames Trains to the Royal Oak recommendation was that he asked Mr Cobb, Safety Manager, and Mr Savage, Fleet Manager, to carry out the risk benefit analysis. He told the Inquiry that "it was undertaken and a report was produced". There is, however, no working documentation of this in the company's records, but the indications are that the work was carried out in 1996. All that could be found was one page of a report which estimated the cost of fitting all the company's trains with the on-train ATP equipment to be £3,402,000. In addition it was considered that Railtrack would expect Thames Trains to pay at least a part of the cost of fitting the trackside equipment. It should be noted that ATP equipment had already been fitted to the trackside in the case of about 75% of the route miles covered by Thames Trains, for the purposes of the original BR trials.

8.8 Mr Franks told the Inquiry that the result of this internal analysis was that the cost of installing ATP outweighed the benefits of doing so, and towards the end of 1996 a decision was taken that ATP should not be fitted to Thames Trains' trains. The "Board" minutes (see para 8.9) for meetings held at this time had been checked, but no record was found of the decision having been considered. Mr Franks assured the Inquiry that he had had sufficient documentation at the time to allow him to make his decision. When he was asked about what benefits had been taken into account, he said:

> "Well, I don't have the paper here to actually demonstrate the point, but I wouldn't have been satisfied with any outcome unless that had been the case… I do recall seeing sufficient papers produced to enable me to close the recommendation out".

In September 1996, Mr Franks advised Mr Wilkinson of Railtrack of the decision by saying "We could not see the justification for installing ATP". Mr Franks also said in evidence "In terms of the work done in 1996, it was an internal piece of work and probably not as comprehensive to deal with the points mentioned here".

8.9 It may be noted, in the light of the evidence of Mr M Ballinger, Managing Director of the Go-Ahead Group, the parent company of Thames Trains, that there was a misunderstanding regarding the title "Board". He explained that the management executive meeting of Thames Trains should not have been "dignified with the title of Board meeting". The properly constituted Board was the joint Board of Thames Trains and Victory Railways. At no time was the question of ATP referred to this Board. Mr Ballinger went on to point out that the Thames Trains executive team did have the authority to work within their budget and had day to day control of the organisation. He said their decisions "were very valid" but the meetings were not "Board meetings". Subsequent references in this report to the Thames Trains "Board" (as it was generally referred to in evidence) should be understood in the light of this explanation.

The cost benefit analysis by W S Atkins

8.10 Mr Franks told the Inquiry that following the Southall crash, he decided that "Thames Trains should be perhaps more rigorous and get some independent validation of the work we had done. So a full quantified risk assessment was undertaken at this stage". At the beginning of March 1998 Thames Trains employed W S Atkins to conduct the assessment. Their brief stated:

> "… what we (Thames Trains) want to achieve: either justification for not fitting ATP to our fleet or the financial case for doing so".

This brief could be construed as inviting a conclusion adverse to the fitting of ATP. However, in evidence, Mr J Cope of W S Atkins, one of the co-authors of the report, stated in this regard that the study was objective and that he was not influenced in any way by the wording of the brief.

8.11 A cost benefit analysis seeks to establish the costs of a project, estimated over a finite period, and to compare these costs against an estimate of the financial value of the benefits accruing from the project over the same period.

8.12 The conclusion of the analysis by W S Atkins in September 1998 was that, in their opinion, the fitting of ATP was not justified financially, as the costs outweighed the benefits. They analysed the costs and benefits of the potential introduction of an ATP system for two of Thames Trains' routes, namely:

(i) Paddington to Didcot; and

(ii) Didcot to Oxford.

The first of these was chosen because it featured frequent train movements including crossovers and a high density of conflict points, and therefore would gain the maximum benefit from the installation of ATP. As regards the second, given that the rolling stock would be ATP fitted by virtue of the installation on the Paddington-

Didcot route and therefore that only trackside equipment would be needed for this section, it was felt that installation might be expected to yield a positive return. Further routes were not evaluated as, in comparison with the two selected routes, they would have been expected to show a lower return on the investment.

8.13 W S Atkins summated the costs of installing, operating and maintaining ATP on all of the Thames Trains rolling stock (65 multiple units), and of installing and operating and maintaining the trackside equipment from Paddington to Didcot and Didcot to Oxford respectively. The costs, at their worth in 1998, were calculated to be £8.22 million for the Paddington-Didcot route, and £0.71 million for the Didcot-Oxford route.

8.14 W S Atkins assessed the likelihood and consequences of ATP-preventable SPADs, first without ATP being fitted and, secondly, with ATP being fitted. They took account of the following:

(i) the frequency of SPADs that were ATP-preventable;

(ii) the likelihood of a train reaching a "conflict point", the point at which an accident could occur;

(iii) whether on reaching the conflict point the train was travelling at high speed (more than 25 mph) or low speed;

(iv) what type of accident would occur: collision (rear-end/head-on) or derailment;

(v) whether a collision involved a passenger train, freight train or empty coaching stock (ECS);

(vi) the number of likely casualties (amongst passengers and staff); and

(vii) the loss control costs, namely the damage to rolling stock and disruption to operations and passengers (manifested as revenue loss).

8.15 To facilitate this assessment, W S Atkins developed a mathematical model for assessing the likelihood of, and consequences arising from, SPADs. This was based on one that they had produced in January 1998 for the HMRI to assess the potential benefits of selective fitment of ATP on the line between London (Victoria) and Brighton (the "HMRI-ATP Report"). According to Mr Cope the model had been accepted by the HMRI. The frequency of SPADs was estimated by W S Atkins based on data supplied to them by Thames Trains. They estimated there to be, on average, 7.9 ATP-preventable SPADs per year on the designated routes. They predicted the number of equivalent fatalities and the loss control costs on an annual basis, and compared these with the assumption that ATP would prevent the SPADs occurring on all but 0.1% of occasions. The benefit of fitting ATP was the difference between the two results.

8.16 Historical data was used to assess the number of casualties that might arise. W S Atkins developed an accident database from the HMRI reports of 96 train accidents which had resulted in casualties between 1968 and 1997. These accidents comprised three buffer stop collisions, 20 derailments and 73 train collisions. It was assumed that each accident involved trains carrying 500 passengers. Based on this assumption they calculated average casualty rates for various types of accidents. Not all SPAD accidents resulted in casualties. The BR-ATP Report observed that of 123 SPAD accidents, only 27 (20%) resulted in casualties. From this data, W S Atkins assumed that 10% of low speed SPAD accidents and 40% of high speed SPAD accidents would result in casualties. Based on their accident database and the above assumptions, W S Atkins predicted that in the event of a high speed head-on collision, on average 5% of the passengers would be casualties, and of them 5% would be fatalities, 9% would sustain major injuries and 86% would sustain minor injuries. They further assumed that the average daytime passenger loading for a train of Thames Trains was 150, and, for one of First Great Western's trains, 300. Finally the number of casualties predicted was converted to "equivalent fatalities" (by assuming that 10% of major injuries and 0.5% of minor injuries were equivalent to fatalities) and added to the number of fatalities predicted. The same approach was adopted in the earlier BR-ATP Report.

8.17 From the foregoing, W S Atkins estimated that the number of equivalent fatalities saved per year for the Paddington-Didcot route would be about 0.081 and for the Didcot-Oxford route about 0.0085. When discounted for the 20 year period the results were 1.00 and 0.09 equivalent fatalities avoided respectively for the two routes. From this data, and using the value of £2.45 million which Railtrack used as the equivalent value of a life, W S Atkins estimated the equivalent value of fatalities avoided over the 20 year period from 1 January 1999 on the Paddington-Didcot route to be £2.49 million at 1998 values. W S Atkins also treated as benefits some other losses that fitting ATP would avoid. These included the uninsured loss from damage to rolling stock of £50,000, and revenue loss of £100,000 due to the disruption of services following temporary closure of a section of a route.

The cost benefit comparison

8.18 Based on the above W S Atkins estimated the benefit of fitting ATP to the Paddington-Didcot route to be a total of £2.96 million (made up from £2.49 million for the equivalent lives saved plus £465,124 for the revenue loss and uninsured equipment loss avoided). ATP installation costs were calculated as £8.22 million, as noted above. The costs therefore exceeded the benefits by £5.26 million.

8.19 Using the same methodology on the Didcot-Oxford route, and assuming all the rolling stock had been previously ATP fitted, the study indicated an excess of cost over benefit of £410,000.

8.20 These results could also be expressed in terms of "cost per fatality avoided" which is a calculation widely used in public service operations. It was calculated by dividing the cost of ATP installation (corrected to a net monetary cost) by the number of equivalent fatalities avoided. The cost per fatality avoided for the Paddington-Didcot and the Didcot-Oxford routes was calculated as £7.75 million and £6.90 million respectively. It exceeded the value of £2.49 million by a factor of 3.1 on the Paddington-Didcot route, and by a factor of 2.8 in the case of Didcot-Oxford.

8.21 W S Atkins concluded:

> "From this analysis it is not possible to make a case in cost benefit terms for installing ATP on sections of route over which Thames Trains operate and for equipping the Thames Trains fleet of rolling stock with ATP".

The decisions of the management of Thames Trains

8.22 These results were reported initially to Mr Franks of Thames Trains by letter from W S Atkins on 21 April 1998. Mr Cobb put some questions of detail to Mr Cope on 6 August 1998, and the final report was submitted to Thames Trains in September 1998. Mr Cobb prepared a paper for the Thames Trains Board meeting making the following points:

(i) following the Southall accident and regarding automatic train protection "the industry appears to be near to resolving the issues… it would appear that the currently favoured kit is Train Protection Warning System TPWS";

(ii) despite the likelihood that TPWS would be the adopted system, Thames Trains had contracted with W S Atkins for a cost benefit analysis on ATP;

(iii) the results of the study showed that ATP could not be justified financially; and

(iv) it was not intended to take the study further.

This paper was reviewed by the Board of Thames Trains on 13 August 1998.

8.23 The Board of Thames Trains concluded that a case had not been made for the fitting of ATP. This was based on the following:

(i) in their belief, the cost benefit analysis was robust and did not show a cost benefit in favour of ATP;

(ii) in November 1995 Railtrack had presented to the Secretary of State for Transport their train protection strategy which included TPWS, and this had been accepted by him;

(iii) the HSE reported in their 1997/98 report that "TPWS forms the basis of the train protection systems being proposed under the draft regulations";

(iv) trials of TPWS were successfully being carried out on part of the routes operated by Thameslink, a sister company of Thames Trains, in July 1998; and

(v) negative comments had been made regarding ATP by Mr Hellicar, the field officer for the HMRI, in regard to the Bristol to Paddington route in 1996/7, namely "The onboard equipment is not reliable".

Although they agreed to keep the question of ATP under review Thames Trains therefore decided that they should not fit ATP, but should proceed with all possible haste to fit TPWS. Mr Worrall explained to the Inquiry his belief that TPWS would provide the same level of benefit in the 0-2 miles region of Paddington as would ATP, and that it would do so more quickly.

8.24 Mr Ballinger informed the Inquiry that full provision had been made in the Thames Trains budget for 2001 for the fitment and installation of TPWS. He also said that cost benefit was not the only reason for the decision not to fit ATP. The company were aware of the environment which favoured TPWS, and recognised the difficulties in retrofitting ATP. The company were also aware of the problems with reliability in the Great Western Zone pilot scheme, and considered the limited life expectancy of the equipment on the pilot scheme.

Review of W S Atkins' cost benefit analysis

8.25 The W S Atkins analysis was subjected to critical scrutiny at the Inquiry, which commissioned an analysis of it by Det Norske Veritas (DNV). The author of the DNV analysis was Dr Louise Smail who spoke to it in evidence. Following the Ladbroke Grove crash Thames Trains separately commissioned an independent review of the W S Atkins study by AEA Risk Solutions. A draft of their review (of July 2000) was referred to in the evidence but was not spoken to.

Criticisms of W S Atkins' cost benefit analysis

Estimates of costs

8.26 The W S Atkins estimate of £25,000 for the cost per signal of installing ATP was criticised for being some three times higher than the equivalent figure used in the BR-ATP Report, which was commissioned only four years earlier. AEA Risk Solutions voiced a similar criticism. Mr Cope of W S Atkins explained that the costs per signal in the BR-ATP Report were general industry costs whereas W S Atkins had used cost information direct from the manufacturers. I note that W S Atkins appear to have used the highest of the costs quoted by the possible suppliers. The use of higher, albeit quoted manufacturers' costs, was not material to the conclusions of the W S Atkins study.

8.27 A mathematical error was disclosed in W S Atkins' calculation of the operation and maintenance costs, which led to these costs being underestimated by a factor of 100. The effect of the error was to increase the factor by which the costs of ATP exceed the benefits. The error was rectified in the subsequent analysis by DNV, but the sum involved was relatively small.

8.28 There was criticism that it was inappropriate for W S Atkins to include the cost of the trackside equipment (which might be expected to be borne by Railtrack) and to weigh this against benefits which accrued to Thames Trains alone. Mr Franks explained that Thames Trains expected to contribute to the trackside costs of fitting ATP, because of their contractual arrangements with Railtrack. He believed that it would be a negotiable cost. A similar view was expressed by Mr Cobb. However Mr Cope said that at the time of performing the study his understanding was that Thames Trains believed that they would bear the whole cost of trackside fitment. I accept that there is a weakness in logic if the benefits that accrue to one party are weighed against costs that are borne by other parties. In this case it did not have a material effect on the outcome. However, I will return to the issue of comparing like with like later in this chapter.

Estimates of benefits

Frequency of ATP-preventable SPADs

8.29 W S Atkins were criticised on the ground that they wrongly excluded some relevant SPAD data from the analysis, with the result that their estimate of 7.9 ATP-preventable SPADs per year was too low. In particular, it was suggested that the analysis should have included SPADs that occurred on the Paddington-Didcot main line, although the designated route for Thames Trains was to use the relief line. Had this data been included, the assumed frequency of SPADs would have been increased by some 25% (although that figure was itself disputed, an increase of 35% being thought to be more appropriate). I consider it was appropriate for W S Atkins to base their predictions on data that was specific to Thames Trains. The AEA Risk Solutions report states that across the national network the average rate of SPADs per signal is estimated to be 0.02 per year (i.e. one SPAD in 50 years per signal). The SPAD rate used by W S Atkins in their model was between 0.028 and 0.2 per year for the Paddington-Airport Junction route and between 0.008 and 0.07 per year for Airport Junction-Oxford. These estimates, which are up to ten times the national average, do not support a view that the estimated SPAD rate was unjustifiably low. In any event the increase in benefit arising from including data for the main line was estimated to be £0.74 million. By itself, this would be insufficient to make benefits outweigh costs.

Fitting the trains with ATP and relying on existing track fitment

8.30 It was suggested to Mr Cope that 75% of the benefits of fitting ATP would be achieved by incurring the cost of traction unit fitment alone, without any trackside fitment, as the relief line between Paddington and Airport Junction had already been fitted for ATP. In response Mr Cope explained that the cost of cab fitment was unlikely to be outweighed by the benefit on the small section of infrastructure that was already fitted with ATP. Further, and more importantly, he believed that it would create a potentially dangerous situation whereby drivers might be confused and think that they were covered by ATP when that was not the case. I accept Mr Cope's views on this matter. In any event this option did not form part of W S Atkins' remit.

Casualty rates

8.31 Dr Smail criticised the casualty rates used by W S Atkins for high speed accidents on the basis that they appeared to be underestimates when compared with recent accidents. The base figure used by W S Atkins assumed that 5% of passengers involved in the total of high speed accidents would be casualties. However, it has to be borne in mind that, of all these high speed accidents, only 40% were assumed to lead to any casualties at all. Thus, the estimated casualty rate in those accidents where there were casualties was 12.5% of passengers. W S Atkins subsequently re-ran their analysis incorporating casualty data relating to the Ladbroke Grove crash (which happened after their report) into their accident database. They found that this increased the benefits only marginally, with the costs still exceeding the benefits by more than a factor of three.

8.32 At the end of the day Dr Smail's only disagreement with W S Atkins analysis on this point was that their assumption of an average loading of 500 passengers was an overestimate. Mr Cope said that the figure was based on reasoned assumptions from his knowledge of the accidents. It was not statistically derived. He believed that it was a reasonable number in the light of accidents such as those at Clapham Junction and Cannon Street, where very high numbers of passengers were on board the trains. Furthermore, the figure of 500 had been used in the HMRI-ATP Report. AEA Risk Solutions made a cross check on the consistency of the W S Atkins estimate of SPAD casualty rates against statistics for the national network. The W S Atkins model predicted a casualty rate of 0.009 per SPAD. Previous BR research had predicted an average rate of 0.005 per SPAD. AEA Risk Solutions assumed that an average of 100 passengers per train was appropriate, and based on that figure they concluded that for Thames Trains the average casualty rate was about 0.007 per SPAD. They concluded that these estimates were consistent with W S Atkins' predictions.

8.33 There is a disparity between the various estimates of the number of passengers who were involved in previous SPAD accidents. I remain unconvinced with Mr Cope's reasoning on this point and suspect that the assumption of 500 passengers per train may be an overestimate. However, if the effective casualty rate used by W S Atkins had been doubled then the DNV analysis would still show that the costs outweighed the benefits by a factor of 2.5. W S Atkins would have had to underestimate the number of casualties by a factor of 7.2 before the benefits equalled the costs. I found no evidence that their analysis is suspect to that degree.

Effect of catastrophic accidents

8.34 There was criticism that the W S Atkins study had taken average casualty rates based on historical accident data for 30 years and did not examine the effect of very unlikely but catastrophic accidents. Inclusion of these accidents would tend to increase the average casualty rate assumed. There is force in this criticism. The problem was raised in the BR-ATP Report, in which it was suggested that one method of accounting for such uncertainty in the data was to double the calculated number of equivalent fatalities. However if such a factor had been applied by W S Atkins, it would not have influenced materially the conclusions of the study, as I have noted in para 8.33.

Passenger numbers and loadings

8.35 As part of their sensitivity analysis DNV examined off peak and peak hour passenger loadings to test the assumption by W S Atkins of average passenger numbers. Initially Dr Smail expressed concern that the passenger loading used in the model did not specifically calculate the maximum number of casualties that might be expected to occur at times of peak loading. Under cross-examination she conceded that an error had been made in the DNV analysis and therefore the effect of including peak loadings in the analysis would be small. As to the W S Atkins assumption of an average of 150 passengers on Thames Trains, this was supported by a count carried out on one typical day. Even if the daytime passenger loading had been doubled, the results still indicated that the costs exceeded the benefits by a factor of 2.5.

Improvements in Crashworthiness

8.36 W S Atkins reduced the predicted number of equivalent fatalities by 0.77% per annum to reflect changes which would arise naturally over the next 20 years from improved rolling stock crashworthiness. This figure was taken from the BR-ATP Report. I note, however, that this reduction factor was intentionally not incorporated in the HMRI-ATP Report undertaken by W S Atkins several months earlier. It was put to Mr Cope that the use of such a factor for improvement in crashworthiness was not justified. In response he stated that this was “probably fair comment”. However, he stated that if it was not included then it would be necessary to reduce the casualty rates predicted from the accident database, since this covered historical accidents involving predominantly mark I rolling stock. The fact that Thames Trains and Great Western used mark III rolling stock meant that it was legitimate in his view to take some benefit for improvements in crashworthiness.

8.37 AEA Risk Solutions stated that W S Atkins should have made a one-off allowance for improved crashworthiness rather than assuming a gradual improvement over 20 years. By not making a one-off allowance, they concluded, W S Atkins under-stated the importance of crashworthiness, and therefore over-estimated the cost effectiveness of ATP by as much as 23%.

8.38 By itself the inclusion or non-inclusion of allowances for improved crashworthiness did not materially affect the conclusions of the W S Atkins analysis.

Loss control costs

8.39 As noted earlier, these were costs were assumed to be saved by fitting ATP. They included damage to rolling stock and disruption to operations and passengers (manifested as revenue loss).

8.40 There was criticism of the W S Atkins study for assuming that the losses from damage to rolling stock would be limited to the cost of an insurance excess of £50,000. The effect of using this insurance excess was to cap Thames Trains’ assumed losses for major accidents, although W S Atkins did also include an allowance for an average revenue loss of £100,000 for each such accident. Dr Smail observed that in DNV’s experience it was not normal for companies to assume, when conducting cost benefit analyses, that losses from damage to equipment would be limited to the cost of an insurance excess. When Mr Cope was challenged on this point there was some dubiety in his evidence. Initially he appeared to suggest that the railway industry had traditionally taken this approach, and also that it was exceptional to include any revenue loss. However a little later he acknowledged that it had been the first time that W S Atkins had limited loss control costs by using insurance excess payments and that he was unaware of it being done in other cost benefit analyses. He could not point the Inquiry to any document or guidance which suggested that it was appropriate to look only at the costs of insuring against accidents in assessing loss control costs.

8.41 Mr Cope explained, however, that the rules governing cost benefit analysis in the railway industry were "not set in tablets of stone", and that there were different schools of thought as to whether account should be taken of e.g. infrastructure damage, or whether only equipment and revenue loss should be included. Counsel for W S Atkins argued that the fact that the W S Atkins study took any account of loss control costs favoured ATP fitment. He took support from Dr Smail's agreement under cross-examination that in her experience not all cost benefit analyses included these avoided costs as benefits.

8.42 W S Atkins asked Thames Trains for data on loss control costs and were supplied with typical costs of damage that had occurred in previous collisions and derailments. For example the cost of one particular accident at Slough had been estimated to be between £800,000 and £1 million. This involved a buffer stop accident where there was one major injury, no structural damage to the train, but damage to the station.

8.43 It was put to Mr Cope that the BR-ATP Report used a figure of about £3 million per major accident involving injury or death to represent the loss control costs, and it might have made a difference if W S Atkins had adopted a similar approach in their analysis. Mr Cope's response was that BR had historically been self-insured but, following privatisation, individual companies like Thames Trains could not afford to be self-insured and therefore took cover from the insurance market. The Inquiry was presented subsequently with the results of a sensitivity analysis whereby a value of £3 million for major (Category F) accidents was used in the W S Atkins model. It showed that the costs of fitting ATP exceeded the benefits by 1.64 times and the value per fatality figure by 2.6 times.

8.44 DNV examined the effects of including insured losses as part of their sensitivity analysis. They did this by multiplying the loss control costs by a factor of between eight and 36, based on an HSE study on the cost of accidents. However Dr Smail conceded that the multiplier had been applied inappropriately, and that DNV had only used these factors to illustrate the potential impact of uninsured losses. In any event, the analysis showed that if all the loss control costs were multiplied eight times then the cost of fitting ATP still exceeded the benefits by 1.64 times.

8.45 Given the general confused industry practice on what should or should not be included in cost benefit analysis, I conclude that W S Atkins' work was not fundamentally flawed. A preferable approach might well have been for W S Atkins not to have capped the loss control costs by limiting equipment losses to the insurance excess. There is uncertainty as to what factors should be included for a range of cost benefit analyses within the railway industry and its various components. Had W S Atkins adopted the approach used in the BR-ATP Report then this would not have changed their conclusions.

Comparison of "like with like"

8.46 There was criticism that W S Atkins did not compare like with like, when including the costs of fitting ATP to the infrastructure while excluding benefits to other parties arising from fitment of ATP. As Dr Smail said: "Normally, in a cost benefit analysis, you would expect the costs incurred by a company to match the benefits incurred, but not to incur other people's costs, unless they take into account other people's benefits".

8.47 I have considered above the costs of fitting ATP to the infrastructure. With regard to the benefits arising to other railway parties, W S Atkins did include benefits, both in terms of casualties avoided and loss control costs avoided by other parties, when they included the potential for casualties of drivers and passengers involved in trains other than Thames Trains, and in the loss control cost assumption for non-major accidents. This was accepted by Dr Smail.

8.48 Ideally the costs and benefits in a cost benefit analysis should be properly matched so that there is no imbalance in the assumptions being made. However there are inherent difficulties to be faced when only part of a system is being examined, as was the case for Thames Trains. I am not persuaded that the approach of W S Atkins was unreasonable in this regard.

Sensitivity Analysis

8.49 Both the DNV and the AEA Risk Solutions reports criticised the W S Atkins study for not undertaking a sensitivity analysis. Dr Smail stated:

> "A CBA is only part of the decision-making process and should not be the only parameter relied on. The value of any CBA relies on the validity of the assumptions made and the sensitivity of the model to those assumptions".

This is undoubtedly correct. The provision of a sensitivity analysis should provide a client, such as Thames Trains, with a greater understanding of the importance, or otherwise, of key parameters. Mr Cope's response was that they did not have to undertake one, because a sensitivity study had already been undertaken for the HMRI-ATP Report, and they had a "very good feel for the sensitivities of this model". There was no rule that a sensitivity analysis was necessary. Had one been undertaken it would not have affected their conclusions. I accept Mr Cope's view on this point, in that he was well aware of the sensitivity question but was confident of his conclusions, because of the work he had done on the HMRI-ATP Report. However it would have improved the clarity of his report if he had stated this in it.

Overall conclusions and observations

8.50 Examination of the individual criticisms of W S Atkins' study leads me to conclude that none of the criticisms was individually material in affecting the conclusions of the report. The questions that remain are, first, whether W S Atkins should have taken a different combination of assumptions, which were generally more favourable to the fitting of ATP; and, secondly, if so, whether their overall conclusions would have been so different as to alter the decision of Thames Trains not to fit ATP, in the light of the other factors which they considered (see para 8.23).

8.51 In regard to the first question, whilst a combination of assumptions could have been selected by W S Atkins that was less unfavourable to the fitment of ATP (leading to the balance of costs and benefits being more marginal), given the BR-ATP Report and W S Atkins' own study for the HMRI, the overall approach was not so contrary to industry practice as to be unreasonable. I should add that, subject to what I have said above about the question of sensitivity, the Inquiry heard no evidence that a reasonable combination of different assumptions would have led W S Atkins to a conclusion that was materially different.

8.52 As to the second question, even if the W S Atkins report had concluded that the balance between costs and benefits was marginal, I doubt this would have materially affected Thames Trains' decision, which was reasonable, given the history of poor reliability of ATP and the abandonment of the ATP system by Government and the industry in favour of TPWS.

8.53 The use of a cost benefit analysis where human life is concerned is intuitively difficult to accept, but it is a concept which is well used by the rail industry, the HSE and Government. There is no nationally accepted standard as to how one should value certain benefits. It is left to the person performing the analysis to make assumptions regarding the benefits and to justify those in the process. It is also usual to perform a sensitivity analysis by calculating the benefits on a range of assumptions to determine which assumptions have significant effects on the outcome. Due to the imprecise nature of the process, it would not be normal practice to use a cost benefit analysis as the only decision-making tool. Rather, it should be seen as one of many inputs that management should consider when deciding on a course of action.

8.54 The 1998 analysis was, however, presented in great detail to the Inquiry and subjected to thorough cross-examination. It is to Thames Trains' credit that the 1998 study was conducted at their own initiative. It was carried out by W S Atkins who have considerable experience in these matters. The W S Atkins study was said to "lack robustness" by DNV who had been commissioned by the Inquiry to verify the study. The DNV criticisms were, however, challenged by Counsel for W S Atkins. I am led to conclude that whilst the W S Atkins analysis was not entirely satisfactory, this did not vitiate their conclusion. Thames Trains knew it was very likely that they would require to install TPWS, and that operating experience of ATP was poor. In the circumstances their decision not to proceed with ATP, but to install TPWS, was reasonable.

Chapter 9
Thames Trains and driver management and training

Introduction

9.1 In this chapter I will examine the evidence about the adequacy of the systems within Thames Trains for driver training and management, and the performance of the company in these respects. Chapter 5 has covered the recruitment and training of driver Hodder. However, it is appropriate to consider the wider aspects of the training and management of drivers in Thames Trains, along with a number of matters which concern TOCs as a whole. I will deal with the following topics:

- general background (paras 9.2-9.16);
- SPAD performance (paras 9.17-9.22);
- communications (paras 9.23-9.29);
- route knowledge (paras 9.30-9.35);
- defensive driving (paras 9.36-9.39);
- safety auditing of Thames Trains (paras 9.40-9.47);
- driver licensing (paras 9.48-9.53);
- the use of simulators (paras 9.54-9.56);
- "no blame" culture (paras 9.57-9.61); and
- human factors (paras 9.62-9.67).

Consideration of these topics inevitably calls for repetition of some material already examined in Chapter 5

Background

9.2 Driver training processes have evolved from the days of British Rail when a trainee, who usually came from within the established workforce, brought with him or her a basic knowledge of the railway system, and was given a period of a year or so to travel with, and learn from, a qualified and experienced driver. The trainee then progressed through the training process, known latterly as Driver 2000.

9.3 Initially drivers were trained according to the existing British Rail Driver 2000 syllabus, but changes were made to this syllabus to reflect the fact that Thames Trains had only one type of locomotive and no freight operations. The evidence before the Inquiry did not yield a clear account of the development of the training process. An investigation into the company's driver training, conducted by the parent company of Thames Trains, the Go-Ahead Group, found that much of the early documentation on training and management could not be found.

9.4 Driver training and driver management within Thames Trains were carried out by driver team leaders, subsequently named as driver standards managers, who reported to a senior driver standards manager; who in turn reported to the Operations Manager at Thames Trains headquarters. The Thames Trains railway safety case shows that each driver standards manager should lead approximately 35 drivers, and that he or she is the key person responsible for ensuring that drivers keep their equipment, documentation, traction knowledge and route knowledge up to date. However, in practice, due to a shortage, and a high turnover, of driver standards managers they shared their duties amongst the workforce of the depots as matters arose. The system was described by Mr Chilton, Thames Trains' Operations Manager, as "driver standards managers conducting their own classes as they thought best, based loosely on what had been the practice in British Rail days".

9.5 Mr Cox, a driver standards manager who taught Mr Hodder traction, said that he was given no structure to the course. "One didn't exist, to my knowledge… I was given four weeks and told to teach them how a Turbo works and how to get by when things go wrong, faults and failures". This section of the training was not validated. Mr Lyford, a senior driver standards manager, described how he taught rules and regulations. He himself was responsible for allocating to each of the six weeks the particular subjects available for this element of training. It was a matter for him, based on his own discretion: "It was also based very much on my own experience and what was considered previously to have been best practice amongst colleagues." Again this material was not validated.

9.6 The training process continued to evolve, with the driver trainers using their own initiative to modify existing practices in the light of the needs as they saw them. This undoubtedly left some gaps in the training. The most obvious lacuna of which the Inquiry heard was the fact that driver instructor Adams did not recognise it as part of his job to teach route knowledge in and out of Paddington. He said "This is Paddington and sort of make the best of it really". This contrasts with the evidence of Mr Chilton who said that route knowledge was an integral part of train handling training. This view was reinforced by Mr Winkworth, a driver standards manager.

9.7 The fact that this confusion existed in the training team as to what should or should not be taught to trainee drivers, combined with the specific admission of failures in the system as accepted by Mr Worrall, Director and General Manager, and the lack of a validation process, leads me to conclude that the safety culture in regard to driver training was slack and less than adequate.

9.8 At a meeting on 20 August 1996 Mr Holmes of the HMRI told Mr Franks that he "was very concerned about driver training", and believed that Thames Trains could be prosecuted if an incident occurred where driver error was partly to blame. He said his concern extended towards driver leaders who were too young or too inexperienced to deal with at risk drivers. Yet shortly afterwards Thames Trains assured the HMRI that "all drivers on Thames Trains have had, or are receiving, briefings on SPADs".

9.9 Mr Baird, a driver standards manager at Thames Trains between 1997 and January 1999, described to the Inquiry how he was asked by his line manager, Mr Shepherd, to redesign the driver training scheme with a view to modifying the British Rail Driver 2000 Programme to make it more specific to Thames Trains' operations.

9.10 It is regrettable that there was little communication between Mr Baird and Mr Chilton when the latter took over as Operations Manager in February 1999. Mr Chilton was unaware of much of Mr Baird's work. He was not aware of Thames Trains' previous poor SPAD performance, or of the details in two memoranda by Mr Waters of Halcrow to Mr Brewer, on 17 December 1998 and on 19 January 1999, which described driver performance problems and proposed a course of remedial action. This lack of "corporate memory" is regrettable and reflects poorly on the management processes and communication processes prevalent within Thames Trains at that time.

