Ufton Level Crossing:
Passenger Train Collision with a
Road Vehicle and Subsequent Derailment
on 6 November 2004
Formal Inquiry: Collision with a Road Vehicle and Subsequent Derailment of Passenger Train 1C92 1735 hrs Paddington to Plymouth at Ufton Automatic Half Barrier Level Crossing on 6 November 2004

FI3103/F

SMIS Reference No: QGW/106754

Lead Organisation: Rail Safety and Standards Board

21 June 2005

Final Report

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Statement
The inquiry has been conducted with the objective of determining the facts of the accident, the immediate and underlying causes and of making recommendations to prevent, or reduce the risk of, recurrence. The report is for the use of persons with a direct responsibility for improving or maintaining railway safety.

The objectives of this inquiry were not the allocation of blame or liability and thus the information contained should not be construed as creating any presumption of these.

Acknowledgements
The Panel wishes to express its appreciation to the following organisations for the support that they gave to the inquiry:

- Rail Safety and Standards Board
- British Transport Police
- Health and Safety Executive
- AEA Technology Rail
- Transport Research Laboratories

The Panel also wishes to acknowledge the valuable assistance that it received from the observers who attended the Inquiry during the taking of the evidence and who subsequently contributed at the review stage of the draft report.

Finally, the Panel expresses its gratitude to the witnesses who willingly gave their evidence, in particular the passengers and the train crew who suffered the trauma of the accident and the off-duty policeman who was witness to the collision of the train and the car.

Conventions
In this report:

(1) On the first occasion that a particular speed in mph is quoted, its equivalent in km/h is also given.

(2) All references to left or right relate to the direction of travel of the train.
Contents
Statement ......................................................................................................................... 1
Acknowledgements ....................................................................................................... 1
Conventions .................................................................................................................. 1
Remit ............................................................................................................................... 8

1. Basic Details ............................................................................................................. 13
2. Brief Description of the Sequence of Events ...................................................... 13
3. Infrastructure and Train ........................................................................................ 14
   3.1 Track .................................................................................................................. 14
   3.2 Signalling / AHB Level Crossing .................................................................. 14
   3.3 Train ................................................................................................................. 15
4. Detailed Sequence of Events .................................................................................. 16
   4.1 Events Leading up to the Derailment ............................................................. 16
   4.2 The Course of the Derailment ...................................................................... 19
   4.3 Events Following the Derailment .................................................................. 23
5. Condition of the Infrastructure and the Train Prior to the Derailment ............. 25
   5.1 Track .................................................................................................................. 25
   5.2 Signalling ......................................................................................................... 25
   5.3 AHB Level Crossing ....................................................................................... 26
   5.4 Telecommunications ......................................................................................... 26
   5.5 The Train ......................................................................................................... 26
6. Level Crossing Safety ............................................................................................. 27
   6.1 Background ...................................................................................................... 27
   6.2 Permitted Types of Level Crossing .................................................................. 29
   6.3 Principles of Operation of the AHB Level Crossing and Conditions for Determining its Suitability for Installation ................................................................. 29
   6.4 General Statistics for Level Crossings ............................................................ 31
   6.5 Ufton AHB Level Crossing ............................................................................. 32
   6.6 The Public Emergency Telephone System .................................................... 33
   6.7 Proximity of the Facing Points ...................................................................... 35
   6.8 Risk Assessment .............................................................................................. 35
   6.9 Ufton AHB Level Crossing Risk Assessment ................................................ 36
   6.10 Influence on Risk Assessment of the Proximity of Track and Lineside Features .................................................................................................................... 37
   6.11 Current Level Crossing Research .................................................................. 37
   6.12 Obstacle Detection on Level Crossings ......................................................... 38
   6.13 Potential for Design Improvements at AHB Level Crossings ..................... 39
   6.14 Lessons from Previous Level Crossing Accidents ......................................... 39
7. Train Behaviour ........................................................................................................ 40
   7.1 Introduction ....................................................................................................... 40
7.2 Effect of Power Car Design on the Initial Derailment.................41
7.3 Influence of the Couplers on the Behaviour of the Train Following the Derailment.........................................................42
7.4 Bogie Retention........................................................................44
7.5 Effectiveness of the Vehicle Structures in Protecting the Passengers and Crew.................................................................46
7.6 Effectiveness of the Coach Interior Design Features in Protecting Passengers and Crew......................................................50
7.7 Effectiveness of Systems and Procedures to Allow Escape........52
7.8 Relevant Research......................................................................56
7.9 Lessons from Previous Accidents................................................61

8. The Rescue Operation..................................................................62
8.1 Actions of On-Train Staff............................................................62
8.2 Off-Site Care of the Passengers....................................................64
8.3 The Emergency Services..............................................................66

9. Personal Experiences of Passengers.............................................66
9.1 The Interview Arrangements.......................................................66
9.2 Passengers 1 and 2.................................................................67
9.3 Passenger 3.............................................................................68
9.4 Passengers 4 and 5.................................................................68
9.5 Passenger 6.............................................................................69
9.6 Passenger 7.............................................................................71
9.7 Passenger 8.............................................................................73

10. The Recovery Operation..............................................................74
10.1 Establishment and Operation of the Accident Command Structure.........................................................................................74
10.2 Attendance on Site of Network Rail’s Senior Management......77
10.3 Attendance on Site of AEAT’s Derailment Investigation Team.................................................................................................78
10.4 Clearance of the Derailed Vehicles............................................78
10.5 Restoration of the Infrastructure................................................79

11. Staff Training, Competence and Fitness for Duty..........................79

12. Weather and Environment............................................................80

13. Factors for Consideration..............................................................81
13.1 Infrastructure and Train.............................................................81
13.2 Level Crossing Safety...............................................................82
13.3 Train Behaviour.........................................................................93
13.4 The Rescue..............................................................................102
13.5 The Passengers........................................................................104
13.6 The Recovery............................................................................105
13.7 Staff Training, Competence and Fitness for Duty....................109
13.8 Weather and Environment.........................................................110

14. Conclusion..................................................................................110
14.1 Immediate Cause......................................................................110
14.2 Underlying Causes....................................................................110
15. Recommendations ........................................................................112
  15.1 Level Crossings .......................................................................112
  15.2 Trains .....................................................................................115
  15.3 Rescue and Recovery ............................................................119
16. Appendices .....................................................................................121
    A Witness Evidence .......................................................................121
    B Fatalities and Injuries ..............................................................121
    C Emergency Services ..................................................................122
    D Damage to Infrastructure ........................................................122
    E Damage to Rolling Stock ........................................................123
    F Diagrams ................................................................................125
    G Photographs ...........................................................................135
    H Charts and Tables ..................................................................147
    J Ufton Risk Assessment ..........................................................155
    K Remit for NLXSG ....................................................................159
    L Map of Ufton Local Area .........................................................161
    M Level Crossing Research Projects .........................................163
    N Glossary of Terms ..................................................................165

Pages 5-7, 12 and 111 contain personal information and are therefore not reproduced in the web version of this report.
Remit

This remit is issued in accordance with Railway Group Standard GO/RT3473 and requires an inquiry into the following accident.

<table>
<thead>
<tr>
<th>Accident</th>
</tr>
</thead>
<tbody>
<tr>
<td>The 1735 hrs London Paddington to Plymouth train travelling at approximately 100mph, struck a car on the level crossing killing the car driver and causing the train to derail. As a result of this derailment, six people on the train were killed (including the train driver) and a number received serious injuries.</td>
</tr>
</tbody>
</table>

| Date       | 6 November 2004 |
| SMIS Reference | QGW/106754 |
| Lead Organisation | Rail Safety and Standards Board |

1 Appointment of person to lead the formal inquiry
1.1 An independent Civil Engineering expert has been appointed as chairman to lead the inquiry.

2 Type of investigation
2.1 The form of investigation is to be formal inquiry.

3 Inquiry panel
3.1 In accordance with Railway Group Standard GO/RT3473, the following shall be invited to participate in the inquiry:

Panel members:
- An independent Traction and Rolling Stock expert
- An independent Signalling and Telecommunications expert

4 Authority of chairman
4.1 The chairman has the authority to request information to be provided by Railway Group members involved in the accident, to interview witnesses, request technical evaluations to be conducted and obtain other information and support as required for the purpose of achieving this remit.

4.2 The person appointed may request similar information from non-Railway Group members. These organisations may not, however, be bound by the requirements of Railway Group Standard GO/RT3473 to provide this unless incorporated into contractual requirements with Railway Group members.
5

Objectives of inquiry

5.1 The Panel is required, through inquiry, to identify the circumstances of the accident, including:

a) The events leading up to the accident.

b) The immediate and underlying causes.

5.2 As such the inquiry must address at least the following issues:

a) The mechanism of the derailment and subsequent behaviour of the train and infrastructure up to the point where the vehicles came to rest.

b) The installation, maintenance and operation of the AHB crossing involved and its compliance with laid down standards, including:
   - Layout
   - Signage
   - Operating timing and distances
   - Inspection and testing
   - Signalling arrangements

c) The operation of the train, including:
   - Speeds during the journey
   - Braking times and performance
   - Examination and testing

d) The effectiveness of arrangements in place for managing risks at Ufton AHB Level Crossing, including previous incident history and traffic patterns.

e) The effectiveness of industry arrangements for managing overall risks associated with AHB level crossings.

f) The effects of train design and construction on the initial derailment, including obstacle deflection.

g) The performance of the train in its derailed state including factors that may have affected the extent of derailment and exacerbated damage to the train.

h) The integrity of the rail vehicle structures and their effectiveness in providing protection to passengers and workforce during the derailment.

i) Interior vehicle design and construction factors, including instructions and equipment, that affected passenger/workforce injuries, survivability and means of escape.
j) The adequacy of, and compliance with, instructions, rules, regulations and standards, and the specific controls therein, concerning:
   - The operation of the level crossing
   - The operation of the train
   - The management of the incident

k) The competency (knowledge, skills and experience), capabilities (mental and physical) fitness for duty (including medical fitness) of any staff involved in the accident, and the systems for ensuring their medical fitness and competence. This should include the effectiveness of arrangements for management of hours of work and rest periods.

l) The effectiveness of the industry’s response to the relevant lessons learned from previous events such as:
   - Great Heck 2001 (including road/rail interface risks)
   - Ladbroke Grove 1999 (regarding HST vehicle performance
   - Southall 1997 and post accident management)

m) The effectiveness of post accident evacuation, first aid and arrangements for attendance of the emergency services, protection, reporting, testing, evidence preservation, investigation and restoration, etc.

n) The effects of weather and other environmental conditions.

o) Any relevant information that may emerge during the course of the inquiry from separate investigations into the road component of the accident.

5.3 The Panel shall make relevant recommendations for:

a) Action(s) that may be taken to prevent, or reduce the likelihood of, the occurrence of a similar accident.

b) Action(s) that may be taken to reduce the severity of the consequences of a similar accident.

c) Other matters relevant to safety revealed during the inquiry.

Recommendations from formal inquiries may be addressed to any Railway Group member.

6 Reporting and timescales

6.1 The inquiry shall commence as soon as possible. The Panel are required to provide:
A preliminary report to RSSB by 14 January 2005 (unless the final report is available within this time – in which case a preliminary report is not required).

A draft final report to RSSB by 8 April 2005 or, if this is not available and is unlikely to be available by 6 May 2005, a provisional report including a statement regarding the timescales for the final report.

6.2 The format and structure of reports shall be in accordance with Railway Group Standard GO/RT3473. (A template is available from RSSB.)