9.11 A factor which may have affected the quality of driver training could have been the strain of the speed and scale of the recruitment in 1998 and 1999. Mr H Dunglinson, Human Resources Director of Thames Trains, said in evidence that over 80 employees were recruited and trained in 1999, out of a total complement which rose to 259 drivers. However, even allowing for these pressures it is unacceptable that such failures occurred in the training programme.

9.12 Thames Trains commissioned a review of training by Mr A Waters of Halcrow Transmark. His review of March 1998 concluded that:

> "… the driving and braking technique being adopted by drivers is to a very high standard. TT policy on defensive driving is being applied in practice and drivers are taking pride and ownership of the improvements gained in safety performance by the company… In general the company's commitment to developing a positive safety culture is reflected in the significant improvements which have been gained in safety performance".

9.13 In the accident at Royal Oak on 10 November 1995 a Thames Trains driver passed SN74 at Danger. The Formal Inquiry into this accident made 14 recommendations, all of which were accepted by the Safety Review Group on 20 March 1996. Three of these recommendations were directed to TOCs and related to the subject of driver management and training. The TOCs were to review the route learning methods and SPAD briefing techniques. Thames Trains were also required to carry out a risk benefit analysis regarding the fitting of ATP to Thames Turbos (see Chapter 8).

9.14 The response by Thames Trains to the recommendations on driver management and training was described to the Inquiry by Mr Franks, who was Production Director of Thames Trains from May 1996 for two and a half years and responsible for operational safety. He described weekly team meetings, monthly safety meetings and the production of a video and posters that were used to educate drivers. The Inquiry was also told of information prepared by Thames Trains about SPADs, such as a defensive driving pack in June 1996, and their "SPAD Strategy".

9.15 Mr Franks said in evidence that when he joined Thames Trains he was concerned about driver safety performance, for example, the fact that SPADs occurred at twice the industry rate. He appointed Mr Cobb as Safety Manager and set up a programme under the title "Signals Passed At Danger - A Strategy for Thames Trains". This programme was endorsed by the Board of Thames Trains on 23 July 1996.

9.16 Mr Franks undoubtedly had some success with these programmes. The Inquiry was told of a 70% improvement in SPAD performance between June 1996 and June 1998. However, more could and should have been done to organise driver training and management in a systematic manner.

SPAD performance

9.17 An expert report by Mr Fairbrother showed that, of the 67 SPADs that occurred in the Paddington area between February 1993 and July 1999, 33 were associated with Thames Trains. This was the highest number for any TOC, the next highest being First Great Western with 18. In regard to SN109, of the eight SPADs which occurred at this signal between August 1993 and August 1998, six were associated with Thames Trains. Counsel for ASLEF pointed out that Thames Trains operated more services out of Paddington than any other TOC and, because of the location of the platforms which they used, their trains were more subject to having to cross over between the Main and the Relief sides. Further, as providers of local train services, their trains were subject to more red aspects. While these points are correct as matters of fact, they underline the need for particular caution in view of the resulting increased risk of SPADs.

9.18 Mr Worrall, who joined Thames Trains in May 1999 after having previously worked with them as a consultant (employed by Halcrow) from November 1998, said that on his arrival at Thames Trains he recognised the initiatives already in place including action on the SPAD reduction programme, the use of the DRA and a monitoring process for driver performance. He said he asked Mr Chilton to prioritise driver issues, to examine staffing levels and to ensure that competencies matched needs. As a result he increased the number of senior driver standards managers and driver standards managers.

9.19 He commissioned Halcrow to examine driver training practices. He received their report "Validation of driver training process: Thames Trains" in May 1999. It confirmed that the SPAD problem still needed to be managed and that the driver training programme had still not been validated. Halcrow also pointed out that the training system did not meet Railway Group Standard GO/RT 3251.

9.20 The company addressed this poor SPAD performance and in a SPAD review in August 1999 Mr Waters of Halcrow discussed SPAD management. He said:

> "It is evident from the review the company is currently focusing considerable attention and resources on this subject in an attempt to reduce and mitigate the consequences of such incidents… The review has not identified any single area of significant concern".

9.21 The Inquiry also heard how the number of driver standards managers had been increased from seven to nine at each of the three train driver depots, and that an operations manager had been added in May 1999 to match the increase in the driver establishment and to cover the increased workload in training, assessing and monitoring the new drivers. However, it is unacceptable that despite these efforts driver Hodder and driver instructor Adams had not been made aware of the SPAD history of SN109.

9.22 As I narrated in Chapter 5, the Inquiry was told of the inadequacy of driver Hodder's training in regard to route knowledge and briefing on signals at which multi-SPADs had occurred. These failures to implement fully the Royal Oak recommendations were acknowledged by Mr Worrall. When I consider these failures, along with

Mr Adams' evidence that he was only aware that SN109 was a multi-SPAD signal after the crash at Ladbroke Grove, I must conclude that the implementation of these recommendations was deficient.

Communications

9.23 I have already referred in para 9.10 to the question of "corporate memory" in Thames Trains. This might also be thought of in terms of how well communications flowed within the company, and how well these communications were recorded and, in particular, understood. The Inquiry heard a number of examples of how poor communications had hindered good performance on driver training.

9.24 At senior management level, for example, the Inquiry heard evidence from Mr Worrall about how in March 1999 he had attempted to investigate what had prompted a driver re-structuring initiative. "I expected to find that there would have been some evidence as to what had prompted the project… I found no such evidence". Mr Worrall said that until November 1999 he was not aware of a video which had been produced in 1996 to show the driver's cab view of the approach to Paddington. Neither he nor anyone else could find a copy of the video or evidence that it had been used.

9.25 In another example of poor communication at driver level I heard how the one day SPAD avoidance and awareness training had not been given to the current group of drivers in training.

9.26 A report by Mr J Mummery to the Board of the Go-Ahead Group in November 1999, following his investigation of Thames Trains' management processes, found that "records are vague". Mr Baird, who devised the revised driver training package, said that whilst he was aware of the video of driver training which had been produced in 1996 and recommended its use, he had never actually seen it. When Mr Chilton took over he did not meet him or give him a formal handover. Mr Chilton said: "When I arrived… I could not put my finger on what was happening".

9.27 These examples of poor communication and poor record keeping are of considerable concern. It is essential that an organisation has a system to record what it has learnt, and a process to pass those lessons on to its employees. This is especially the case in a period of considerable business expansion and staff changeover, such as Thames Trains were experiencing.

9.28 With regard to drivers and signallers, there appears to be little or no formal communication or joint training between signallers and drivers. This is a major concern as they have to co-operate closely. I support the suggestion that has been made that signallers and drivers should jointly attend away days and other training processes to develop their mutual understanding.

9.29 The Inquiry heard evidence about the system of team briefings within Thames Trains whereby each driver received a written brief every four weeks covering operational matters and local issues. This written briefing process was reinforced by a rostered face to face meeting between the drivers and a driver standards manager. These meetings were held every eight weeks and it was expected that no driver would miss more than two consecutive briefings. I consider that a driver should have a face to face meeting with his or her driver standards manager at least monthly, if not more often, and that safety should be the first item on the agenda of these meetings. Thames Trains should ensure that they adhere to this frequency.

Route knowledge

9.30 Route knowledge is an important part of a driver's training. I have already referred to the admission by Mr Worrall that Thames Trains' training – which failed to ensure that Mr Hodder's route learning assessment questions specifically covered the area between Paddington and Ladbroke Grove – was inadequate.

9.31 Mr Chilton told the Inquiry of the methodology that Thames Trains employed in teaching route learning. He explained that there was no formal system. Drivers learned by driving the route with qualified instructors and drivers. The company did not provide route maps to help drivers learn this aspect of their job, or require drivers to prepare maps themselves, although there was evidence that some drivers did this on their own initiative, and on occasions shared the maps informally with each other.

9.32 Mr Chilton explained that a key part of the teaching process was an ad hoc questioning process between the driver standards managers and the trainees, but drivers were given no specific information on difficult aspects of the route (which would include, for example, multi-SPAD signals). Mr Winkworth, a driver assessor for Thames Trains, described the process which he used to test a driver's route knowledge. He asked verbal questions relating to the route and then filled out a route assessment card. Drivers were advised in advance of some 80% of the questions to be asked, and of the correct answers to these questions. The remainder were asked spontaneously and without warning. Mr Winkworth explained that most drivers answered all of the questions correctly and he had never found that a driver failed this part of the test. He said that there was no set pass mark given as a guide by management, but he never had any doubt in his mind as to what was a satisfactory pass performance.

9.33 As I said earlier in this chapter, Mr Adams, who was largely responsible for the training of driver Hodder, said that he did not consider the teaching of route learning to be part of his job. He explained that he taught drivers to drive from signal to signal. It was apparent that Mr Chilton was unaware of this gap in the teaching process until the day he gave evidence. He said that it was his belief that driver instructors were carrying out route training as part of the training in practical handling.

9.34 I conclude that there was a significant problem in the management processes for setting out the job descriptions appropriate to the trainers in Thames Trains.

9.35 Professor Groeger gave evidence about such training practices. He said that a lack of objective standards made it impossible to validate the assessment process. He was concerned that no specific criterion was being used by the examiners to determine whether a driver had competently handled a situation. He was also concerned about the lack of definition as to how frequently a driver should have to perform a task appropriately before being assessed as competent. He also stressed the need to define very specifically a level of deviation which was tolerated. I share these concerns, and I would expect Thames Trains to note the points raised as they further develop their driver training programmes.

Defensive driving

9.36 In guidance produced by Railtrack and the TOCs in November 1999 defensive driving was described as being about thinking ahead: "Know what you are driving; where you are driving; how you are driving; and how you are braking". It was also about reading conditions, knowing black spots and multi-SPAD signals, not taking chances by anticipating signals or other actions, stopping well short of signals or obstructions and "killing" speed to maintain total control.

9.37 The Inquiry heard from Mr Adams that he instructed his pupils in the principles of defensive driving. The Inquiry was also shown excellent training material used by Thames Trains to promote the principles of defensive driving. Driver instructors said that they did in fact use this material.

9.38 I have no doubt that drivers were given, for example, appropriate instructions in training material about the effect of sunlight. If a driver was unsure of the aspect of a signal because of sunlight, the advice was clear – stop and ask the signaller; "Do not take a chance". The Inquiry heard from Mr Adams that he gave these instructions clearly to driver Hodder.

9.39 On a more general consideration of defensive driving, I welcome the enthusiasm shown by TOCs towards following its principles.

Safety auditing of Thames Trains

9.40 Audits are an essential part of the management process. Their purpose is to assist management in identifying weaknesses in systems or procedures in order that they can address them.

9.41 Under the Railway (Safety Case) Regulations 1994 the infrastructure controller has to audit the TOCs to ensure compliance with their safety cases. Evidence was given about an audit of Thames Trains' management systems in 1999 which was carried out by Railtrack's Safety and Standards Directorate. This led on to an examination by the Inquiry of not only the findings of the audit, but also the quality of the audit, and the audit process. With regard to the latter Mr D Belmont, who was the principal auditor, said that he was concerned that senior management at Thames Trains had not given the audit due attention. He alleged, for example, that Mr Cobb, the Safety Manager, took annual leave during the audit and that he had also done so in 1998. Subsequently, it was shown that neither allegation was correct.

9.42 The audit process should start with a pre-audit meeting to establish the protocol and arrange for suitable involvement of management in the audit process. This should be followed by the audit itself, concluding with a de-briefing meeting with the management team, leading to a draft report inviting comments from the TOC and in due course a final report which should include a TOC action plan. It appears from the evidence that this process was followed but there seem to have been significant misunderstandings about what was communicated, or should have been communicated, at the de-briefing meeting. Mr Belmont asserted that he was critical of the Thames Trains processes in many areas including unprofessional certification of competence for driver assessors, a lack of route instructions or route maps and of details about multi-SPADs, and poor record keeping of trainees' performance. However, it may be noted that his allegations about the certificates of competence were not put in his formal report on the audit. His notebook for the audit was put in evidence. The entries in it were superficial. Nothing was entered under "Issues raised with the Head of Assurance", "Issues arising from the last audit" and "Issues raised by Lead Zone", which were matters calling for comment.

9.43 As against Mr Belmont's criticisms of the company in his report, Thames Trains drew attention to the meeting held to review the audit, which Mr Worrall and Mr Cobb attended with senior audit personnel from the Safety and Standards Directorate, who "complimented Thames Trains on the quality and comprehensiveness of the action plan".

9.44 It is clear to me that the audit process needs to be strengthened, that the quality of communication during the audit process needs to be improved, and that both parties need to understand clearly what was found during the audit and to discuss those findings at the de-briefing meeting so that the audit reports are agreed as a true reflection of the findings.

9.45 The HSE also submitted that the management of Thames Trains failed to disclose crucial safety information to the auditors. They particularly referred to the report on driver training processes which was provided by Halcrow to Thames Trains in May 1999, and to which I referred in para 9.19. This report included some criticisms of Thames Trains' training processes. In the submission of the HSE Thames Trains disclosed only what was favourable to them or what they were specifically asked for. Mr Cobb seemed to confirm this when he said "We would certainly disclose anything to our advantage and anything that he requested". When asked about the spontaneous disclosure of anything which was to Thames Trains' disadvantage, he replied:

> "The practice on Thames Trains is that we are perfectly straight with the auditors and if he requested self-certification documentation or internal audit documentation we would provide it. We would not hide anything from him even if it was to our detriment. We would be perfectly open and honest with the auditor".

This reply implied that whilst Thames Trains would answer any questions fully, they would not necessarily disclose information which was not the subject of a direct question.

9.46 It should be clearly understood that, since the purpose of an audit is to help an organisation improve its performance, it is not only to the organisation's advantage, but essential, that the organisation discloses all material and relevant information to the auditor in regard to the area of the activity being audited, at the pre-audit meeting or before it.

9.47 With regard to the quality of the audit performed for 1999, I consider that it left much to be desired. Unsubstantiated allegations were made which did not survive scrutiny in cross-examination, and the written reports are difficult to reconcile with Mr Belmont's verbal criticisms. This was an unsatisfactory way in which to perform an audit.

Driver licensing

9.48 The Inquiry heard a considerable body of evidence regarding the training and certifying of drivers.

9.49 Under Issue 3 of Group Standard GO/RT 3251, which was issued in December 1999, drivers must be tested on the Rule Book, on traction knowledge and route knowledge, and be trained in defensive driving techniques, addressing as a minimum potential hazards arising from cautionary and stop signals, weather and environmental conditions, approaching stations, buffer stops and other rail vehicles, and the failure or isolation of warning or protective systems. TOCs are also required under this Group Standard, at a frequency determined by the individual TOC, to review the effectiveness of the systems in place to deliver this level of competence. I recommend that this review should be conducted at least once every three years, and that the TOCs should retest the driver against the revised systems at the same frequency.

9.50 ATOC are carrying out a study on driver licensing which has indicated the scope for some central licensing, for example, on the testing of the Rule Book, and other areas of common interest. This process would have the benefit of being open to independent verification against the national standard, and might provide some cost benefits and improve the efficiency of the training. I recommend that this study be expeditiously progressed under the direction of ATOC.

9.51 The Inquiry was also informed that ATOC had retained Halcrow to review driver training. Recommendations from this review are to be incorporated into guidelines which the Safety and Standards Directorate of Railtrack (now succeeded by Railway Safety) will issue as codes of practice. Mr M R Wilsdon, of AEA Technology Rail, who was appointed to manage Railtrack's Ladbroke Grove Response Programme, stated that he was reviewing the standards relating to driver competence and training. He drew particular attention to safety briefings and defensive driving techniques. It is understood that after the crash every TOC carried out detailed briefing of drivers on multi-SPAD signals. Mr Corbett said in evidence that Railtrack had issued guidelines to ATOC about driver training and had provided a CD ROM to assist in the briefing of drivers about SPADs, and that the Safety and Standards Directorate were to ensure that driver training is covered in future audits of every TOC.

9.52 Mr Belmont informed the Inquiry of the limited use of National Vocational Standards D32, D33 and D44 regarding train driving and driver instruction. I recommend that ATOC consider the application of these standards to the driver licensing scheme presently under their consideration.

9.53 Counsel for the bereaved and injured submitted that a formal set of procedures should be put in place to ensure that drivers were kept abreast of the latest developments in driving techniques, and routinely informed of problem areas on the network and relevant accidents as they occur and are analysed. This suggestion of continuous improvement has much merit. I will consider the general issue in my report on Part 2 of this Inquiry.

The use of simulators

9.54 Simulators are extensively used for the training of airline pilots, and in many countries for that of train drivers. However, only limited use appears to have been made of them in the UK railway system in recent years.

9.55 Mr Worrall's attention was drawn to page 139 of the Thames Trains Driver's Manual which stated that: "particular attention should be applied to rules, infrequently applied emergency skills, and procedures… ". Mr Worrall agreed that simulators would be an appropriate way to address this requirement and indicated that Thames Trains would be proceeding with their use.

9.56 The Inquiry also heard from Mr A Carroll, Managing Director of First Great Western, that his company agreed with the use of simulators and that their introduction would be progressed. I support these initiatives, especially for their use in regard to complex junctions.

"No blame" culture

9.57 The HSE for many years have encouraged a "no blame culture" within the rail industry, as elsewhere, in an endeavour to ensure that all incidents, including near misses, are reported so that they can be investigated thoroughly without concern about punishment or criticism. Mr Worrall said that a no blame culture had been developing on the railways since the late 1980s, aimed at encouraging employees to report all incidents so that they could be properly investigated. He told me that this had been supported and developed by Mr Franks at Thames Trains and that he himself had continued with it. He stressed that it was not only for drivers but applied to all staff.

9.58 Mr Worrall referred to the review by Mr Waters of Halcrow in October 1998 which analysed reports of the nine SPADs that had occurred with Thames Trains between 18 March and 11 October 1998. Eight of the nine instances had been classified after investigation at the time as having been caused by "driver distraction".

9.59 There is a potential drawback in a "no blame" culture. The Inquiry heard evidence that to most drivers a SPAD is a traumatic incident and that there is a possibility that they accept blame in order to conclude the investigation as quickly as possible. This belief is reinforced by the fact that 85% of SPADs are reported as "driver error". In an examination of the SPAD investigation process mentioned in para 9.20, Mr Waters questioned whether the SPAD investigators were getting to the root cause of the incidents. He said "Basic and underlying causes need to be identified and recommendations [made] more meaningful… ". I am led to conclude that the ready acceptance of "blame" by drivers, encouraged by the "no blame" culture, may have contributed to this poor analysis of root causes.

9.60 The Inquiry heard from Dr Lucas of the HSE of her interpretation of an acceptable no blame culture. Rather than a blanket assertion of no blame, she preferred the phrase "justifiable blame". She made the point that if someone had broken a serious rule they should not be able "to get away with it". This is an important point: people must be accountable for their actions. I agree with this, and commend to the industry the development of a culture in which information is communicated without fear of recrimination and blame is attached only where this is justified.

9.61 A confidential reporting system, CIRAS, is now in place across the industry. This allows employees to report safety-related incidents confidentially. It undoubtedly enables "near miss" incidents to be reported and receive attention. It also enables incidents to be categorised by type and location, and to measure trends. It has great merit. It is to be hoped that in the longer term the culture of the industry would be such as to make confidential reporting unnecessary. I accept that this situation may be a long time in coming to pass in the industry. In the meantime I fully support and encourage the further use of the CIRAS system.

Human factors

9.62 Human factors can be thought of as the interplay between the operator, the machinery and the working environment. Professor Groeger gave evidence of his concerns about the appreciation of the human factors in driver training and performance.

9.63 Considering the human factor question of memory, he referred to a comment made by Mr Chilton that training requirements dictate that there should remain a great deal of discretion and flexibility in the way training is conducted. Professor Groeger's concern was that this flexibility might involve the risk that a driver might not be trained in how to perform in particular circumstances. He went on to question the criteria used during the testing of trainee drivers and especially how frequently a driver had to perform an operation successfully before he or she could be considered competent.

9.64 I share these concerns in regard to the need for specific, relevant and validated criteria for testing trainee drivers. Thames Trains and other TOCs should ensure that these are adequately covered by their driver training and testing programmes. Drivers should be tested against these criteria, and a definite pass standard should be established. Consideration should be given to how often drivers should repeat key steps in their training before submitting themselves for testing.

9.65 The Inquiry also heard from Professor Moray about how visual attention is distributed amongst a number of tasks which have to be performed at the same time. He explained, for example, how drivers must at the same time look out for signals, monitor their speed, observe the track, look for speed restrictions and look at their documentation. Using a well established statistical analytical technique, and assuming drivers could switch their visual attention every second, he said that on about half of the occasions they were carrying out these tasks they would return to any point of observation in about four seconds, and that on a quarter of the occasions more than 7½ seconds would elapse. He also pointed out that since these times were averages, on occasions the time interval could be considerably longer. Under these conditions there was a possibility that a driver's attention would be elsewhere when a significant event occurred. He suggested that it was important, therefore, during training, to give drivers instruction on how to assess priorities in complex situations. He also stated that to ensure that a driver would always stop at a red signal, and considering the many human factors involved, the driver should be given technical assistance by automatic braking devices.

9.66 Professors Groeger and Moray suggested that further research should be carried out to develop the understanding of human factors as they are related to train driving and I endorse this suggestion. Dr Lucas said that she agreed with Professor Groeger who said in evidence:

> "I think that most of us, in whatever walk of life we are in, would be uneasy if we were expected to perform at our absolute maximum on every single occasion".

9.67 It is essential that the industry redoubles its efforts to provide a system of direct management and training that is secure against ordinary human error whilst endeavouring to reduce the incidence of such human error to an absolute minimum.

Chapter 10
Her Majesty's Railway Inspectorate

Introduction

10.1 This chapter is concerned with the performance by Her Majesty's Railway Inspectorate (HMRI) of their responsibilities in regard to the track and signalling with which earlier chapters have been concerned. Since 1 December 1990 the HMRI have formed part of the HSE. The Inquiry heard the evidence of a number of members of the Inspectorate, including Mr A Cooksey, Deputy Chief Inspector, Dr R J Smallwood, Deputy Chief Inspector and Mr V P Coleman, Chief Inspector, along with Miss Jenny H Bacon, at that time Director General of the HSE. The Inquiry also had the benefit of considering a report by an inquiry board set up by the HSE to examine their role in regulating safety on the railways with regard to the crash at Ladbroke Grove, within the context of the existing regulatory framework applicable to railway safety, and in securing compliance with regulatory requirements by the infrastructure controller and other duty holders involved in the crash. I will refer to that report as the "Internal Inquiry Report". The Inquiry was also furnished with a report on some general issues arising from the internal inquiry. The latter report is principally concerned with matters with which Part 2 of the Inquiry will deal.

10.2 I will deal with the subject under the following headings:

- the application for approval of the scheme (paras 10.3-10.11);
- the problems in the Paddington area (paras 10.12-10.16); and
- matters of concern (paras 10.17-10.23).

The application for approval of the scheme

10.3 On 26 February and 22 April 1993 the HMRI, through their Technical Division, granted InterCity Great Western provisional approval of the component parts of Phase 1 of the scheme for resignalling from Paddington Station to Kensal Green. This was subject to the works being inspected in due course. It was stated that there was no objection to the works being brought into use before such inspection, subject to there being compliance with any requirements of the inspecting officer.

10.4 On 5 April 1994 the provisions of the Road and Rail Traffic Act 1993, which had previously governed the procedure for approvals, were replaced by the Railways and Other Transport Systems (Approval of Works, Plant and Equipment) Regulations 1994. In terms of these regulations approval required to be obtained from the Secretary of State for Transport (in practice the HMRI) before any new or altered works, plant or equipment which were capable of materially affecting the safe operation of a railway were first brought into use for the purposes of that railway. Unlike the previous legislation the regulations did not permit the HMRI to grant provisional approval, with or without conditions. Regulation 4(4)(a) provided that, in ascertaining the time when new or altered works were first brought into use, no regard was to be had to any period during which they were "necessarily used in order to avoid interruption to the operation of existing transport services before sufficient information is available for a decision to be made on an application for approval". In the result, therefore, where it was necessary to avoid such interruption, the new or altered works could be used for an extended period pending the availability of sufficient information for a decision to be made by the HMRI in regard to the application for approval. Unhappily this is what happened in the present case.

10.5 The inspection by the HMRI of Phase 1 of the resignalling scheme took place on 31 January 1995 and the two following days. On 8 February 1995 Mr Cooksey wrote to the Zone Director warning him that there were some issues which needed careful consideration and might result in full approval not being possible. Mr Cooksey wrote again to him on 1 March 1995 stating that he was unable to give approval to the works, and enclosed a list of items which should be dealt with urgently to bring the installation to an acceptable standard. The items, which were 27 in number, included as No. 22:

> "There are a number of instances where the signals are considered to be poorly positioned from a driver's sighting point of view…".

The letter also drew attention to the fact that there had been 31 SPADs in the newly signalled area over 1993 and 1994, of which over a quarter had occurred in the latter half of 1994. Mr Cooksey stated:

> "The level of instances of Signals Passed at Danger gives rise for concern in view of the fact that the inspection team identified signal sighting problems today which are likely to be made worse when structures and catenary systems are erected for the Overhead Electrification. Please provide HMRI with details of measures taken to reduce the unacceptable level of SPADs in such a small area".

The letter ended by pointing out that until the matters above had been resolved and the 27 items on the enclosed list had been attended to, formal approval could not be given, and that a further inspection would be necessary. The inspection which had taken place had involved inspectors from the Technical Division of the HMRI along with a number of field inspectors. The inspection process was essentially a sampling process of the built installation to confirm so far as was possible that standards had been complied with, along with the quality and sustainability of the equipment. The inspection team also planned to review the documentation relevant to the signalling works, for example, testing records, signal sighting forms and SPAD reports. Mr Cooksey wrote a second letter to the Zone Director on the same date, indicating that, in accordance with Regulation 4(4)(a), the HMRI had no objection to the works remaining in use until attention had been given to the outstanding matters.

10.6 In a letter dated 17 May 1996 – which was over a year later – Mr Southwell, the Project Manager, advised the HMRI of the current position in regard to the outstanding works. He claimed, inter alia, that there had been eight SPADs in 1995/96, compared with the 31 in 1993 and 1994 referred to by Mr Cooksey. In regard to item No. 22 of Mr Cooksey's list, Mr Southwell stated, as I have narrated earlier in para 7.36:

"… with the introduction of the electrification works, a detailed signal sighting exercise has been completed and the effect of electrification equipment has resulted in negligible effect to signalling".

It is evident from the evidence that the HMRI relied on the statement about "a detailed signal sighting exercise" and, as the Internal Inquiry observed, did not find it necessary to challenge the assessment which the letter contained. While it is understandable that the HMRI had no reason to doubt that Railtrack had complied with their obligations in regard to signal sighting, it is to be noted that the letter did not provide assurance that measures had been taken to reduce SPADs.

10.7 After the inspection of Phase 2 of the scheme in October and November 1996 Mr D Timothy, Principal Inspector, HMRI, wrote to the Zone Director on 11 November detailing a number of points which required action. These included the following: "I shall be pleased if you will confirm that the whole of the Paddington to West Drayton resignalling has been subject to a Layout Risk Analysis and that the provision of Automatic Route Setting has been fully taken into account". On 15 January 1997 Railtrack wrote to the HMRI enclosing completion certificates for both phases. Appended was a status report which repeated that the number of SPADs had been reduced to eight in 1995/96, and stated: "Formal Layout Risk Assessment has not been carried out, as the scheme was designed and implemented prior to Railtrack". The HMRI regarded the certificates as unacceptable because not all of the relevant works had in fact been completed.

10.8 It may be noted that Railtrack wrote to the HMRI on 10 February 1997 giving details of a scheme of revised line identity signage in the approaches to Paddington Station "to assist drivers to recognise better their position within the layout". The HMRI indicated that this required approval under the 1994 Regulations. Railtrack suggested that the question of acceptance should be deferred as what was proposed was only experimental. In the event the scheme for this signage remained unapproved.

10.9 On 27 March 1997 Railtrack wrote to the HMRI pointing out that layout risk analysis was new and was not required retrospectively, but confirming that a risk assessment of platform starting signals had been carried out. On the same date Railtrack sent to the HMRI a list of actions and timetables to enable approval of Phases 1 and 2 of the resignalling scheme to be granted. It appears that these actions were still being implemented when the crash at Southall occurred on 19 September 1997. The HMRI then took the view that it was inappropriate to approve the resignalling scheme until the Inquiry into the crash at Southall had been concluded and any concerns which had been raised about signalling had been taken into account. Unfortunately that Inquiry was greatly delayed by having to await disposal of a criminal prosecution. It was still under way when the crash at Ladbroke Grove took place.

10.10 In the result, the resignalling scheme was never approved prior to the crash at Ladbroke Grove, and no action was taken on revised certificates of completion which had been submitted by Railtrack. In contrast, the Heathrow Express scheme was treated differently, in respect that it was part of a new railway and hence not covered by Regulation 4(4)(a). It was approved by the HMRI on 12 December 1997.

10.11 The Internal Inquiry questioned whether the approval process for Phase 1 of the signalling scheme had been operated with sufficient urgency; whether, as operated, it should have picked up the unusual nature of SN109 which I have described in Chapter 7; and, if so, whether it did so. Mr Cooksey accepted that the HMRI were "concerned about their ability to close down this particular scheme". They had about six Inspectors, roughly half what the complement should have been. A lot of new work schemes were coming through.

> "We were simply overwhelmed with work. We had gone from something like 350 maybe 400 active schemes to something in the order of 1,300. During that sort of period we were dealing with schemes like the Jubilee Line Extension, which was an enormous drain on our resources. We were dealing with Channel Tunnel rail link, we were dealing with the development of the West Coast Main Line project. We had something like 20 odd different train builds in progress. And we are concerned about the time it has taken to close out this scheme; I am not hiding that at all. But it has to be put in the context of all the other things we were trying to do at the same time".

While it is not difficult to appreciate that the HMRI were facing a considerably increased workload, this surely entailed that management should have pressed for increased resources.

Problems in the Paddington area

10.12 The problems in the Paddington area also came to the attention of the HMRI's Field Operations Division. Counsel for the bereaved and injured correctly pointed out that in March 1995 the HMRI had identified signal sighting problems in this area and were aware of a high rate of SPADs. However, they had never verified whether their concerns about signal sighting were borne out. The HMRI field inspectors investigated the serious SPAD at SN109 on 4 February 1998. By that time there had been five SPADs since 1993 at each of SN109 and SN63.

10.13 The HSE submitted to me that the HMRI relied on assurances given by Railtrack as to the actions which would be taken to follow up the investigation of the SPAD on 4 February 1998. I have referred in Chapter 7 to a number of recommendations made by the Formal Inquiry which were not in fact implemented. Miss Bacon said that this was a good example of "where we were told things were going to happen. We took that on trust and did not issue an improvement notice". She added: "With the benefit of hindsight, it might have been a good thing if we had done so". The Internal Inquiry observed that it was the responsibility of Railtrack to follow up the recommendations of the Formal Inquiry, but questioned whether there should have been more follow up by the HMRI of the activities of the field inspectors.

10.14 One of the consequences of the SPAD on 4 February 1998 was the proposal that flashing yellows should be removed from signals leading up to SN109. The HMRI were clearly in support of this proposal from an early stage. Thus Mr Harvey, one of the field inspectors, when writing to Mr Robson, Railtrack's Safety and Standards Manager, on 16 March 1998, referred to the flashing yellows as being potentially misleading as well as of minimal benefit. He observed that there was some similarity to what had happened in an incident at Colwich. Dr Smallwood went so far as to describe the removal of the flashing yellows as a "major improvement". However, it is important to note that in his letter of 16 March 1998 the inspector said: "You mentioned the previous history of trains passing signal SN109 at Danger, and that you were in the process of reviewing options to address the remaining risk if the flashing aspect sequences on approach are removed. Please advise me of your conclusions". There appears to have been no response to this enquiry and, more importantly for present purposes, no pursuing of this enquiry by the HMRI. This was in the aftermath of a SPAD which Dr Smallwood described as a "near catastrophe", and which was referred to at the Inquiry as a "dress rehearsal" for the SPAD on 5 October 1999.