6.3 The Panel must inform the Designated Competent Person (DCP) in the following circumstances:

a) If they believe that the objectives of the remit (including the timescales) will not be achieved.

b) If, at any time, their inquiry reveals a safety issue of significance such that, in their opinion, there is an urgent need to inform Railway Group members prior to completion of the inquiry.
1. Basic Details

Date: Saturday, 6 November 2004
Time: 1812 hrs
Location: On the Down Line between Reading and Westbury at Ufton Automatic Half Barrier (AHB) Level Crossing at 43 miles 39 chains.
Weather: Dark and dry at the time of the derailment turning to slight drizzle shortly afterwards.
System of Signalling: Multiple aspect colour light signalling with continuous track circuiting and electric power operated points, controlled from the Reading Signalling Centre, which is located at Reading station.
Features of the Line: The line lies on a right hand curve of approximately 1,000 metres radius with a level gradient.
Train Involved: 1C92 1735 hrs Paddington to Plymouth High Speed Train (HST) operated by First Great Western (FGW).
Train Crew: Driver, two train managers and one customer host.

2. Brief Description of the Sequence of Events

2.1 The train departed from Paddington on time and after making a booked stop at Reading, it left the station one minute late at 1803 hrs. It subsequently accelerated to just below the line speed of 100mph (160km/h) and passed the ‘strike-in’ point for Ufton AHB level crossing at 1811 hrs, initiating the crossing sequence of lights, audible alarms and lowering of barriers.

2.2 On reaching the level crossing, the train struck a Mazda 323 car, which was obstructing the Down Line and had been stationary on the crossing prior to the commencement of the closure sequence. The collision caused the leading wheelset of the leading bogie of the front power car to derail towards the left hand side.

2.3 The bogie ran for approximately 95 metres in a line almost parallel to the rails with only one wheelset derailed until it reached the facing points to the Down Goods Loop. The bogie was then guided to the left by the diverging rails of the points, causing the following bogies to derail and resulting in the full and catastrophic derailment of all the vehicles in the train. The layout of the track and signalling is shown in Appendix F, Fig. 1.
2.4 Extensive damage was caused to the vehicles, particularly those in the centre of the train where the couplers broke and vehicles parted from the train formation. The rear power car came to rest 165 metres from the point of derailment and the leading power car came to rest 360 metres from the same point. The derailed vehicles are shown in Appendix G, Figs. 1 to 8 inclusive.

2.5 The car was broken up by the impact, with component parts being carried forward by the train and scattered along some 100 metres of track.

2.6 There was widespread damage to the track in the area where all the vehicles finally derailed.

2.7 The response to the accident by the railway companies and the emergency services was both rapid and efficient. The evacuation of the passengers from the train, for the most part, proceeded smoothly. Sadly, five passengers and the train driver died in the accident, as well as the driver of the car.

2.8 A total of 71 passengers, including 18 who were badly injured, were conveyed to hospital for treatment. Many of the remaining passengers received minor cuts and bruises, for which they were treated locally.

2.9 A detailed list of the fatalities and injuries suffered by the passengers, coach by coach, is shown in Appendix B.

3. **Infrastructure and Train**

3.1 **Track**

3.1.1 The Down Line leading up to and through the AHB level crossing comprised continuously welded 113lb flat bottom rail secured to concrete sleepers by Pandrol clips. The ballast was in good condition.

3.2 **Signalling / AHB Level Crossing**

3.2.1 The signalling equipment comprised British Rail (BR) standard 3 aspect colour light signals, electric power operated point machines and continuous track circuiting. The BR standard AHB level crossing equipment comprised lifting booms, flashing light warning signals and audible alarms, all operated automatically by the approach of the train. There were two emergency telephones connected to Reading Signalling Centre for use by members of the public wanting to contact the signaller, either in an emergency or to seek permission to use the crossing when animals or an exceptionally large or slow moving vehicle are required to pass over it.

3.2.2 At the level crossing, a data recorder automatically monitored and recorded the operation of the level crossing control devices. In
Reading Signalling Centre, a voice recorder automatically recorded the use of the emergency telephone system.

3.2.3 The roadway over the crossing was formed of pre-cast concrete slab units laid to form a continuous road surface at rail level. In the four-foot, the units were basically of a standard design, with the exception that some had the addition of a steel frame around the vertical edges of the slab. All the units measured 1,320mm by 600mm in plan.

3.2.4 Appendix G, Fig. 9 is a series of four photographs which show Ufton AHB level crossing from the aspect of a road user approaching from the direction of the A4 ie all the photographs are taken from the Upside of the line. Fig. 9(a) shows the advance crossing sign, Fig. 9(b) shows the ‘phone for permission to cross’ sign, Fig. 9(c) shows the crossing with the barriers raised and Fig. 9(d) shows the crossing with the barriers lowered.

3.3 Train
3.3.1 The train was a 10 vehicle HST, having an overall length of 220 metres and weighing approximately 425 tonnes. It was leased from Angel Trains Ltd by FGW. HST services operated by FGW would normally leave London with the standard class accommodation at the front but on this occasion the train was running in reverse formation with the first class leading such that the train formation, from front to rear, was as follows:

<table>
<thead>
<tr>
<th>Power car</th>
<th>Vehicle number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>43019 (J)</td>
</tr>
<tr>
<td>Coach H</td>
<td>41013 (I)</td>
</tr>
<tr>
<td>Coach G</td>
<td>41014 (H)</td>
</tr>
<tr>
<td>Coach F</td>
<td>40206 (G)</td>
</tr>
<tr>
<td>Coach E</td>
<td>42018 (F)</td>
</tr>
<tr>
<td>Coach D</td>
<td>42022 (E)</td>
</tr>
<tr>
<td>Coach B2</td>
<td>42017 (D)</td>
</tr>
<tr>
<td>Coach B1</td>
<td>42020 (C)</td>
</tr>
<tr>
<td>Coach A</td>
<td>44006 (B)</td>
</tr>
<tr>
<td>Power car</td>
<td>43029 (A)</td>
</tr>
</tbody>
</table>

3.3.2 Both the second and third coaches from the rear of the train were carrying the designation B and there was no coach C. This situation came about because vehicle 42017 had been transferred into the train during the night of 4/5 November and its previous designation had not been changed. For clarity in this report, the second and third coaches from the rear (vehicles 42020 and 42017 respectively) are referred to throughout as coaches B1 and B2.

3.3.3 The letters A to J in brackets are temporary designations allocated by the emergency services and painted on the vehicles after the accident to allow easy recognition during the rescue operation. Some of these letters can be seen in Appendix G, Figs. 1 to 8 but they are not used in this report.
4. Detailed Sequence of Events

4.1 Events Leading up to the Derailment

4.1.1 Operation of the Train

4.1.1.1 An analysis by one of FGW’s Driver Managers of the on-train monitoring recorder (OTMR) record for the journey from Paddington to the scene of the accident was provided to the Panel in the form of a written report. Only the rear power car of the train was fitted with an OTMR. This was of the Arrowvale type and had been supplied originally as a trial unit. Although it was not covered by the vehicle maintenance regime, it was still in a usable condition, so it had been left in-situ pending implementation of a programme to fit OTMRs to all the power cars in the FGW fleet.

4.1.1.2 The OTMR was not capable of recording brake pipe pressure as a result of a transducer fault. Because the only OTMR was in the rear power car, a number of the Driver’s actions and in-cab events, such as use of the horn, use of the emergency brake plunger and the activity of the automatic warning system/train protection warning system, were also not recorded.

4.1.1.3 The Driver Manager reported that the recording showed the train was driven normally, with the speed restrictions leaving Paddington and Reading being correctly observed. Following departure from Reading and having reached a speed of 96mph (154km/h) after using full power from the end of the speed restriction at Southcote Junction, the Driver began to reduce power to notch 3, at a rate of about 1 notch per second. As the train approached Ufton level crossing, he moved the power controller from notch 3 to Off in one movement. Four seconds later, at a speed of 98mph (158km/h), he moved the brake controller to the emergency position.

4.1.1.4 The position of the brake controller determines whether or not each of three control wires is energised. The state of energisation of these wires in turn controls the brake pipe pressure and hence the braking effort which is applied to the train. Putting the brake controller to the emergency position causes all three wires to become de-energised, which state corresponds to maximum braking effort. This represents a fail safe condition in the case of loss of electrical supply to the three wires.

4.1.1.5 The OTMR record of the state of energisation of the control wires enabled the Driver Manager to determine the moment when the brake controller had been put to the emergency position by the Driver. One quarter of a second later the train wires began to change rapidly from a de-energised to an energised state and vice-versa. In conjunction with FGW’s engineers, the Driver Manager determined that these changes would, if produced by movement of the brake controller, have required it to be moved from emergency to step 5, then back to emergency and then to step 3 in a total of
1.75 seconds. They concluded that this was not the cause of the rapid changes but that they were produced by the ‘bouncing’ of the relays in the brake control unit as a result of the impact with the car. The Driver Manager concluded that the Driver had braked one quarter of a second before the impact.

4.1.1.6 AEA Technology Rail (AEAT) reached a slightly different conclusion regarding the timing of the brake application. They used the OTMR speed/time record to calculate the distance travelled by the rear power car from the point where the brakes were applied. By combining this information with the distance beyond the point of collision at which the power car came to rest, they concluded that the brake application was made by the Driver between 1 and 2 seconds after the moment of collision with the motor car.

4.1.1.7 The Driver Manager also looked at OTMR records of a number of previous runs of the train, in both directions of travel and with different drivers. He noted that at many locations the recorded speed was about 3mph (5km/h) higher than would normally be expected. He considered that this was not the result of the cab speedometer under reading since the same effect occurred in both directions of travel. He concluded that the calibration of the OTMR was incorrect and the speed being recorded was 3mph high at mid range speeds. He took this error into account when compiling his report.

4.1.1.8 FGW’s Fleet Engineering Manager confirmed to the Panel that the speed compensation of the OTMR was set to maximum wheel diameter. This is the facility by which speed compensation is introduced when the wheels from which the speed signal is taken are reprofiled. Failure to reset the compensation when the wheels were reprofiled would have the effect of making the OTMR record too high a speed.

4.1.1.9 Two Train Managers and a Customer Host, who were rostered to the train, gave evidence to the Panel. The Train Managers confirmed that before leaving Paddington, a brake test had been carried out in conjunction with the Driver and that following departure, the journey had been uneventful up to the time of the accident. After the train left Reading, Train Manager A was attending to standard class passengers and was standing in the vestibule at the leading end of coach B2 when the accident occurred, whilst Train Manager B was attending to first class passengers and was standing in the centre of coach G.

4.1.1.10 The Customer Host, who was working in the buffet section of coach F, confirmed that the journey had been uneventful up to the time of the accident.
4.1.2 Operation of the Signalling / AHB Level Crossing

4.1.2.1 The train was running under clear signals on the Down Line at just under the permitted line speed of 100mph when it reached the ‘strike-in’ point for Ufton AHB level crossing. This is located 1907 yards (1744 metres) from the crossing and provides for a time of 39 seconds at 100mph for the train to reach the crossing. The crossing data recorder confirmed that all the crossing equipment operated correctly for the passage of the train. The automatic controls caused the road warning lights to flash and the pedestrian audible alarms to sound for the correct minimum warning time followed by the lowering sequence of the barriers, again within the correct minimum warning time.

4.1.3 Communications

4.1.3.1 Ufton AHB level crossing is provided with a standard railway public emergency telephone system (PETS). The equipment design provides for continuous monitoring of the availability and integrity of the telephone handsets, illumination, telephone control equipment and the transmission path of the connecting circuit. Calls made from the emergency telephones are automatically recorded in Reading Signalling Centre. The data records showed that the telephone system was working correctly at the time of the accident.

4.1.3.2 An off-duty policeman, who was a member of the Thames Valley Police Force, witnessed the accident. He made an abortive attempt to use the emergency telephone just prior to the accident occurring. His action was registered on the recording equipment in the Signalling Centre.

4.1.4 The Obstruction

4.1.4.1 The obstruction was caused by the presence of a Mazda 323 hatchback car, which was stationary on the level crossing and fouling the Down Line at the moment of the collision. A reconstruction of the events leading immediately to the positioning of the car on the crossing was staged by the British Transport Police (BTP) on the night of 20 December. For the purpose of the reconstruction, the police had obtained a car of the same model and year of manufacture.

4.1.4.2 The off-duty policeman who witnessed the accident was able to demonstrate the precise position of the car at the moment it was impacted by the train. The position is shown in the photograph (Appendix G, Fig. 10), which was taken looking in the direction of travel of the train. It can be seen that the front of the car, where the heaviest components were located, was straddling the four-foot of the Down Line.
4.2 The Course of the Derailment

4.2.1 The Derailment of the Leading Axle

4.2.1.1 AEAT’s Principal Derailment Investigator gave evidence to the Panel regarding the mechanism of the initial derailment and subsequently provided a written report. His analysis was based on his examination of the marks on the rails, on the rail fastenings, on the sleepers and on the pre-cast concrete slab units forming the roadway in the four-foot of the Down Line (Appendix F, Fig. 2).

4.2.1.2 The left hand wheel of the leading axle of the train had climbed the rail at a point about 3.9 metres from the running-off end of the crossing apron. Whilst there were marks indicating flange climb on the gauge face of the left hand rail, these were lighter in appearance than would normally be the case in a flange climbing derailment. The mark on the rail head persisted for 300mm beyond the point where flange climb began but then disappeared. It reappeared just beyond the end of the crossing apron, suggesting that the wheel had been in free flight. In its flight the flange tip had progressed from a lateral position 12mm from the gauge face to one of 48mm from the gauge face. Approximately 1.5 metres beyond the end of the crossing apron, the wheel had dropped to the cess side of the left hand rail.

4.2.1.3 The pre-cast concrete slabs in the four-foot were of two types, disposed as shown in Appendix F, Fig. 2. In some of the slabs, the concrete was surrounded on its vertical faces by a steel frame and in others it was not, although the overall dimensions were substantially the same in each case. The two different types of units appeared to have been placed at random into the roadway.

4.2.1.4 A slab of the steel frame type was positioned at the point of flange climb and from about 100mm beyond this point there was longitudinal abrasion of increasing severity of the right hand edge of the metal surround. This was attributed to contact with the back of the flange of the leading right hand wheel. The next three slabs had no metal surround and fragments of the right hand edge of the concrete were broken away, with the degree of the breakage increasing as the right hand wheel progressed.

4.2.1.5 At the end of the third slab, the amount broken away indicated that the right hand wheel had moved laterally to an extent sufficient for the flange to find purchase on, and then to climb, the lateral edge of the next slab, which was of the steel frame type (Appendix G, Fig. 11). The wheel then rolled on its flange along the surface of the three remaining slabs, leaving the crossing apron with its flange tip 90mm from the gauge face of the right hand rail. No further marks of the passage of the right hand wheel were seen until the tread corner made contact with a bolt of an insulated rail joint 6.4 metres from the end of the crossing apron, suggesting that the wheel was airborne between these points.
4.2.1.6 There were scuff marks on the upper surface of the slabs, beginning approximately 200mm before the point of flange climb. Just beyond the point of flange climb, there were score marks in the concrete, 20mm wide and about 10mm deep. These were at a distance of 535mm from the gauge face of the left hand rail.

4.2.1.7 The Derailment Investigator concluded that:

(a) There was no evidence to suggest that derailment of the leading wheelset occurred as a result of material becoming trapped between the wheel and the rail.

(b) The derailment almost certainly took place as a result of material becoming trapped between a bogie component and the road surface. Given the position of the abrasion on the concrete, it is likely that the contact was in the vicinity of the gear case/traction motor interface as shown in Appendix F, Fig. 3.

(c) The disposition of the different types of pre-cast concrete slabs forming the road surface in the four-foot could have played a significant role in the behaviour of the derailed wheelset. The steel frame of the first slab to be encountered by the derailed right hand wheel restricted the movement of the wheelset in the direction of ultimate derailment, as to a lesser degree did the edges of the succeeding slabs. With the left hand wheel probably airborne at the time the right hand wheel climbed onto the slab surface at the point where the slabs reverted to the steel framed design, all lateral restraint was lost. Had the degree of lateral movement continued to be restrained by the slabs over the full length of the crossing apron, wheel/rail tread contact at the right hand wheel would have been maintained. The wheelset might then have been re-railed as a result of the corrective steering mechanism which would have applied when the left hand wheel flange returned into contact with the rail head.

(d) The track condition was satisfactory and there was no evidence to suggest that it had been a contributory factor to the derailment.

4.2.1.8 After the accident, the damaged vehicles were conveyed to Crewe, with the exception of the rear power car which sustained only slight damage. The Derailment Investigator examined the underside of the gearbox and traction motor of the leading axle for signs of contact with components of the motor car. However, these had been abraded by ballast to such a degree that it was not possible to draw meaningful conclusions from the examination.

4.2.1.9 AEAT’s Team Leader (Structural Integrity) submitted a written report to the Panel in which he described the results of an examination of the remains of the car, the main part of which had
been pushed aside and was found in the Downside cess close to the level crossing. The report also contained the results of his calculations of the dynamics of derailment, which indicated that the rapidity of the lift of the leading axle was such that the lifting force would have been about 30 tonnes. The car engine, which had travelled much further than the main body of the car, was badly damaged in the upper and lower parts, with both the camshaft and crankshaft having been torn out of their bearings. However, the remaining part of the engine, which was approximately 180 mm wide x 300 mm high x 430 mm long, was sufficiently substantial to have become jammed beneath the leading axle gearbox and the roadway. There were no other components of a similar size and solidity that could have lifted the axle.

4.2.1.10 The Team Leader noted that the damage to the bodywork of the car suggested that, at the time of the collision, it was positioned such that the engine would have been roughly coincident with the track centre line. This was confirmed during the reconstruction of the accident (4.1.4). In addition, the fact that the engine block of the car had travelled much further than the main part of the car body indicated that the former had been swept forward by the train, whereas the latter had not.

4.2.1.11 He concluded that the engine block was the most likely object to have been trapped beneath the leading axle assembly, that it was probably trapped beneath the leading axle gear case and that the effect of the trapped component was not only to lift the axle but also to yaw the bogie anticlockwise. Flange climb then occurred as a result of the combination of wheelset lift and bogie yaw. Appendix F, Fig. 4 illustrates ‘yaw’ and other terms relating to bogie and vehicle movements.

4.2.2 The Behaviour of the Leading Bogie between the AHB Level Crossing and the Facing Points to the Down Goods Loop

4.2.2.1 The Derailment Investigator reported that the derailed right hand wheel of the leading axle had initially run on the Pandrol rail clips but had subsequently begun to contact the sleepers at a point roughly 11 metres beyond the running-off end of the crossing apron. At this point the flange tip was 220 mm from the gauge face of the right hand rail. By the time the wheelset reached the switch toe of the facing points approximately 80 metres further on, the flange tip was 275 mm from the gauge face. He concluded that if the train had continued running on plain line, it would probably have come to a stand without any further wheelsets derailing.

4.2.3 The Influence of the Facing Points

4.2.3.1 The Derailment Investigator reported that the points were correctly set for the normal through route. The leading right hand wheel of the train struck the detection bar and bracket at the switch toes and passed to the left of the open right hand switch rail. Approximately
5 metres beyond the switch toes there were marks on the right hand stock rail, which indicated that the tread corner of the trailing right hand wheel of the leading bogie had traversed the rail head towards the left. It ran into full derailment about 6 metres beyond the switch toes. Other marks showed that a third right hand wheel tread had crossed the right hand stock rail head a further 10 metres beyond the switch toes.

4.2.3.2 The leading left hand wheel was guided further to the left by the diverging left hand stock rail. Marks on the left hand switch rail showed that the trailing left hand wheel of the leading bogie had derailed to the left about 6 metres beyond the switch toes. Approximately 10 metres further on there were signs of wheel contact with both the inner and outer fishplates of the left hand stock rail. Beyond this point there was no further reliable evidence of the course of the derailment owing to the severe damage to the track in both the Down Line and the Down Goods Loop.

4.2.4 The Behaviour of the Vehicles Beyond the Facing Points

4.2.4.1 The Team Leader told the Panel that he had carried out an extensive on-site examination of the vehicles forming the train. All were derailed when passing over the points and in addition to the track damage, there was considerable ploughing of the ballast. Many of the coach bogies, which do not have any form of positive retention, became separated from their respective coach bodies and in a number of cases the underfloor equipment compartment was completely lost. However the power car bogies, which have retaining straps, remained in position.

4.2.4.2 His subsequent written report contained a description of the probable trajectory and structural behaviour of the vehicles forming the train in the period between when it reached the facing points and when it came to rest (Appendix F, Figs. 5 and 6). This was based on an assessment of the observed damage to the vehicles and of passenger injuries.

4.2.4.3 The report concluded that high longitudinal loading, as evidenced by damage to the canopies above the gangways at the vehicle ends, was produced as the three leading vehicles became fully derailed and began to destroy the sleepers and dig into the ballast. The effect was exaggerated as the bogies became detached from coaches H and G and the body of coach G passed over the embedded bogies from coach H. The combined effect of compressive loading and lack of rail guidance as the coaches in the centre of the train derailed was that they began to move out of line in a concertina effect. However, the damage to the bodies of coaches F and E suggested that their bogies, which also became detached, did so when the coaches were still moving in a predominantly longitudinal direction. The leading power car and coach H eventually turned onto their left hand sides and slid a
considerable distance along the ballast, still coupled together and coupled to coach G, which remained almost upright.

4.2.4.4 Substantial yaw angles developed between coaches G, F, E, D and B2. These coaches separated from each other with the exception of coaches G and F. However there was little damage to the body corners at the points of separation, suggesting that they had separated before a large relative yaw angle had developed between adjacent coaches. Coaches F and E probably separated first, allowing coach E to pass to the right of coach F. Coach D rolled onto its side, possibly as a result of striking debris as it yawed.

4.2.4.5 Coach F impacted a detached bogie from the trailing end of coach G, causing extensive penetration of the structure. Deep scoring of the bodyside ahead of the area of penetration suggested that the coach presented an oblique angle to the bogie at the time of impact. Towards the end of the impact, the leading end of the coach became embedded in a low earth embankment. The inertia of its trailing end caused the severely weakened body structure either to bend around the embedded bogie or to increase what may have been a degree of existing bending induced by the initial impact with the bogie.

4.2.4.6 Coaches E and D remained coupled, with coach D sliding on its side with its roof leading until it contacted a detached bogie. This caused the roof and bodyside to collapse at the point of impact and the coach to roll through a further 240 degrees as well as to yaw in a clockwise direction. The deceleration on impact with the bogie caused the coupler connection with coach E to fail. Coach E then rolled onto its side and slid along the Up Line at an approximately constant yaw angle until it came to rest.

4.2.4.7 Coaches B2, B1 and A and the rear power car came to rest, still coupled together, at angles of between 10 and 45 degrees to the vertical.

4.2.4.8 The Team Leader calculated that the average deceleration of the train was 0.51g from the moment the brakes were applied but peaks experienced by individual vehicles within the train reached at least 2g.