10.15 It may be noted that Mr John White, a field inspector, was present at the first meeting of the Golden Two Miles Group which took place on 15 January 1999 and was attended by representatives of Railtrack and FGW. Mr White gave evidence that he was left in no doubt as to the seriousness of the SPAD problem in the first two miles out of Paddington. It was his first inkling that the Zone believed they had a "big problem in the area". It may be seen from the minutes of that meeting that one of the possible solutions which was mentioned was the provision of additional AWS ramps on the approach to SN63 and SN109 on lines 3 and 4, although, surprisingly, there is no mention of the possibility of uni-directional running or of installation of co-acting signals. From this meeting the HMRI could reasonably infer that Railtrack were pursuing solutions beyond that of the removal of flashing yellows, and that Railtrack were taking all appropriate steps to reduce the risk of SPADs at SN63 and SN109. At about the end of January 1999 flashing yellows were removed and in due course this was formally approved by the HMRI. This did not imply that the HMRI approved the resignalling scheme as a whole. It is plain that approval specifically related to the removal of flashing yellows.

10.16 What I have narrated above can appropriately be considered against the background of the HMRI's decision, in view of the increase of SPADs in 1998/1999, to conduct a national audit of Railtrack's SPAD management. This showed that SN109 was one of the 22 signals which had been most frequently passed at Danger. This project involved the inspection of SPAD management systems over a period of several months, leading up to its completion in early 1999. The report was not published until September of that year. It listed 22 actions which Railtrack were required to take. Dr Smallwood was asked why the HMRI had not taken enforcement action. He said that this had depended on whether it was justified, how the resources of the HMRI should best be deployed, and the risk of demotivating those who were doing good work. It was, he said, a "close call" whether such action was taken.

Matters of concern

10.17 In her evidence Miss Bacon summarised the concerns of the HSE in regard to the activities of the HMRI. She candidly accepted that the HMRI could have done more. The HSE were concerned about, first, the length of time taken for the approval of the signalling scheme; secondly, the slow progress by Railtrack and the HMRI in bringing issues to a conclusion; and, thirdly, the inadequate risk analysis. She also regretted that after the SPAD on 4 February 1998 matters had not been followed up with more urgency. More could have been done to enforce health and safety legislation.

10.18 Miss Bacon attributed these deficiencies to three causes:

(i) a lack of resources on the part of the HMRI;

(ii) a lack of vigour by the HMRI in pursuing issues; and

(iii) the placing of too much trust in the duty holders.

10.19 As to the first of these causes, I have already referred to the evidence given by Mr Cooksey about the Technical Division to which the problem about resources particularly applied. The HSE had stated that at 1 April 1999 there had been a shortfall of 24 personnel in the HMRI, including 16 inspectors. When Miss Bacon gave evidence on 14 July 2000 she said that additional inspectors had been recruited, and at that time there were the equivalent of 69.5 inspectors in post, against the target of 71. However, this was after the importation of personnel from other branches of the HSE through a process of "brigading". At the same time, Miss Bacon told the Inquiry that, if the HMRI were "to continue to operate a rather light touch form of regulation", they could do with something like 25% more staff than they had at the moment. She said that with this, and a much sharper prioritisation of work, the HMRI could (a) tackle some of the overworking and "try to get a better grip on what is going on", and (b) deal with the additional burden of handling the safety cases of TOCs under the forthcoming regulations:

> "I think we could begin to make much more of an inroad into the approvals and adopt a much more proactive stance than we are currently able to do on inspection audit and making full use of safety cases, which at the moment I do not think we are able to do".

On the other hand, additional burdens such as handling the safety cases of TOCs under the forthcoming regulations would require substantially increased effort. A bid had been made for a significant increase in resources. She also said:

> "We are not as far off it as we would be if we were to operate a regime which was much more interventionalist, got much more into prescriptive regulation rather than goal-setting, and relied rather less on self-regulation in the Robens sense that you are fully familiar with and much less on the duty holder actually complying, having a will to comply, in all respects. If that is the kind of regulatory regime that we are going to need to put in place, to try to secure that disasters of this kind do not occur in the future, then there has got to be a political process that stands behind that and says this is what is in the public interest and this is what the Government wants to devote its resources to; we are looking at a very, very much larger organisation than we have at present".

By the "light touch form of regulation" and "self-regulation in the Robens sense" she referred to the approach set out in the report of the Committee on Safety and Health at Work, under the chairmanship of Lord Robens, Cmnd 5034, 1972.

10.20 As to the second of these causes, this is plainly a matter which is wholly within the control of management. It is for management to learn the lessons of what has taken place in the past.

10.21 As to the third Miss Bacon said:

> "The idea of BR's public sector responsibility as something to be relied on has died hard and indeed was perpetuated by Railtrack's initial assertion that it was the directing mind for safety on the railway. Reality has not lived up to expectation, but expectation has affected the HMRI's attitudes to industry standards to enforcement and toughness and checking follow-up and follow-through… HSE as a whole were assuming compliance and that duty holders would exercise their responsibilities, because that was very much part and parcel of what we had expected from BR and we did not feel the need to intervene, to probe, to audit, to inspect as much when you had a single body exercising its responsibilities in that way".

Referring to evidence at this Inquiry, she said:

> " People that I have spoken to who have been listening to witness evidence and have read transcripts I think have been quite shocked is not too strong a word at the degree to which they think that to some extent they have had wool pulled over their eyes or have simply not been kept in touch. On one or two occasions it is wool pulled over the eyes, more generally it is not being in touch with what has been going on with thinking in the industry, where in the past they certainly would have expected to and where we really would have expected to also as regulators of people who were taking their responsibilities as duty holders seriously".

10.22 In the light of the evidence which I have heard I have no doubt that the criticisms expressed in the Internal Report and candidly accepted by Miss Bacon are well founded. For the deficiencies which could have been corrected the management of the HMRI must take responsibility. However, the root causes of these deficiencies go much deeper since they involve questions of resources on the one hand and of the relationship between the HMRI and the duty holders, and in particular Railtrack, on the other. I should add that there is no basis on the evidence before me to suggest that there was a specific action which the HMRI should have taken which would have prevented the crash on 5 October 1999. That is not to say there is no need for change. Miss Bacon said that the HMRI now were less willing to accept, when Railtrack or other companies said that something was going to be done, that it would be done and that it would be done on the timescale in particular that was promised. She added:

> "We have had some quite bad experiences of timescales being promised which simply have not been kept to or kept to in only a sort of vestigial carrying through of things that had been expected".

10.23 Questions relating to the future of the functions presently discharged by the HMRI as part of the HSE with respect to railways, and the way in which these functions may be or should be discharged in the future, are matters with which I will deal in my report on Part 2 of this Inquiry.

Chapter 11
Signal sighting

Introduction

11.1 This chapter deals with a number of signal sighting issues arising out of Chapters 5 and 7. It does not pretend to be a treatise on the subject of signal sighting. In writing this chapter I have drawn upon the evidence given by expert witnesses, the report of the committee of experts on signal sighting and the report by W S Atkins "Initial Study of Signal Sighting Practice on Railtrack Infrastructure", Issue 1, 6 March 2000, to which I referred in para 2.26. For brevity I will refer to it as the report by W S Atkins.

11.2 The topics with which I will deal are as follows:

- the effectiveness of signals (paras 11.3-11.8);
- the Group Standard on signal sighting (paras 11.9-11.18);
- the report by W S Atkins (para 11.19);
- signal sighters (para 11.20);
- signal sighting committees (paras 11.21-11.24); and
- the investigation of SPADs and the reporting of signal deficiencies (paras 11.25-11.33).

The effectiveness of signals

11.3 The overall objective of signalling arrangements is that the train driver has adequate advance sighting of his signal and receives a clear and unambiguous message from it. Thus this is the stated purpose of the positioning of signals to which the Group Standard on signal sighting, GK/RT 0037, Issue 3, December 1997 applies.

11.4 The full implications of what is needed to attain that objective are important. It is necessary to take account not only of signal visibility but also of the driver's ability to take cognisance of the signal. It appears that in the past the limitations of human ability were not adequately taken into account. It was assumed that drivers would obey signals which were visible. However, as W S Atkins point out in their report, a number of recent studies:

> "… have emphasised the need for the driver not only to have a clear view of all the relevant signals but also to have the information from those signals presented in a way that enables him/her to gain a clear understanding of the message being conveyed".

Accordingly, signals require to be not only visible but also readable.

11.5 The wider subject of human factors is one on which much has been written. Railtrack informed the Inquiry that they had instructed experts in response to Recommendation 1 of Professor Uff in his report on the Southall crash, which was:

> "All parties in the rail industry should co-operate in the collection of evidence to support reliable research into human behaviour studies relating to driver performance. Railtrack should co-ordinate this work and TOCs incorporate the results into training programmes".

In the course of the evidence of Mr Martin Brown, Assistant Chief Inspector of Railways, HMRI, reference was made to a review of human factors literature relating to signals passed at Danger which had been carried out by Ms Karen Wright and Dr David Embrey in June 1999. This listed a large number of factors which could have a bearing on whether a train driver passed a signal at Danger. They included not only matters personal to the driver and his or her knowledge, skill and training but also factors such as track curvature, physical environment, variability of the positioning of signals, signal clarity, visual ability, route expectations, route signal checks and distractions. These are some examples of things which may affect the successful operation of what Professor Moray referred to as the "human-machine system" which is the railway.

11.6 A more detailed analysis of the demands which a complex layout may make upon the recognition and interpretation of signals by a train driver may lead on to a study of matters described by Professor Watt and Professor Groeger in their evidence, such as visual discrimination, the dynamics of visual attention and the impact of temporary interruptions.

11.7 It is by now well recognised that poor signal sighting may affect driver performance. Thus the SPADRAM report "Driver Distraction: Factors Which Influence Driver Performance and Safety", October 1996, to which I was referred by Counsel for ASLEF, lists at para 6.5 a number of examples, including signals positioned on bends, signals positioned close to each other and obscured signals. In their report W S Atkins state:

> " Poor signal sighting decisions may not be immediately apparent, but tend to leave their legacy for many years and are commonly very costly to rectify… Drivers have every right to expect a well sighted signalling system on their route and must be encouraged to insist upon that right. There will, inevitably, be instances where the signalling system cannot, for a number of reasons, meet the drivers' expectations. It is the responsibility of the system managers and train operators to analyse these sub-standard installations and apply appropriate risk control measures rather than relying on driver tolerance and local knowledge to overcome the shortfalls of the signalling system… Tolerance of sub-standard signalling cannot be allowed to become the norm".

In his evidence Mr Wilkins, while recognising that the signal sighter cannot eliminate mistakes, pointed out that there was a danger in working to minimum standards:

> "The minimum distance is nothing better than a minimum distance. Good practice is to ensure that twice the minimum distance is available where this can be reasonably achieved".

11.8 Signal sighting plainly requires attention throughout the life of a signalling system. It has to be undertaken at an early stage in the design process. While paper exercises may be valuable, there is no real substitute for signal sighting in situ. The signal sighting process, as W S Atkins state, takes the design and adapts it to take account of the situation "on the ground". The maintenance and repair processes which are needed to check and maintain the performance of the signalling system have to look at the signal sighting and alignment, and alert signal sighting committees to any changes which might have a detrimental effect on the signal performance. There also have to be regular review and feedback processes to ensure that potential weaknesses are identified and corrected at an early stage. Part of this is the process of learning from, disseminating, and applying, the results of investigation of SPADs, to which I will refer later in this chapter.

The Group Standard on signal sighting

11.9 As I stated in Chapter 5, Mr Wilkins drew a clear distinction between the visibility of a signal and its readability. Though the Group Standard on signal sighting declares that its mandatory requirements are, inter alia, "to convey a clear and unambiguous message", it does not, as he pointed out, require the signal sighter to take into account factors which are relevant to the readability and hence to the driver's interpretation and understanding of signals. Mr Wilkins warned against accepting the meeting of minimum requirements as adequate: "When sighting signals it is always important to maximise the driver's view".

11.10 Section 4.1.2 of the standard states in regard to sighting distances for a signal:

> "Signals shall normally be positioned to give drivers an approach view for a minimum of seven seconds and an uninterrupted view for at least four seconds. Where these timings cannot be achieved but the sighting committee is satisfied that an adequate approach view is achieved (i.e. the signal is viewed for long enough for the driver to assimilate the aspect and indications displayed by the signal), the sighting committee shall record their decision and reasoning on the signal sighting form.
>
> If these sighting distances cannot be achieved (and there is not an adequate approach view at a lesser distance), a banner repeating signal (see section 4.5) or co-acting signal (see section 4.6) may be required.
>
> Note: Interruptions of very short duration (e.g. caused by overhead line equipment) may be ignored when determining the uninterrupted sighting distance…".

11.11 Mr Wilkins stated that the periods of seven and four seconds had stood for the past 20 or 25 years. In Annexe A to their report W S Atkins comment on this rule as being "probably the paramount measure". They also state that the reputed rationale for the seven seconds was two seconds to identify the aspect, three seconds to assimilate meaning and two seconds for loss of sight as the train closed on the signal. The standard for signal sighting which was first issued in October 1994 introduced the word "normally" and added the note which appears in the current issue.

11.12 In their report W S Atkins comment that there is a need to re-define the criterion for the minimum approach view of main signals in order to take account of a number of factors including "the need for a greater assimilation time when approaching a complex array of signals" and "quantification of the rules for dealing with partial obscuration of a signal". Mr Wilkins said that it might be necessary to take the view that where there were a large number of signals which were simultaneously visible, and the driver had to differentiate between them before he could read them, the sighting time should be increased, perhaps to ten seconds. As I have already narrated in Chapter 5, he strongly distinguished signals standing on their own from signals which were mounted on a gantry. However, the only reference to a gantry in the current issue of the standard is contained in the following passage in section 4.1.3:

> "In all cases, and particularly where signals are mounted on gantries or on the right hand side of the line, care must be taken to ensure that confusion does not arise as to which line the signal applies. Care must also be taken to ensure that confusion cannot arise from inconsistencies in signal positioning along the route".

This provision has been part of the standards since Issue 2 of February 1996.

11.13 The standard on signal sighting should, in my view, be revised so as to require that explicit consideration is to be given to the readability of a signal, as well as its visibility, in judging its adequacy. It also should be made clear that the fact that a signal complies with a minimum requirement is not of itself to be taken as meaning that it is adequate. The significance of a minimum requirement should be understood as being that if it is not achieved the signal is necessarily inadequate. The standard on signal sighting should also deal explicitly with the additional time required for the reading of certain signals, including (but not necessarily limited to) those mounted on gantries. I agree with the submission made to me that human factors experts should be involved in the revision of the standard, particularly by assisting in the description of readability and the way in which it should be assessed, and in the formulation of the additional time to be allowed for reading the types of signals referred to earlier in this paragraph.

11.14 The reference in the standard to "very short duration" was of concern to the committee of experts on signal sighting. In their report to the Inquiry they drew attention to its considerable ambiguity, stating that it was uncertain what was meant by it. "It is understood that, at the time the standard was drafted, the nature of the interruption was expected to be confined to wires and droppers and more substantial items such as insulators, heavy brackets and bridge girders would not be tolerated". This may be compared with the evidence of Mr Bray to which I referred at para 7.13. I agree with the committee that the reference in the standard should be clarified. Mr Fairbrother observed in his report to the Inquiry that this expression gave too great a degree of flexibility and was too open to interpretation to permit the consistency of signal readability which was essential. In his view it should be clarified, and there should be a retrospective provision to identify areas where the ambiguous wording may have caused, or may still cause, problems. I agree with the submission that there should be a retrospective review of all locations where this may be the case, so that appropriate action may be taken.

11.15 Mr Wilkins commented in his evidence that it might be that the better approach would be to express the proportion of the aspect that might be obscured, and to impose a time limit on that obscuration e.g. half of the aspect for only two seconds. "We are unlikely to go along the lines of saying that the whole of it may be obscured for any longer". While bridges and overhead line equipment could not be eliminated, it was a question of taking steps to minimise the obscuration

11.16 What is meant by "overhead line equipment" in the standard should be clarified by stating that this expression refers only to wires and droppers. Acceptable limits to the temporary obscuration of a signal should be defined. This should, however, be subject to the overriding right of a signal sighting committee to determine whether the nature and extent of the interruption in the individual case is such that the sighting is unacceptable.

11.17 Section 4.1.9 of the standard on signal sighting states in regard to cab sight lines: "All signals must be positioned to fall within the cab sight lines of all rolling stock currently authorised to use the route (refer to GM/RT 2161)". The committee of experts observed:

> "Whilst the standard calls for positioning of the signals to fall within the cab sight lines of all rolling stock currently authorised to use the route, it is silent on what those sight lines are or how they are to be defined. It is understood that standards for rolling stock specify an envelope governing the position of the driver's eye and it is felt that this same envelope should be set out in the signalling standard so as to enable signal sighting committees to come to an appropriate view as to whether or not the sighting of a particular signal was compliant".

I endorse this.

11.18 The committee also referred to the fact that the Institution of Railway Signal Engineers had been invited by Railtrack and the HMRI to consider the wider implications arising from the crash and to examine the current standards and principles which were used to design, implement and maintain railway signalling systems. This invitation had been accepted by the Institution on the basis that the work would be done independently and impartially and that whatever resulted would be in the public domain.

The report by W S Atkins

11.19 This report contains a large number of recommendations going beyond the scope of what was discussed in the Inquiry. I commend the work of W S Atkins for the further attention of the railway industry and the HMRI.

Signal sighters

11.20 W S Atkins point out that in the aftermath of the Southall crash in 1997 there was a renewed upsurge of interest in signal sighting matters. The crash at Ladbroke Grove turned the upsurge into an "explosion". In these circumstances I view with concern what they say about signal sighting expertise. Very few of the processes of signal sighting have been documented below the level of Group Standards. There is very little understanding, outside the signal sighting community, of the true nature of the role of signal sighting, the base line criteria or the "rules of thumb" against which signals are judged. It is seen as a dying art, in which the expertise mainly comes from a small cadre of specialists who had learned their trade "on the job" in the days of British Rail. Since the art of signal sighting was to achieve the best compromise in particular situations, the consequence was that wide powers of discretion were left to the signal sighting committee:

> "The major risk inherent in such an approach is that there will be limited control on those determined to design to the absolute minimum. This risk increases the need for controls on the competence of all involved at any level in the signal sighting process, including those endorsing and those countermanding signal sighting committee decisions".

In my view Railtrack, in consultation with the TOCs, should examine the availability of signal sighters to meet the expected workload and take all necessary steps to ensure that there is an adequate supply of trained signal sighters, and an adequate range of skills.

Signal sighting committees

11.21 As I have narrated in Chapter 5, the Group Standard on signal sighting (GK/RT 0037) requires a signal sighting committee to be convened to view the position and form of all new and altered signals, including associated notice boards and indicators. In the light of the requirements of that standard as to the recording of the committee's decisions and the maintenance of those records by Railtrack, there should be no doubt as to when the committee has or has not been convened. It is the responsibility of management to ensure that identified persons have the duties of convening the committee and of monitoring that this is done within a satisfactory timescale. I note from section 3.3 of the standard that Railtrack do not have to accept the decision in all circumstances, but if they do not do so, the reasons for this are to be recorded on the signal sighting form. In that case a further signal sighting committee is to be convened to re-examine the signal concerned and to decide on an effective form and/or position for the signal to satisfy the requirements of the standard, and also to meet the design and other project criteria. It may be noted that it is stated: "Sighting considerations must be regarded as paramount; where no other solution is available, the design shall be altered to enable the signals to be positioned in accordance with this standard". Thus if a signal is unacceptable, a satisfactory change must be made.

11.22 A signal sighting committee is also to be convened to assist investigation of a SPAD where that is required by the Group Standard on SPADs (GO/RT 3252). Issue 2, October 1999 of that standard, which was current at the time of the Inquiry, requires this to happen if it is requested by Railtrack, the TOC involved or the person appointed to lead the investigation, or if the signal has been passed without authority during the previous 12 months or more than once during the preceding five years and the incidents indicate a recognisable pattern, or if the signal has been passed more than once within five years and it protects conflicting movements (section 5.2.4). In the case of this standard, the committee do not make a "decision" but submit a report, with conclusions and recommendations. Railtrack are to be responsible for implementing the committee's recommendations. Section 5.2.6 states:

> "Where it is decided not to implement such recommendations, the reasons together with alternative measures for controlling risks identified shall be documented".

Under this standard it appears that the committee do not themselves determine what those alternative measures should be. It is essential that the recommendations of such a committee are adequately followed up. It should form part of Railtrack's safety management system that it is the responsibility of senior Zone operating and signal engineering management to decide whether the recommendations are to be implemented and, if not, what alternative measures are to be taken, and, in either event, that the relevant measures are implemented.

11.23 As regards the composition of the signal sighting committee, this requires to be in accordance with section 3.2 of the standard for signal sighting which states that committees are to consist of:

> "… persons who have the competence to meet both the engineering and train driver requirements in the sighting of signals, including a competent representative of a train operator operating over the route. The committee shall be led by a chairman, appointed in advance and approved by Railtrack, who will be responsible for ensuring that all relevant matters are considered and decided".

Counsel for ASLEF maintained that steps should be taken to see that the signal sighting committee obtained the views of a driver. However, in view of the reference to train driver requirements, I do not consider that more requires to be done. The Inquiry was informed that, in view of the difficulty of obtaining persons with the required competence to chair signal sighting committees, Railtrack were reviewing the process and examining the possible use of external contractors to chair them. They were also considering the need for expertise in human factors.

11.24 In regard to the signal sighting committee process, W S Atkins state:

> "Once again there is a need for an auditable trail showing the changes, risks and palliative measures being applied. The signal sighting committee needs also to examine the whole life implications of the signal position and where appropriate recommend special maintenance measures which may be needed to maintain the signal's visibility and readability".

The investigation of SPADs and the reporting of signal deficiencies

11.25 Counsel for Railtrack acknowledged that in the past there had been a systemic and unacceptable failure to carry out adequate root cause analysis of SPADs, with investigation not going beyond the driver's acceptance of responsibility. Counsel for ASLEF pointed out that 85% of SPADs had been regarded as simply "driver error". The reliability of such an acknowledgement by the driver was, in any case, questionable in view of the effect which such a stressful event had on the reliability of recollection.

11.26 It is also plain that using the investigation of a SPAD as a means of determining whether, and if so what, disciplinary action should be taken, or as a means of determining questions of liability, for example as between companies, tends to discourage full root cause analysis. In this connection Counsel for ASLEF referred me to a passage in paragraph 3.5 of a consultation document issued by the Safety and Standards Directorate of Railtrack "The Future of Accident Investigation in the Railway Industry" dated 14 May 1999, which includes the following:

> "It is widely accepted that an investigation into responsibility for an accident will produce evasive behaviour on the part of those who believe that they might (rightly or wrongly) be found at fault. Clearly this may deprive the investigation of important evidence and could impact on its ability to fully establish both the immediate and underlying causes".

11.27 Mr G J White, Inspector of Railways, HMRI, stated that in his experience "simply by recording driver error as a cause of the signal being passed at Danger is substituting one mystery for another one". Mr Coleman said: "In relation to a SPAD, I think it is always important to examine the nature of the environment and, of course, the nature of the infrastructure is the most important part of that in the context of a SPAD". In these circumstances it is perhaps surprising that, as was pointed out by Counsel for ASLEF, the Group Standard on SPADs refers to signal sighting or signal operation only as a possible "contributory factor". The Group Standard on SPADs and its associated documentation should be reviewed to ensure that there is no presumption that driver error is the sole or principal cause, or that any part played by the infrastructure is only a contributory factor.

11.28 The need for root cause analysis is not in dispute. As was stated in the HSE publication "Reducing Error and Influencing Behaviour" (HSG 48), Second Edition 1999, "Finding out both the immediate and the underlying causes of an accident is the key to preventing similar accidents through the design of effective control measures". It also stated: "Many accidents are blamed on the actions or omissions of an individual who was directly involved in operational or maintenance work. This typical but short-sighted response ignores the fundamental failures which led to the accident. These are usually rooted deeper in the organisation's design management and decision-making functions".

11.29 "Error" should, of course, be distinguished from a deliberate violation of a rule or procedure. In this connection Counsel for ASLEF drew my attention to the remarks of Dr Lucas about the problem created by the use of the word "disregard" in the report forms used in the current issue of the Group Standard on SPADs. The word "disregard" is unfortunate, and should be reconsidered.

11.30 Railtrack have acknowledged the need to ensure that adequate analysis of SPADs takes place. Mr Corbett, the then Chief Executive, informed the Inquiry that all managers were to be re-trained in the conducting of SPAD investigation. This was to be achieved by means of a training course in root cause investigation which was designed for the purpose and would take between five and seven days. I also understand that experts in human factors now advise and assist Formal Inquiries, and evaluate them, with recommendations for any suitable improvements. The Inquiry was also informed that, in view of the increasing importance of human factors, the Safety and Standards Directorate of Railtrack had commissioned research into this subject and had appointed a trained psychologist.

11.31 Those who investigate, and make recommendations as a consequence of, SPADs should be trained in the identification of human factors and in root cause analysis. Their competence in these areas should be formally recorded, and renewed by refresher courses. It is also important that the analysis of SPAD data should be specifically directed to eliciting the part played by human factors and assessing the significance of the hazards against which the signals which have been passed at Danger were intended to afford protection.

11.32 However, as W S Atkins observed, it is not enough for the industry simply to rely on the outcome of the investigation of SPADs. When a SPAD takes place it may be too late to prevent serious injury or damage. SPADs are intermittent, and analysing them is expensive in time and resources. The effort is better employed in eliminating as many potential SPADs as possible "before the event". As they point out, it is a matter for concern that SPAD investigations frequently reveal signal sighting problems which have been present for some time. The system must provide "a means of capturing the user view". What is needed is a robust and effective reporting system, combined with appropriate follow-up. This leads into a discussion of the type of culture in which employees can report incidents and make complaints without fear of recrimination. My attention was drawn to the report by DuPont Safety Resources to Railtrack on "Safety Management in the Railway Group", which was presented in January 2000. Referring to the culture within the rail industry in the United Kingdom the authors state in their conclusions:

> "The culture that has been allowed to develop is too often one that drives apportionment of blame rather than aligned, supportive problem solving. There is evidence that this inhibits free and open reporting of incidents especially near misses. There is also evidence the investigations that do take place often aim to find the guilty party rather than the act and the reasons behind it".

I will return to the subject of the culture within the industry in my report on Part 2 of the Inquiry.

11.33 In her statement to the Inquiry Miss Bacon cited the approach to SPADs as an example of the tendency of the industry "to look at outcomes, with insufficient attention to the potential for harm, and at frequencies rather than consequences".

Chapter 12
The work of signallers

Introduction

12.1 In this chapter I will discuss a number of ways in which the work of signallers may be assisted, whether they are monitoring the operation of the ARS or are themselves controlling train movements. The subjects which I will consider are as follows:

- signallers' instructions (paras 12.2-12.11);
- training and briefing (paras 12.12-12.16);
- working conditions (paras 12.17-12.19);
- IECC equipment (paras 12.20-12.24);
- automatic controls (paras 12.25-12.28);
- radio communications (para 12.29); and
- preservation of data (para 12.30).

Signallers' instructions

12.2 The evidence given by the signallers at the Slough IECC and by others showed confusion about the implications of their standing instructions.

12.3 The first point of confusion was whether signallers were expected to act immediately on the occurrence of a SPAD, as opposed to waiting until the train which had passed the signal at Danger had gone beyond the normal overlap of 200 yards. As I have already narrated in Chapter 6, Mr Allen and Mr Winters took the view that the signaller was not expected to act merely on the strength of the SPAD as such, whereas other witnesses took the opposite view.

12.4 The second point was whether, at a given stage, one set of instructions took precedence over another, and whether the signaller was expected to observe an order of priority in his actions. As I have narrated earlier, Railtrack witnesses stated that the priority was for the signaller to put the signals for other trains to Danger. Counsel for Railtrack submitted that Regulation 6 of the TCBR was free standing: the signaller was to place or maintain signals at Danger "and then" to consider taking all other practical steps to avoid a collision.

12.5 Mr Burchell informed the Inquiry that there was a certain amount of confusion among signallers as to the priority between SGI 47 and Regulation 6. In his view it would be more satisfactory if they were brought together by re-drafting so as to set out a number of options. He illustrated this by reference to text which he used in discussing the matter with signallers. Thus, under the heading of "Stopping the movement", he put the options of sending an emergency stop message, the general stop message (both applying only to trains which were fitted with the CSR), and the setting of signals. Under the heading of "Diverting trains away" he set out the diversion of the train which had passed the signal at Danger and the use of Regulation 6.

12.6 Dr Weyman and Mr Boddy called for the clarification of signallers' instructions. In particular Mr Boddy pointed out that it was not clear to signallers "which order things should be taken in".

12.7 An associated matter is the attitude of signallers to the use of the CSR. None of the signallers from the Slough IECC had used it for the purpose of sending an emergency stop message. Mr Andrews had used it once, but for the purpose of warning the driver that there was a trespasser on the line. In regard to the 46 SPADs which had occurred in the area of the Slough IECC between 1993 and 1999, Mr Winters could not recall any occasion on which the CSR had been used (he initially thought that it had been used at the time of the SPAD of SN109 on 4 February 1998, but agreed that, in the light of the records, this was not so). At the same time Mr Brooker rightly warned against making the sending of a CSR message a mandatory response to a SPAD. Even if the train was fitted with the CSR, this might not always be the appropriate course of action. Further it was possible that, unknown to the signaller, the CSR was not working. Although a driver had to "log on" before setting off on his journey, this could be outside the area of the IECC, so that the signaller would not necessarily know whether the CSR had been properly set up. Further, the CSR might cease to be operational during the course of the train's journey. If that happened the driver had to take the train out of service, but he was only expected to do so at the first available opportunity. Where there were very short track circuits between signals, it might be quicker to set back a signal ahead of the train.

12.8 As I have already noted, the traditional way in which signallers dealt with SPADs was by putting signals back to Danger. Mr Holmes pointed out that the rules perhaps did not fully take into account the potential use of the CSR because they had been written at a time when it was not available. Thus neither SGI 47 nor the TCBR mentioned it. He said that these regulations were being reviewed in order to eliminate ambiguity.

12.9 My conclusions are as follows. First, I am in no doubt that the standing instructions for signallers as to their response to a SPAD should be:

(a) clarified; and

(b) set out in a single set of instructions.

No doubt the re-drafting can draw upon SGI 47 and Regulations 4 and 6 of the TCBR, but instructions as to how a signaller should respond to a runaway train should be covered separately. It is most undesirable that a train which has passed a signal at Danger should be regarded as covered by one set of instructions at one stage of its progress, and by another a later stage. At the same time I recognise that if there are matters which are specific to a particular area they should be covered by separate local instructions.

12.10 Secondly, the re-drafted instructions should state explicitly that the signaller is expected, in the event of a SPAD, to make an assessment and to take action immediately.

12.11 Thirdly, I recognise that it is not wise to prescribe that a particular course of action, or order of actions, is mandatory, since this may involve the signaller in taking what is not the best course of action, or even taking the worst one. What is required is a set of options. This would include the use of the CSR (where it is available) either to send an emergency stop message to a particular train or a general message. This range of options should be supported by full and regularly repeated briefing of signallers as to the type of circumstances in which each option is or may be appropriate.

Training and briefing

12.12 Mr Holmes informed the Inquiry that signallers were briefed every eight weeks. They discussed emerging issues and were informed about lessons which could be learnt from inquiries. In addition they received weekly operating notices which informed them about multi-SPAD signals. Where any information required to be issued immediately, he would ensure that this was done. He also said that signallers at the Slough IECC and also nationally were in the course of being briefed that where the CSR facility was available, they should not hesitate to use it in order to broadcast an emergency stop message immediately. Mr Leah, who gave evidence on 11 July 2000, said that a national briefing had been given two or three months previously as part of the 8-weekly briefing cycle. I noted, however, that neither Mr Brooker nor Mr Thoburn was aware of a national briefing on this subject. Mr Corbett said that Railtrack was undertaking a revision of the training package for signallers, with particular regard to safety critical communications and responses to SPADs.

12.13 The submission of First Great Western, with which I fully agree, was that Railtrack should institute a system whereby all signallers in the signal box (or centre) are briefed by their line manager following a SPAD in their area, and that there should be appropriate dissemination of information which may be of assistance to signallers elsewhere. It is important that signallers should see themselves as part of a system for the prevention and mitigation of SPADs. Railtrack should ensure that the reports which are made to the Zone on a SPAD should include a report by the signaller as to the actions taken by him or her and the reasons for such actions.