4.3 Events Following the Derailment

4.3.1 The off-duty policeman, seconds after trying to contact the Signaller via the emergency telephone, witnessed the train impacting with the car. Although deeply shocked, he quickly contacted a police operator in the Thames Valley Control Room by dialling 999 on his mobile telephone. He identified himself and advised the operator of the accident and the location, giving the name of the local inn as a landmark. Whilst keeping open the telephone connection to the
police operator, he obtained a small torch from his own vehicle, which enabled him to see the body of the car driver and the wreckage of the car in the Downside cess just a short distance along the track from the crossing. At this time he was not aware that the train had derailed, although he described seeing a shower of deep red sparks in the sky shortly after the rear of the train disappeared into the darkness following the collision.

4.3.2 As he stood on the level crossing, looking along the track, the police officer was able to discern the movements of small lights in the distance. He was fortunate in being able to obtain a more powerful torch from a member of the public who arrived at the level crossing and with the aid of this stronger illumination, he made his way along a grass area at the side of the track towards what he could now see was the rear of the train. He kept the police operator continuously advised of his actions via his mobile telephone.

4.3.3 His police training in dealing with road traffic incidents was invaluable in enabling him to assess the situation and report to the police operator that this was a major accident with many coaches derailed and numerous casualties. The police operator confirmed that the emergency services were on the way to the site, which by this time had been clearly established as Ufton level crossing.

4.3.4 The police officer then did as much as he could to help the injured passengers pending the arrival of the emergency services, which he estimated to be within twenty minutes of his 999 call reporting the accident.

4.3.5 The emergency services, in the form of the ambulance, police and fire services, carried out a very difficult task with both speed and efficiency. The evacuation of the passengers from the derailed coaches and attention to their injuries were dealt with expeditiously. In the early post-derailment stage, some of the passengers found their own way out of the derailed coaches, in many cases assisted by other passengers who volunteered to take the lead. The two Train Managers gave advice and re-assurance to the passengers, although they did not manage to access all of the derailed coaches. The evacuation became better organised once the emergency services had established themselves on the site.

4.3.6 Those passengers who were able to walk were directed to an inn, which was close to the accident site and which served as the initial reception point. From there they were transported to a hotel, also in the same general locality, which had been established as the eventual clearing point. From the hotel, the passengers were conveyed to their intended destinations by road transport, either by coach or taxi.

4.3.7 Those passengers with minor injuries, mostly in the form of cuts and bruises, received treatment at the reception point. The more
severely injured passengers were taken by ambulance to the Royal Berkshire Hospital in Reading. Representatives of FGW attended the hospital, as well as the reception point, to deal with the passengers’ needs and concerns. A small number of passengers who received less serious injuries were taken to a hospital in Basingstoke but they were not detained.

4.3.8 Network Rail’s accident command structure functioned well on the site after experiencing some minor organisational difficulty, mainly associated with site communications, during the very early stages of the rescue operation. FGW set up a parallel command structure, which liaised closely with that of Network Rail.

4.3.9 In the recovery operation, the last of the derailed vehicles was lifted clear of the site on Thursday evening, five days after the derailment, enabling the renewal of the severely damaged track and signalling equipment to proceed. This work was completed and the Down Line returned to normal traffic on Tuesday of the following week, ten days after the derailment and one day ahead of plan. Line speed was resumed two days later.

4.3.10 The renewal of the facing points into the Down Goods Loop and the damaged track in the loop itself were not included in the recovery programme at this time. Network Rail completed this outstanding part of the work for the reinstatement of the infrastructure in March 2005.

5. Condition of the Infrastructure and the Train Prior to the Derailment

5.1 Track

5.1.1 The track leading up to and through the level crossing was in good condition throughout. Following the derailment, AEAT carried out a survey of the track on the approach to the level crossing and through the crossing itself. The survey showed that the track gauge, longitudinal level (top), cant and alignment were all good and well within the limits at which maintenance attention would be required.

5.1.2 The record of the most recent run of the Track Recording Vehicle prior to the accident, which took place on 22 October 2004, similarly showed that all the track geometry parameters lay inside the limits for maintenance attention.

5.2 Signalling

5.2.1 The signalling equipment was in good condition and properly maintained. It operated correctly for the passage of the train.
5.3 AHB Level Crossing
5.3.1 The AHB equipment was in good condition and properly maintained. The train operated it correctly. The pre-cast concrete units forming the road surface over the crossing were also in good condition.

5.4 Telecommunications
5.4.1 The emergency telephone equipment was in good condition, being properly maintained and capable of being operated in accordance with the emergency telephone instructions posted inside the instrument for the guidance of users.

5.5 The Train
5.5.1 The Influence of the Train Condition on the Initial Derailment
5.5.1.1 Train maintenance was carried out by FGW to a plan approved by an accredited Vehicle Acceptance Body under a maintenance policy forming part of FGW's Railway Safety Case. The Panel was given access to the maintenance records for the train, which showed that the last occasion on which the bogies and running gear were examined was on the occasion of the ‘A’ exam on 4 November 2004. Coach 42017 (B2), which was shunted into the formation after that examination, also had an ‘A’ exam on the same date whilst forming part of another HST set. Nothing of significance in respect of bogies and running gear was recorded on the exam sheets.

5.5.1.2 AEAT’s Principal Derailment Investigator did not submit, either when interviewed by the Panel or subsequently in his written report, any evidence that led him to suspect that the maintenance condition of the vehicles had any effect on the mechanism of derailment.

5.5.2 The Influence of the Train Condition on the Consequences of the Initial Derailment
5.5.2.1 The Panel saw no evidence of pre-existing problems with the condition of the couplers, the vehicle body and bogie structures or the internal fittings of the coaches which might have increased the severity of the derailment or its consequences for the passengers and train crew.

5.5.3 Speedometer
5.5.3.1 FGW's Fleet Engineering Manager told the Panel that, owing to the damage to the leading power car, it had not been possible to carry out a test to measure the accuracy of its speedometer.
5.5.3.2 FGW's Driver Manager, who analysed the OTMR records (4.1.1), assessed the speedometer accuracy via an examination of the records of a number of previous runs of the train in both directions of travel and concluded that it was reading correctly.

5.5.4 Brakes

5.5.4.1 The damage to the vehicles was severe and no post-accident brake tests were carried out. However the OTMR record from the rear power car showed that all three control wires had been de-energised at about the time of the collision (4.1.1) suggesting that the braking system was responding correctly to an emergency brake application by the Driver. Unfortunately the brake pipe pressure signal was not recording on the OTMR so it was not possible to establish definitively that a drop in brake pipe pressure had resulted from the de-energisation. However the Panel found no evidence to suggest that the braking system was behaving other than normally at the time of the accident.

6. Level Crossing Safety

6.1 Background

6.1.1 From the earliest days, where any railway crosses a highway in the UK, it has been the railway's responsibility to provide suitable means to fence the railway. This was usually done by the provision of swinging gates and a person dedicated to operating them for the passage of a train. Such an arrangement is known as a manually operated crossing.

6.1.2 The full cost of the provision, maintenance and operation of the crossing equipment was the responsibility of the railway. The law enforced this principle and the earliest act is the Level Crossings Act of 1839. The legislation, which is complex, has been updated from time to time but the principle has not changed and the railway is still responsible for the installation, maintenance and the railway operation of road level crossings, despite the exceptional growth in road traffic that has taken place and which was never envisaged when the original legislation was enacted.

6.1.3 Owing to this massive increase in road traffic, changes in the legislation in the 1950s allowed the railway to substitute lifting barriers for gates in manually operated crossings and for the operation of this type of crossing by a signaller from a remote location. The changes also allowed for the introduction of the automatic half barrier type of level crossing. These changes, which were aimed primarily at saving road traffic delays, also assisted the railway in reducing the heavy burden of labour intensive operating costs in attending and manually operating level crossing gates.
6.1.4 The protective arrangements to be provided at each level crossing are prescribed by the Secretary of State for Transport under the Level Crossing Regulations 1997.

6.1.5 The AHB method of level crossing protection is used throughout the world and was developed in this country by the railway in response to the 1950s legislation.

6.1.6 An AHB level crossing is protected by half barriers that close the entry to the crossing but leave the exit clear to allow road vehicles to escape if they have failed to stop following the operation of the red lights that alert road traffic to the approach of a train and to the imminent lowering of the barriers. Audible alarms are also provided to alert pedestrians that the crossing is about to close. A telephone system enabling contact to be made with a continuously staffed signalling centre is also provided as standard equipment. This is intended for use either in an emergency or to seek permission to use the crossing when animals or an exceptionally large or slow moving vehicle are required to pass over it.

6.1.7 Unlike most manually operated crossings, an AHB level crossing is not provided with any protection by railway signals. It may be installed only where the line speed for trains passing through the crossing does not exceed 100mph. The crossing equipment is operated entirely automatically by the approach of the train and is required to give a minimum warning time for road users of 27 seconds for trains running at line speed. It is an important principle of operation of the AHB crossing that the delay to road users is minimal and therefore the train will arrive at the crossing very shortly after the barriers are fully lowered i.e. within a few seconds. This is to encourage good discipline on the part of road users and to discourage the impatient user from attempting to zigzag around the barriers.

6.1.8 The first AHB level crossings were installed in the early 1960s and there were 458 AHB crossings in use on Network Rail’s infrastructure at the time of the accident. There have been two previous accidents at automatic level crossings resulting in fatalities of rail passengers. The first was at Hixon AHB level crossing in 1968 in which 11 people died (including 3 staff) when a passenger train collided with a long low-loader road vehicle carrying a very heavy transformer that was being escorted by the police and which failed to clear the crossing within the warning time. The second was at Lockington in 1986, in which 9 people died when a passenger train collided with a van that was attempting to cross against the warning lights. Public inquiries were held into both these accidents and recommendations were made for improvements that have since been implemented by the railway.

6.1.9 The level crossing at Lockington was an automatic crossing operating on similar principles to an AHB, but of a particular type.
which is no longer permitted to be installed. All but one of them, which is located at Rosarie in Scotland, have been replaced.

6.1.10 The railway’s aim over many years has been to reduce the number of level crossings where it was practicable and economic. The railway has always recognised that the safest action is for a level crossing to be closed. For many years it has pursued a programme of closure by extinguishing the right of way where possible or alternatively by the provision of a bridge.

6.1.11 However, level crossing closures by extinguishing rights of way are emotive subjects for local communities and are frequently vehemently resisted. Closures can be difficult and take many years to implement. Where closure is not practicable or economic, Network Rail uses the results of a risk assessment to determine whether and what risk mitigation measures are required over and above those already specified in the relevant statutory and industry requirements for the level crossing. These may, for example, include changing the type of level crossing control, enhancements to the road or rail approaches, provision of additional signs or a crossing safety publicity campaign in the local area.

6.2 Permitted Types of Level Crossing

6.2.1 The various types of level crossing currently permitted for use on the railway are described in Appendix H, Fig. 1. A typical example of a manually operated barrier crossing is shown in Appendix G, Fig. 12.

6.2.2 Where the line speed exceeds 125mph (200km/h), level crossings are not permitted.

6.2.3 The flow chart in Appendix H, Fig. 2 provides a guide to selecting an appropriate form of level crossing protection.

6.3 Principles of Operation of the AHB Level Crossing and Conditions for Determining its Suitability for Installation

6.3.1 The principles of operation and the conditions for determining the suitability of an AHB level crossing for installation at a particular location are defined by the Health and Safety Executive (HSE) in the Railway Safety Principles and Guidance, part 2 section E, Guidance on Level Crossings which are not for retrospective application but state:

General description:

This type of crossing is protected by road traffic light signals and a lifting barrier on both sides of the railway. Audible warning to pedestrians is also provided. Lifting barriers are normally kept in the raised position and pivoted on the left-hand side of the road.
When lowered, the barriers extend only across the entrances to the crossing, leaving the exits clear.

The crossing equipment is initiated automatically by an approaching train. The lowering of the barriers is preceded by the display of road traffic light signals. The period between the initial display of the road traffic light signals and the arrival of the fastest train should be sufficiently long to enable road vehicles and pedestrians to clear the crossing.

The barriers rise immediately after the train has passed unless another approaching train is so close that the minimum road open time cannot be achieved. In this situation the barriers remain lowered and the intermittent red lights continue to flash but the sound emitted by the audible warning device changes in character as soon as the first of the trains arrives at the crossing.

Telephones for use by the public and those who are required to phone for permission to cross are normally provided near each road traffic signal on the right-hand side of the road. The telephones are connected to a supervising point, which is always open when the railway line is open.

A supervising point should have the appropriate means to stop any train approaching the crossing, and means of communicating with any assigned railway staff operating the crossing equipment locally at the crossing in an emergency or abnormal situation.

Method of operation:

The operation of the crossing equipment is initiated automatically by a train as it approaches the crossing.

The time elapsed between the amber lights of the road traffic light signals starting to show and the train arriving at the crossing should not be less than 27 seconds. The train should pass as soon after 27 seconds as possible. At least 95% of trains should arrive within 75 seconds and 50% within 50 seconds, once the sequence of events to close the crossing to road traffic has begun. Where the crossing length is longer than 15 metres, the 27 seconds should be increased by 1 second for every additional 3 metres of crossing length.

The sequence of events to close the crossing to road traffic is as follows:

a) The amber lights of the road traffic light signals immediately show and an audible warning for pedestrians begins. The lights should show for approximately 3 seconds.

b) Immediately the amber lights are extinguished, the intermittent red lights should show.
c) Approximately 4 to 6 seconds later the barriers should start to descend and take a further 6 to 10 seconds to reach the lowered position.

If the barriers remain down for another train, as soon as the first of the trains arrives at the crossing the warbling rate of the audible warning for pedestrians should be increased.

Both barriers should begin to rise simultaneously and should take normally 4 to 10 seconds to reach the raised position after the train has cleared the crossing. The intermittent red lights of the road traffic light signals should not be extinguished and the audible warning for pedestrians should not stop until the barriers have risen to at least an angle of 45 degrees above the horizontal.

If both intermittent red lights in any of the road traffic light signals fail, the barrier should remain lowered. If there is a total power failure, the barriers should fall and remain lowered. If either barrier fails to reach the lowered position, neither barrier should rise until both have been fully lowered. If either barrier fails to rise from the lowered position, the intermittent red lights of the road traffic light signals should continue to show.

6.3.2 The Conditions for Suitability state that, ‘The choice of level crossings should avoid causing unnecessary delay to road users’. The specific conditions applicable to AHB level crossings are:

The speed of trains over the crossing should not normally exceed 160kph (100mph).

There should not be more than two running lines.

Appropriate means to stop any train approaching the crossing in an emergency situation are required.

Trains should arrive at the crossing in not less than 27 seconds after the amber lights of the road traffic signals first show. At least 95% of trains should arrive within 75 seconds and 50% within 50 seconds.

The carriageway on the approaches to the crossing should be sufficiently wide to enable vehicles to pass safely.

There is no limit to the amount of road traffic, but the road layout, profile and traffic conditions should be such that road vehicles are not likely to become grounded or block back obstructing the railway.

6.4 General Statistics for Level Crossings

6.4.1 As at April 2003, there were 8,188 level crossings of all types on Network Rail controlled infrastructure. At April 2004 the figure was 7,938. The number of crossings had been reduced to this level from the total of 9,213 existing 10 years previously. The types and numbers of crossings of each type can be seen in Appendix H,
Fig. 3. The table shows that the majority of crossings are either user worked, typically farm type crossings where the user is required to operate field gates, or are on footpaths.

6.4.2 Of the 458 AHB level crossings on Network Rail controlled infrastructure at the time of the accident, Ufton level crossing was one of a total of 31 located on lines with a line speed of 100mph. Appendix H, Fig. 4 shows the distribution of AHB level crossings according to line speeds. It can be seen from this table that well over half of the total number of AHB level crossings were on lines where the line speed is 70mph (112km/h) or more.

6.4.3 The table in Appendix H, Fig. 5 shows the number of incidents of trains striking road vehicles on level crossings in the UK. There are about 20 such incidents a year and about a quarter of these occur on AHB level crossings.

6.4.4 The table in Appendix H, Fig. 6 lists the derailments resulting in injury to passengers or train crew that have been caused by trains striking road vehicles at level crossings since 1992. During the ensuing period, there have been 14 such incidents, excluding Ufton.

6.4.5 The table in Appendix H, Fig. 7 shows the road vehicle occupant and pedestrian fatalities at level crossings from 1992 to 2004. Pedestrian fatalities averaged 7 per year over the ten year period to 2004. Road vehicle fatalities averaged 3 per year over the same period.

6.4.6 The table in Appendix H, Fig. 8 gives international comparisons for level crossing fatalities. The table shows that Great Britain compares favourably with other EU countries.

6.4.7 Suicides, mostly of pedestrians, at level crossings on Network Rail controlled infrastructure, have averaged 12 per year over the last 10 years with no discernible trend and this figure represents approximately 7% of all suicides committed on the railway. The statistics are shown in Appendix H, Fig. 9. There have been two occasions in the recent past, at Pirton on 16 September 1995 and at Dunhamstead on 7 April 2003, of suicides involving road vehicles stationary on level crossings.

6.4.8 Network Rail invests considerable sums of money annually on improving level crossing controls to mitigate the risks caused by violations by members of the public. A total of £13 million was spent in 2003/2004 and £20 million in 2004/2005.

6.5 Ufton AHB Level Crossing

6.5.1 Ufton AHB level crossing is situated on an unclassified road leading from the A4 to the village of Ufton Nervet in Berkshire. The road approach to the crossing is straight and the road markings and
crossing signs were correct, in good condition and legible to road users and pedestrians at the time of the accident.

6.5.2 The road surface over the level crossing is formed of pre-cast concrete units providing a reasonably even and level surface for road vehicles to pass over the crossing safely and also to allow the unrestricted passage of the train wheels along the rails.

6.5.3 The level crossing is visible to the driver of a Down train at a maximum distance of 585 metres. The track in the area of the crossing is level. Down trains approach the crossing on a slight right hand curve before the line passes over the crossing and reaches facing points No. 979 at 43 miles 44 chains leading to the Down Goods Loop. The crossing is not required to be provided with road lighting or closed circuit television (CCTV) surveillance.

6.5.4 The level crossing is not connected with, or protected by, the railway signalling system. The crossing is operated entirely automatically by the approach of a train and the operating ‘strike-in’ point for Down trains is positioned to comply with the required minimum warning time for road users of 27 seconds for trains running at line speed.

6.5.5 The equipment and operation of the level crossing as an AHB was authorised by the Secretary of State for Transport under the British Railways Board (Berks and Hants Railway) Ufton Level Crossing Order 1977 which came into force on 19 September 1977. Two subsequent amendments to the order have been made ie the British Railways Board (Berks and Hants Railway) Ufton Level Crossing Amendment No. 1 Order 1983, which came into force on 16 May 1983 and Amendment No. 2 Order 1983, which came into force on 14 August 1983.

6.5.6 The equipment and operation of the level crossing is in accordance with these orders and the automatic half barrier equipment and all its associated ancillary equipment, at the time of the accident, was in good condition and properly maintained.

6.5.7 An examination of the maintenance history of the level crossing did not reveal any cause for concern regarding the safe and reliable operation of the level crossing equipment.

6.6 The Public Emergency Telephone System

6.6.1 The telephone is provided for the use of members of the public wanting to contact the signaller, either in an emergency or to seek permission to use the crossing when animals or an exceptionally large or slow moving vehicle are required to pass over it.

6.6.2 The telephone is installed in a high visibility yellow case with a retro-reflective telephone symbol on the exterior. Upon opening the door
of the case, the user is presented with an illuminated instruction panel with the following wording:

‘TO CALL SIGNALMAN
LIFT TELEPHONE
AND PRESS BUTTON’

The button itself is positioned immediately below the illuminated instruction panel and is also illuminated and engraved with the word ‘PRESS’.

The telephone is shown in Appendix G, Fig. 13.

6.6.3 To operate the telephone and speak to the signaller, the user must first lift the telephone handset and then press the call button. This action immediately draws the attention of the signaller to the fact that the telephone is being used.

6.6.4 Upon lifting the handset the user will first hear the dial tone, which changes to a ringing tone when the call button is pressed. When the signaller answers the call, the ringing tone ceases and speech communication may commence.

6.6.5 The system is fully self monitoring and a failure of the remote equipment eg power supply, vandalism of the telephone handset or failure to replace it after use, is recorded by the signalling centre equipment.

6.6.6 When the handset is lifted, the illumination for the instruction panel dims with the result that the instructions are almost impossible to read in the dark. This is a feature inherent in the design of the telephone. The design philosophy presumes that a user will approach the telephone from the front, open the case and read the illuminated panel before lifting the handset and pressing the button to make the call.

6.6.7 The off-duty policeman, who had observed the car obstructing the Down Line, went quickly to the emergency telephone in an attempt to alert the signaller to the emergency. He was standing at one side of the telephone case when he opened the door and therefore did not see the illuminated instruction panel. He said that he had expected the telephone to operate in a similar manner to the motorway emergency telephone that he was accustomed to using, which connects the user directly to an operator when the handset is lifted. On lifting the handset at Ufton, he heard the dial tone but did not realise that it was necessary to press the call button to connect with the signaller, so he aborted the attempted call when he failed to establish contact.

6.6.8 The telephone data recorder in Reading Signalling Centre recorded the policeman’s attempted use of the telephone at 1811 hrs, even though the call was not connected to the signaller. The attempted
call lasted 9 seconds before it was aborted without the call button at the telephone having been pressed.

### 6.7 Proximity of the Facing Points
6.7.1 A Down Goods Loop runs adjacent to the Down Line from the facing points at 43 miles 44 chains to sidings at 44 miles 20 chains. As noted in Section 4.2.3 of this report, the left hand turnout of these points guided the derailed leading bogie to the left, causing the bogies of all the following vehicles to derail.

### 6.8 Risk Assessment
6.8.1 Level crossings are recognised as a significant risk area on Network Rail controlled infrastructure for train accidents involving road users and pedestrians. The first option in choosing an appropriate form of level crossing protection always includes the removal of the interface with the public.

6.8.2 In order to understand and control the risk at level crossings which cannot be closed, a considerable amount of work and investment has been expended by Network Rail and its predecessors over a number of years.

6.8.3 The greatest risk at AHB level crossings arises from the lack of discipline of road users who fail to obey the road warning signals and who either deliberately or inadvertently do not stop when the crossing is about to close to allow a train to pass. Zigzagging around the half barriers at AHB level crossings is a particularly dangerous but common occurrence.

6.8.4 An Operations Risk Control Specialist from Network Rail explained to the Panel that an annual risk assessment is carried out on all AHB level crossings. The risk assessment method is based on a quantitative risk assessment model that was developed for use originally in 1993. The model has been refined subsequently in the light of experience and the process is ongoing. The risk model was authorised for use with AHB level crossings in 1997 and has been validated to ensure that it gives results consistent with historic data. Further refinements have been incorporated into later versions.

6.8.5 The flow chart in Appendix H, Fig. 10 illustrates the process to be followed for assessing level crossing risks. The model assesses separately the individual risk to all types of road vehicle users of the level crossing, to pedestrian users and to rail passengers and staff. At present the process does not specifically mandate consideration of crossing closure as the first and preferred option.