12.14 Many of the parties called for better training of signallers in dealing with emergency situations. The submissions were particularly directed to the use of simulators. Mr Corbett said that work was being done to identify systems and equipment which might enable layout-specific interactive training to be of use to signallers, as well as to drivers. In that connection I note that Dr Weyman said that simulators would be advantageous, given that signallers were expected to deal with a large number of contingencies. Hence their standing instructions should not be over-prescriptive. He said that research suggested (in his words) that individuals' ability to deal with an emergency situation "is greatly enhanced if the responses they should make are well known to them and regularly rehearsed". Mr Brooker said that simulators were often used to train signallers in Kent, although they could not reproduce an emergency situation. In the assessment of signallers, which took place about four times a year, simulation was used in addition to question and answer sessions. He and Mr Burchell and Mr Thoburn all considered that emergency simulation would be of real assistance to signallers, in particular in assisting them to react more quickly. At the same time Dr Weyman stressed that it was necessary to take account of the demands which the system made on the individual. The maintenance of vigilance over a long period of time could be a problem for those who were monitoring automatic systems.

12.15 I endorse the calls for fully effective training of signallers in dealing with emergencies. It is clear that simulators have a part to play in this. It may be that the most effective way of providing this would be if a signalling centre such as the Slough IECC is provided with an additional set of screens so that exercises in hypothetical situations can be carried out in a realistic setting.

12.16 I also agree with the submission made by ASLEF that signallers should be encouraged not to view SPADs as a driver problem, but to see themselves and the system with which they work as part of a defence against a SPAD developing into a potential or actual collision. It would be helpful if Railtrack and the TOCs sought to ensure that signallers and drivers obtain a full appreciation of the nature and demands of each other's work.

Working conditions

12.17 Mr Thoburn listed the numerous tasks which were given to signallers to perform while they were on duty. This included, in addition to monitoring the operation of the ARS and the manual setting of routes where the ARS was not in operation, answering up to 100 phone calls during a 12 hour shift. These could be calls from engineers, internal and external control staff, Railtrack, TOCs, and even unauthorised calls from members of the public. Also included were reading and digesting notices for amendments of train running; temporary speed restrictions and changes to the Rule Book; making decisions in regard to the regulation of train services; reading publications such as team brief reports; checking the rail timetable updates; and dealing with problems such as signal failures. Mr Thoburn said that he wanted to see a reduction in the number of incoming calls, and he considered that certain tasks, such as reading notices and team briefing notes, could be done in rostered time at the beginning or end of a shift, rather than during it. In my view, management should ensure that the work done by signallers is reviewed to identify all non-essential tasks and eliminate them from the work which is performed by signallers while they are in charge of a workstation. The evidence which I heard also satisfied me that there was a need for a supervisor. By that I do not mean simply a senior member of staff, but a person who is appointed on a continual basis to ensure that the workstations are operated in the most effective way.

12.18 I agree with the submission by ASLEF that signallers should take the opportunity from time to time to practice the controlling of train movements, so as to maintain their skills.

12.19 In Chapter 6 I set out the number of hours which Mr Allen had worked prior to the disaster. Some of the parties expressed criticism of the absence of any criteria for the giving of permission for exceeding the maximum of 72 hours a week. This is a matter which should be attended to by management. It is a question not only of whether there is a good reason for exceeding that maximum, but also whether the workload is satisfactorily spread among the available personnel. There was nothing to suggest that the number of hours which Mr Allen had worked played a part in what happened, but nonetheless the whole matter of hours which may be worked by signallers gives cause for concern. It is desirable that, as well as ensuring that an adequate supply of trained signallers is available to cope with periods of peak activity, management should provide a clear lead in setting out the criteria for allowing signallers, in exceptional circumstances, to exceed the maximum of 72 hours of work per week and ensuring that these criteria are, and continue to be, correctly applied.

IECC equipment

12.20 Mr Rayner expressed concern about the ability of signallers, given the present IECC equipment, to react promptly to a SPAD. The equipment consists of the multiple screens, tracker ball, keyboard and buttons which I described in Chapter 6. He also said that it was not clear whether the IECC had ever been risk assessed. The evidence before me did not, in my view, go so far as to indicate that there was or might be a fundamental problem with the ability of signallers in the IECC to make a prompt and effective response in an emergency created by a SPAD. Thus I do not consider that I should recommend that there should be a study of the human factors involved in their work. However, I consider that, in addition to the instructions and training which I have already mentioned, there are a number of changes which should be made to the equipment in order to provide improved support to the signallers.

12.21 First, there is clearly a need for a unique alarm for SPADs, as was advocated by many of the parties. As I narrated in Chapter 6, Mr Thoburn said that an alarm could sound as many as 60 times in an hour in the Slough IECC. As he pointed out this involved a risk: “Certainly you do tend to ignore alarms at certain periods when you are busy with other tasks”. It is regrettable that so far no substantial progress has been made with the implementation of Recommendation 4 of the Royal Oak inquiry, which was that there should be a risk assessment of the possibility of a more urgent alarm to draw attention to SPADs on selected signals. Mr Fairbrother said in evidence that he found it surprising that all levels of alarms had the same sound associated with them. He recommended a specific sound. This was supported by Mr Rayner and Dr Weyman, although the latter emphasised the need to assess any safety disbenefits. When he gave evidence on 3 July 2000, Mr Burchell said that he had found out a week or two before that AEA Technology Rail had been commissioned to consider the required modification to the IECC software. I also agree with the submission by Counsel for First Great Western that such an alarm should sound until it is turned off.

12.22 Secondly, there is a need to improve the speed with which points can be moved in an emergency, for example by the detailed screen being brought up automatically.

12.23 In Chapter 6 I indicated that the “signals on” buttons were not used in order to deal with an emergency because their use might put other trains and their passengers at risk. This would result from the widespread effect of pressing an individual button. Thus pressing the button for area 2 would replace 33 signals to Danger. The signaller would not know which signals would be affected unless he referred to the supplementary instructions which were kept at the IECC. Mr Winters said that, as far as he was concerned, the buttons had never been used, although they were tested during the course of routine maintenance. The Inquiry was informed that there had been a development in recent years. A working group had developed a Signal Group Replacement Control which was made mandatory for all new schemes approved on or after 1 June 1999, in accordance with Railtrack Line specification RT/E/S/10131. This enabled a signaller to replace a small number of signals to red, without affecting the recording of data or the use of other interlockings. This specification also required Zones to assess the need for installing such a control in existing systems. Mr Holmes informed the Inquiry that, as part of the re-opening of the lines between Paddington and Ladbroke Grove, the Great Western Zone would be considering what required to be done in order to comply. This was one of the matters mentioned by Mr Leah in his letter to the HMRI dated 27 June 2000, to which I referred in para 7.122. He stated that the current thinking was that the groups of signals covered by the Signal Group Replacement Control would line up with ARS sub areas. AEA Technology were to report on the IECC implications of such a change. I consider that the "signals on" buttons should remain available for their original purpose of dealing with a breakdown of the visual display system. The Inquiry heard evidence that in other IECCs than the one at Slough there were positively latched buttons which, when pushed, remained depressed until 15 seconds had elapsed. The fitting of such buttons in IECCs where they are not already fitted would have the useful effect of releasing the signaller so that he can attend to other tasks.

12.24 In his letter to the HMRI dated 27 June 2000, Mr Leah stated that Railtrack had placed a contract for the 01 upgrade of the Slough IECC "which will significantly improve the reliability of the Automatic Route Setting".

Automatic controls

12.25 The Inquiry heard criticism of the way in which the ARS was programmed. Mr Rayner commented on the fact that trains would be routed from one track to another and then back again, which had the effect of increasing problems for drivers understanding where they were. He also said that the way in which the ARS had been programmed, which had the effect of the Turbo being routed down line 3, was "foolish", as it was inevitable that it would be held at SN109. He believed that if a signalman had been controlling train movements, he would have seen that there was an opportunity to run the Turbo and the HST in parallel, with the Turbo proceeding to the Down Relief line. In that situation, as he put it, "all the trains concerned would have run on clear signals and no collision opportunities would have occurred". ASLEF called for the application of the ARS to be risk assessed, and the Rail Users' Committees sought a review of its principles in order to ensure that there was consistency of routings and minimisation of potential conflicts. I am not persuaded such recommendations are called for. In general the complexity of the track and signalling between Paddington and Ladbroke Grove is such that there is a strong case for the burden being taken by an automatic system. While it may be desirable that the interlockings of the SSI should be reviewed, what is critical to safety is the layout.

12.26 Some of the parties called for a recommendation that there should be a system under which, when a train passed a signal at Danger, points would be moved automatically to divert the train from a path which would lead it into conflict with another train or trains. Mr Fairbrother gave evidence that, while this would involve a complicated modification to the operation of the ARS and the SSI, it was, in his opinion, possible. It would involve a modification whereby an instruction from the ARS to move points would only take effect if the SSI agreed that it was safe for this to be done. He accepted that the capacity of the system might be a problem as the interlockings at Paddington were very full, but he considered that this was an option which warranted further exploration. I am not persuaded that this course of action, which appears to be fraught with difficulty, is called for.

12.27 On the other hand, one area where the available technology could perhaps be used to better effect is in the automatic replacement of a signal to Danger where a SPAD has occurred and the layout is such that there is a significant danger of collision. If this was to be applied to SN109, the interlocking would be adjusted so that SN120 reverted to red if track circuit GE was occupied without SN109 showing a proceed aspect and the points ahead were lying normal. It would have the advantage of relieving the signaller from placing a signal to Danger on a converging route and allowing him to concentrate on stopping the train which had passed the signal at Danger. I recommend that a study of this possibility should be carried out.

12.28 The latter part of Recommendation 6 of the Royal Oak inquiry (prior to amendment by the Safety Review Group) was that there should be a study and risk benefit assessment of the use of an emergency button to send an automatic "all trains stop" to trains fitted with the CSR. On the other hand Mr Fairbrother indicated it would be technically feasible for the ARS to be linked with the CSR so that an audible warning would sound in the cab of the train which had passed a signal at Danger without the signaller having to press a button. Counsel to the Inquiry and a number of the parties advocated the introduction of this change, subject to satisfactory risk assessment, and I recommend that this should be done.

Radio communications

12.29 Counsel for First Great Western rightly submitted that it was most unfortunate that there was still no national system of radio communication between trains and signallers. Counsel pointed out that First Great Western had pressed for a modern radio system. In April 1999 Railtrack had cancelled the DART project (to introduce such a system nationwide) without explanation. It was common ground that such a system is desirable and, in the light of the evidence given by Mr Leah, there appeared to be no insurmountable technical difficulty. Mr Leah said in evidence that Railtrack was developing a national radio project in a form of CSR which was European-compatible. This was for all passenger lines and it was being looked at as a matter of urgency. The proposal had been put to the Investment Committee of Railtrack for their approval. In my view, there should be a national system of direct radio communication between trains and signallers.

Preservation of data

12.30 In Chapter 6 I set out that there had been a failure of communication of the need to ensure that the CSR data disks were recovered after a serious incident. I would emphasise the need for all signallers, managers and maintenance staff working at IECCs to be instructed as to the need to preserve such disks in the event of a SPAD taking place.

Chapter 13
Crashworthiness and fire mitigation

Introduction

13.1 In Chapter 4 I set out in some detail the crash performance of each of the trains and the fires which ensued upon the crash. In this chapter I consider the lessons of these events and the extent to which there is room for improvement. The Inquiry was assisted by the three reports which were made to it by committees of experts in the fields of:

(i) crashworthiness;

(ii) fire and crashworthiness; and

(iii) fire.

Crashworthiness

General

13.2 From the late 1950s investigations by the European Railways Office of Research and Experimentation led to the specification for international vehicles of standards of resistance to higher loads at various levels. These loads were adopted by British Rail for their passenger vehicles in the 1960s, subject to a variation, in common with a number of other European railways, in the requirements for compressive loads at buffer coupler level, as between multiple unit stock and locomotive-hauled stock.

13.3 In the 1980s British Rail Research began to investigate the potential for incorporating crumple zones at the ends of vehicles. This led to the incorporation of features to resist overriding in collisions, which had been a particular problem with mark I rolling stock. It also led to the demonstration that the capability of vehicles to absorb one megajoule energy would control their behaviour in collisions at speeds up to 40 mph. Since that time development work has demonstrated that construction to absorb 5-10 megajoules is possible, and this capability is being designed into current new vehicles.

HSTs

13.4 It was agreed by the experts on crashworthiness that in the case of the Ladbroke Grove crash, the survival space in all of the vehicles of the HST had generally been well maintained, although one factor was that the leading power car had provided protection to the coaches. The principal cause of concern was that several bogies had become detached. There are no standards governing bogie retention in high speed collisions. Of the prior accidents involving HSTs, the most serious was that at Southall, where one of the coaches had sustained serious damage. Other accidents involving mark III vehicles have demonstrated good crashworthy performance, providing excellent protection for passengers. It is, however, important to bear in mind that the higher the speed of impact the less predictable the effect on the integrity of the carriage. The experts on crashworthiness reported to the Inquiry that two changes to HSTs should be considered further with a view to possible retro-fitting. These were:

(i) the enhancement of the cab to improve driver protection along with energy absorption and compatibility with other vehicles; and

(ii) the enhancement of measures for the retention of bogies on the coaches.

The consideration of such changes would involve the addressing of feasibility, costs and benefits. I endorse these recommendations. I also consider that, in regard to new vehicles, the current standard for crashworthiness should be reviewed in the light of what happened in the crash at Ladbroke Grove, in order to ensure that there are adequate measures for the protection of drivers and the retention of bogies.

Turbos

13.5 Of the two previous incidents involving Turbos, neither involved significant structural damage or led to any modification of the structure of this class of train. In the crash at Ladbroke Grove, as I have already narrated, survival space was entirely lost in the leading car and was compromised in the middle one. This loss of survival space was regarded by the experts as inevitable in the extreme circumstances of the collision, although it was thought that the poor welds in the middle car may have reduced protection which otherwise would have been afforded in lower-speed collisions. The extremely strong underframe of the HST may have exacerbated the damage to the Turbo. Survival space in the rear car was not a cause for concern. The committee of experts on crashworthiness recommended for further consideration, with a view to possible retro-fitting, the following:

(i) the enhancement of end pillar weld connections;

(ii) the possible enhancement of crashworthiness by weakening the ends and strengthening the saloon of the cars; and

(iii) the fitting of shear-out couplers and anti-overriding devices.

Once again, consideration of these changes would be subject to an assessment of feasibility, costs and benefits. I endorse these recommendations. In regard to new vehicles, the current standard for crashworthiness should be reviewed, in the light of what happened in the crash at Ladbroke Grove, in order to ensure that there are adequate measures for safeguarding survival space.

Aluminium

13.6 There is general agreement among experts, which is endorsed by ATC and ADtranz, that aluminium is not worse than steel for use as a material in building trains. It is used all over the world for this purpose and has certain important advantages over steel, namely:

(i) lower weight and hence lower energy/power costs;

(ii) greater resistance to corrosion; and

(iii) greater side strength where a double skin construction is employed, as for example in the new Pendalino trains.

One disadvantage of aluminium is that, because it is less ductile than steel, it is less able to deform, more prone to cracking and less able to withstand higher stresses. The attention of the Inquiry was drawn to a British Rail research report by Mr J Lewis in 1996: "Review of Crashworthiness Work Undertaken by BR Research 1984-1996". The author questioned the crashworthiness behaviour of aluminium alloy, stating that welded aluminium vehicles exhibited poorer crashworthiness behaviour than similar steel vehicles, making it more difficult to meet the requirements of the current Group Standard. Nevertheless the parent material used for the Turbo exceeded the design loading requirements. Conventional aluminium welds are considered to be less strong than the equivalent steel welds. The heat affected zone of the weld is potentially weaker than the parent metal. In the case of the Turbo, as I have stated in Chapter 4, some of the welds, for example from the vehicle end pillars to the floor/roof, were not of reasonable quality. The experts agreed that the majority of welds exhibited partial penetration. However, the welds met the relevant design loading requirements. Dr Kirk told the Inquiry that most aluminium vehicles had steel ends, as it is considered difficult to design a crashworthy aluminium end.

13.7 Since the Turbos were constructed there have been substantial advances in design and manufacturing capability. This is perhaps best exemplified in the case of the Pendalino trains which are being built by Fiat for ATC, in which provision is made for 10 megajoules of energy absorption (3 megajoules in respect of the impact crumple zone, and the balance throughout the train). It is clear that aluminium can meet the standards proposed under the European Safe Train Project. This is a European initiative to develop a common standard for European trains, based on achieving a desired standard of crashworthiness in particular scenarios, such as striking a vehicle on a level crossing. It involves the participation of most European railways, including those of the United Kingdom.

13.8 The experts did not consider, in the circumstances of the collision, that the outcome in terms of casualties would have been less grave if the Turbo had been constructed of steel. This was the first major crash in which these aluminium vehicles were involved.

13.9 The experts on crashworthiness were agreed in recommending that consideration should be given, in the case of new vehicles constructed of aluminium, to the following:

(i) the use of alternatives to fusion welding;

(ii) the use of improved grades of aluminium which are less susceptible to fusion weld weakening; and

(iii) the further development of analytical techniques to increase confidence in the crashworthiness of rail vehicle structures, particularly those constructed of aluminium.

I endorse this.

Development of crashworthiness standards

13.10 Counsel for the bereaved and injured submitted that the current standard on crashworthiness (GM/RT 2100) fell short of what was achievable and was inadequate. This standard, which is currently undergoing revision by Railtrack, was based on techniques which had been established in the car industry for 20 years. The requirement for rail vehicles to absorb only one megajoule of energy was said in particular to provide insufficient protection for passengers and to be far below what was attainable.

13.11 Certainly it is undeniable that considerable progress has been made in design and construction, enabling much higher energy absorption rates to be achieved at little additional cost. It is now believed that up to 10 megajoules energy absorption is feasible, as against the standard requirement of one megajoule in a given static crash test. Even in 1996 it was recognised that the absorption requirement could easily be increased to 1.5 megajoules but no change was made to the standard. A structural investigation carried out by W S Atkins found that the given static crash tests, as currently required by the standard, are considerably inferior to dynamic impact scenario testing. For instance static tests do not consider the effect of bogies in a collision. Another example is that the quasi static crush tests are conducted against a flat wall, whereas dynamic tests involve impacts with other trains. It has been pointed out that a typical rail vehicle would need to be travelling only at 16 mph for it to have a kinetic energy of one megajoule, and that after one megajoule has been absorbed there are no further requirements specified in the standard for the performance of a vehicle on impact. Further, Dr Kirk indicated that the current crashworthiness requirements for trains aimed to address collisions taking place at 30-40 mph, so that no real account is taken of high-speed accidents. For these reasons it was argued by Counsel for the bereaved and injured that the standard was wholly inadequate for actual impact conditions.

13.12 One issue which was raised during the course of the Inquiry was whether the provision of crumple zones would have reduced the severity of the collision. In his report on the Southall crash Professor Uff indicated that the matter of crumple zones should be given attention by this Inquiry. The experts who advised this Inquiry considered that crumple zones would have made little difference, given the kinetic energy involved in the crash at Ladbroke Grove. It was noted that the ends of the carriages of the HST had in fact acted as crumple zones, despite the apparent lack of any intent that they should do so.

13.13 It is argued that computer modelling should be developed by joint research to provide a better prediction of the behaviour of vehicle structures. Railtrack would like to carry out a thorough revision of the standard, but are prevented from doing so by rolling stock companies retaining, on the ground of confidentiality, information about what is now possible to be achieved by modern manufacturing methods. Accordingly while there will be a revision of the standard which will improve somewhat on the existing inadequate basis, it is very unlikely to be as challenging as it could and should be. It is, of course, to be borne in mind that even if the standard had been revised so as to require the absorption of 1.5 megajoules energy in a head-on collision at 37 mph, this would have made no significant difference in the case of the crash at Ladbroke Grove.

13.14 While the general view is that at the speed involved in that crash no practicable improvements to the standard would have made a significant difference to what happened, it is important that improvements are made and are embodied in the applicable standards.

13.15 Another issue which concerned the bereaved and injured is the speed with which any new or changed standards will be applied. There is concern that one of the effects of fragmentation and privatisation of the rail industry is that TOCs prefer to refurbish existing rolling stock rather than purchase new rolling stock. One example which was cited was the continued use of mark I vehicles, despite the original intention that they should be phased out by the late 1990s. It was also pointed that because Group Standards are not applied retrospectively, improvements tend to be made very slowly. Counsel for the bereaved and injured also questioned the industry's heavy reliance on cost benefit analysis. Decisions on whether to introduce improvements in crashworthiness, particularly to existing vehicles, had often been made on analyses which did not clearly set out the methodology or assumptions which had been used. Counsel also questioned the desirability of any dependence on such analyses in a low risk industry. If decisions were made on such a narrow basis it would only be rarely that improvements in crashworthiness would be said to be justified. It was said that this has been borne out by past experience where studies concluded that improvements were justified only if they involved minimal cost. Nevertheless it was maintained that analyses might be of some value.

13.16 The disappearance of British Rail has meant the loss of a central body which could take forward research into crashworthiness and keep track of developments in Europe in this field. Privatisation and the resulting fragmentation of effort, with results not being shared, have led to the need to focus and control research with a view to establishing new improved standards. The lack of focus and drive on safety-related issues in this field arises from unwillingness to fund work which would benefit competitors as well as the funder. As well as design, the commercial and franchise requirements to maintain fleets of vehicles in service can lead to delay or non-implementation of modifications to vehicles which would improve safety. When reporting the views of the committee of experts on crashworthiness Dr Kirk strongly emphasised that there was a lack of coherence in development of standards, and little activity in this field in the United Kingdom. For commercial reasons there was little cross-fertilisation, and research in the industry lacked co-ordination and direction. He said that research was now being done by a multiplicity of bodies. Somebody needed to take control of this issue and set the relevant standards.

13.17 I endorse the recommendation of the committee of experts that revision of the Group Standard for crashworthiness should be pursued with particular reference to the design requirements for more realistic accident scenarios, for high speed accidents, and for dynamic verification testing.

Internal design

13.18 The experts on crashworthiness were agreed that the interiors of the vehicles had performed well in the crash, with the exception of some of the seats in the Turbo and the table fittings in the HST, which were thought to have failed in an undesirable manner. The former had collapsed in a fairly brittle way.

13.19 As I state in para 14.4 there is no up-to-date standard for the interior design of rail vehicles. Previous Group Standards relating to this now have only advisory status. Work is being done by ATOC with a view to pursuing their own standards. The experts on crashworthiness recommended that the status and content of the current standards for vehicle interiors should be examined. They also recommended that consideration should be given to the following aspects of interior design with a view to possible retro-fitting, subject to an assessment of feasibility, costs and benefits, namely:

(i) enhancing the seating in Turbos; and

(ii) enhancing the securing of tables in HSTs.

I agree.

13.20 There is normally little additional cost involved in meeting codes of practice relating to vehicle interiors, whereas the potential for reducing injuries and fatalities is considerable. Attention should therefore be paid to improvements in these areas, although it has to be remembered there may be a conflict between competing safety objectives. For example, it has been pointed out in regard to possible escape routes through removable or breakable windows that it is necessary to consider the risk of fuel entering the vehicle by such routes. The wish to provide additional escape routes should not compromise the ability of the train to contain passengers in an accident. It was said by Mr Allan Sutton of ADtranz that sometimes passengers' desire to travel in attractive surroundings and comfort conflicted with measures which were designed to provide the highest level of safety. The accuracy of this statement was questioned by others. It is clear there is a need for comprehensive market research in regard to safety related measures to take account of the views of informed passengers.

Fire mitigation

13.21 Current fire standards are now contained in Group Standard GM/RT 2120, which was issued in August 1998, taken along with the "Railway Safety Principles and Guidance" issued by the HSE in 1996.

13.22 The fuel tanks on both trains were made of welded aluminium alloy. The experts were agreed that there was no reason why aluminium should not be used for the construction of fuel tanks. Unlike the welds in the body shell of the Turbo, the welds on the fuel tanks were not under-matched.

13.23 There is relatively little guidance in Group Standards on the design or location of fuel tanks on diesel powered trains. The standards simply indicate that they must be capable of withstanding prescribed loads, and that the engine fuel system and fuel storage system must not present a hazard in normal use. There are differing views in regard to the existing practice of siting fuel tanks. However much it is desired to remove fuel tanks from behind leading bogies and place them in less vulnerable and exposed positions, the alternatives which are available have drawbacks which would bring greater risk. Locating a fuel tank inside the power car would place it too close to the engine, which is the most likely source of ignition. It also might affect the whole balance of weight across the vehicle. The location of fuel tanks under carriages would be dangerously close to passengers and would involve a great deal of piping which would be at risk of rupturing. It would also mean that the power car could not be operated independently from the rest of the set. It is therefore considered that concentration on the design of the tanks themselves might bring greater benefits. This would include consideration of the question whether tanks should be designed in such a way as to release fuel in a particular direction when they are penetrated. As was recognised in the report by the experts on fire and crashworthiness, there is an argument that the strengthening of fuel tanks can make matters worse by enabling higher internal pressures to be generated, resulting in a greater risk of fuel being atomised on its release.

13.24 The start has already been made in experimenting with the fitting of rubber bladders, foam inserts and reticulated foam within fuel tanks. These are methods which have been pioneered by the Ministry of Defence and the racing car industry. Desktop analysis and tests, followed by full scale testing, should lead to the publication of a new standard. This standard should also cover construction standards, where the use of aluminium is not considered undesirable by experts but needs further detailed research into the best construction methods.

13.25 Maintenance of structural integrity to prevent the ingress of fire is important. However, there is nothing in the events at Ladbroke Grove which suggests that it is necessary to revise the standards in this respect. The fire which occurred in coach H of the HST subjected the interior to what went far beyond the possible scope of standards following the impregnation of the seat materials with diesel fuel.

13.26 The committee of experts acknowledged that it was not possible to eliminate sources of ignition but pointed out a number of steps which could be taken in this direction. These were:

(i) a transition to electrification;

(ii) the addition of an anti-misting agent to diesel fuel to prevent atomisation; and

(iii) mechanical means of preventing the dispersion of fuels.

13.27 The fuel tanks of the trains could not have been expected to withstand the extreme forces which were generated in the crash. The experts on fire and crashworthiness identified a number of measures which could be considered, to prevent the recurrence of such fires. However, they pointed out that broader operational issues also required to be considered and appropriate risk assessments/cost benefit analyses undertaken to ensure that the impact of any proposed changes did not create more hazardous situations in other respects. The measures which were suggested were as follows:

(i) reviewing Group Standards in respect of improved crash resistance of fuel tanks;

(ii) considering the feasibility of reducing fuel inventories and of utilising smaller fuel tanks;

(iii) in respect of frontal impacts, considering the repositioning of fuel tanks away from the leading ends of trains from behind bogies wherever this is practicable;

(iv) avoiding placing fuel tanks in exposed and vulnerable locations;

(v) examining the use of additives to reduce the propensity of a fuel to atomise;

(vi) seeking to avoid penetration of tanks in low speed accidents or by flying debris by employing internal flexible linings or a honeycomb construction;

(vii) considering the most appropriate material for fuel tanks; and

(viii) recognising the need for supporting theoretical and experimental work in respect of the foregoing.

In agreeing with the above I would add in regard to (ii) that the aim should be that trains should carry the minimum amount of fuel which is consistent with efficient operation.

Chapter 14
Passenger protection, evacuation and escape

Introduction

14.1 Where it is necessary for passengers to leave a train after a crash or other emergency, they should do so, if circumstances permit, under the supervision of train staff in a controlled or organised manner. That is what I mean by "evacuation". It should be distinguished from "escape". There may be cases where there is no organised evacuation and where the apparent hazards inherent in remaining on board are substantial. Even when due recognition is paid to the efforts of Mr Paton, Mr Thomas and Miss Ryder, this is one of the lessons of the crash at Ladbroke Grove. In these circumstances provision has to be made to enable individual passengers to escape on their own initiative. The means of evacuation and escape must be readily identifiable, available and effective. The Inquiry heard evidence from representatives of the two train operating companies involved in the crash, principally Mr Burrows, Director of Engineering and Miss Forster, Operations and Safety Director, both of First Great Western, and Mr Pamment, Fleet Manager, Thames Trains. The Inquiry also heard the evidence of Mr Wadey, Senior Account Engineer, Angel Trains Contracts Limited (ATC), which is one of the companies owning passenger rolling stock (ROSCOs). Expert evidence was provided by Professor Galea, Director of the Fire Safety Engineering Group, University of Greenwich and Dr Weyman of the HSL. The report by Professor Galea was commissioned by the Collins Passengers' Group, who are referred to in this chapter as the bereaved and injured. Professor Galea also spoke to a joint report which he and Dr Weyman provided to the Inquiry on the subject of escape.

14.2 I will deal with the following topics:

- some general matters (paras 14.3-14.10);
- safety information for passengers (paras 14.11-14.20);
- emergency lighting (paras 14.21-14.22);
- escape routes (para 14.23);
- doors (paras 14.24-14.38);
- windows (paras 14.39-14.50);
- hand and foot holds (para 14.51);
- escape hatches (paras 14.52-14.54);
- passengers' luggage (paras 14.55-14.56);
- partitions (para 14.57);
- train crew (paras 14.58-14.62);
- communications (paras 14.63-14.69);
- evacuation exercises (paras 14.70-14.71)
- security of passengers (paras 14.72-14.73); and
- emergency equipment (paras 14.74-14.75).

Some general matters

14.3 In 2000 the HSC issued a consultation document outlining proposals for, inter alia, the amendment and consolidation of the Railways (Safety Case) Regulations 1994, and the amendment of the Railways Safety (Miscellaneous Provisions) Regulations 1997. As to the latter it was proposed, in respect of both new and existing trains, that TOCs should be under a duty requiring them to ensure the provision of suitable and sufficient facilities for the escape of passengers in an emergency, suitable instructions to passengers on means of escape and the use of escape equipment, and sufficient signs to identify emergency equipment and means of escape. In the event this proposal was not proceeded with but an addition was made to the particulars which a duty holder was required to include in a safety case under Schedule 1 to the Railways (Safety Case) Regulations 2000, namely particulars of the arrangements which the duty holder had established "for the provision of equipment and arrangements for the evacuation of persons in an emergency from trains operated by the duty holder". In view of the alteration to the safety case regulations, I do not consider that it is necessary that there should in addition be a statutory duty of the type that had been proposed. However, the scope of Schedule 1 to the Railway (Safety Case) Regulations 2000 should be extended so as to include explicitly the arrangements which the duty holder has established in regard to facilities, instructions and signs for the **escape** of persons in an emergency, as distinct from their **evacuation**. Further it is highly desirable that the provisions in the schedule as to both evacuation and escape are supported by adequate guidance from the HSE. I would also emphasise the implications of the duty under the 2000 regulations. It involves the duty holder considering the full range of contingencies which could occur, taking an overall view of what is reasonably practicable in the case of each type of rolling stock and reviewing, in light of experience, the sufficiency and effectiveness of the measures which have been taken.

14.4 By virtue of the terms on which they are permitted access to Railtrack's network, TOCs are also subject to the mandatory requirements of Railway Group Standards. However, in the present context there is an important limit on their scope. The Railway Group Standards Code, which was prepared by the Safety and Standards Directorate of Railtrack in order to meet the requirement of Railtrack's network licence, states that such standards are to apply to issues of system safety and safe inter-working. Thus matters which are entirely within the control of one TOC and do not affect the safety of the staff or passengers of any other TOC or the general public are deemed to be outside the scope of such standards (c.f. para 4.88). It follows that the internal design and fitting out of trains, and the emergency egress of passengers from them, fall outside. Thus, for example, Standard GO/OTS 220 "Emergency Egress from Passenger Rolling Stock", which was first issued by British Rail in 1993, was withdrawn from being a Group Standard in 1998. Thereafter it was treated as placed in the public domain for access by all members of the railway industry.

14.5 In this connection I note that in his report on the Southall rail crash Professor Uff's Recommendation 46 was:

> "A single body should be empowered to specify common standards for safety features in the interior of passenger vehicles and to identify and approve types of vehicles and/or operators to which particular standards are to apply".

14.6 At the same time I note that for many years there has been a general lack of uniformity and standardisation in regard to passenger safety features and information. It appears that in the years immediately preceding privatisation British Rail had not introduced standard passenger safety features because in seeking competitive tenders they adopted the practice of specifying only the performance which was required of equipment in new trains rather than laying down a detailed specification as to its design. It was pointed out at the Inquiry that a representative of First Great Western who attended a conference on escape from trains in 1997 commented that there did not seem to be any co-ordinating agency to promote a unified system of signage and procedures. He observed that it might be more appropriate to work by consensus through ATOC rather than "face a series of possibly impalatable and expensive mandates from the H & SE". However, there appears to have been little movement towards a concerted approach between that time and the crash on 5 October 1999. Miss Forster pointed out the absence of any mandatory requirements in regard to passenger safety information. There was only the code of practice BR/BCT 610 "Public Information on Train Safety and Emergencies", which was first issued by British Rail in 1996 after the accident at Maidenhead in the previous year. However, as this code of practice was not "owned" by any party, no one had responsibility for updating it. Accordingly it was in the "no home" category. This was plainly unsatisfactory. The code of practice should be kept up to date.

14.7 However, there have been some advances. In his report on the Southall rail crash, which was published in February 2000, Professor Uff's Recommendation 44 was:

> "A review should be carried out by ATOC, with input from all interested bodies, on the ways in which internal safety features may be modified and standardised to provide the best practicable means of emergency exit under accident conditions, including vehicles lying on their side, to include the provision of emergency lighting and standardised public announcements".

ATOC have taken up these matters with a view to issuing their own standards, supported by approved codes of practice and guidance notes. I understand that it is intended that the safety cases of TOCs are to undertake compliance with such ATOC standards. The Inquiry heard evidence from Mr Cobb, Safety Manager, Thames Trains, who is the chairman of the Train Operators Safety Group which is concerned with matters such as emergency egress, signage, passenger information, the training and role of train staff and the implications of overcrowding. He said that this group had recently become linked to ATOC. This would enable ATOC to be made fully aware of developments within the group and to ask the group to examine and report on particular questions of train safety. The group also now reported to the Safety Advisory Board of Railtrack. Miss Forster said that there was now a mechanism for ATOC to promulgate a more consistent approach to signage through their own codes of practice and their operation scheme council which discussed such matters. I should add that Mr Burrows said that the introduction of legislation against discrimination on grounds of disability had resulted in greater standardisation of features, although he considered that there was "still a long way to go".

14.8 I am in no doubt of the need to secure, so far as is feasible, the standardisation of the safety information issued to passengers and the means by which they can be evacuated or escape from a train. In that connection I note that Professor Galea and Dr Weyman suggested the establishment of a system for the collection of human factors information pertinent to issues of passenger safety following rail accidents, similar to that used in the aviation industry. I agree with the principle of this proposal. As regards the body which should specify common standards for safety features and related matters, the mantle has for the moment been taken up by ATOC. Whether a different solution should be adopted for the future is a subject with which I will deal in my report on Part 2 of the Inquiry.

14.9 Mr Wadey gave evidence about the responsibility of ROSCOs for safety initiatives. The exact boundary between their responsibility and that of the TOCs was not entirely clear. However, he illustrated the difference between them by saying that the management of the evacuation of trains was a matter for the TOCs, whereas engineering issues relating to the fabric of the vehicles were for the ROSCOs. In practice a proposal for a safety improvement might be made by a TOC or by a ROSCO, depending on which company had the information from which the proposal arose. Some TOCs showed more initiative than others. Discussions might well focus first on the containment of the problem which had been identified, and then on the long term solution. Under the Master Operating Lease Agreement (MOLA), if a particular improvement was mandatory, for example under a Group Standard, 90% of the cost was borne by the ROSCOs and 10% by the TOCs. If, on the other hand, it was not mandatory, for example if it was a recommendation made by an inquiry into an accident, the sharing of the cost was a matter for negotiation. Mr Wadey spoke of the practical difficulty of a ROSCO, such as ATC, identifying changes when they had no direct contact with passengers. It was true that their role tended to be reactive rather than proactive. On the other hand ATC had a strong safety culture and were able to take a longer term view of safety than the TOCs. They took a deep interest in the safety of their vehicles, and carried out a daily review of the National Incident Register which recorded safety-related defects, in order to identify possible questions of safety. They had commissioned research into matters of crashworthiness and the feasibility of fitting power-operated doors to HSTs. They were regularly in contact with TOCs on safety matters, and were becoming increasingly involved with ATOC. While there was no process for sharing technical developments or innovations with those responsible for setting standards or granting approvals, research and development on safety issues was shared through a ROSCO liaison group and ultimately with the TOCs. In his report on the Southall crash Professor Uff drew attention to what he saw as the inability of the rail industry, as presently constituted, to deal effectively with a number of aspects of research and development in the field of safety. This is another subject to which I will turn in my report on Part 2 of the Inquiry.

14.10 In the light of the evidence at the Inquiry the parties suggested a large number of possible recommendations, all of which I have considered. They recognised that if any of these suggestions was to be taken further it would require to be the subject of risk assessment. I agree, and the recommendations which I make in this chapter should be understood as subject to such an assessment. It was recognised, for example, that a designer can well be faced with a conflict between two or more safety objectives. Thus while increasing the strength of windows gives greater protection against the windows being penetrated by missiles from outside or passengers being ejected from within, it can also operate against the windows being used as an escape route.

Safety information for passengers

Leaflets

14.11 As I mentioned in para 4.68, at the time of the crash First Great Western provided guidance in their timetables about what passengers should do in case of an emergency. The advice reflected the policy of the company that the safest place for passengers was normally on board the train. In regard to evacuation, this was in accordance with the code of practice BR/BCT 320 "The Competence and Training of Personnel in Dealing with Train Emergency Procedures", which was first issued by British Rail in 1996. It states: "The complete evacuation of the train should only be undertaken as a last resort if absolutely necessary". Options to be considered before total evacuation were the moving of passengers from the affected carriage to another carriage, then evacuation of passengers from the train to another train. Miss Forster said that this guidance had been introduced in 1996 after the Maidenhead accident and a report by Human Engineering Ltd which reviewed the level of passenger awareness of door operation, train safety and emergency procedures. However, Miss Forster accepted that for passengers to stay on board the train was not always the safest course. Counsel for the bereaved and injured pointed out that the advice given to passengers on some railways abroad did not state that they should remain on the train but should look around them before leaving it. Miss Forster accepted that the safest course was to ensure the swift protection of the train so that it was safe for passengers to leave it.

14.12 Miss Forster also said that from February 2000 First Great Western had distributed a safety leaflet which informed passengers that the best course of action was usually to stay on the train, and informed them of the locations of safety features and equipment. These leaflets were visible from seats and had proved to be unexpectedly popular. Professor Galea and Dr Weyman commended this initiative but commented that the leaflet was too small, contained too much written information and was not adequately self-explanatory. They also suggested that it should be laminated to increase durability and allow both sides of the card to be used. Miss Forster acknowledged that improvements could be made to the size and layout. First Great Western had employed Robert Gordon Institute of Technology in Aberdeen to assist the company in making improvements. A recommendation was made in 1997 to the Great Western Safety Council that laminated versions of safety information should be provided. This body deals with the strategic direction of safety in the company. The recommendation had not been followed, but First Great Western had ordered a vinyl version of the leaflet which would be stuck on the back of passengers' seats and on the windows beside them.

14.13 Thames Trains had not issued safety leaflets. Mr Pamment gave a number of reasons for this. First, as the route used by Thames Trains was shared with at least six other TOCs and provided services over large areas, there was a need for a standardised approach. It would be confusing for passengers if inconsistent information was provided by different TOCs travelling over the same route. Secondly, Thames Trains were seeking to comply with the findings of this and other inquiries. There was also a concern that, because of the shortness of the journey which most of their passengers made, leaflets would be easily discarded or lost.

14.14 I am in favour of passengers being given general safety advice both before and after they have boarded their train. I am not persuaded that TOCs such as First Great Western should in general depart from their advice to passengers that in case of an emergency it is safer for them to remain on board. Pending the protection of the train there is a risk of injury to passengers if they leave a train on their own initiative. Examples are being hit by a passing train or coming into contact with live wires. On the other hand there may be circumstances where staying on board carries a greater risk. With that in mind, the advice given by TOCs might appropriately be qualified by recognising an exception where there is a known threat of serious danger to passengers in remaining on board. This is plainly a matter on which experts in emergency procedures and human factors should assist in devising the best way in which the advice should be expressed. As regards the emergency facilities of individual trains I support the action taken to provide explanatory information on board.

Announcements

14.15 One of the recommendations made by the HSE investigation of the accident at Maidenhead in 1995 was that there should be a review of the on-board communication systems and that the use of pre-recorded or automatic announcements should be considered. In his report on the Southall crash, in addition to referring in Recommendation 44 to standardised public announcements, Professor Uff stated the following as Recommendation 48:

> "Safety briefings or other appropriate means of communicating safety information to passengers should be adopted, including pointing out safety notices to passengers. ATOC should monitor the methods adopted by TOCs and issue guidance documents after a suitable trial period, including recommendations for different types of journey".

Miss Forster stated that First Great Western were about to start making announcements on trains after leaving key stations, drawing the attention of passengers to the safety leaflets. Mr Pamment considered that a possible alternative to leaflets would be for safety information to be scrolled on the passenger announcement screens which were already fitted in Turbos operated by his company.

14.16 I endorse the recommendation by Professor Uff. In regard to main line trains, the public address system on board should be used in order to provide safety announcements for passengers when the trains are leaving major stations and at intervals during the journey. I envisage that pre-recorded messages can be utilised for this purpose. For services which have frequent stops, a different approach may be appropriate. This could include the use of passenger announcement screens, where these are available.

Signage

14.17 Miss Forster did not dispute that in the case of the crash at Ladbroke Grove, there had been a deficiency in the communication of passenger safety information. She accepted that there was a deep underlying problem of the need to raise passenger awareness of emergency procedures. "It is quite clear that the signs were inadequate to give them the information that they need". Many passengers had acted on instinct in the emergency. This had highlighted the need for safety information to be communicated to and absorbed by passengers **before** any emergency, so that they instinctively acted in accordance with it in the event of an accident. I agree with that approach. It should be coupled with the need for as much uniformity and standardisation of signage as is feasible, so as to ensure that safety devices are readily identified, and the way in which they are intended to be used is readily understood.

14.18 One way in which signs can be improved is by being made luminous, although the benefit of this will be lessened if the carriage becomes filled with smoke. It has the advantage of not being dependent on any source of electricity. Group Standard GM/RT 2177 "Emergency and Safety Equipment and Signs on Rail Vehicles", which was first issued in 1995, states that emergency signs should be luminous. However, this provision was not retrospective, and accordingly pre-existing trains require to be made compliant on the occasion of "overhauls and repairs when emergency and safety signage is replaced or updated". Miss Forster accepted that a paper presented to the Great Western Safety Council in August 1996 and the report by Human Engineering Ltd in the same year had each recommended that signs should be luminous. However, First Great Western did not yet have a policy of making all signs luminous. Mr Burrows said that he saw no reason why luminous signs should not be used, provided that they did not cause confusion. Mr Pamment told the Inquiry that it was expected that all the trains operated by his company would be fitted with luminous signs by June 2000. In my view the requirement for emergency signs to be luminous should be made retrospective. If such a sign is needed, it should be luminous.

14.19 Another possible improvement in signage would be the greater use of pictograms. It was noted that the signage on board trains operated by Thames Trains consisted entirely of text. This poses obvious problems for those who have reading difficulties. Mr Pamment stated that, although there was no plan to include pictograms in signs, his company would not ignore a recommendation on this point. He also agreed that the size of the signs might need to be increased. I consider that it is important that, so far as is feasible, emergency signs on all trains should be capable of being understood by passengers without the necessity for them to read text.

14.20 In the light of the evidence which I have outlined, I consider that the aim should be to arrive at a system of signage which is common to all trains in Great Britain. As suggested by Counsel to the Inquiry, this should be the subject of research. This should be undertaken by the TOCs, the ROSCOs and the train manufacturers. It should be understood as applying to all trains, whether new or existing.

Emergency lighting

14.21 Each of the carriages which was involved in the crash had its own back-up system to provide light in an emergency. However, as I described in paras 4.76 and 4.92, the system failed in each case, apparently due to the severity of the impact. I would emphasise the importance of emergency lighting assisting in speedy and efficient evacuation or escape. I consider that research should be carried out into the means of safeguarding such emergency systems from disablement by the forces involved in sudden deceleration.

14.22 Mr Burrows stated in evidence that First Great Western were being advised by Robert Gordon Institute about the possibility of installing airline-style strip lighting to guide passengers and highlight exit routes. They were also looking into the possibility of providing "snap wands" in the boxes for emergency hammers. These were short plastic tubes. When they were snapped, there was a chemical reaction which produced a glow for several hours. They were capable of providing a form of emergency illumination in the dark and could be used outside the train. Counsel for the bereaved and injured suggested that such tubes should be located in the hammer boxes, the senior conductor's compartment and the buffet coach. I agree that these devices are worthy of consideration as a supplementary means of providing lighting in an emergency.

Escape routes

14.23 Mr Burrows told the Inquiry that so far as possible escape routes were concerned, it was necessary to bear in mind the number of competing considerations. These included the need to avoid passengers accidentally falling from the train, the need to contain passengers safely in the event of a collision, the risks posed by vandals, the need to affect a rapid exit in an emergency and the need to protect passengers from external dangers such as overhead wires or passing trains. These factors did not always point towards the same solution.

Doors

Internal doors

14.24 In paras 4.66 and 4.85 I described the difficulties experienced by passengers in attempting to open the internal doors in coaches F and G, when they had fallen shut under the force of gravity. Section 3.5 of the standard on emergency egress states:

> "Passengers shall be able to open internal doors in emergency exit routes regardless of the state of the door power or control supplies. Internal and external staff only doors may form part of the emergency exit route with appropriate override devices for locked doors. To assist in emergency egress from overturned vehicles, internal doors in emergency exit routes shall slide open in opposing directions, or be hinged from opposite sides at each end of a passenger saloon".

The requirements of that standard apply to existing vehicles undergoing refurbishment "insofar as it is opportune and practicable to incorporate them".

14.25 In the aftermath of the crash at Southall passengers experienced the same difficulty after coach H had ended up on its side. At para 11.12 of his report Professor Uff noted that some work had already been carried out to ensure that internal sliding doors would always provide exit from a coach on its side by providing for one of them to fall away. This was an elementary design issue that ought to be applied to every high speed coach. His Recommendation 47 included the following:

"The design of coaches should be such that internal doors can be easily opened in a crash situation, in darkness and irrespective of the attitude of the vehicle".

A similar recommendation was made at Recommendation 13.4 of the report of the Formal Inquiry into the crash at Ladbroke Grove. I was invited to recommend that existing trains, such as the HST, in which all the internal doors opened in the same direction should be modified so that the doors at either end of a carriage opened in opposite directions. Another submission made to me was that they should be replaced by bi-parting doors. Mr Burrows stated in evidence that First Great Western had engaged experts to report on how doors could be more easily opened in a crash situation. However, the submission made on behalf of First Great Western was that the retrospective fitting of doors falling in an opposite direction to the original was costly, and that a better long-term solution might be to make doors which were bi-parting. On the other hand Professor Galea said that he was not convinced of the merit of the latter type of doors because internal bi-parting doors in the middle car of the Turbo had jammed, making them unusable as a means of exit.

14.26 Professor Galea and Dr Weyman recommended that two things should be done to assist passengers when the power to operate internal doors had been lost. The first was the provision of suitable handles to make it less difficult to move the doors. The second was an automatic catch mechanism for holding such doors in an open position. The operation of such a mechanism could be controlled by an orientation switch. I favour these proposals.

14.27 Evidence was also directed to the panels in the internal doors on the HST. These were made of polycarbonate and were virtually unbreakable. Group Standard GM/TT 0122 "Structural Requirements for Windscreens and Windows on Railway Vehicles", which was first issued by British Rail in 1993 and later reduced to having only an advisory status, stated that all interior windows should be made of toughened glass and hence able to be broken. Mr Burrows pointed out that a great deal of work had been done to prevent vehicles from turning on to their sides in the first place. It was very rare for all the carriages of a train to turn over simultaneously. There was usually a way out from the end of each vehicle. However, he considered that there had been a "lack of preparedness" which was shown in the case of the crash at Ladbroke Grove. An obvious solution was to put toughened glass in place of the polycarbonate panels. However this would make the doors much heavier and hence more difficult to lift if the vehicle was on its side. Professor Galea and Dr Weyman were in favour of the examination of a mechanism for removing the panels from the sliding doors, in preference to the installing of bi-parting doors, and suggested consideration of the method used on AMTRAK trains in the United States of America for the removal of exterior windows. ATC submitted that this was an obviously sensible solution, not least because it would still be capable of being employed even if the door had jammed.

14.28 I consider that, in the case of every coach (on any train) which has internal doors which slide in the same direction one of the following should be carried out by 31 December 2003:

(i) the coach should be fitted instead with opposite-handed internal doors;

(ii) the coach should be fitted instead with double leaf internal doors; or

(iii) a panel in the door should be rendered removable so as to enable passengers to pass through.

By "internal doors" I refer, of course, to doors which allow access to external doors on the train. The above is subject to the proviso that if the HMRI are satisfied, on application by the TOC concerned, that it is not practicable for that change to be achieved within the period which I have stated they may grant a deferment for an appropriate period within which the work is to be done.

14.29 As regards the use of staff-only doors, Mr Burrows confirmed that on the HST the door between the guard's compartment and the passenger saloon was kept locked for security reasons because the external doors of the guard's compartments were not fitted with central door locking. However, on the saloon side of the internal door there was an override device which could be operated after breaking a glass cover next to the door catch. As regards the Turbo, Mr Pamment stated that the door between the cab and the saloon area of the end cars was kept locked, and there was no override device. This was because of the considerable problem with vandalism. There had been many instances of people trying to get through the locked door into the driver's area. In my view the staff-only doors on all trains should have an override device to enable them to be used by passengers in an emergency.

External doors

14.30 The difficulties which passengers experienced in opening the external doors of the HST (see para 4.77) derived from their lack of awareness of:

(i) the location of means of releasing the doors, principally due to the fact that they were above eye level; and

(ii) the need to lower the window and reach outside the door in order to operate the external door handle in the normal way.

It does, of course, have to be borne in mind that opening such a door can carry with it the risk of injury, for example from a passing train as happened in the Maidenhead accident. In the case of Ladbroke Grove there was a risk of passengers being injured by external fires. In the Maidenhead accident there was a risk of injury through contact with the external handles which had been heated by fire. In any event injury could be caused if the window of the door proved difficult to lower and the glass was smashed in order to gain access to the handle.

14.31 As regards the first of the difficulties experienced by the passengers on the HST, Miss Forster said that the location of the signage would be examined with the assistance of Robert Gordon Institute.

14.32 Mr Burrows informed the Inquiry that in the early 1970s internal door handles had been introduced on the East Coast Main Line. However, they were soon removed because of a number of deaths which had been caused by passengers falling out of trains after the internal handles had been operated inadvertently. He said that he was presently working towards an engineering solution which would enable the doors to be opened immediately upon the operation of the release handle. Because of the dangers posed by inadvertent operation of that handle while the train was moving, he considered that the most likely solution would be the provision of two internal handles. One would be for normal operation of the door and could be used only when the central door locking system had been deactivated in stations. The other would be adjacent to the door and would enable the door to be opened immediately in an emergency. This might be situated in the glass box for the emergency release handle. He indicated that a difficulty in finding a solution was that slam doors were not a feature of new rolling stock. Development was currently concentrated on modern plug doors which slid along the exterior of the vehicle and then dropped back into the bodyside at the last moment.

14.33 In the case of the Turbo it appears that, in contrast with the situation in the HST, the difficulty which passengers experienced in opening its external doors was due to the effect of impact or to the need to overcome inertia in the door mechanism.

14.34 Professor Galea and Dr Weyman advocated the development of signage, primarily in the form of pictograms similar to those used on aircraft, depicting correct operation of emergency door mechanisms. They should conform to current human factors standards on signage and should be displayed prominently adjacent to each door and beside the door release mechanism, as well as within the carriage. They further recommended that door release mechanisms should be provided with artificial illumination to highlight their location at all times and, for an emergency, additional levels of illumination and a back-up power supply. I agree with what they said, subject to the exception of additional levels of illumination in an emergency, for which I do not see a compelling need. This should apply to all trains.

14.35 When an external door of the HST had been opened passengers were still left with the difficulty of getting down to the ground, a distance of some five feet. While there were three ladders on the HST, they were not readily available throughout the train. Two were in the power cars, and the third was in the senior conductor’s compartment. Mr Thomas, who was travelling in that compartment, gave evidence of having had difficulty in prising it off the wall in order to assist in evacuating passengers. Counsel for RMT submitted that the daily routine check of every train should include confirming that all ladders could readily be used, and that it should be possible to devise a better way of securing ladders which incorporated a quick release mechanism. I agree with these submissions.

14.36 Miss Forster pointed out in the course of her evidence that there were steps built into the bodyside of each HST coach under alternate doors. These could be used by a person to descend from a doorway, facing towards the bodyside. They were primarily intended for rail staff but in emergencies could be used by passengers. However, it appears that none of the passengers on board the HST were aware of them, and accordingly most passengers were helped out by others or jumped down to the ground. Miss Forster indicated that it was the intention of First Great Western to point out the location of the steps in future safety leaflets.

14.37 In 1974 the difficulty which passengers would experience in reaching the ground had been recognised in a report by Mr J C Williams on Emergency Escape Provisions for Advanced Passenger Trains. It acknowledged that the fabrication of steps of adequate size on the outside of the carriages would present problems of design safety. It was suggested at that time that there should be experiments with simple rope ladders.

14.38 In the course of the Inquiry it was suggested that there should be ladders or aircraft-type chutes at every exit point. However, it is plain that the adding of protrusions to a carriage has safety implications, and I do not favour this type of development. It also involves, as was argued by First Great Western, the danger of rapid uncontrolled exit. However, it is plain that assistance in dealing with a drop of five feet is highly desirable. The answer to the problem in the case of the HSTs seems to me to be better communication of information about the steps below the alternate doors.

Windows

The availability of hammers in the HST

14.39 The windows of the HST were made of toughened glass and could, if broken, serve as a route for emergency egress. The standard on emergency egress provides in section 4.7:

> "Where a bodyside emergency exit is provided by a breakable window, a suitable and easily accessible device for breaking the window shall be provided locally at each such exit".

14.40 It is convenient to point out at this stage that new rail vehicles, such as those commissioned by Eurostar and the new vehicles which are being built for First Great Western, make extensive use of laminated rather than toughened glass. The development of the use of laminated glass, which is virtually unbreakable, was prompted by past incidents in which passengers had been ejected from trains when they were derailed after striking obstructions. The standard for structural requirements for windscreens and windows provides that its requirements apply to new vehicles and to existing vehicles under refurbishment "insofar as it is opportune and practicable to incorporate them". It states in section 5.2:

> "All windows, except those designated for emergency egress, shall have at least one panel of laminated glass, or other transparent material with similar structural properties or better".

Windows designated for emergency egress, on the other hand, are to be of toughened glass. Section 4.1 of the standard for emergency egress states:

> "No passenger in a passenger saloon shall be further than 12m from a bodyside door or a bodyside emergency exit on each side of the vehicle".

14.41 Despite the terms of the standard to which I referred in para 14.39, hammers were not provided at each window on the HST. There were four hammers in each coach, towards the end and on both sides of it. Miss Forster said that, in the light of evidence given by passengers, First Great Western needed to review the number of available hammers. This was one of the matters on which the company would have the assistance of Robert Gordon Institute. First Great Western hoped that these reviews would be finished by the end of August 2000. Professor Galea and Dr Weyman gave evidence that there were insufficient hammers on board a HST and that they should be available at each window. Mr Burrows pointed out that this gave rise to certain human factors complications. Having regard to the development of vehicles in which most of the windows were of laminated glass, and were therefore not useable for emergency egress, with the consequence that there were far fewer hammers, there was a concern that confusion would arise when passengers saw that on some trains there were many hammers and on others there were far fewer. This was a matter on which First Great Western would be seeking the advice of the Institute.

Information about the location and use of hammers in the HST

14.42 At para 4.80 I described the difficulties experienced by passengers in locating and correctly using the hammers. Miss Forster accepted that information about the location of the hammers was "far from adequate" in the circumstances. Such information was contained in the pocket timetable. Otherwise passengers could only look around the coaches for them.

14.43 As to the instructions on the use of the hammers, Miss Forster said that the placing of these instructions was based on advice given by Human Engineering Ltd in their report. There had been a concern that to display a notice indicating where a window should be struck in order to break it would invite vandalism. I note that the fact that passengers were unaware that the windows required to be struck in the corner was confirmed by an informal survey of 20 commuters which was carried out by Mr Glen Webber, a train driver based at Paddington. 18 of them said that they would hit a window in its centre. It is certainly understandable that in an emergency the first instinct of passengers would be to use the hammer in that way without reading the notice, especially in smoky conditions and poor light. Mr Burrows said that this was a possible explanation of hammers having broken. As the glass was very difficult to break if it was struck in the centre, the energy of the blow would be reflected back into the handle.

14.44 Professor Galea and Dr Weyman said that improved means of communicating safety information could assist passengers in knowing where to hit the windows. There should be an independent assessment of the effectiveness of these means, incorporating user trials and passenger surveys. If these proved ineffective consideration should be given to putting additional signage on each window. In the light of the failure of some of the hammers the suitability of this type of hammer should be evaluated. There should be physical performance tests and trials of usability.

Removable windows

14.45 Professor Galea and Dr Weyman also said that in the longer term the removal of windows by means of using hammers to break them required to be reviewed as it placed excessive reliance on untrained individuals. Hence there should be a method of removing a window. With the introduction of laminated glass the need to seek an alternative was urgent. Professor Galea expressed his concern that, with the greater use of laminated glass windows, a passenger would not understand that it was not possible to break all the windows or that he or she needed to find the appropriate emergency window. In the United States of America there were removable windows. This type of window was in fact required under federal rules for all main line passenger trains. However, he accepted that there were difficulties in importing that experience into this country. One difference was that in the United States there was greater surveillance of passengers and hence less risk of vandalism. Mr Burrows told the Inquiry that First Great Western had been considering the possibility of providing removable windows. He described a type of window which was secured by a rubber insert. When the window required to be removed, a tag was pulled. This removed a rubber cord from the surround of the window, causing it to fall out. However, the major problem was the possibility of vandalism. This was, in his words, "a very, very, high risk unless we had some system to make sure it was only used in the event of real emergency". First Great Western were looking to see whether an engineering solution could be devised so that the window could only be removed in such circumstances. Another danger was that the window would fly out at speed, risking injury to passengers on board the train or at stations or on passing trains. Professor Galea indicated that one possibility was a push-button system to release a shock which would shatter the window, similar to that used in double-glazing. However, the preliminary investigations by First Great Western indicated that it was preferable to keep the glass in a single pane. The Formal Inquiry into the crash recommended at Recommendation 13.5 that removable windows should be evaluated. ATC stated that they and First Great Western were already addressing this, in conjunction with manufacturers. There were problems with the structural integrity of the glass and with the danger of the window becoming detached at speed.

The need for review

14.46 In the short term there should, in my view, be a thorough review of the adequacy of the number of, and signage relating to, emergency hammers. This should include the provision of means of illuminating the location of hammers in an emergency. For this purpose a back-up power supply would be required. For the longer term there is plainly a need to carry out research into the feasibility of, and risks associated with, removable windows which could supersede the need for the use of hammers. The general question of the adequacy of windows as a means of emergency egress requires further study as well. This should include a review of the number of dedicated windows which are necessary and the provision as to the maximum distance between each passenger and a bodyside door or emergency exit.

The absence of hammers on the Turbo

14.47 As I stated in para 4.89, the occurrence of substantial vandalism led to the removal of hammers from Turbos. The risk assessment which Thames Trains obtained from Engineering Link concluded that it was:

> "… evident that the risk associated with hammers being stolen from vehicles far outweighed the possible benefits from their fitment, and that given the number of hammers being stolen it was reasonable to expect a serious incident involving their use either on or off a vehicle in the future".

14.48 Mr Pamment agreed that vandalism should not be an excuse for a lack of passenger emergency safety features. In the present case it may be noted that the passengers in the rear car of the Turbo owed their escape to the fortuitous circumstance that Mr Dicker and Mr Barrell were able to unlock the door to the rear driver's cab. Similarly Professor Galea stated that vandalism was really a separate issue from passenger safety. He said:

> "If the risk assessment case shows that the suggested recommendation is of benefit, of net benefit to passenger safety, then the issue of vandalism should be addressed as an issue of vandalism and not as an issue potentially of passenger safety".

I agree that, as a generality, vandalism is not a good excuse for not taking measures which are needed in order to provide adequate safety for passengers. On the other hand it is unrealistic to ignore the risk of vandalism when considering a particular measure: the risk of vandalism may be so great as to render it ineffective as a practical matter. The search should then be for an alternative which will meet the need in another way but without the same vulnerability.

14.49 It may be noted that following the crash Thames Trains reinstated the hammers in the first class section of their 165s because the bi-parting doors which separated that section from the rest of the saloon were considered to constitute a barrier. I agree with Counsel for the bereaved and injured that the removal by Thames Trains of all the hammers prior to the crash compromised the safety of passengers. As I pointed out at paras 4.86 and 4.93 if it had not been for the fortuitous assistance of Mr Dicker and Mr Barrell, passengers in the rear car of the Turbo would have had great difficulty in escaping from it.

14.50 Professor Galea suggested that the theft of hammers could easily be addressed by attaching them to a chain, especially if a hammer was at every window. He suggested that most thefts were opportunistic, and most vandals would not have means of cutting through chains. I am extremely sceptical about these observations which seem to me to be unrealistic. It should be noted, however, that in 1995 Mr D A Sawer, Assistant Chief Inspecting Officer of Railways, had suggested to Thames Trains that the hammers could be built in to the passenger alarm system, so that they could be released only after the alarm had been activated. Mr Pamment accepted that Thames Trains had not acted on this suggestion. I agree with the submission by the Collins Passengers' Group that tests should be carried out into the practicability of this proposal. In that connection I note that the Formal Inquiry into the crash recommended at Recommendation 13.1 that the non-provision of window hammers should be re-appraised and consideration should be given to providing them in secure locations. The Formal Inquiry report shows that, at para 5.43.2 of the notes of the Ladbroke Grove Special Review Group Meeting on 11 April 2000, it was recorded that Mr Worrall agreed that Thames Trains would implement that recommendation.

Hand and foot holds

14.51 Professor Galea and Dr Weyman suggested that access to enable escape through windows and side doors in overturned carriages could be improved by blending into the design of seats, tables and door areas suitable hand and foot holds which would assist passengers in climbing up to them. There is, of course, a risk that this could facilitate vandalism. I do not favour this proposal, as I consider that the feasibility of making and using such hand and foot holds is dubious.

Escape hatches

14.52 Because of the difficulties described by passengers in escaping from coaches of the HST which were on their sides it was suggested that escape hatches should be provided in the roof of such coaches. This was suggested in the report in 1974 in regard to Advanced Passenger Trains to which I have already referred. Professor Galea and Dr Weyman said that this merited further consideration, particularly in view of the introduction of laminated glass windows. Account should be taken of human factors, including ease of operation, accessibility, size of aperture and the size of step-up and step-down. The experience of the aviation industry in the design of type III over-wing emergency exits should be taken into account as well.

14.53 Mr Burrows said that he had considered the possibility of roof hatches. He believed that it would be possible to insert them, although there would have to be fundamental changes in the layout of the equipment within the roof space, since this was used for in-train systems such as lighting and air-conditioning. The owners of the coaches, ATC, would have to be involved. The introduction of roof hatches was a "very, very major modification to make to the vehicles" and in the case of a number of types of rolling stock, "the structural integrity would be severely impaired". Care would have to be taken to avoid creating dangerous situations such as passengers coming into contact with overhead power lines or the hatch becoming detached when the train was running at high speed. Vandalism was another concern. There would require to be a balancing of risks. Counsel for First Great Western submitted that little was to be gained from roof hatches. When a coach had fallen on its side passengers usually escaped from its ends, as they did in the case of coaches F and G. Counsel for ATC submitted that vandalism, unauthorised use, the possibility of a hatch coming loose when the train was travelling at speed, the effect on structural integrity and the dangers of overhead lines would require to be considered. Professor Galea and Dr Weyman mentioned the possibility of an orientation mechanism which allowed the hatch to be opened only when it was beyond a certain angle to the vertical. It appears that this idea has not yet been considered, otherwise than in a very preliminary way. They also suggested that the hatches should have a porthole or transparent fire-resistant area within the hatch design to allow passengers to detect the presence of any external fire before the hatch was opened.