6.8.6 The level of risk to all types of road and rail user is measured as the individual risk of fatality to a regular user per year. A regular user is
defined as one undertaking 250 or more return journeys over the crossing per year. The upper limit of tolerability is set at 1 in 10,000 which is the level accepted by the road authorities for considering improvements at road intersections, beyond which is the intolerable region. If the risk level is assessed to be at 1 in 10,000 or above, then Network Rail takes immediate action to reduce it.

6.8.7 The broadly acceptable region is where the individual risk to a regular user of an AHB level crossing is 1 in 100,000 or better. This level was set in the Railway Group Safety Plan 1997/1998 and remains in force today.

6.8.8 Where individual risk falls between the intolerable and broadly acceptable regions (ie in the range 1 in 10,000 – 1 in 100,000 for level crossing risk), the risk must be reduced to as low as reasonably practicable (ALARP). The risk remains tolerable only if there is no reasonably practicable means of reduction. Risks within this range are reviewed to identify possible actions for improvement. These actions are then subject to a cost benefit analysis to determine whether the estimated safety benefits to be gained justify the cost of the improvement.

6.9 Ufton AHB Level Crossing Risk Assessment

6.9.1 Network Rail’s Level Crossings Risk Control Co-ordinator explained to the Panel that the annual risk assessment for Ufton was undertaken on 8 July 2004, using the latest version of the risk assessment model that had been released for use in March 2004.

6.9.2 The risk assessment was carried out using the approved data input form to ensure that all relevant information was captured. The Risk Control Co-ordinator said that a site visit was made during which a 30 minute sample traffic census was taken and the road approaches, surfaces, markings and signs were inspected. The speed of road vehicles, the number of trains using the crossing and the failure record of the crossing equipment were noted. It was also noted that there was no record of user abuse of the crossing or of traffic blocking back. There were no local environmental changes such as new buildings or a caravan site that would affect usage. The data that had been collected was entered into the risk assessment model.

6.9.3 The Risk Control Co-ordinator confirmed that improvement action to cut vegetation that partially obscured some road signs had been noted during the site visit and was dealt with subsequently. He also confirmed that the local Network Rail operations team made a monthly check of the crossing warning times.
6.9.4 The results from the Ufton level crossing model showed that the individual risks were assessed as follows:

<table>
<thead>
<tr>
<th>Category</th>
<th>Risk Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road vehicle users</td>
<td>1 in 88,000</td>
</tr>
<tr>
<td>Pedestrians</td>
<td>No pedestrian use was made of the crossing during the risk assessment</td>
</tr>
<tr>
<td>Rail passengers</td>
<td>1 in 120,000,000</td>
</tr>
<tr>
<td>Rail staff</td>
<td>1 in 760,000</td>
</tr>
</tbody>
</table>

6.9.5 Owing to the individual risk to road vehicle users at the level crossing being assessed at 1 in 88,000 ie a greater individual fatality risk than the 1 in 100,000 benchmark, a conversion of the AHB installation to a CCTV supervised manually operated barrier installation was considered and subjected to a cost benefit analysis. The results showed that an expenditure of some £1 million would be required to achieve a safety benefit with an equivalent value of £65,000. It was concluded therefore that an expenditure of this magnitude was grossly disproportionate to the safety benefit to be gained and could not be justified. The details of the risk assessment are shown in Appendix J.

6.10 Influence on Risk Assessment of the Proximity of Track and Lineside Features

6.10.1 The nature of a railway system is such that many track and lineside features are encountered along the route. Underbridges, overbridges, viaducts, embankments, stations, lineside buildings, points and crossings are all features that normally do not present a hazard to the safe passage of trains. Their presence can however become a consequential factor on the rare occasion when a train derails.

6.10.2 In the case of the accident at Ufton, the proximity of the facing points leading to the Down Goods Loop was the feature that promoted the catastrophic derailment of the complete train.

6.10.3 The level crossing risk assessment does not specifically address the proximity of track and lineside features, such as was the case at Ufton.

6.11 Current Level Crossing Research

6.11.1 In 2002, Railway Safety which was the predecessor of the Rail Safety and Standards Board (RSSB), Railtrack which was the predecessor of Network Rail and Her Majesty’s Railway Inspectorate (HMRI) set up the National Level Crossing Safety Group (NLXSG). This also involved the wider rail industry, the road
authorities, the Driving Standards Agency, the police and representatives of user groups. The remit for NLXSG is shown in Appendix K.

6.11.2 A four-strand approach to level crossing research was adopted viz:

(a) **Enabling**: The provision of resources through people, procedures and systems to deliver the following elements in (b), (c) and (d).

(b) **Engineering**: The protection fitted to level crossings through lights, horns, barriers, telephones and signs together with research into other innovative means of increasing safety.

(c) **Education**: Increasing public awareness of the dangers of level crossings and educating users how to use them correctly.

(d) **Enforcement**: Prosecution of those who misuse crossings.

6.11.3 These are the four strands of a substantial research programme, commissioned by RSSB and fully supported by Network Rail, which is ongoing with the objective of improving the safety performance of level crossings.

6.11.4 A list of all the level crossing research projects and their status, as at the time of the accident, is shown in Appendix M.

6.11.5 A Research Manager from RSSB explained to the Panel that currently the most significant risk at AHB level crossings arises from road users zigzagging around the half barriers. He said that a research project for the installation of median strips in the roadway on either side of the AHB level crossing for the purpose of maintaining lane discipline is to be trialled in East Anglia. Research is also being conducted into the economics of level crossing upgrades in Britain and abroad, into various deterrent and enforcement mechanisms and into the economics of crossing closures, including the involvement of the road and local authorities. Further research is examining ways for improving road user and pedestrian behaviour at level crossings, including human factors studies and various technical options.

6.12 **Obstacle Detection on Level Crossings**

6.12.1 The Research Manager explained that detectors to identify obstacles on a level crossing have been suggested as a means to improve safety on Network Rail. Such devices have been used abroad to assist the signaller in detecting that the crossing is clear before the barriers are lowered at manually operated level crossings remotely supervised by CCTV. One experimental site has been tested at Everton manually operated level crossing near Peterborough for this purpose. There were ensuing road delays as
a result of false readings as well as interference due to acts of vandalism.

6.12.2 A Level Crossing Engineer from Network Rail told the Panel that it appeared theoretically possible to provide obstacle detection using radar or laser principles at AHB level crossings. He envisaged that the detection system would be designed to trigger an emergency visual lineside signal to warn the train driver if the crossing was obstructed. It would normally not be possible by this means to stop a train before the crossing but it might significantly reduce the speed of any subsequent collision. Further research work would be required before it would be possible to say whether a practical, reliable and economic warning system based on obstacle detection could be devised.

6.13 Potential for Design Improvements at AHB Level Crossings

6.13.1 The Level Crossing Engineer informed the Panel of the following improvements, either underway or proposed, which have the objectives of rendering AHB level crossing warning lights even more arresting to road users and of improving user discipline:

(a) Light emitting diode (LED) boom lights and flashing warning lights, which are brighter and more reliable than the incandescent lamps used at present.

(b) New barrier machines to improve further the reliability of operation.

(c) Predictor technology to introduce constant warning times, irrespective of the speed of the approaching train, to reduce the temptation of the road user to zigzag.

(d) Median strips (plastic bollards) to improve lane discipline and discourage zigzagging.

(e) Red light violation cameras and yellow box markings to assist with enforcement action.

6.13.2 He said that other developments may also include the possible linking of obstacle detectors with the driver’s cab in association with the proposed signalling system of the future.

6.14 Lessons from Previous Level Crossing Accidents

6.14.1 When the AHB system of level crossing control was first introduced in the early 1960s, it was relatively simple in design and cheap to install. The Hixon accident in 1968 promoted a number of changes to the design of the AHB level crossing and the criteria for its use. Further changes to the criteria were implemented following the Lockington accident in 1986.
6.14.2 The changes introduced following these two previous fatal accidents were aimed at improving the visibility and presentation of the crossing to road users. The warning times and cycles were revised and a preliminary warning flashing yellow cycle together with the present emergency telephone system were introduced. Also, the road signs and presentation of notices were revised with the benefit of human factors input and the road profiles were standardised. More recently, automatic monitoring of the correct operation of the crossing equipment has been introduced.

6.14.3 Over the years, these additional safeguards and improvements have added very significantly to the costs of the implementation of AHB installations. Network Rail informed the Panel that an AHB level crossing today typically costs at least £750,000 to install. For comparison, a CCTV remotely supervised manually operated full barrier installation typically costs £1m or more.

7. **Train Behaviour**

7.1 **Introduction**

7.1.1 HSTs first entered commercial fleet service on the principal main lines of the then Western Region of BR in the mid 1970s. They were the first trains in the UK to be capable of operating at 125mph. A total of just under a hundred train sets were eventually built. They were progressively introduced on other regions and were the mainstay of the BR InterCity fleet on non-electrified routes for many years. Recent deliveries of new underfloor-engined multiple unit trains have led to a reduction in their deployment but they are still in use by FGW, Midland Mainline and Great North Eastern Railway (GNER). At present there are no trains on order to replace HSTs on these duties.

7.1.2 With such a large fleet in service over many years and with each train covering a high annual mileage, HSTs have been involved in a number of serious accidents. However the Panel has found no record of any accident in which the derailment of an HST following a collision with a road vehicle resulted in on-train fatalities.

7.1.3 This part of the report looks at a number of aspects of the performance of the vehicles. Except where otherwise indicated, the content of Sections 7.2 to 7.7 is based on evidence given, both orally and in the form of a written report, by two witnesses. A Principal Engineer from AEAT, who inspected the vehicles at Crewe, gave evidence in respect of coach interiors. The AEAT Team Leader (Structural Integrity), who inspected the vehicles both on site and at Crewe, gave evidence in respect of the power cars and other matters related to the coaches.
7.2 Effect of Power Car Design on the Initial Derailment

7.2.1 Design Philosophy

7.2.1.1 The Team Leader explained to the Panel that there are two devices, obstacle deflectors and lifeguards, that are commonly fitted to leading vehicles of trains in order to reduce the probability of derailment following collision with an obstruction.

7.2.1.2 An obstacle deflector, colloquially known as a ‘cow catcher’, is designed to be fitted to the lower part of the front end body structure. It is vertical in elevation, or has a concave forward face, and is slightly V-shaped in plan view so as to sweep aside any large obstructions encountered on the track. It is designed to be as wide as the loading gauge will allow and to come as close as possible to the plane of the rails.

7.2.1.3 The requirements relating to obstacle deflectors were formulated in the 1980s following the derailment of a train which had hit a cow and are currently contained in Railway Group Standard GM/RT2100 Structural Requirements for Railway Vehicles. This standard requires obstacle deflectors to be fitted to leading vehicles having a maximum operating speed of 90mph (145km/h) or above, although vehicles having an axleload in excess of 17 tonnes are exempt.

7.2.1.4 One of the limitations of an obstacle deflector is that in order for it to have the capacity to move aside objects of a significant mass when the vehicle is running at high speed, it must be connected to the vehicle body. If the obstacle deflector was mounted on the bogie, the reaction of the forces required to move obstructions would entail the risk of derailing the bogie. With the obstacle deflector being body-mounted, it must be located at a sufficient height above rail level such that if the primary and secondary vertical suspensions are fully compressed, the obstacle deflector cannot come into contact with the rail. This normally means that the obstacle deflector on a high speed vehicle would be mounted with its lower edge about 200mm above the rail, thus making it ineffective in deflecting certain obstacles.

7.2.1.5 Lifeguards are designed to be fitted in pairs, one directly in front of each wheel of the leading axle. They are intended to prevent small objects getting between the wheel and the rail. They are mounted on the bogie frame and, like an obstacle deflector, are designed to come as close as possible to the plane of the rails.