14.54 I consider that, while there appear to be significant drawbacks, the incorporation of escape hatches in existing carriages should be the subject of feasibility and risk assessment, and the provision of escape hatches in new carriages should likewise be considered.

Passenger's luggage

14.55 Luggage can present a risk of injury to passengers or of hindering easy egress from the train when it is dislodged in the course of a collision. It should be noted, however, that in the present case it appears that no passengers were injured in this way. Professor Galea and Dr Weyman suggested that, in the case of luggage which was located near the interior doors of an HST, means should be found to make it secure, or alternatively consideration should be given to providing an alternative secure location, such as between the seats and in facilities that did not stretch to the ceiling. They also suggested that the storage and location of unsecured items, such as bicycles, deserved further consideration; and that effective means should be developed to secure luggage placed in overhead racks. Briefing cards and/or announcements should instruct passengers to leave all carry-on luggage behind in the event that an evacuation proved to be necessary. Professor Galea also stated that the location of wheelchairs should be carefully considered.

14.56 The evidence before me is not sufficient to persuade me that I should make recommendations on these matters.

Partitions

14.57 Professor Galea and Dr Weyman observed in their report that carriage partitions may create obstructions which in some circumstances could impede the process of evacuation. They suggested that to resolve this issue and to quantify the parameters that impeded escape there should be a series of trials which would consider the impact of a number of variables. I am not persuaded that it is necessary or appropriate for me to recommend this. As was pointed out by First Great Western, there does not appear to be any evidence that the partitions impeded evacuation. Indeed there was some evidence that they were positively helpful, in the event of a crash, in limiting the effect of the impact on persons and objects. The evidence given by witnesses from coach H and by the fire expert Mr Christie suggested that the partition in that coach may have been instrumental in limiting the development of the fireball in it.

The train crew

14.58 In para 4.62 I referred to the recent change which had been made in the responsibilities of the driver and guard, and the attempts by Mr Paton to contact the driver of the HST who had become, according to the change in the Rule Book, solely responsible for the protection of the train. In the event Mr Thomas put down track circuit clips as a safeguard. Mr Paton pointed out in his evidence that, in the event of an accident, even if the driver was not injured, he was likely to be very shocked. He described the notion that the driver would then be expected to get out and start taking charge of the accident site as "ludicrous". Counsel for RMT submitted that the previous rule should be reinstated and that the driver and the guard should be jointly responsible for the protection of the train. Hence they would be expected to take immediate steps to protect the train at each end.

14.59 Mr Worrall told the Inquiry that driver-only trains constituted about 50% of Thames Trains' operations. Even in the case of a driver-only train, there were usually other company employees on board, such as staff concerned with catering, revenue protection and ticket examination, whose presence was not essential for the running of the train. Counsel for RMT submitted that the move towards more driver-only operated trains was shortsighted and that every train should have a guard.

14.60 As regards training, Mr Paton had reservations. He felt that training would be better if it was given by external agencies rather than by fellow-employees. He had been on a guard's training course and was reassessed every two years. The last time when he had been assessed was on 30 April 1999. Miss Querino, a despatch supervisor employed by First Great Western who was a passenger in coach C, said that she had been given one day of fire training in 1991 and one day of station evacuation training in about 1993/1994. She had also been trained in first aid and had obtained a St John's Ambulance Certificate in 1992. However, she had not had any refresher fire or first aid training since the original courses. This was despite the fact that her first aid certificate, which was valid only for a period of three years, had expired some years earlier. She felt that further training in first aid, fire and evacuation would be helpful. Miss Forster told the Inquiry that the HSE report into the Maidenhead accident had recommended that TOCs carry out a review of the emergency training and instruction given to on-train staff. Thereafter First Great Western had trained all their staff in regard to the action to be taken in an emergency, and had supported this with the distribution of a leaflet which described the location and use of emergency equipment, the roles of the conductor and the driver, and gave guidance as to what action was expected of them. Catering staff were given training in fire and first aid as part of their classroom induction. They were given an on-train familiarisation session to make them aware of where the emergency equipment was located. However, they were not given training in train evacuation or protection. First Great Western staff were presently undergoing training by means of a training package called "Reality". This had been available since August 1999 and trained all staff on how to recognise, evaluate and act in certain emergency situations.

14.61 It may be added that Mr Thomas, who was a train manager with Virgin Trains, felt that he had received more training when he was employed by British Rail. He had concerns that new employees who were working on trains such as the HSTs would not have the experience or confidence to take the required actions in an emergency. He felt that since privatisation employees were not being given as much as training as they ought to be. Miss Ryder, who was a senior stewardess with Virgin Trains, indicated that after privatisation she had received only classroom training, by means of "safety briefs". The principles of what was required to be covered in staff training were set out in the code of practice on the competence and training of personnel. It states that staff training should include awareness of the hazards and principles of train evacuation, including the identification of safe exits, the location and use of ladders, and instructions to passengers on track safety and hazards which they should be looking out for. Miss Ryder confirmed that her training had covered these matters. However, she said that senior stewardesses were no longer expected to go on to the track unless there was an evacuation. She considered that there was less training than during the days of British Rail. From about 1998 employees in her position had less responsibility for track safety. They were no longer given training involving "scenarios".

14.62 While I see force in the submissions which were made by Counsel for RMT in regard to the presence of guards and their responsibilities, the issues which these raise go beyond the scope of health and safety alone. In any event I recommend, not increasing the number of on-train staff, but increasing the training of the existing staff so that all members of the on-board staff (including persons working under contract) are trained in train evacuation and protection. This should be augmented by improved means of communication to which I will refer next.

Communications

14.63 So far as external communications are concerned, I have already referred to the limited usefulness of the NRN radio system, and to the restricted scope of the CSR. There is plainly a need for the development of a nation-wide radio system which will enable there to be direct communication between train drivers and signallers.

14.64 Miss Forster informed the Inquiry that First Great Western had issued mobile telephones to their senior conductors, and since February 2000 had been conducting trials to see whether it was beneficial for their drivers to have them also. In order to avoid the danger of drivers being distracted they had been issued with a protocol as to their use. The provisional view was that issuing them to drivers was a success, but it would be risk-assessed before it was made a permanent arrangement. There would still be a need for drivers to use signal post telephones because the signaller needed to know exactly where the driver was and to be sure that he was speaking to the right person. Mr Paton, the senior conductor on the HST, said that it would be useful for guards to be issued with a small pocket-size card showing all relevant telephone numbers. He said that he had been unable to recall the telephone number of the IECC and instead used the trackside telephone. I agree that his suggestion has merit.

14.65 There should also, in my view, be a study of the possibility of installing on driver-only trains a telephone by which passengers can communicate with the signaller in the event of the driver being killed or incapacitated, so as to enable them to obtain advice and information in such an emergency.

14.66 One of the recommendations of the report of the HSE's investigation of the Maidenhead accident was that there should be a review of on-board communication systems. In that case the driver had been unaware that there was a fire on the exterior of the train.

14.67 Miss Forster said that First Great Western had given consideration to improvements in internal communications, such as additional points throughout the train from which the senior conductor could make announcements. Radio communication had also been considered, but there were technical difficulties associated with it. It was currently being re-examined by First Great Western with the assistance of an external risk assessor. The action taken by First Great Western in response to the recommendation by the HSE's report of the investigation of the Maidenhead accident had been limited to the issue of mobile telephones to senior conductors and, on a trial basis, to the drivers. This would enable the senior conductor and the driver to contact each other and the buffet car staff.

14.68 Professor Galea and Dr Weyman suggested that the feasibility of introducing a "roaming" communication system used by train staff should be examined. They said that ideally it should interface with the public address system and also allow crew to communicate among themselves. It should be capable of operating despite de-coupling of carriages. Counsel for RMT submitted that a modern communication link should be available between the guard and the driver so that the guard was able to obtain access to the public address system from any of the coaches and not merely his own compartment or the buffet car. I agree with the substance of that submission and, in addition, the submission made on behalf of the Rail Users' Committees. But the possibility of remote broadcasting from outside the train, where it is not already available, should also be investigated.

14.69 The public address system in a Turbo could normally be used by the driver to make announcements to the passengers. A signaller could also speak directly to the passengers from the signalling centre, provided that he or she had entered the headcode for the train.

Evacuation exercises

14.70 The standard on emergency egress recommends that evacuation trials should be carried out by TOCs. Miss Forster indicated that First Great Western took part in such trials which were organised by Railtrack about once a year, although their primary purpose was to evaluate the response of the emergency services. Mr Wadey told the Inquiry that ATC took part in these exercises but did not get any feedback from them. He said that ROSCOs sometimes felt that they were "kept out of the loop". ATC would have benefited from feedback. Mr Worrall expressed the view that, while evacuation exercises were of some value, they tended to be restricted to the area where the exercise was held. They could also become unwieldy. Robust arrangements needed to be made because there were always adverse comments about the extent to which volunteer passengers were put at risk.

14.71 In his report on the Southall rail crash Professor Uff's Recommendation 52 was:

> "Train crews should be given improved training and briefing on emergency actions, including a practical evacuation".

A recommendation to the same effect was made by the Formal Inquiry at Recommendation 13.2 in their report into the crash at Ladbroke Grove. Professor Uff's Recommendation 53 was:

> "Standards for evacuation of passengers should be proved by practical exercises using typical groups of passengers and train crew, and repeated on a regular basis to be approved by HMRI".

In view of these recommendations, with which I agree, I do not consider it necessary to make any further recommendation on this subject.

Security of passengers

14.72 In the course of the Inquiry some references were made to the implications of the overcrowding of trains. I noted that a report on the implications of overcrowding on railways for the HSE in 1999 concluded that while at lower speeds seated passengers would be less at risk of serious injury, particularly if they had sufficient warning to prepare for the impact, there was otherwise no evidence to suggest that there was a difference in the severity of injuries depending on whether passengers were seated or standing. Counsel for First Great Western submitted that the lack of need to pre-book, freedom of movement within a train and the ability to get on to a train even if there was only standing room were part of the attractions of train travel which would be compromised by making trains "all seated". On the other hand I understood that First Great Western are considering the possibility of dissuading passengers from moving forward in the train shortly before arrival at the terminus. I do not consider that it is necessary for me to make any recommendation, but I would be in favour of passengers being dissuaded in the way which is envisaged by First Great Western.

14.73 Professor Galea and Dr Weyman suggested the feasibility of passenger restraint systems. In their view they had the potential to prevent fatalities and reduce injuries caused by passengers being thrown out of their seats. Their report stated that before any firm conclusions could be drawn on preferred seating direction and the potential feasibility of passenger restraints, there should be a more detailed study to correlate the type and nature of injuries sustained with the seating configuration and the point when in the course of the impact the injuries were sustained. Professor Galea said that the U.S. Federal Rail Authority had a programme of research underway into the possibility of introducing seat belts. On the other hand I was informed that there did not appear to be any railway network in the world which used seat belts. It was suggested by Counsel for First Great Western that injuries would arguably be worsened by seat belts. In any event the willingness of many passengers to wear them was in doubt. I do not consider that the evidence before me justifies me in making a recommendation on this subject.

Emergency equipment

14.74 The standard on emergency and safety equipment states that in each operative driving cab, and, where applicable, the guard's accommodation, there are to be portable fire extinguishers. It also states that on trains carrying passengers a number of items of emergency equipment are to be provided for the use by the train crew, and, if desired, for the use of passengers. These are a ladder or step ladder made from non-conducting material, first aid equipment and portable fire extinguishers. In my view the availability to passengers of the latter items of emergency equipment should not be at the discretion of the TOC, and the qualifying words "if desired" should be removed.

14.75 It was submitted by Counsel for the RMT that there should be a daily routine check of every train to ensure that all fire extinguishers are not only in place but also full. I see no basis in the facts of the present case to call for such a recommendation. I also do not consider that I should make a recommendation as to the number, type or distribution of fire extinguishers. No doubt after the crash at Ladbroke Grove the fire extinguishers proved inadequate for the purpose of dealing with the considerable fires which took place, but this could not have been cured by provision of more fire extinguishers or fire extinguishers of a different specification. The fire extinguishers were never capable of dealing with fires of such magnitude.

Chapter 15
Summary of recommendations

Introduction

15.1 In this chapter I will set out my recommendations in the light of the matters which I have discussed earlier in this report. I thank Counsel to the Inquiry and the representatives of the parties for their suggested recommendations, all of which I have considered.

15.2 Counsel for Railtrack requested that there should be an opportunity, if at all possible, for draft proposed recommendations to be the subject of constructive comments in writing before any recommendations were finalised by the Inquiry. Having regard to the nature and scope of my recommendations I do not consider that it is necessary or appropriate to proceed in this way.

15.3 Each recommendation is followed by a reference to the paragraph in the report to which it is most directly related. I set out the recommendations in, so far as possible, the order of the paragraphs to which they refer.

15.4 While I attach importance to all of my recommendations I regard some of them as central. These key recommendations are printed in italics.

15.5 Beside each recommendation is the name of the body (in some instances more than one) which should, in my view, be primarily responsible for its implementation.

15.6 I have given consideration to the period which I should recommend for the implementation of each of my recommendations, where that is not specified in the recommendation itself. I have sought to avoid the imposition of unrealistic requirements. The periods which I have selected are denoted by numbers, as follows:

- ‘1’ means up to 6 months
- ‘2’ means up to 12 months
- ‘3’ means up to 2 years

I have not stated a period where that is unnecessary or inappropriate, as in the case of a continuing duty. I draw particular attention to the words “up to”. All reasonable efforts should be taken to achieve implementation in significantly less than these periods.

15.7 Counsel for the bereaved and injured submitted that I should ensure that my recommendations are implemented. I consider that the appropriate course for me is to follow that taken by Professor Uff in his report on the Southall crash, and make Recommendation 89 below accordingly.

Support of the bereaved and injured

1.	The system for the reception of information about missing persons, casualties and survivors should be computerised. It should be possible for information which has been received to be entered directly into the computer and for information from it to be provided, to the extent appropriate, to callers. There should be a set procedure for the returning of a call (para 4.119).	**ACPO** **ACPOS**
2.	Computerisation should be extended to all police forces, so that the information collated by each is readily available to all others (para 4.120).	**ACPO** **ACPOS**
3.	The police service, in co-operation with the emergency services, should use their best endeavours to ensure that common telephone numbers are issued for the use of members of the public who are seeking to give or obtain information about persons who have, or may have, been involved in a major incident (para 4.121).	**ACPO** **ACPOS** **1**
4.	The Railway Group should review emergency planning, including liaison with the emergency services, arrangements for the after-care of survivors and the provision of support and facilities for the bereaved and injured (para 4.122).	**Railway Group Members** **1**

Track and signalling changes

5.	*Where a material change to track or signalling or both is proposed, there should be an express consideration of all relevant safety issues by an analysis of the material factors, if necessary by means of a risk assessment. This should be done on a holistic basis at the design concept stage and repeated at defined stages up to and including full implementation (para 7.17).*	**Railtrack** **1**

Implementation of Formal Inquiry recommendations

6.	*Railtrack procedures, and the actions of management to enforce them, should be directed to ensuring that:* (i) *a recommendation which is accepted is implemented according to a defined timescale;* (ii) *the person to whom a recommendation is allocated for implementation is required to report periodically the action which has been taken, the state of progress and the reasons for any delay;*	**Railtrack** **1**

(iii) *the monitoring of the implementation of a recommendation is assigned to an identified individual whose duties are clearly defined, whether by job description, formal instruction, or training or a combination of these methods;*

(iv) *the person to whom monitoring is assigned is required to ensure that the recommendation is implemented according to a defined timescale;*

(v) *a recommendation should not be abandoned unless, exceptionally, this is shown to be fully justified to the person to whom monitoring is assigned;*

(vi) *any management system to which the recommendation relates is altered to align it with the recommendation;*

(vii) *the effectiveness of a recommendation is audited after its implementation;*

(viii) *full records are kept of all recommendations and their state of progress; and*

(ix) *there is a system for the central tracking of recommendations which are directed to Railtrack Line and those which, either immediately or thereafter, are directed to one or more of the Zones (para 7.106).*

7. Consideration should be given to extending sub-para (ix) of Recommendation 6 to recommendations which are directed to one or more of the TOCs and others (para 7.106). **Railtrack 2**

Signalling in the Paddington area

8. Railtrack should ensure that the risk assessments and any consequent actions required under Group Standard GK/RT 0078 in respect of the signals in the Paddington area are carried out as soon as possible (para 7.125). **Railtrack 1**

9. *Railtrack should conduct a safety examination of the layout over 0-2 miles from Paddington Station so as to satisfy the HMRI, if necessary by a risk assessment and additional measures, that it is safe for operation at current speeds and to current traffic arrangements. Such a safety examination should be repeated before the implementation of any change which is or may constitute, in the opinion of the HMRI, a material change of circumstances (para 7.126).* **Railtrack 1**

10. *No change should be made in the direction of running on line 3 or in the current speed limits on any of the lines out to two miles six chains from Paddington Station unless and until the following have been done to the satisfaction of the HMRI, namely:* **Railtrack**

    (i) *a risk assessment has demonstrated that the change can be implemented in safety, and, if this can be achieved only if certain measures are taken, what these measures are; and*

    (ii) *such measures have been implemented and shown to be effective*.

The risk assessment should take account of the following possible measures, inter alia:

(i) *the conversion of four-aspect to three-aspect signals;*

(ii) *the addition of flank protection at SN109 and elsewhere if appropriate;*

(iii) *the installation of standard, simple, non-distracting and consistent means of line identification;*

(iv) *the alteration of the height, configuration and mounting of signals; and*

(v) *the installation of an additional gantry to the east of Portobello Bridge for carrying Down signals previously carried on gantry 8.*

The risk assessment should be carried out by persons independent of Railtrack and in accordance with usual standards and the best available methods. It should take account of human factors which may affect the actions of drivers and signallers, and any risks which the carrying out of any of these measures might create (paras 7.127 and 7.128).

Driver management and training

11.	Signallers and drivers should jointly attend away days and other training processes to develop their mutual understanding (para 9.28).	**Railtrack** **TOCs** **2**
12.	*Thames Trains should increase the frequency of the briefing of drivers with a view to ensuring that each driver has a face to face meeting with his or her driver standards manager at least monthly, if not more often, and safety should be the first item on the agenda of these meetings (para 9.29).*	**Thames Trains** **1**
13.	The adoption by TOCs of the teaching and practice of defensive driving is endorsed (para 9.39).	**TOCs**
14.	*TOCs should review the effectiveness of the systems in place to deliver the required level of driver competence at least once every three years, and should retest the driver against the revised systems at the same frequency (para 9.49).*	**TOCs** **1**
15.	The ATOC study on the central licensing of drivers should be progressed expeditiously (para 9.50).	**ATOC** **2**
16.	ATOC should consider the application of NVQs to the driver licensing scheme presently under their consideration (para 9.52).	**ATOC** **2**
17.	The development of a culture within the industry in which information is communicated without fear of recrimination, and blame is attached only where this is justified, is commended (para 9.60).	**Railway Group Members**
18.	Thames Trains and other TOCs should ensure that their driver training and testing programmes adequately reflect the need for specific, relevant and validated criteria. Drivers should be tested against these criteria, and a definite pass standard should be established. Consideration should be given as to how often drivers should repeat key steps in their training before submitting themselves for testing (para 9.64).	**Thames Trains** **TOCs** **2**
19.	Further research should be carried out to develop the understanding of human factors as they relate to train driving (para 9.66).	**Railway Safety** **TOCs**

Safety Auditing

20.	The safety audit process should be strengthened, and the quality of communication during the process should be improved (para 9.44).	**Railway Safety** **Railtrack** **TOCs** **1**

21. An organisation the activities of which are being audited should disclose all material and relevant information to the auditor in regard to the area of the activity which is being audited (para 9.46). **Railtrack TOCs 1**

Signal sighting

22. *The standard on signal sighting should require that explicit consideration is to be given to the readability of a signal. It should be made clear that the fact that a signal complies with a minimum requirement is not of itself to be taken as meaning that it is adequate (para 11.13).* **Railway Safety 1**

23. *The standard on signal sighting should deal explicitly with the additional time required for the reading of certain signals, including (but not necessarily limited to) those mounted on gantries (para 11.13).* **Railway Safety 1**

24. *Human factors experts should be involved in the revision of the standard on signal sighting (para 11.13).* **Railway Safety 1**

25. *The reference to "very short duration" in the standard on signal sighting should be clarified (para 11.14).* **Railway Safety 1**

26. *Areas where ambiguity in the meaning of "very short duration" may have caused, or may still cause, problems should be identified. There should be a retrospective review of all locations where this may be the case, so that appropriate action may be taken (para 11.14).* **Railtrack 2**

27. *The expression "overhead line equipment" in the Group Standard on signal sighting should be clarified by the statement that it refers only to wires and droppers (para 11.16).* **Railway Safety 1**

28. *The standard on signal sighting should define acceptable limits to the temporary obscuration of a signal, subject to the overriding right of a signal sighting committee to determine whether the nature and extent of the interruption in the individual case is such that the sighting is unacceptable (para 11.16).* **Railway Safety 1**

29. *The standard on signal sighting should explicitly define the cab sight lines within which signals must be positioned by reference to the envelop governing the position of the driver's eye which is specified for each particular rolling stock (para 11.17).* **Railway Safety 1**

30. The report by W S Atkins "Initial Study of Signal Sighting Practice on Railtrack Infrastructure", Issue 1, 6 March 2000, is commended (para 11.19).

31. Railtrack, in consultation with the TOCs, should examine the availability of signal sighters to meet the expected workload and take all necessary steps to ensure that there is an adequate supply of trained signal sighters and an adequate range of skills (para 11.20). **Railtrack TOCs 2**

32. It should form part of Railtrack's safety management system that it is the responsibility of senior Zone operating and signal engineering management to decide whether the recommendations of a signal sighting committee under the Group Standard on SPADs are to be implemented and, if not, what alternative measures are to be taken, and, in either event, that the relevant measures are implemented (para 11.22). **Railtrack 1**

SPAD investigation

33. *The Group Standard on SPADs and its associated documentation should be reviewed to ensure that there is no presumption that driver error is the sole or principal cause, or that any part played by the infrastructure is only a contributory factor (para 11.27).* **Railway Safety 1**

34. *The use of the word "disregard" in the Group Standard on SPADs and its associated documentation should be reconsidered (para 11.29).* **Railway Safety 1**

35. Persons who investigate, and make recommendations as a consequence of, SPADs should be trained in the identification of human factors and in root cause analysis. Their competence in these areas should be formally recorded, and renewed by refresher courses. The analysis of SPAD data should be specifically directed to eliciting the part played by human factors and assessing the significance of the hazards against which the signals which have been passed at Danger were intended to afford protection (para 11.31). **Railtrack TOCs 2**

Signallers' instructions

36. *The instructions for signallers as to their response to a SPAD should be:* **Railtrack 1**

    (a) *clarified; and*

(b) *set out in a single set of instructions, while if there are matters which are specific to a particular area they should be covered by separate local instructions (para 12.9).*

37. *The instructions for signallers should state explicitly that the signaller is expected, in the event of a SPAD, to make an assessment and to take action immediately (para 12.10).* **Railtrack 1**

38. *The instructions for signallers should provide a set of options, including the use of the CSR (where it is available) either to send an emergency stop message to a particular train or a general stop message. This range of options should be supported by full and regularly repeated briefing as to the type of circumstances in which each option is or may be appropriate (para 12.11).* **Railtrack 1**

Signallers' training and briefing

39. Railtrack should institute a system whereby all signallers in the signal box (or centre) are briefed by their line manager following a SPAD in their area, and there is appropriate dissemination of information which may be of assistance to signallers elsewhere (para 12.13). **Railtrack 1**

40. Railtrack should ensure that the reports which are made to the Zone about a SPAD should include a report by the signaller as to the actions taken by him or her and the reasons for such actions (para 12.13). **Railtrack 1**

41. The use of simulators in providing fully effective training of signallers in dealing with emergencies is endorsed (para 12.15). **Railtrack 3**

42. Railtrack and the TOCs should take steps to ensure that signallers and drivers obtain a full appreciation of the nature and demands of each other's work (para 12.16). **Railtrack TOCs 2**

Signallers' working conditions

43. *Railtrack should review the work done by signallers to identify all non-essential tasks and eliminate them from the work which is performed by them while they are in charge of a workstation (para 12.17).* **Railtrack 1**

44. A supervisor should be employed on a continual basis to ensure that the workstations are operated in the most effective way (para 12.17). **Railtrack 2**

45. Signallers should take the opportunity from time to time to practise the controlling of train movements (para 12.18). **Railtrack**

46. Railtrack management should set out the criteria for allowing signallers, in exceptional circumstances, to exceed the maximum of 72 hours of work per week, and ensure that these criteria are, and continue to be, correctly applied (para 12.19). **Railtrack 1**

IECC equipment

47. *There should be a unique alarm for SPADs, which should sound until it is turned off (para 12.21).* **Railtrack 1**

48. *The speed with which signallers can take action to move points in an emergency should be improved (para 12.22).* **Railtrack 2**

Automatic controls

49. There should be a study of the possibility of the automatic replacement of a signal to Danger where a SPAD has occurred and the layout is such that there is a significant danger of collision (para 12.27). **Railtrack 3**

50. Subject to satisfactory risk assessment, an arrangement should be made whereby, when a train which is fitted with the CSR passes a signal at Danger, an audible warning automatically sounds in the cab (para 12.28). **Railtrack 3**

Radio communications

51. *There should be a national system of direct radio communication between trains and signallers (para 12.29).* **Railtrack TOCs 3**

Preservation of data

52. Signallers, managers and maintenance staff working at IECCs should be instructed as to the need to preserve CSR data disks in the event of a SPAD taking place (para 12.30). **Railtrack 1**

Crashworthiness

53.	*The enhancement of the cabs on HSTs to improve driver protection along with energy absorption and compatibility with other vehicles, and the enhancement of measures for the retention of bogies on the coaches of HSTs, should be considered, subject to an assessment of feasibility, costs and benefits, with a view to possible retro-fitting (para 13.4).*	**TOCs ROSCOs 2**
54.	*The current standard for crashworthiness in respect of new vehicles should be reviewed in the light of the crash at Ladbroke Grove with respect to the objectives referred to in Recommendation 53 (para 13.4).*	**Railway Safety 2**
55.	*In the case of Turbos, the enhancement of end pillar weld connections, the possible enhancement of crashworthiness by weakening the ends and strengthening the saloon of the cars, and the fitting of shear-out couplers and anti-overriding devices should be considered, subject to an assessment of feasibility, costs and benefits, with a view to possible retro-fitting (para 13.5).*	**TOCs ROSCOs 2**
56.	*The current standard for crashworthiness should be reviewed, in the light of the crash at Ladbroke Grove, in order to ensure that there are adequate measures for safeguarding survival space (para 13.5).*	**Railway Safety 2**
57.	In the case of new vehicles constructed of aluminium, consideration should be given to: (i) the use of alternatives to fusion welding; (ii) the use of improved grades of aluminium which are less susceptible to fusion weld weakening; and (iii) the further development of analytical techniques (para 13.9).	**ROSCOs Manufacturers 3**
58.	*The revision of the Group Standard for crashworthiness should be pursued with particular reference to:* (i) *the design requirements for more realistic scenarios;* (ii) *high speed accidents; and* (iii) *dynamic verification testing (para 13.17).*	**Railway Safety 2**
59.	The enhancement of the security of seating in Turbos and of tables in HSTs should be considered, subject to an assessment of feasibility, costs and benefits, with a view to possible retro-fitting (para 13.19).	**TOCs ROSCOs 1**

60. Comprehensive market research in regard to safety related measures should be carried out in order to take account of the views of informed passengers (para 13.20). **TOCs 2**

Fire mitigation

61. *The following measures should be considered with a view to enhancing protection against fire:* **Railway Safety TOCs ROSCOs 2**

(i) *a review of Group Standards in respect of improved crash resistance of fuel tanks;*

(ii) *consideration of the feasibility of reducing fuel inventories and of utilising smaller fuel tanks;*

(iii) *in respect of frontal impacts, consideration of the repositioning of fuel tanks away from the leading ends of trains from behind bogies wherever this is practicable;*

(iv) *avoidance of placing fuel tanks in exposed and vulnerable locations;*

(v) *examination of the use of additives to reduce the propensity of a fuel to atomise;*

(vi) *the employment within fuel tanks of internal flexible linings or a honeycomb construction;*

(vii) *consideration of the most appropriate material for fuel tanks; and*

(viii) *recognition of the need for supporting theoretical and experimental work in respect of the foregoing (para 13.27).*

Passenger protection, evacuation and escape

62. The scope of Schedule 1 to the Railway (Safety Case) Regulations 2000 should be extended so as to include explicitly the arrangements which the duty holder has established in regard to facilities, instructions and signs for the escape of persons in an emergency (para 14.3). **HSE 1**

63. The provisions in the schedule as to evacuation and escape should be supported by adequate guidance from the HSE (para 14.3). **HSE 2**

64.	The code of practice on public information on train safety and emergencies should be kept up to date (para 14.6).	**ATOC**
65.	So far as is feasible, the safety information issued to passengers and the means by which they can be evacuated or escape from a train should be standardised (para 14.8).	**ATOC** **2**
66.	A system should be established for the collection of human factors information pertinent to issues of passenger safety following rail accidents (para 14.8).	**ATOC**
67.	Passengers should be given general safety advice both before and after they have boarded their train (para 14.14).	**TOCs** **1**
68.	*Expert assistance should be obtained on the advice which should be given to passengers as to what to do in the event of there being a known threat of serious danger to them in remaining on board (para 14.14).*	**ATOC** **1**
69.	*The provision on board of explanatory information about the emergency facilities of individual trains is endorsed (para 14.14).*	**TOCs** **1**
70.	*The use of on-board announcements to draw attention to safety information is endorsed (para 14.16).*	**TOCs** **1**
71.	The requirement for emergency signs to be luminous should be made retrospective (para 14.18).	**TOCs** **ROSCOs** **2**
72.	*So far as is feasible, emergency signs on all trains should be capable of being understood by passengers without the necessity to read text (para 14.19).*	**TOCs** **ROSCOs** **2**
73.	There should be research with the aim of arriving at a system of signage which is common to all trains in Great Britain (para 14.20).	**ATOC** **3**
74.	Research should be carried out into the means of safeguarding emergency lighting systems from disablement by the forces involved in sudden deceleration (para 14.21).	**ROSCOs** **3**
75.	The provision of "snap wands" should be considered as a supplementary means of providing lighting in an emergency (para 14.22).	**TOCs** **1**
76.	*In the case of every coach (on any train) which has internal doors which slide in the same direction one of the following should be carried out by 31 December 2003:* (i) *the coach should be fitted instead with opposite-handed internal doors;*	**TOCs** **ROSCOs**

(ii) *the coach should be fitted instead with double leaf internal doors; or*

(iii) *a panel in the door should be rendered removable so as to enable passengers to pass through.*

The above is subject to the proviso that if the HMRI are satisfied, on application by the TOC concerned, that it is not practicable for that change to be achieved within this period, they may grant a deferment for an appropriate period in which the work is to be done (para 14.28).

77. *The staff-only doors on all trains should have an override device to enable them to be used by passengers in an emergency (para 14.29).* **TOCs ROSCOs 1**

78. *Signage primarily in the form of pictograms similar to those used on aircraft, and depicting the correct operation of emergency door mechanisms, should be developed. The signage should conform to current human factors standards on signage and be displayed prominently adjacent to each door and beside the door release mechanisms, as well as within the carriage. The mechanisms should be provided with artificial illumination to highlight their location at all times, with a back-up power supply in case of an emergency (para 14.34).* **TOCs ROSCOs 2**

79. The daily routine check of every train should include confirming that all ladders can readily be used. A mechanism to enable ladders to be released quickly should be devised and fitted (para 14.35). **TOCs 1**

80. *There should be a thorough review of the adequacy of the number of, and signage relating to, emergency hammers. This should include the provision of means of illuminating the location of hammers in an emergency, with a back-up power supply in case of emergency (para 14.46).* **TOCs ROSCOs 2**

81. *There should be research into the feasibility of, and risks associated with, removable windows, the adequacy of windows as a means of emergency egress, the number of dedicated windows which are necessary and the provision as to the maximum distance between each passenger and a bodyside door or emergency exit (para 14.46).* **TOCs ROSCOs 2**

82. *Tests should be carried out into the practicability of building emergency hammers into the passenger alarm system so that they could be released only after an alarm has been activated (para 14.50).* **TOCs ROSCOs 2**

83.	*The incorporation of escape hatches in existing carriages should be the subject of feasibility and risk assessment and the provision of escape hatches in new carriages should likewise be considered (para 14.54).*	**TOCs** **ROSCOs** **Manufacturers** **1**
84.	All members of the on-board train staff (including persons working under contract) should be persons who have been trained in train evacuation and protection (para 14.62).	**TOCs** **2**
85.	The possibility of installing on driver-only trains a telephone by which passengers can communicate with the signaller in the event of the driver being killed or incapacitated should be studied (para 14.65).	**Railtrack** **TOCs** **ROSCOs** **2**
86.	*The feasibility of a "roaming" communication system for train staff should be examined (para 14.68).*	**TOCs** **ROSCOs** **2**
87.	The possibility of remote broadcasting from outside the train, where it is not already available, should be investigated (para 14.68).	**Railtrack** **TOCs** **ROSCOs** **2**
88.	The availability on trains carrying passengers of the items of emergency equipment mentioned in the standard on emergency and safety equipment should be unrestricted (para 14.74).	**ATOC** **1**

The implementation of recommendations

89.	*A review of compliance with the above recommendations should be conducted on behalf of the HSC within six months of publication of this report, and further reviews should be put in hand as necessary thereafter. The HSC should publish the outcome of such reviews (para 15.7).*	**HSC**

Appendix 1
Parties and their representatives

The Inquiry

Mr Robert Owen QC, Mr Neil Garnham, Barrister, Ms Susan Chan, Barrister; Mr Michael Fitzgerald, Solicitor, Mr Myles Hothersall, Solicitor, both of the Treasury Solicitor's Department, London

Ladbroke Grove Solicitors' Group

Mr John Hendy QC, Mr Michael Ford, Barrister, Mr Rohan Pirani, Barrister; Ladbroke Grove Solicitors' Group, comprising 54 firms of solicitors, representing 168 bereaved and injured

Collins Passengers' Group

Mr Kenneth Hamer, Barrister; Messrs Collins, Solicitors, Watford, representing 78 bereaved and injured

Associated Society of Locomotive Engineers and Firemen

Mr Anthony Scrivener QC, Mr Gerard Forlin, Barrister; Messrs Thompsons, Solicitors, Ilford

Thames Trains

Mr Anthony Seys-Llewellyn, Barrister, Mr Keith Morton, Barrister; Messrs Elborne Mitchell, Solicitors, London

First Great Western

Mr Greg Treverton-Jones, Barrister, Mr Clive Fletcher-Wood, Solicitor, Ms Melissa Pack, Barrister; Messrs Burges Salmon, Solicitors, Bristol

Railtrack

Mr Roger Henderson QC, Mr Stephen Powles QC, Mr Jonathan Harvey, Barrister, Mr Roger Eastman, Barrister; Company Secretary and Solicitor to Railtrack Plc

Rail Users' Consultative Committees

Mr John Cartledge (lay representative)

Health and Safety Commission and Health and Safety Executive

Mr Hugh Carlisle QC, Mr David Barr, Barrister; Solicitor to the Health and Safety Commission and the Health and Safety Executive

British Transport Police

Mr Richard Lissack QC, Mr Hywel Jenkins, Barrister, Mr Tom Leeper, Barrister; Solicitor to the British Railways Board

Amey Rail

Mr Tom Custance, Solicitor Advocate of Messrs Herbert Smith & Co, Solicitors, London

Angel Train Contracts Limited (now Angel Trains Limited)

Mr Philip Havers QC, Mr David Evans, Barrister; Messrs CMS Cameron McKenna, Solicitors, London

ADtranz

Miss Stephanie Barwise, Barrister; Messrs Wragge & Co, Solicitors, Birmingham

W S Atkins Consultants Limited *

Mr David Thomas, Barrister; Messrs Shadbolt & Co, Solicitors, London

National Union of Rail, Maritime and Transport Workers

Mr Jeremy McMullen QC, Mr Jonathan Clarke, Barrister, Mr Graham Watson, Barrister; Messrs Pattinson & Brewer, Solicitors

Transport Salaried Staffs' Association

Mr Fraser Whitehead, Solicitor of Messrs Russell Jones & Walker, Solicitors, London

Note: * indicates party permitted to appear at the Inquiry on days 50 and 51 concerning its report entitled "Cost-Benefit Assessment of the provision of ATP", September 1998, prepared for Thames Trains

Appendix 2
Lay witnesses

Witnesses who gave oral evidence are designated "O"; witnesses who gave written evidence are designated "W".

Witnesses are, as far as possible, described either as at the time of the crash or other relevant period, as appropriate.

Adams, C	Product Development Manager, Angel Trains	O
Adams, K J	Passenger	W
Adams, R L	Driver Instructor, Thames Trains	O
Adams, T P	Divisional Officer, LFCDA	O
Allcock, J J	Passenger	O
Allen, D R	Signaller, Slough IECC, Railtrack GWZ	O
Anderson, R A	Business Manager, West Coast Main Line Project, Railtrack	W
Andrews, A J	Duty Operations Assessor, FGW	W
Andrews, K	Signaller, Slough IECC, Railtrack GWZ	O
Andrews, P J	Maintenance Technician, Thames Trains	W
Austwick, M A	Police Officer, MPS	W
Bacon, J H	Director General, HSE	O
Badu, K B	Passenger	O
Bailey, A W	Train Driver, Thames Trains	O
Baird, R S	Former Driver Standards Manager, Thames Trains	O
Baker, T A	Firefighter, LFCDA	W
Baker, W D	Police Inspector, BTP	W
Ball, K W	Driver Standards Manager, Thames Trains	O/W
Ballinger, M S A	Managing Director, Go-Ahead Group	O
Balmer, B E	Passenger	W
Barrell, A D	Passenger; Driver Instructor, Thames Trains	O/W
Bartlett, C J	Passenger	W
Beckerlegge, P T	Passenger	W
Beer, R	Station Officer, LFCDA	O
Beever, F C	Train Driver, Heathrow Express	O
Belcher, V R	Train Driver, Thames Trains	O
Belmont, D	Safety Strategy Manager, Railtrack GWZ; former Safety Auditor, Railtrack SSD	O
Bent-Marshall, J	Passenger	O
Blake, R H	Fitter's Assistant, FGW	W
Blencoe-Jones, P	Passenger	O
Blosse, M	Passenger	W
Boddy, D J	Passenger	W
Boekbinder, C P	Passenger	W
Bonham-Carter, R F	Railway Consultant; Independent Chairman of the Formal Inquiry into the Ladbroke Grove Collision and Train Fire	O
Booth, K I	Security Officer, Eurostar North Pole Depot	O
Bourne, M S	Project Site Manager, Amey Rail	W

Boyer, G	Police Sergeant, MPS	W
Bracken, N P	Temporary Detective Superintendent, BTP	O/W
Bray, C R	Signalling Development Engineer; former Signal Standards Engineer, Railtrack GWZ	O
Brazier, C S S	Gas Emergency Engineer, Transco	W
Brennan, M	Passenger	O
Brooker, G	Signalling Manager, Railtrack Southern Zone	O
Brookes, K E	Driver Trainer, Heathrow Express	O
Brown, M H	Assistant Chief Inspector of Railways, HMRI.	O
Bunney, D A	Former Train Driver, FGW	O
Burchell, C D D	Area Operations Manager, Railtrack GWZ	O/W
Burrows, C	Director of Engineering, FGW	O
Burton, G A	Passenger	O
Capewell, I M	Detective Sergeant, BTP	W
Cardall, A J	Group Driver Manager, FGW	W
Carrigan, P	Production Technician, Thames Trains	W
Carroll, M A	Deputy Managing Director, FGW	O
Carter, C	Train Crew Delivery Manager, Thames Trains	O
Castle, R A J	Passenger	W
Cerasale, G	Police Officer, MPS	O
Chappell, P	Passenger	O
Chilton, J C	Operations Manager, Thames Trains	O
Clatworthy, A J	Forensic Scientist, Forensic Science Service, Metropolitan Laboratory	W
Clegg, A	Passenger	W
Clooney, D	Passenger	W
Clulow, P	Superintendent, MPS	W
Coates, M J	Train Driver, Thames Trains	O
Cobb, P J	Safety Manager, Thames Trains	O
Cole, R C	Customer Access Manager; former Timetable Manager, Railtrack GWZ	O
Coleman, B R E	Acting Superintendent, BTP	O
Coleman, V P	Chief Inspector of Railways, HMRI	O
Collett, C V	Inspector of Health and Safety, HMRI	W
Collins, D A	Signal and Telecommunications Engineer, Amey Rail	O
Collins, T	Director, Heavy Crane Division, Baldwins Industrial Services	O
Connell, C A	Detective Inspector, BTP	W
Cooksey, A	Deputy Chief Inspector of Railways, HMRI	O
Coombs, J E	Passenger	W
Coome, N	Former Scheme Development Planner, British Rail	W
Cooper, B	Consultant Occupational Physician, BUPA Occupational Health	W
Cooper, C	Widow of Brian Cooper, Train Driver, FGW	W
Cope, J	Principal Consultant, W S Atkins	O
Coppieters, R A	Passenger	O
Coppinger, S	Driver Standards Manager, Thames Trains	O
Corbett, G M N	Chief Executive, Railtrack	O
Cowgill, A E	Passenger	O
Cox, R S	Driver Standards Manager, Thames Trains	O

Crosskey, E (formerly Paler)	Passenger	O
Dale, K	Former Driver Standards Manager, FGW	W
Darke, A C	Police Officer, BTP	W
Davies, G E	Consultant in Accident and Emergency Medicine, Royal London Hospital	O
Davis, R	Passenger	O
Derbie, A	Electrification Plant Engineer, Amey Rail	W
Devi, S	Passenger	W
Dhami, L	Signaller, Slough IECC, Railtrack GWZ	O
Dicker, G D	Signaller, Swindon, Railtrack GWZ	W
Dicker, S W	Passenger; Trainee Train Driver, Thames Trains	O/W
Dodd, A E	Passenger	W
Downes, S E	Passenger	W
Dudakia, D	Train Driver, Thames Trains	O
Dunbar, J D	Fire Advisor, Railtrack	W
Dunglinson, H	Human Resources Director, Thames Trains and Thameslink	O
Dyckhoff, I J	Duty Manager, Emergency Response Unit, London Underground	O
Ellis, G A	Assistant Divisional Officer, LFCDA	O
Evans, C	Manager, Ladbroke Grove Response Programme, Railtrack	W
Evans, D W	Police Inspector, MPS	O
Farmer, C J	Passenger	O
Feltham, D J	Mobile Operations Manager, Railtrack GWZ	O
Ferguson, G	Detective Chief Inspector, MPS	O
Field, C	Passenger	W
Fletcher, S	Chartered Occupational Psychologist, Occupational Psychology Centre	W
Forster, A E	Operations and Safety Director, FGW	O
Foster, N A	Acting Engineering Manager, Thames Trains	W
Fox, D J	Passenger	W
Franks, D R	Managing Director, First North Western Trains; former Production Director, Thames Trains	O
Freeman, D M	Passenger	W
French, D R A	Assistant Divisional Officer, LFCDA	O
Fuoco, C P	Area Performance Manager, Railtrack GWZ	W
Furness, N	Signal Maintenance Engineer, Railtrack GWZ	W
Gahlot, S	Technical Support Assistant at the Slough IECC, Amey Rail	O
Gale, K	Performance Manager, FGW	W
Ganning, T	Passenger	O
Gasan, C	Passenger	O
Ginty, N S	Assistant Divisional Officer, LFCDA	O
Glasscock, J	Current Operations Manager, Railtrack	W
Gollop, S	Senior Driver Standards Manager, Thames Trains	O/W
Goodall, C F W	Passenger	O
Gorla, A	Signaller, Swindon, Railtrack GWZ	W
Gough, G M R	Passenger; EWS Trainman	O
Gowan, B J L	Relative	W
Green, S W	Leading Firefighter, LFCDA	W
Hackett, N C	Firefighter, LFCDA	W

Hale, S C	Detective Inspector, BTP	W
Hall, L R	Recruitment Officer, Thames Trains	O
Hall, T J	Police Officer, BTP	W
Hancock, A P	Account Executive, former Production Manager, Railtrack GWZ	O/W
Hanson, D G	Passenger	W
Harman, I A	Contracts Manager, Railtrack	O
Harrhy, P G	Senior Driver Standards Manager, Thames Trains	W
Harrison, R M	Independent Expert on Traumatic Loss	O
Harvey, A P	Inspector of Railways, HMRI	W
Hawkins, J E L	Fleet Engineering Manager, FGW	W
Hay, N	Firefighter, LFCDA	O
Hay, S C H	Passenger	W
Hellicar, J	Inspector of Railways, HMRI	O/W
Hemming, A M	Commercial Manager, FGW	W
Hendry, C D	Assistant Chief Fire Officer, LFCDA	O
Hendry, S P	Level Crossings Manager, Railtrack GWZ; former HQ Signalling Inspector (Reading), Railtrack	O
Heymer, K A	Assistant Divisional Officer, LFCDA	W
Hickmott, R A	Assistant Divisional Officer, LFCDA	W
Hillman, J	Signaller, Slough IECC, Railtrack GWZ	O
Hilton, P J	Chief Superintendent, BTP	W
Hodder K,	Widow of Michael Hodder, Train Driver, Thames Trains	W
Hodghton, F E M	Signalling Technician, Balfour Beatty Rail Maintenance	W
Hodson, R	Station Officer, LFCDA	O
Holmes, D	Production Manager, Railtrack GWZ	O
Hopkinson, J	Principal Inspector of Railways, HMRI	O
Hotston, S	Chief Superintendent, BTP	W
Howarth, P J	Controller, Technical Services, Railtrack SSD	O
Hu, S X	Passenger	W
Hussain, S S	Driver Instructor, Thames Trains	O
Jackson, C A	Train Driver, Thames Trains	W
Jacobs, D P	Driver Instructor, Thames Trains	W
Jacotine, D P	Passenger	O
James, M	Technical Engineer, FGW	W
Jeffcot, B G	Firefighter, LFCDA	W
Jenkins, J	Level Crossings Signal Engineer, Railtrack GWZ	W
Jenkins, P	Telecommunications Asset Manager, Railtrack	W
Jones, S J	Passenger	O
Joyce, M S	Superintendent, BTP	W
Karavadra, K	Rail Operator Supervisor, Thames Trains	O
Keating, D	Detective Inspector, MPS	W
Kelleher, A A	Production Controller, Railtrack GWZ	W
Kelly-Brown, J A	Passenger	W
Kerr, S	School Teacher, Barlby Primary School	W
Khodawizi, B	Stores Team Member, Eurostar North Pole Depot	O
King, C J	Senior Consultant, MHA Systems; former Assistant Scheme Development Engineer Reading), British Rail	O
King, D J A	Firefighter, LFCDA	W
Kingston, R D	Maintenance Technician, Thames Trains	W

Kisluk, T	Signal and Telecommunications Technician, Amey Rail	W
Knee, R G	Passenger	W
Knox, A M	Passenger	O
Leah, C R	Director, Safety and Environment; former Director, Operations, Railtrack	O
Lee, C	Detective Inspector, MPS	W
Levin, D L	Passenger	W
Levy, W M	Passenger	O
Lineahn, M J	Advanced Operator, Emergency Response Unit, London Underground	W
Ling, A R	Principal Inspector of Railways, HMRI	W
Lukins, P	Passenger	W
Lyford, J A	Senior Driver Standards Manager, Thames Trains	O
Lyons, M	Passenger	O
MacDougall, D B	Acceptance and Safety Manager, East Coast Main Line Project; former Project Engineer, Signalling and Telecommunications Engineering Department, Railtrack	W
Mackellar, A E	Booking Office Clerk, Chiltern Railways; former Train Driver, Thames Trains	O
Macro, A M	Passenger	O
Maguire, A J O	Stores Team Leader, FGW	W
Manners, D K	Police Sergeant, BTP	W
Matthews, J	Construction Manager, ADtranz; former Signal Engineer, New Works Projects (Swindon), British Rail	W
Mayo, T M	Production Standards Manager, Railtrack GWZ	O
McCulloch, R	Acting Business Development Manager; former Zone Signal Engineer, Railtrack GWZ	O
McDonnell, A P	Superintendent, BTP	W
McDonnell, J A	Firefighter, LFCDA	O
McGowan, J E	Passenger	O
McHugh, B A P	Carpenter	W
McNaughton, A	Zone Director, Railtrack GWZ	O
Melanophy, B J	Production Manager, Railtrack Midland Zone; former Operations Manager, Railtrack GWZ	O
Minshall, R P L	Passenger	W
Mitchinson, B A	Assistant Divisional Officer, LFCDA	W
Moodie, M	Operations Manager West, Railtrack GWZ	W
Moran, S	Train Driver, Thames Trains	W
Morrissey, J J	Detective Chief Inspector, BTP	W
Moyce, D P	Passenger	W
Moylan, P J	Passenger	W
Mullany, D J	Passenger	O
Mure, N	Senior Divisional Officer, LFCDA	W
Murphy, P D	Service Delivery Manager, Thames Trains	W
Murrant, S	Former Train Operations Liaison Manager, Railtrack GWZ	O
Neal, M R	Doctor, Helicopter Emergency Medical Service, Royal London Hospital	W
Neale, C D	Overhead Line Technician, Amey Rail	O
New, N L	Passenger	W
Newman, D	Train Driver, Thames Trains	W

Nicholas, P W	Assistant Chief Constable, BTP	O
Niemeyer, R H A	Passenger	W
Norwood, G V	Station Officer, LFCDA	W
O'Connell, M A T	Manager, Emergency Response Unit, London Underground	O
O'Conner, B J	Builder, London Underground	O
O'Dowdall, D	Temporary Leading Firefighter, LFCDA	W
Offen, F S	Train Driver, Thames Trains	O
Ogolo, H E	Retail Manager; former Train Driver, Thames Trains	W
Organ, M	Signalling Standards Manager, Railtrack GWZ	W
Otter, R A	Temporary Superintendent, BTP	W
Overell, A M	Passenger	W
Overton, S R	Production Manager, FGW	W
Palmer, P S N	Passenger	O
Pamment, R	Fleet Manager, Thames Trains	O
Paton, C	Senior Conductor, FGW	O
Perkins, C V	Train Crew Supervisor; former Train Driver, Thames Trains	W
Philbert, F	Former Occupational Health Nurse, BUPA	W
Pilsbury, D J	Passenger	W
Pittaway, B	Passenger	O
Poole, S A	Driver Standards Manager, Virgin Trains; former Driver Standards Manager, Thames Trains	W
Powell, A T	Former Production Engineer, British Rail	W
Poynter, R J	Former Regional Operations Manager, British Rail Western Region	O
Querino, U S	Passenger	O
Rapson, A J	Passenger	O
Ratcliffe, C G	Inquiries Manager, Railtrack SSD	W
Relf, D A	Driver Standards Manager, Thames Trains	O
Rennie, A T M	Passenger	W
Reynolds, S D	Service Training Delivery Manager, Virgin Trains	W
Roberts, A J	Relative	W
Robinson, A M	Passenger	W
Robinson, G N	Train Driver, Thames Trains	O
Robson, J A	Former Safety and Standards Manager, Railtrack GWZ	O
Roffe, S A	Passenger	O
Rogers, B W	Train Driver, FGW	O
Rosenheim, A K	Passenger	O
Rousell, J	Signaller, Bristol, Railtrack GWZ	W
Ryder, W F	Passenger; Senior Stewardess, Virgin Trains	O
Saravanamuttu-Butler, P C	Assistant Divisional Officer, LFCDA	W
Saunders, G B	Train Driver, Thames Trains	O
Sawer, D A	Assistant Chief Inspector of Railways, HMRI	W
Sawyer, S	Detective Superintendent, MPS	O
Scholes, D L	Infrastructure Development Manager, Railtrack GWZ	O
Scotcher, P B	Passenger	O
Shirley, M J	Assistant Divisional Officer, LFCDA	W
Siddell, T E	Signaller, Slough IECC, Railtrack GWZ	O
Simmons, A	Head of Signals Asset Group, Railtrack	W
Skipp, M D	Security Team Leader, Eurostar North Pole Depot	O

Smallwood, R J	Deputy Chief Inspector of Railways, HMRI	O
Smith, P	Senior Duty Officer, London Ambulance Service	W
Speight, A	Passenger	W
Spencer, A G	Shift Production Manager, Railtrack GWZ	W
Spencer, M J	Signal Engineer, Railtrack GWZ	O
Spencer, R H	Design and Construction Engineer (Signalling), Railtrack GWZ	O
Spooner, J B	Sub Officer, LFCDA	O
Stacey, R J	Permanent Way Maintenance Engineer, Amey Rail	W
Steer, M V	Police Sergeant, BTP	W
Stewart, I A	Driver Standards Manager, Thames Trains	O/W
Stiles, K	Passenger	O
Stradling, P A	Passenger	W
Suckling, G J	Technical Services Manager, Total Fina	W
Surridge, G	Passenger	W
Sutton, A	Technical Manager, Safety and Standards, ADtranz	O/W
Sutton, M	Assurance Manager; former Performance Services Manager, Railtrack GWZ	O
Taylor, B J	Passenger	W
Thoburn, R G	Signaller, Oxford, Railtrack GWZ	O
Thomas, M W G	Passenger; Train Manager, Virgin Trains	O
Thompson, N D	Quality Adviser, Esso Petroleum	W
Timothy, D	Principal Inspector of Railways, HMRI	O
Tribe, G R	Formal Inquiries Process Manager, Railtrack	O
Tyack, L J	Passenger	O
Van-Tuinen, S L	Passenger	W
Wadey, C	Senior Account Engineer and Safety Advisor, Angel Trains	O
Walker, S V	Assistant Chief Inspector of Railways, HMRI	O
Warmington, E P	Passenger	W
Warren, P C	Passenger	O
Watson, J D	Acting Superintendent, MPS	O
Wells, P B	Driver Instructor, Thames Trains	O
Weston, S	Trainee Train Driver, Thames Trains	W
Whatley, S	Trainee Signaller, Slough IECC, Railtrack GWZ	O
Whewell, G K	Station Officer, LFCDA	O
White, G J	Inspector of Railways, HMRI	O
Wilkinson, R L	Maintenance and Reliability Manager, West Coast Rail Modernisation Programme; former Network Development Manager, then Production Manager, Railtrack GWZ	O
Willacy, J	Relative	W
Williams, R O	Passenger	W
Wilsdon, M R	Principal Consultant, AEA Technology Rail	W
Wilsher, R	Senior Divisional Officer, LFCDA	W
Winkworth, M P	Driver Standards Manager, Thames Trains	O
Winn, A	Former Projects Manager, Operational Planning Dept, Railtrack GWZ	W
Winters, H	Signalling Manager, Slough IECC, Railtrack GWZ	O
Wiseman, P W	Business Development Manager, Railtrack GWZ	O
Wood, C	Relative	W
Woodbridge, P	Signal Engineer, MHA Systems	O

Woodman, P D	Central Roster Clerk, Thames Trains	W
Worrall, T P	Director and General Manager, Thames Trains	O
Wright, N C	Trainborne Systems Manager, FGW	O
Wyeth, M	Signal Engineer, W S Atkins; former Network Development Manager, then Production Manager, Railtrack GWZ	O/W
Young, C W	Train Driver, Thames Trains	W

Appendix 3
Expert witnesses

Witnesses who gave oral evidence are designated "O"; witnesses who gave written evidence are designated "W".

General

Hemsley, J R	W S Atkins	W
Smail, L	Business Leader, Det Norske Veritas Consulting	O
Walley, M J	Forensic Meteorologist, Meteorological Office	O/W

Fire

Christie, C C	Consulting Forensic Scientist, Geoffrey Hunt & Partners	O/W
Drysdale, Prof D D	Professor in Fire Safety Engineering, University of Edinburgh	W
Field, P	Deputy Managing Director, Fire Research Station, Building Research Establishment	W
Fletcher, R G	Consultant, RB Hawkins and Associates, Forensic Scientists and Engineers	W
Hill, J	Vehicle Engineer, Interfleet Technology Ltd	W
Jagger, S F	HSL	W
Moodie, K	HSL	W
Polhill, D	Senior Works Design Engineer, Railcare	W
Roebuck, B	HSL	W

Human factors

Goff, T	Independent Consultant	W
Groeger, Prof J A	Professor of Cognitive Psychology, University of Surrey	O
Lucas, D	Principal Psychologist, HSE	O
Moray, Prof N	Professor of Applied Cognitive Psychology, University of Surrey	O
Watt, Prof R J	Professor of Psychology, University of Stirling	O/W
Weyman, A K	HSL	O/W

Rolling stock crashworthiness

Bradley, G P	W S Atkins	W
Bright, A	W S Atkins	W
Chitham, J W H	W S Atkins	W
Crossland, Prof Sir B	Engineering Consultant	W

Gittos, M F	Principal Metallurgist, The Welding Institute	W
Hinds, J	W S Atkins	W
Hollis, E J	HSL	W
Kirk, N	W S Atkins	O/W
Manteghi, S	W S Atkins	W
Moodie, K	HSL	W
Moore, P E	Technical Director, Kidde International	W
Murrell, P	W S Atkins	W
O'Connor, O	W S Atkins	W
Palmer, F C	Fleet Electrical Engineer, TT	W
Phillips, M	Consultant Engineer, Burgoynes	W
Rasaiah, W G	Structural Engineer, AEA Technology Rail	W
Scholes, A	Mechanical Engineer; Independent Consultant	W
Tattersall, J G	HSL	W
Wilson, C	HSL	O/W
Wray, A M	HSL	W

Signalling and track layout

Balmer, P	Railway Consultant	O
Bell, R M	Signal Engineering Consultant	W
Billinge, R H	Principal Derailment Investigator, AEA Technology	O
Boddy, W G	Independent Consultant	O/W
Cross, A E	W S Atkins	W
Fairbrother, R J	Signalling Consultant	O/W
Felton, M J	W S Atkins	W
Fenton, R J	W S Atkins	O/W
Finn, J A	W S Atkins	W
Hotchkiss, D A	W S Atkins	W
McKenzie, D H	W S Atkins	W
Moodie, K	HSL	W
Murphy, I S	Lecturer, Department of Mathematics, University of Glasgow	O
Porter, N	W S Atkins	O
Rayner, P G	Partner, MWW Consultants	O
Robins, P S	W S Atkins	W
Ross-Myring, J	W S Atkins	W
Tattersall, J G	HSL	W
Walter, K	W S Atkins	W
Weedon, D N	Signal and Telecommunications Engineer, AMEC Rail	W
Wilkins, S J	W S Atkins	O

Escape

Galea, Prof E R	Director, Fire Safety Engineering Group, University of Greenwich	O
Weyman, A K	HSL	O/W

Appendix 4
Previous SPADs at signal SN109

Introduction

1. This appendix sets out a summary of the evidence to the Inquiry about previous SPADs at SN109 from 2 August 1993 to 22 August 1998. It is based on the oral evidence given by the drivers and those who investigated the incidents, and on a number of documents, principally the forms on which the results of the investigation of each SPAD were reported.

2. The first SPAD, on 2 August 1993, was investigated and reported to British Rail by the responsible driver manager. The report form stated, inter alia, whether signal sighting, braking distance, driver distraction or preoccupation had contributed to the SPAD; and who was wholly or partly responsible; in the case of the driver, whether it was due to the following categories of error: "misjudge", "misread", "disregard", "miscommunication" or "none of them"; and the conclusions, including, where the driver was responsible, his physical and mental state and whatever corrective actions had been taken.

3. The second SPAD, on 13 February 1995, was investigated and reported in accordance with standard GO/OTC 508, which came into force in September 1993. The report covered essentially the same ground as the previous type of report, but there were the following additions:

   (i) the conclusions were signed by the depot driver manager; and

   (ii) the hazard ranking detail by a hazard ranking officer. For this purpose a score between A and C was assigned to (1) consequences; (2) recurrence factors – equipment/environment; and (3) recurrence factors – driver, in accordance with numbers marked for various factors. These factors included the number of previous SPADs at the signal.

4. The remaining SPADs were investigated and reported in a similar manner in accordance with Railway Group Standard GO/RT 3252, Issue 1 of March 1995.

5. In addition there were available to the Inquiry copies of additional documents including internal reports by the driver to his employers, and SMIS (Safety Management Information System) and TRUST reports. SMIS has provided a computerised programme for the recovery of incidents since 1997. The data is available for use at national or zone level. Prior to 1997 a record of SPADs was maintained through an earlier system, SPADMIS. TRUST is a system for the recording of data relating to the running and progress of trains.

First SPAD at 18:25 on 2 August 1993

6. This was the only SPAD before the reverse "L" configuration was introduced on 7 August 1994. An InterCity Great Western train was driven by driver Palmer. He was a conductor driver for the Paddington remodelling and was driving the train "through the recently laid track". The normal booked driver of the train was sitting beside him in the cab. The train overran the signal by six feet. Driver Palmer had eight years ten months of driving experience. He drove this route and this type of train daily. In answer to one of the questions in the form he indicated that SN109 was "usually clear". The incident was categorised as "misjudge". The "misjudge train behaviour" box was ticked. In the section for additional comments on the form it was stated: "Driver Palmer though accepting responsibility for the misjudgement also remarked about the poor positioning not only of this signal but of many others in the remodelling scheme. He accepted this is no excuse and as stated accepts responsibility". He was given a verbal caution.

Second SPAD at 08:10 on 13 February 1995

7. This SPAD involved a "misread", where the driver mistook an adjoining signal for his own. Driver McKellar of Thames Trains was driving three coaches of empty stock. He left Paddington a few minutes late although he said that this did not affect the way that he drove. He would normally be routed across to line 1 and then along the Down Main. At SN81 (on line 1) he saw a single yellow with an indication to take him over to line 3. As he was crossing from line 1 to line 3 he looked at the next signal and saw a yellow aspect with an "R" indication. He believed that as he was running late he was being put on to the Down Relief to let a faster train behind him pass. In fact SN109, the signal which applied to him, was showing red at all times. He said that as he approached SN109 he still believed that he had a yellow aspect. He crossed from line 1 to line 3 and looked up to re-check the signal, but this was only when he was "about 5-6 feet away from the signal" which he then saw was showing red. He applied the emergency brakes, but passed the signal by 105 yards. He told the Inquiry that he had looked up to check the signal when he was only at that distance away because he had previously been looking out for the permanent way men. Immediately after this incident he contacted the signaller and said that he thought that this signal had gone back on him. The signaller told him that SN109 had been at red. Mr McKellar at his interview became convinced that he must have misread SN111, thinking that it was his signal. He told the Inquiry that the signals were difficult to see because of the bridges; it was also difficult to identify which of the signals applied to his line as they were so close together on the gantry. Normally if he had time he would count across the signals from the left or the right, but on this day he did not do so as he believed there were permanent way men working in the area and his main concern was for them. The incident was categorised as "misread" – "viewed wrong signal". On the form "signal sighting confusion" was identified as a contributory factor. The box allocating responsibility indicated that he was wholly responsible, but also stated that equipment was partially responsible. The form also recorded that the signal was normally at "clear". Mr McKellar had four years ten months of driving experience and drove this route weekly. He was taken off driving duties as it was his third SPAD. The hazard ranking officer stated: "no recommendations re the signal".