7.2.1.6 Railway Group Standard GM/RT2100 also contains requirements relating to the provision of lifeguards, which are required to be fitted on all leading axles irrespective of vehicle operating speed and axleload. Because they are bogie frame mounted, they are able to be positioned much closer to the rails than an obstacle deflector and are thus more effective in deflecting small objects. However the mass that they are capable of deflecting at high speed is very
They are also limited in width because of loading gauge restrictions, such that they sweep only the area immediately above the rail head.

7.2.2 Obstacle Deflector and Lifeguard Provision on HSTs

7.2.2.1 HST power car construction pre-dated the requirement to fit obstacle deflectors to high speed vehicles but the power cars would be exempt from the requirement even if built today because they have an axleload in excess of 17 tonnes. However, they are fitted with lifeguards.

7.2.2.2 The issue of whether the accident would have been prevented if the leading power car had been fitted with an obstacle deflector was studied in detail by the Team Leader. He considered that because the initial impact had been with the sloping glass reinforced polyester (GRP) skirt of the power car (Appendix F, Fig. 7), the motor car had been pushed downwards, so it was possible that the engine block could have passed beneath an obstacle deflector mounted behind the GRP skirt. However, the installed position of the engine block was 300mm above ground level. He considered that with a deflector mounted well forward and integrated into the front end design such that the car was impacted by a vertical rather than a forward sloping surface, the deflector would have been likely to sweep aside the engine block with the rest of the car. He therefore concluded that the likelihood of derailment would have been substantially reduced if a forward mounted obstacle deflector, to current design requirements, had been fitted.

7.2.2.3 His report concluded that the lifeguards had no significant influence on the outcome of the collision with the car.

7.3 Influence of the Couplers on the Behaviour of the Train Following the Derailment

7.3.1 Coupler Design Principles

7.3.1.1 The prime function of inter-vehicle couplers is to maintain the longitudinal integrity of a train. However they also have a role in restraining relative angular and linear movements of adjacent vehicles, as an aid to keeping them in line in an accident.

7.3.1.2 Current standards relating to vehicle bodies require them to be fitted with anti-climbers. These are devices fitted to each end of the body which have serrated surfaces designed to engage with those on adjacent vehicles if they are forced into contact. When subjected to very high compressive longitudinal loading, the inter-vehicle coupler is designed to collapse. This allows the anti-climbers of adjacent vehicle ends to engage and to resist over-riding.
7.3.2 HST Coupler Design

7.3.2.1 HSTs are fitted with ‘Alliance’ couplers, as illustrated in Appendix F, Fig. 8. The coupler head has pivoted ‘knuckles’ which, when the heads are pushed together, come into contact (Fig. 8a) and rotate anticlockwise, as seen from above, about a vertical axis to allow the heads to engage. They then move back to their as-shown position and are restrained from further opening so that the coupler heads will not then pull apart in service (Fig. 8b). Each coupler head has two ‘knuckles’, one above the other, which in normal usage share the longitudinal load when the couplers are tensioned.

7.3.2.2 The behaviour of the couplers was examined from the point of view of how well the design inhibits relative movements of the vehicles and of how well it prevents the vehicles from separating from one another. The Team Leader’s report concluded that the resistance of the coupler to the relative roll of the vehicles is low, because the resilient rubbers allow the tail-pin to rotate about a longitudinal axis under the action of a very small roll torque.

7.3.2.3 Relative pitch of the vehicles can occur as a result of flexibility in the resilient rubbers and the vertical clearance between each coupler shank and the wall of the aperture in the vehicle headstock. Maximum relative pitch was estimated at around 5 degrees.

7.3.2.4 Relative yaw of the vehicles can occur as a result of the clearance between the jaws of the coupler heads, clearance at the aperture in the vehicle headstock and the ability of each coupler to rotate about a vertical axis through the coupler pin. The maximum relative yaw angle was estimated to be 36 degrees.

7.3.2.5 The coupler heads do not grip each other tightly and relative vertical movement of around 105mm can occur. Further vertical movement is limited by a device known as a ‘lower shelf bracket’ which was introduced after accidents in which coupler heads had disengaged as a result of such movement. With a vertical height difference of the coupler heads approaching the 105mm limit imposed by the lower shelf bracket, the tensile strength of the coupler is considerably reduced as the force is carried by the upper knuckle of one coupler head and the lower knuckle of the other, rather than distributed over the two knuckles of both heads.

7.3.3 Observed Coupler Behaviour

7.3.3.1 Examination of the couplers of the coaches, which had separated, showed that they had failed as follows:

<table>
<thead>
<tr>
<th>Coach</th>
<th>End</th>
<th>Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Trailing</td>
<td>Fractured lower knuckle</td>
</tr>
<tr>
<td>E</td>
<td>Leading</td>
<td>Missing lower shelf bracket</td>
</tr>
<tr>
<td>E</td>
<td>Trailing</td>
<td>Fractured and bent knuckles</td>
</tr>
</tbody>
</table>
7.3.3.2 No evidence was found of pre-existing flaws in the material or that the couplers were in any way sub-standard. The Team Leader’s report concluded that the vertical displacements of the vehicles, as they became embedded in ballast or ran over embedded bogies, would have been likely to produce relative movements exceeding 105mm as well as creating forces well above the 70kN ultimate vertical load capacity of the lower shelf brackets. This would explain the lower shelf failure at the leading end of coach E. On coaches B2 and F it was concluded that the single knuckles had fractured as a result of the tensile forces generated at a time when there was significant relative vertical displacement of the coupler heads. It was concluded that at the trailing end of coach E, the coupler had failed as a result of a tensile load in excess of its 500kN load capacity.

7.3.3.3 In respect of alternative designs of coupler that, by design, are better able to resist excessive yaw and vertical movement, the Team Leader considered that these may have helped to keep the train in line. However, he noted that very high loads would have been induced in such couplers and there are clearly practical limits to the forces and torques which they can resist.

7.4 Bogie Retention

7.4.1 Design Requirements

7.4.1.1 The Team Leader told the Panel that the retention, or otherwise, of bogies beneath the vehicle body in an accident continues to be the subject of much debate. The argument for keeping the bogies captive is that it is undesirable that they should become loose missiles, which can impact other vehicles. The argument for their being able to break free is that the effective mass of the vehicle is lower and thus the kinetic energy that might otherwise be dissipated by deformation of the vehicle body is reduced. His personal view was that bogie retention is preferable.

7.4.1.2 Current Railway Group Standards mandate that the body and bogies remain connected. The Group Standard GM/RT2100 requires the body to bogie connection to be capable of sustaining, without permanent deformation, loads corresponding to 5g longitudinal and 2g vertical accelerations of the bogie. Fifty percent higher loads must be sustained without rupture of the connection.
7.4.2 Bogie Behaviour in the Accident

7.4.2.1 A particular feature of the derailment was that as a result of their ploughing through the ballast, most of the coach bogies became completely or partially detached and the loose bogies significantly influenced the subsequent course of events. They were a contributory factor to the longitudinal forces that promoted the uncontrolled behaviour of the coaches in the centre part of the train and were the direct cause of the reduced survival space in coaches D and F.

7.4.2.2 The body/bogie connection in the coaches is via a centre pivot casting which is bolted to the body bolster by six bolts; three bolts each fore and aft (Appendix F, Fig. 9). Detachment of the bogies was the result of the failure of this connection. In some cases this was a consequence of the tearing and bending of the body bolster, allowing the bolts to pull through or causing the bearing plate to be torn away from the body bolster. In others, the mechanism of failure was fracture of the centre pivot casting itself at the bolted connection. However in no case was the damage to the body bolster of a nature that risked compromising the integrity of the body structure.

7.4.2.3 The coach bogies have a mass of 5.5 tonnes. To meet current requirements it must therefore be possible to sustain a longitudinal load of $5 \times 1.5 \times 5.5 = 41.25$ tonnes without failure of the body/bogie connection. The equivalent vertical figure is 16.5 tonnes. Simple calculations of the longitudinal strength of the connections indicated a failure force of 30 to 50 tonnes, suggesting that HSTs may meet the current requirements. In the vertical sense there is no resistance to the bogie falling away from the body. The cylindrical lower portion of the centre pivot casting can slide within, but is not in any way fastened to, a tube that forms part of the bogie assembly. This arrangement can therefore transfer longitudinal and lateral forces between body and bogie but does not provide restraint against the bogie falling away from the coach body.

7.4.2.4 The Team Leader’s report concluded that if the bogies had been retained, they would have arrested the train under more controlled conditions, albeit with high decelerations. As the bogies embedded themselves ever deeper into the ballast, the body/bogie longitudinal forces became too large to be sustained, exceeding those that current standards require vehicles to meet. He argued that a body/bogie vertical restraint could have prevented, in principle, the lifting of the body relative to the bogie and hence prevented a consequent increase in the bending moment on the body/bogie connection. However almost all of the assemblies failed in a similar way and he considered that it is unlikely that all were subjected to additional stress as a result of body lift. Hence he concluded that lack of vertical restraint was not a significant factor in the accident.
7.4.2.5 In contrast to the behaviour of the coach bogies, the bogies of the power cars did not plough through the ballast to the same degree and were retained. The power car bogies have flexible retaining straps, which limit the extent to which the bogies can fall away from the body. However the report concluded that it is unlikely that these straps played a significant part in the bogie retention. The fuel tanks, which are mounted between the power car bogies, and the undersides of the traction motors all acted as skid surfaces and thus inhibited any tendency for the wheels and other bogie components to dig into the ballast.

7.4.2.6 Despite the number of bogies that came loose and which impacted or were impacted by other vehicles, there was no significant loss of bogie integrity. In particular, there was no separation of wheelsets and bogie frames.

7.5 Effectiveness of the Vehicle Structures in Protecting the Passengers and Crew

7.5.1 Structural Design

7.5.1.1 The loadings which a vehicle structure must be able to withstand are specified in Railway Group Standard GM/RT2100. It also requires vehicles to be designed with ‘crumple zones’ at the vehicle ends. These are sacrificial areas of the vehicle which are not normally occupied by passengers or crew and which are designed to collapse in a controlled manner if the specified load capacity of the body is exceeded. The objective is to absorb energy, to reduce the probability of deformation of the passenger saloon and to reduce the accelerations to which passengers and crew are subjected in an accident. Each vehicle end is required to absorb a minimum of 1MJ of energy.

7.5.1.2 HST power cars have a strong fabricated steel underframe to support the power equipment. The superstructure is much weaker and essentially non-structural. A GRP cab module, with some lightweight steel stiffening members, houses the driver console and is bolted to the front of the power car. The power car was designed in the early 1970s and does not meet the strength requirements of modern standards.

7.5.1.3 HST coaches, in contrast, are of a monocoque construction in which the bodysides and roof combine with the underframe to form a strong steel tube. The design is an early one of its type and does not meet all the current loading requirements. Nevertheless, the structure of these coaches has been shown, in a number of serious accidents, to be very resistant to deformation.
7.5.2 The Behaviour of the Power Cars

7.5.2.1 The leading power car came to rest on its left hand side with the overall structure substantially intact but with severe abrasions down the side of the body where it had slid along the ballast. There was structural failure at the top of the left hand side leading pillar of the driver’s cab door, this being the pillar to which the door was latched. The driver’s door was missing and there were clear signs on the cab bulkhead that large quantities of earth and ballast had entered the cab through the door aperture. The Driver died as a result of this ingress of debris.