8. Mr Lyford of Thames Trains subsequently prepared a report of the incident after receiving further information from Mr Gibbs, the signalling and performance manager for the Paddington area, which had not been available at the time of the completion of the SPAD form. Mr McKellar had been adamant that he saw a single yellow with an "R" indication, and that whilst talking to the signalman a train had passed in the Down direction on his right hand side. However, Mr Gibbs stated that the IECC data showed that none of the signals on the gantry had displayed any kind of proceed aspect, and that no other train has passed that gantry in the Down direction. In his report Mr Lyford stated: "Taking into account the totally conflicting statements above, I find it very difficult to draw a clear conclusion. Driver McKellar is convinced that what he saw is what actually happened. I personally would not like to argue with the IECC findings. However, if driver McKellar is not telling the truth then he is doing it very well indeed". Mr Lyford said in evidence that if the IECC was correct it was not a "misread" case at all. However, a letter dated 17 March 1995 from Mr Gibbs seemed to indicate that Mr McKellar might have been correct. He wrote: "Driver McKellar also alleged later in the morning that the next signal on this gantry SN111 had displayed a single yellow aspect and an 'R' indication. I can confirm that this signal was for a train routed down line 4 for the Down Relief after this SPAD had occurred…". On seeing this letter at the Inquiry Mr Lyford said that, whilst it was ambiguous, his view was that SN111 may well have been showing a single yellow aspect and an "R" indication.

Third SPAD at 18:58 on 15 March 1996

9. In this case it is stated in the SPAD form that driver Edwards of Thames Trains overran SN109 by 146 yards. It appears that this figure is correct, rather than the information in the SMIS report which states that he overran by a coach length. The original SPAD forms were lost and accordingly required to be completed again in October 1996. The depot driver manager stated in his summary of the incident:

> "At the same time as driver Edwards was approaching signal SN109 on line 3, a Greenford service was approaching signal 113 on line 5. This signal was showing a green aspect with a route indicator and is on the same gantry as SN109. Despite the driver's initial allegation of misreading of the signals, signal SN111 is situated between SN109 and SN113. It was therefore concluded that the misreading of signals was not the reason and that driver Edwards disregarded signal SN109 due to a lack of concentration (conclusion verified by driver leader riding in cab of Turbo on Down Line 3)".

The SPAD form recorded that the signal was normally at "clear". The SPAD form adopted the conclusion of the depot driver manager that the driver was distracted. "Distractions outside the cab" was categorised as the relevant type of distraction. The driver was deemed "wholly responsible" and the incident was classed as "disregard – failure to check signal aspect". "Late braking due to lack of attention" was classed as one of the factors implicated in this SPAD. The SMIS report states that, when challenged by the Slough IECC, the driver stated that he had erred in judging the braking distance and made no allegation regarding the signalling or the braking. That report indicated that the cause of the incident was "driver's lack of concentration". The driver, who had been driving for 5 years 11 months and had not had any previous

SPADS, was classed as "at risk category A" (ie a driver at highest risk). Thames Trains indicated that a plan would be formulated to highlight any training needs. Corrective action was identified as "informal instruction with emphasis on doing job correctly". It may be open to question whether the depot driver manager was correct in interpreting the incident as due to "misjudgement" of the braking distance.

Fourth SPAD at 17:46 on 23 June 1996

10. Driver Perkins of Thames Trains received flashing yellow aspects at SN37 and SN57, both on line 1. Thereafter at SN81 he had a single yellow aspect with route indicator showing that he would go to line 3. In the report form which he completed on the same day he said:

> "On approaching the junction to take me over to line 3 I realised that signal SN81 had stayed at single yellow and had not changed aspect on approach as I had expected, so I put the brake into emergency immediately, but had left it to (sic) late to be able to stop short of signal SN109 and only succeeded in passing this signal at Danger by approximately one coach length".

The overrun was about 11 yards. In the SPAD form the "primary cause" was stated to be: "Driver Perkins anticipated signal 109 would release to a proceed aspect after receiving flashing aspects at SN37 and SN57".

11. However, the summary of the incident given by the driver leader on 28 June 1996 was rather different. Whereas Mr Perkins' report indicated that SN81 did not change from a single yellow as expected on his approach, Mr Lyford said:

> "Driver Perkins after passing the last proceed aspect did not act upon its meaning. Instead the train continued under power until driver Perkins remembered that the last signal had been showing a single yellow aspect. Upon realising this, driver Perkins immediately placed the brake switch into the emergency position. At this point driver Perkins could not yet see signal SN109. This was due to an overbridge".

The SPAD form indicated that the signal was normally at "Danger". The form also indicated that the driver was "wholly responsible", and assigned the following description "disregard – failure to react correctly to a caution signal". No allegation was made about the signalling. Driver Perkins had been a driver for three years 11 months and had never had a SPAD before. He drove the route daily. The SPAD was given a hazard ranking of category B (six points) for "recurrence factors – equipment/environment", whereas it appears that it should have been given category A (in respect of nine points). Mr Relf of Thames Trains was unable to explain why he had given this score.

Fifth SPAD at 08:12 on 3 April 1997

12. Driver Hussain of Thames Trains, after leaving platform 8 at Paddington Station, received double flashing yellows at SN43, followed by a single flashing yellow at SN63. He stated in his report form that after seeing the single flashing yellow:

> "I was powering the unit up expecting the next signal SN109 to be a single yellow or green with a route indicator, taking me on to the Down Main line".

He then reported that the next signal SN109 was at Danger, so he put on the emergency brakes and contacted the signalman. He passed SN109 by the length of the three car unit, or 72 yards. The SSI tapes showed that he had a steady single yellow at SN87 before getting a red at SN109. The TRUST record indicated that "driver stated on questioning that the signals to the rear of SN109 were flashing indicating that SN109 should have showed a proceed aspect". In his evidence to the Inquiry Mr Hussain said that flashing yellows meant that the next signal would be showing a proceed aspect and the driver would have to prepare to stop at the one after that. He said that he had a flashing single yellow at SN63 and then

> "… the following one after that, according to my report and from memory… I can't really remember now… maybe it is through lapse of concentration I might have missed one, but the one at SN109, that was at red… I crossed over from line 4 to line 3 at that point and as I was crossing over as soon as I saw the red I put the train into emergency brake application".

He did not remember seeing SN87 at all, and agreed that he must have missed it. There are references in the documents to a different explanation. The SMIS report says: "On being challenged by the signaller the driver admitted misjudging the braking distance". This statement was repeated in the TRUST report. Mr Hussain said he did not remember saying that. He told the signalman that the SPAD was caused by "poor sighting of the signal", but he told the Inquiry he obviously could not remember exactly what he said to the signalman at the time. The incident was classed as "misread". Mr Relf admitted that the hazard ranking form appeared to have been under-scored. Instead of being given eight points the SPAD had been given six for "recurrence factors – equipment/environment". However, it would have still received a category B ranking. It was recommended that Mr Hussain, who had been driving for about three years, should relearn the Paddington area and be tested on his knowledge after relearning the route. He was taken off for a couple of days, had to go up and down the route with a driver leader, and was given two videos of signals approaching and leaving Paddington and was asked questions about signals. He said that he was unaware at the time that SN109 was a multi-SPADed signal. He was never told what the outcome of the SPAD investigation was. After the SPAD Railtrack wrote to Thames Trains stating that, as defined in the relevant Railtrack line procedure, SN109 had now been classed as a multi-SPAD signal.

Sixth SPAD at 17:18 on 4 February 1998

13. Driver Bunney of First Great Western was driving an eight car HST. Records showed that he passed SN17, received flashing double yellows at SN43, a flashing single

yellow at SN63, a single yellow at SN87 and a red aspect at SN109. In his statement to the police on the day after the incident he said that he had seen a single yellow with a route indicator to the left (apparently at SN87), and

> "… mistakenly thought that I was going down route 1, which is known as the Main Line. If I was going down that route, the next signal would have been quite a distance away. However, I went on to route 3, I went under the bridge and when I came out from under the bridge, I saw six red signals in a line. I realised I was on route 3 and not going down route 1, I immediately made a full brake application".

He said that having seen the flashing yellows he increased his speed to about 70 mph, thinking that he was going down the Down Main. He thought that the flashing yellows meant that he had a route right through the junction. He told the Inquiry that he understood flashing yellows to mean that he was "clear to cross the junction" or at least "clear to the next signal". He was "under the impression that my next signal was on the Down Main at Ladbroke Grove". When Mr Bunney observed SN109 he was travelling at about 60 mph. He passed SN109 by at least 432 yards while stopping in track circuit GG, clear of the fouling point.

14. Signaller Thoburn, who had been manually routing all trains in that area, replaced SN120 to red as HST occupied track circuit GF. Driver Waite, who was driving a Heathrow Express train, observed the change in SN120 and made an emergency brake application, stopping on track circuit FX. It appears that, even if the Heathrow Express train had not stopped, there would have been no collision since the HST stopped short of the fouling point. The SPAD was classed as "disregard". Recommendations made on the hazard ranking form were:

> "… the sighting of signal SN109 is to be reviewed and consideration be given to some form of reminder to the driver i.e. miniature countdown markers or reminder plate on bridge immediately prior to signal gantry".

15. Driver Bunney was suspended from driving for 3-4 days. He pleaded guilty at a disciplinary hearing. He was required to retrain on the route, but was later removed from driving. He had 34 years of experience, all in the Old Oak Common/Paddington area. He was regarded as "low risk", because of a SPAD at Somerford in 1991 and a minor collision in June 1990 involving empty coaching stock at Paddington. He did not know whether the train had been fitted with ATP. In any event he had not been trained to use it. At an interview on the day after the incident he was asked whether he had ever been stopped at SN109 before. He replied that he could not remember "ever doing that move before". But he told the Inquiry that he remembered being stopped there when taking empty stock to the depot. When he spoke of "not doing that move before", he meant the whole route from platform 9 to SN109. When he was asked why he had SPADed the signal, he said:

> "It was over the flashing lights, because when you get a flashing light entering a platform or going through a junction, it tells you that you have got the route through the junction. I had the route, I had the first two crossings, but where I made a mistake was when I had the single yellow at Westbourne Park. The

> next one was red, which it should have been, and I mistook that, thinking that I was right of way".

He also agreed that it was fair to say that he had overlooked the fact that gantry 8 preceded the junction with the Down Main.

16. A formal industry investigation took place. It concluded that the normal meaning of flashing yellows, that a driver was being diverted to a route of lesser speed, was not appropriate because of the low speeds in the area. Therefore "the continued employment of flashing yellows is… not logical". In addition a source of confusion was identified. If a driver experienced flashing yellows when approaching from lines 1, 2 or 4, this meant that they applied to SN109 (ie SN109 would be at red), whereas if he had flashing yellows when approaching from line 3, the signal at red would be the one beyond SN109 on the Down Relief. The panel said:

> "Five previous instances of signal SN109 have been experienced since 1993. All of these instances have been scrutinised by the panel and it has been found that the flashing signals have played a significant part in most of them and that all drivers have anticipated that signal SN109 would have been cleared to a proceed aspect or that they had forgotten it".

One of the seven recommendations was:

> "A review of the flashing yellow aspects be conducted, initially at the Paddington-Ladbroke Grove location but ultimately through the Great Western Zone".

Seventh SPAD at 17:26 on 6 August 1998

17. Driver Saunders of Thames Trains lost concentration when passing signals displaying caution aspects on the approach to SN109. He had been thinking of how to apologise to passengers about the cancellation of the same train the previous day which had been due to unit failure. The data recorder showed that he was accelerating past the caution aspects and applied the brakes as soon as SN109 was sighted. The length of the overrun was 14 yards. He told the signalman that he had misread SN109. The TRUST report indicated that he had attributed his error to "being distracted by something after observing the preceding signal at single yellow". In evidence to the Inquiry he said that, because he was concentrating on making an announcement, he had read the single yellow as a double yellow, and so accelerated because he knew that the next signal to be read was much further round towards Kensal Green. He had been a driver for 39 years 11 months. He had one previous SPAD in the last ten years. He drove this route about once every fortnight. The signal was said to be normally at "clear". The SPAD was classified as "disregard - failure to react correctly to a caution signal". He was taken off duties and was then put with an instructor driver for a fortnight.

Eighth SPAD at 09:21 on 22 August 1998

18. Driver Offen of Thames Trains was taking empty stock to the Reading depot. He recalled seeing double flashing yellows followed by a single flashing yellow. At SN87 he saw a single yellow with route indication "1". Mr Relf, driver team leader of Thames Trains, stated:

> "In his talking through the incident with me I believe he had convinced himself that SN87 had stepped up to two yellows. This is borne out by the OTMR as he does take the brake off while passing SN87".

He passed the signal by three yards. The signal was said to be normally at "Danger". The signalman's report form states under observations: "This signal is SPADed fairly regularly with this exact route L4-L3-DML, with flashing aspects on L4, which may contribute". Mr Relf wrote to Thames Trains Safety & Performance on 27 August 1998 stating:

> "The data recorder shows a steady acceleration away from Paddington up to about 50 mph. The train is then allowed to coast for a while, just before the train reaches SN87 the brakes are applied in step 1 and are then released. The train then proceeds to coast for a short while before the emergency brakes are applied".

He went on to say that it appeared that driver Offen had left Paddington in a hurry because his route had been called when he was not ready. He also said:

> "I believe that in his own mind he either forgot that SN109 was there or he had assumed that SN87 had stepped up to display two yellows with route indicator position '1'. My personal view is to go for the latter due to the evidence of the data recorder where step 1 is applied and then released in the area of SN87".

Mr Relf recommended the removal of the flashing yellows as he believed it caused drivers to:

> "… falsely believe when they approach a steady yellow after receiving flashing yellows it will always step up, and consequently when it does not it is usually too late and a SPAD occurs".

According to the SPAD form the cause of the incident was said to be: "disregard – failure to react correctly to a caution signal". The incident was hazard ranked as 1AC.

19. Mr Offen told the Inquiry that with the signal prior to SN109:

> "… it didn't register as well as it should have done… The moment I seen SN109 I reacted to it… I realised it (SN109) was there and red as it come into view under the bridgework".

When asked how he came past the signal at Danger he said: "I just think the actual yellow didn't register deep enough in my consciousness". He said that "had I been more aware, I think, I would have had the brakes initially on before I actually see the signal". He said in his written statement that

> "… the problem with SN109 and the other signals on the same gantry is that they are not visible for very long on approach, particularly at the high linespeeds that are in place. This means that they do not 'register' in a driver's mind in the same way as a signal of which a driver has clear continuous sight for appreciable time and distance on approach".

Driver Offen had 37 years' experience and had not had a SPAD in the previous ten years. He drove this route approximately once every fortnight. The corrective action identified was retraining on route and informal instruction with emphasis on doing the job correctly. Mr Cox indicated that the driver should be assessed on his knowledge of signalling at junctions and that he should be accompanied by an inspector driver to assess his concentration ability.

20. Following this incident Miss Alison Foster, Operations and Safety Director, First Great Western, wrote to Mr Les Wilkinson, Production Manager, Railtrack Great Western Zone, referring to this SPAD and stated:

> "I should be grateful if you would advise me, as a matter of urgency what action you intend to mitigate against this high risk signal".

Following the seventh and eighth SPADs, Mr David Franks, the Production Director of Thames Trains, met Mr A McNaughton, who had succeeded Mr Wilkinson. He informed the Inquiry that as both SPADs had involved experienced drivers and

> "… in view of the failure to carry out remedial action, I insisted that Railtrack should accept that the primary cause of these SPADs was the signalling equipment itself. I accepted the drivers had some responsibility but this was not the root cause".

Mr McNaughton said that Mr Franks' concerns were that the drivers had been confused by flashing yellow aspects, and that it was inappropriate that the SPAD forms should merely reflect the driver error. Mr McNaughton agreed that Mr Franks would redo them. Mr Franks gave instructions within Thames Trains for the SPADs to be recategorised, but he was not aware that this had not been done.

Appendix 5
Abbreviations

ACPO	Association of Chief Police Officers
ACPOS	Association of Chief Police Officers in Scotland
ARS	Automatic Route Setting
ASLEF	Associated Society of Locomotive Engineers and Firemen
ATC	Angel Train Contracts
ATP	Automatic Train Protection
ATOC	Association of Train Operating Companies
AWS	Automatic Warning System
BREL	British Rail Engineering Ltd
BRB	British Railways Board
BS	British Standard
BTP	British Transport Police
CBA	Cost Benefit Analysis
CIRAS	Confidential Incident Reporting and Analysis System
CSR	Cab Secure Radio
DOO	Driver-Only Operation
DNV	Det Norske Veritas
DRA	Driver’s Reminder Appliance
DSM	Driver’s Standards Manager
DVD	Driver’s Vigilance Device
ECS	Empty Coaching Stock
ETCS	European Train Control System
EWS	English Welsh and Scottish Railways
FGW	First Great Western
GRP	Glass Reinforced Plastic
GTMG	Golden Two Miles Group
GWZ	Great Western Zone
HMRI	Her Majesty’s Railway Inspectorate
HSC	Health and Safety Commission
HSE	Health and Safety Executive
HSL	Health and Safety Laboratory
HST	High Speed Train
IECC	Integrated Electronic Control Centre
LFCDA	London Fire and Civil Defence Authority
MHA	Michael Hamlyn Associates
MJ	Megajoule
MPS	Metropolitan Police Service
NRN	National Radio Network
OHLE	Overhead Line Equipment
OTMR	On-Train Monitoring and Recording Equipment
RMT	National Union of Rail, Maritime and Transport Workers
ROSCO	Rolling Stock Company
SGI	Signalling General Instructions
SMIS	Safety Management Information System

SN	Slough New (*prefix to signal and point numbers*)
SPAD	Signal Passed At Danger
SPADMIS	SPAD Management Information System
SPADRAM	SPAD Reduction and Mitigation
SSD	Safety and Standards Directorate
SSI	Solid State Interlocking
SSP	Standard Signalling Principle
STSG	SPAD Technical Solutions Group
TCBR	Track Circuit Block Regulations
TOC	Train Operating Company
TPWS	Train Protection and Warning System
VDU	Visual Display Unit

Appendix 6
Glossary

Accelerant	A chemical additive to or surface contaminant on a material which increases the flammability of the material
Anti-climber	A device fitted to the ends of rolling stock to prevent vertical separation of one vehicle from the next in the event of a collision or derailment
Approach release	The restriction of a signal's aspect to ensure that a driver can comply with the speed limit for the route ahead
Aspect	The visual indication displayed by a signal. A four-aspect colour light signal can display one of: • Green (Clear): proceed – the next signal is showing a proceed aspect • Double Yellow (Preliminary Caution): proceed – be prepared to find the next signal at yellow • Yellow (Caution): proceed – be prepared to stop at the next signal • Red (Danger): stop
Automatic route setting (ARS)	A computer based system for setting routes and signals automatically, without the action of the signaller. It is based upon a stored timetable, train running information, defined priorities etc
Automatic train protection (ATP)	A fully automatic system which ensures compliance with signals and speed limits. It continuously monitors train performance and speed and applies the brakes if an unsafe situation should arise
Automatic warning system (AWS)	A system for alerting the driver when approaching a signal (and some speed restrictions). An electro-magnet on the track indicates whether the signal ahead is at green, a clear aspect, (in which case a bell is sounded in the driver's cab) or at some other colour, a restrictive aspect, (in which case a horn is sounded). If a horn is sounded the driver must accept the warning within five seconds by pressing a button, failing which the brakes are applied automatically. Cancelling the horn also sets a visual indicator, which remains all black for clear aspects, to show black and yellow segments (the *sunflower*)

Banner repeater	A supplementary signal that gives the driver preliminary information about whether a signal is on or off, usually provided where sighting of that signal is inadequate
Bogie	A four or six wheeled truck with a central pivot, used in pairs under railway vehicles
Bolster	A transverse member of a bogie frame or vehicle underframe
Braking curve	A graphical representation of the distance required to stop a train from any given speed on straight and level track, used to determine the required distances between signals. The "W" curve is the braking curve for locomotive-hauled vacuum or air braked passenger rolling stock. The "composite curve for multi-traffic lines" applies to all other trains
Cab secure radio (CSR)	One of two radio systems fitted to drivers' cabs, allowing communication between drivers and signallers. Mainly confined to the south-east of England, it enables secure communication directly between drivers and signallers
Cant rail	A longitudinal vehicle body member which forms the boundary between bodyside and roof
Co-acting signal	A signal used, in exceptional situations, to repeat the exact aspect of a signal where there is no continuous sighting of the primary signal
Composite Curve	See *braking curve*
Crashworthiness	A feature of a design which gives the maximum chance of survival or the least amount of significant damage in a collision or derailment
Crossover	A connection between two parallel railway tracks, formed of two points
Crumple zone or Crush zone	The part of (normally) each end of a vehicle which is designed to deform in a predicted way and absorb the energy of a collision, thus affording protection for passengers in the vehicle
Defensive driving	A driving technique which avoids the maximum use of brakes by observing and reacting early to both expected and unexpected events
Double blocking	The maintenance of two block sections between trains
Down	In the context of routes to and from London, away from London

Dragbox	A structure at the end of the main-frame of a locomotive or other vehicle to which the *drawbar* is attached
Drawbar	The bar, carried inside the *dragbox*, which connects the coupling to the inboard end of the *dragbox*
Drawgear	Comprises the coupling (the device which connects one railway vehicle to another) and the *drawbar*
Driver's reminder appliance (DRA)	A device operated by drivers, intended (originally) to remind them not to start away from a signal at red, for example at a platform
Driver's vigilance device (DVD)	A vigilance device sounding a warning in a driver's cab at intervals of between one and two minutes. If not acknowledged (eg by pressing a button) the brakes are applied automatically
Duty Holder	The person in an organisation who is responsible for the preparation and implementation of its *Railway Safety Case*
Fatigue loads	Loads, cyclic between loading and unloading, which eventually could lead to cracking and, possibly, failure in a material or structure
Feather indicator	A form of route indicator used at higher-speed junctions. It is formed by a row of five white lights, inclined to the left or right of vertical and lit according to how the junction is set. Also known as a *position light route* (or junction) *indicator*
Flank protection	The protection of the route set for a train over a converging junction or crossing by proving the track-circuits in advance of the protecting signal on the converging route clear and, in some circumstances, by setting and locking points in the converging route in a direction which would divert overrunning train movements away from the legitimate route
Flashing yellow	A single flashing yellow signal tells a driver to be prepared to find the next signal at yellow with a junction indicator set for a diverging route. A double flashing yellow tells the driver to be prepared to find the next signal is a single flashing yellow
Formal Inquiry	The investigation by one or more people into a railway accident or other serious incident and conducted under rules set out by statute, in a Railway Group Standard or in company procedures. A formal report of the proceedings is normally required
Fouling point	The place where a vehicle on one of two converging lines would come into contact with a vehicle on the other line

Full service brake	A brake application producing maximum braking in normal service but applied less quickly than an emergency brake application
Fusion welding	The joining of two pieces of material by heating both parts to be joined to melting point and bringing them together; or, more generally, by adding new molten material to fill the gap between them
Group Standard	A mandatory safety standard for Railtrack controlled infrastructure, set under the Railways Act 1993
Headcode	A four digit alpha-numeric code uniquely identifying a train
Headstock	A transverse structural member at the end of a vehicle underframe, supporting the buffers
In advance of	Forward from a train, piece of equipment or location with respect to the direction of travel
Interlocking	Points and signals are “interlocked” to prevent: (i) the clearance of a signal unless any points in the route are correctly set and unless any signal which would authorise a conflicting move are at Danger; and (ii) the movement of points until the protecting signal is replaced to Danger after the passage of a train
In rear of	Backwards from a train, piece of equipment or location with respect to the direction of travel for the line in question. Thus in the case of two successive signals, the signal to be reached first is in rear of the second
Layout risk analysis	For a given layout of track, points and signals layout risk analysis provides a formal method of assessing the risk of an accident caused by a train driver failing to observe a stop signal. It is used to grade the relative merits of different designs of a junction
Left	The terms *left* and *right* are used for each train according to its direction of travel
Longitudinals	Structural members of the body or frame of rolling stock which run from end-to-end (or partially so) of the vehicle
Luminance	The measured output or brightness of a light source

Mark I, mark II, mark III, mark IV	Generic types of passenger rolling stock of which mark I is the oldest
National radio network (NRN)	A nation-wide radio communication network for railway staff; one of two radio systems fitted to drivers' cabs, allowing communication between drivers and a control centre. Unlike cab secure radio, it is not secure and does not give direct communication between drivers and signallers
Normal	The lie of a set of points, or the aspect of a signal, to which it is usually set or to which it reverts; or, in the case of points, the major or straight ahead route
On-train monitoring and recording (OTMR) equipment	A data recorder fitted to the cab of a motive power unit for recording a defined set of parameters or functions such as speed, brake applications, warnings, use of horn etc. Analogous to an aircraft "black box"
Overhead line equipment (OHLE)	All the structures and equipment used on or above the track for the supply of electrical traction power via an overhead conductor
Overlap	A safety region beyond a stop signal. It must be proved clear before the stop signal next in rear can be cleared to a proceed aspect
Passenger train curve	See *braking curve*
Position light route indicator	See *feather indicator*
Proceed aspect	Any aspect of a signal other than red
Proof loading	The mechanical or electrical loading which is applied to a piece of equipment and which is greater by a given percentage than the load at which the item is designed to be used or operated
"Protection of the train"	The procedures used when a train is e.g. in an accident, to stop other trains from approaching the accident site
Railway Group	Railtrack; bodies whose activities are subject to a safety case the acceptance of which requires concurrence by Railtrack; and other linked organisations whose activities have the potential to make a significant contribution to railway safety and safe inter-working
Repeater	A signal which repeats the aspect of a running signal. *A banner repeater* is a particular form of repeater

Reverse	Describes the opposite position to *normal*
Reverse L	A conventional four-aspect colour light signal has four lamps mounted vertically above one another, the red aspect at the bottom. SN109 had the red aspect displaced to the left and level with the lower yellow aspect, giving the shape of a reversed L
Right	The terms *left* and *right* are used for each train according to its direction of travel
Safety Case	A document or set of documents which justifies that it is safe to use a piece of equipment or structure, or that an organisation has an adequate safety management system for controlling its undertaking
Shear-out coupler	A coupler which is designed to shear if overloaded and so prevent damage to the vehicle structure on which it is mounted
Signal sighting	The activity of locating a signal to ensure the best approach view for the driver
Signal sighting distance	The distance from a signal to its *signal sighting point*
Signal sighting committee	A group of persons having the competence to meet the relevant engineering, operating and train driving requirements for the sighting of signals
Signal sighting form	The pro-forma on which a *signal sighting committee* note the features of a signal and their acceptance or otherwise of the visibility of that signal
Signal sighting point	The furthest point from a signal at which the driver can reliably observe the aspect of a signal or route indication
Signals on button	A single button, independent of other signalling controls at a signaller's workstation, the operation of which restores all the stop signals controlled by that workstation to Danger
Solebar	The main structural member of a vehicle underframe, running lengthwise along its outer edge
Solid state interlocking (SSI)	A micro-processor based system for the working of points and signals in which the interlocking function or logic is carried out electronically rather than mechanically or by electro-mechanical relays
Sunflower	See *automatic warning system*

Swing nose (crossing)	A crossing with movable parts, which facilitates higher speeds across it
Theatre indicator	A form of route indicator used at lower-speed crossings. An illuminated white letter, letters or number is displayed against a black background. The driver is expected to know, from route knowledge, the significance of the character displayed
Thermite sparking	A spark created when aluminium and rusty steel impact at high speed
Train protection and warning system (TPWS)	A train protection system which ensures that trains which can achieve certain braking rates, and which are not travelling at more than 74 mph, are braked to stop within the *overlap*
Track circuit	An electrical device, using the rails as part of an electrical circuit, which detects and reports the presence of trains on a defined section of line
Track circuit clip	A device, consisting of two clips joined by a wire, for short-circuiting the *track circuit*, thus simulating the presence of a train
Up	In the context of routes to and from London, towards London

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Plate 1: Gantry 6 showing, from left to right, signals SN81, SN83, SN85, SN87, SN89 and SN91. Taken from ground level on Line 4, to which SN87 applies.

Plate 2: Gantry 8 at a distance of 218 metres. Taken from the driver's position in a Class 165 Turbo on the Line 4 to Line 3 crossover. Its signals, from left to right, are SN107, SN109, SN111, SN113 and SN115. SN105 is carried by a post at the trackside.

Plate 3: Gantry 8 at a distance of 188 metres. Taken from the driver's position in a Class 165 Turbo on the Line 4 to Line 3 crossover.

Plate 4: Gantry 8 at a distance of 168 metres. Taken from the driver's position in a Class 165 Turbo on Line 3.

Plate 5: Gantry 8 at a distance of 60 metres. Taken from the driver's position in a Class 165 Turbo on Line 3, under conditions of bright sunlight, at 08:51 on 6 October 1999.

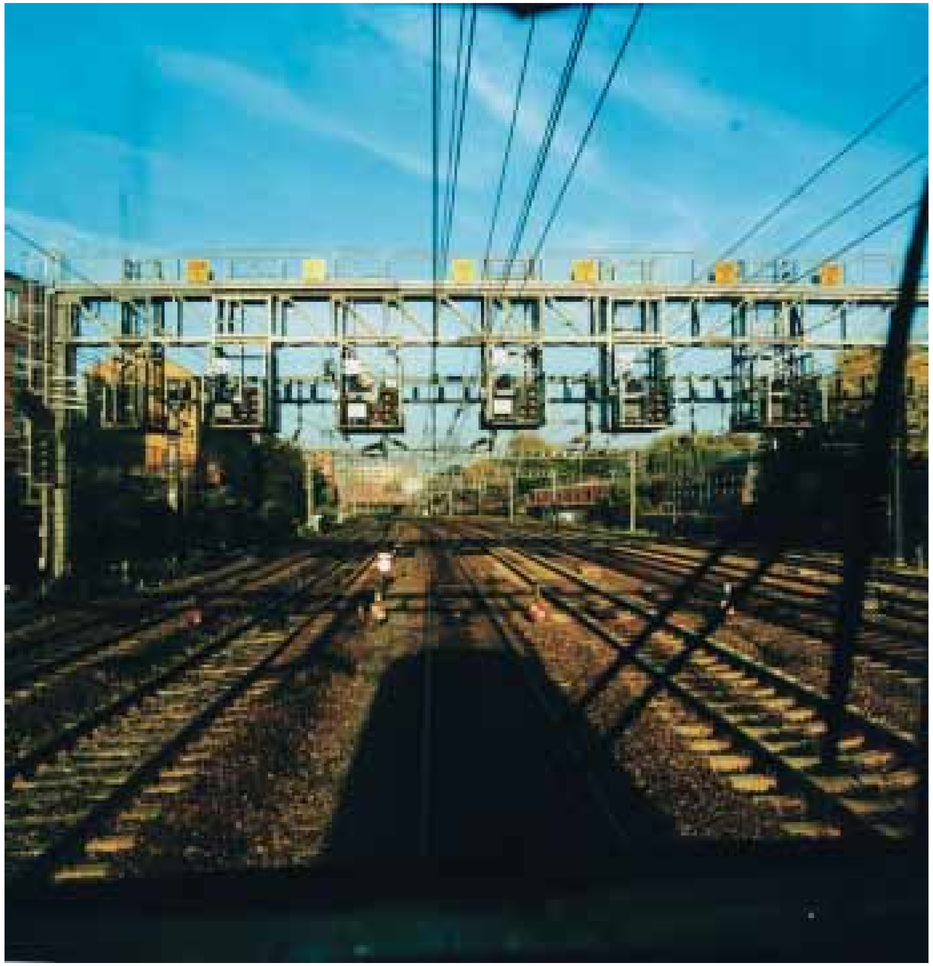

Plate 6: Gantry 8 at a distance of 17 metres. Taken from the driver's position in a Class 165 Turbo on Line 3, under conditions of bright sunlight, at about 08:14 on 6 October 1999.

Plate 7: Part of the front car of the Thames Turbo against coach B of the HST: view from the west (south side of crash).

Plate 8: Front and middle cars of the Thames Turbo: view from the north.

Plate 9: Early stage of the fire in coach H of the HST: view from the south.

Plate 10: Later stage of the fire in coach H of the HST: view from the south.

Plate 11: Crash site showing coaches F and H of the HST: view from the south-east.

Plate 12: Coach H of the HST: view from the west.

Plate 13: Coach H of the HST: view from the west.

Plate 14: View towards Paddington. Taken from Gantry 8 with the camera placed directly above the red aspect of SN109. The lines are numbered 1 to 6 from right to left. SN109 applies to Line 3.

Plate 15: Workstation at IECC, Slough.

Plate 16: Aerial view of crash site taken on 7 October 1999.

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