7.5.2.2 The lower part of the GRP fairing on the left hand side of the cab had been torn off but the draw-gear and buffer equipment behind it was undamaged. The front end of the bogie, the leading axle, the traction motor and the gear casing were all severely abraded by ballast. The fuel tank was ruptured in a number of places, allowing the contents to escape.

7.5.2.3 The trailing power car sustained only minor damage.

7.5.3 The Behaviour of the Coaches

7.5.3.1 Coach H came to rest on its left hand side but with the overall structure essentially maintained. There was severe abrasion of the left hand side, with deep scoring over the rear two thirds of the bodyside just above the level of the underframe. Whatever caused the scoring (possibly either the leading bogie or a length of broken rail), it tore the bodyside outer skin over a length of 4 metres. There was minor damage to the underframe equipment and both bogies were completely detached.

7.5.3.2 Coach G came to rest leaning approximately 30 degrees to the left. The trailing left hand corner was embedded in a low earth bank and the door had been pushed into the vestibule, allowing ingress of soil from the bank. There was severe scoring of the left hand bodyside and the lower trailing right hand corner showed signs of a heavy impact. All the underframe equipment had been torn off and both bogies were completely detached.

7.5.3.3 Coach F, containing the buffet, remained upright but was bent almost double with both leading and trailing ends pointing approximately in the direction of travel. The solebar (the large structural member at the junction of the bodyside and underframe), the bodyside and approximately half of the roof and floor structure had been torn away on the right hand side by the trailing bogie of coach G. This had significantly reduced the lateral bending strength of the structure, allowing it to bend into its final position. Heavy scoring and tearing of the bodyside had occurred on the right hand side of the vehicle forward of the point where it had been penetrated and there was general heavy impact damage to both bodysides. Where excessive bending of the body had occurred, the bodyside
panel seams had split open. Most of the underframe equipment had been torn off and both bogies were detached.

7.5.3.4 Coach E came to rest lying on its right hand side on the Up Line. There was significant scraping down the right hand bodyside, consistent with it sliding along rails on its side. Otherwise the body structure was essentially intact with little sign of damage. Most of the underframe equipment at the leading end had been torn off and both bogies were detached.

7.5.3.5 Coach D came to rest leaning 30 degrees to the right. There was severe damage to the roof and bodyside towards the leading left hand side. This had led to significant structural intrusion into the space normally occupied by passengers in that the left hand side of the roof had been pushed down almost to floor level. There were extensive scrape marks running diagonally along the left bodyside, indicating that the coach had been on its side at some stage. Most of the underframe equipment had been torn off and both bogies were detached.

7.5.3.6 Coach B2 came to rest leaning 20 to 25 degrees to the right. There was noticeable damage to both sides and the floor had been pushed up immediately behind the leading bogie but the structure was fully intact. Most of the underframe equipment was missing and both bogies were detached, although the trailing bogie was displaced but still substantially under the body.

7.5.3.7 Coaches B1 and A came to rest essentially in a straight line and leaning approximately 10 degrees to the right and 45 degrees to the left respectively. Both had minor damage to bodysides, underframe equipment and bogies. The centre pivots of all but the trailing bogie of coach A had partially detached.

7.5.3.8 The details of the damage to all the vehicles in the train are shown in Appendix E.

7.5.4 End-on Collision Crashworthiness of the Coaches

7.5.4.1 HST coaches pre-date the current requirement for energy absorbing crumple zones. Minimal damage was sustained by the coach ends in the accident and the Team Leader considered that the outcome of the accident would not have been mitigated by crumple zones. Even if they had been a feature of the design and had collapsed as intended, the energy absorbed would not have made a significant difference, given that this was a high speed accident in which it was calculated that 390MJ of energy was dissipated by means other than braking.

7.5.4.2 HST coaches also pre-date the requirement to fit anti-climbers. However the Team Leader considered it unlikely that the compressive loads were sufficient to cause the couplers to collapse, so enhanced longitudinal stability would not have been realised even if anti-climbers had been fitted.
7.5.5 Roll-Over Strength of the Coaches

7.5.5.1 The roll-over strength of the coaches was demonstrated by the fact that coaches H and E rolled onto their sides without compromising survival space. Coaches F and D did sustain significant loss of survival space but each was subjected to an impact from a detached bogie in a direction for which there is no specific strength requirement. The Team Leader considered that it would be impracticable to expect a rail vehicle body to be able to survive a lateral or vertical impact with such an obstacle without sustaining gross permanent deformation.

7.5.6 Corrosion in the Coaches

7.5.6.1 Coaches D and F were subjected to a brief corrosion inspection to determine if this played a significant part in their behaviour in the accident. Full access to inspect all significant areas was not available but the areas that were examined showed no evidence of any significant reduction in material thickness or holes. In particular, where the solebars of coaches F and D had been penetrated or torn, the fracture surfaces were examined but no significant corrosion was found. Minor corrosion was found in body bolsters but it was concluded that this was not a factor in the bogie detachment.

7.5.7 Damage to Underframe Mounted Equipment

7.5.7.1 The Team Leader concluded that it is probably impracticable to design underframe equipment capable of withstanding the longitudinal forces that are induced when bogies become embedded in the ballast. The significant energy that was absorbed as the underframe equipment was torn off the coaches would have helped to reduce their velocity.

7.5.7.2 The vulnerability of the power car fuel tanks was again exposed, as in the Ladbroke Grove accident which occurred in October, 1999. However in contrast to what happened in the head-on collision of two trains at Ladbroke Grove, where there was almost instantaneous rupture of the tank, the fuel is likely to have escaped relatively slowly in the Ufton accident. At Ufton, there was little or no atomisation of the fuel and hence little risk of fire.

7.5.8 The Role of the Windows in Passenger Containment

7.5.8.1 Railway Group Standard GM/RT2456, *Structural Requirements for Windscreens and Windows on Railway Vehicles*, requires bodyside windows which are not designated for emergency egress to have at least one pane of laminated glass. Emergency egress windows must have toughened safety glass to BS857. HST coaches pre-date these requirements and all windows are made of toughened glass compliant with BS857, which breaks into non-aggressive pieces if it is shattered.
7.5.8.2 There were at least two and possibly four passenger fatalities as a result of being ejected through windows. Two persons who were ejected in this way survived. Others were injured as a result of limbs being trapped between the coach exterior and the track when the coach fell onto its side or by being cut as they were thrown against broken windows or by being hit by debris. All were the result of the breakage of the glass. There was no evidence of failure either of the attachment of window frames to the bodyside or of the fixing of the glass within the frames.

7.5.8.3 Significant amounts of ballast were found in the passenger saloons of some coaches, although it is not known if this contributed to passenger injury. However a number of passengers are known to have been cut by flying window glass.

7.5.8.4 The Principal Engineer concluded that if the windows had been to current standards, the number and severity of injuries would have been reduced.

7.6 Effectiveness of the Coach Interior Design Features in Protecting Passengers and Crew

7.6.1 Sources of Injury

7.6.1.1 Other than the injuries caused by passenger ejection, the Principal Engineer concluded that most were the result of secondary impacts in which people were propelled into contact with the interior fittings of the coaches. There was no clear evidence of anyone being injured by loose luggage.

7.6.1.2 However, there was evidence that in coach D, where there was significant structural intrusion, passengers sitting in the area where the intrusion occurred had been thrown towards the other side of the coach as the body structure deformed.

7.6.2 Seats

7.6.2.1 The Association of Train Operating Companies (ATOC) Standard AV/ST9001 Vehicle Interior Crashworthiness requires seats to withstand, without significant permanent deformation, a longitudinal load of 1.5kN applied centrally to the uppermost part of the seat back and a load of 2kN applied vertically downwards to the centre of the seat cushion. It also requires seats to meet specific injury level criteria if they are impacted by a passenger or crew member. If there is a conflict between the two, the seat is to be considered sacrificial to the benefit of the passenger or crew member. Although HST seats were designed before these criteria were introduced, they meet the current loading requirements. They are therefore robust but were not designed to be sacrificial if impacted.

7.6.2.2 The seats in HSTs consist of a one-piece sheet moulding compound shell bolted to aluminium armrest castings, which are in
turn fixed to an aluminium tube that lies beneath the seat cushion and is connected to the bodyside and to the seat pedestal supports. The seats are secured by T-bolts fixed in continuous longitudinal aluminium slots. The Principal Engineer’s examination of the seats indicated:

(a) That signs of passenger impact on seat-backs were not accompanied by seat deformation. If the seats had deformed they may have absorbed energy and lessened passenger injury.

(b) Seats generally remained correctly fixed to the body structure. There was no evidence that any seat structures had become detached as a result of deceleration of the coach alone, although there were seat-base and seat-back cushions which could have come loose in this way. However, some rear facing seats that had been occupied by passengers were found to have fractures in the armrest casting securing the seat to the coach bodyside. This would allow significant deformation of the seat-back and give rise to a potentially serious passenger injury mechanism.

(c) Two seat-backs were missing and one had fractured across the seat-back, giving rise to a sharp edge. All were located in coaches D or F in areas where there was significant structural intrusion.

(d) The armrest casting on many seats had been deformed as a consequence of passenger impact resulting from lateral acceleration of the coaches.

(e) There was no evidence that any passenger needed to be released after being trapped as a result of seat deformation.

7.6.3 Tables

7.6.3.1 ATOC Standard AV/ST 9001 requires tables to withstand, without significant permanent deformation, a vertical load of 1kN applied at any position and a longitudinal load of 1.5kN applied at any point along its edge. As with seats, specific injury level criteria also apply and in case of conflict between the requirements, the table may permanently deform in order to allow it to satisfy the injury level criteria, provided that it remains intact and firmly fixed to the body structure. The tables in HSTs predate these requirements and were designed to a standard requiring a longitudinal load resistance of 0.75kN only.

7.6.3.2 Significant numbers of bay tables had become detached from their fixings as a result of passenger interaction. Again, there was no evidence to suggest that tables had become detached as a result of the deceleration of the coach alone. The tables in first class are particularly heavy, having the potential to injure passengers when detached. Where tables had become detached, this had exposed
the wall-mounted metal fixing brackets by which the tables are secured to the bodyside. These brackets, located one near each edge of the table, constituted a hazard to anyone thrown against them.

7.6.3.3 Failures had occurred at the fixings to the brackets as a result of the helicoidal inserts pulling out of the medium density fibre table tops. The inserts allow the table to be bolted to the brackets and avoid the need to use wood screws. In some cases the inserts, of which there are two at each bracket, had been pulled out at the trailing edge only and the table had then pivoted around the remaining fixings near the leading edge. In other cases all four inserts had been pulled out.

7.6.3.4 There were a number of cases of failure of the table leg close to where it was fixed to the floor. These occurred in the heat-affected zone where the table leg had originally been welded.

7.6.3.5 The Principal Engineer considered that although the tearing out of the inserts could cushion the impact felt by a passenger to some degree, it is undesirable for tables to become completely detached. With detachment, they have the potential to become dangerous missiles, in addition to which a degree of passenger containment is lost.

7.7 Effectiveness of Systems and Procedures to Allow Escape

7.7.1 Coach Lighting
7.7.1.1 FGW's Fleet Manager told the Panel that the electrical system in the train uses batteries located beneath the floor of each coach to provide back-up power for services, such as lighting, if the supply from the power car is lost. However, the system is vulnerable to short circuiting of the cables, which can occur when vehicles come apart or when there is extensive underframe damage, as was the case for a number of the coaches in the accident at Ufton. The system is also vulnerable to the loss of the batteries themselves, which again occurred in a number of the coaches. Lighting was lost in all the coaches as a result of the accident.

7.7.1.2 One of the passengers who was interviewed by the Panel said that the coach lighting went off before the train had come completely to rest. He said that his ability to hold on and hence prevent himself being thrown around the coach was compromised by the very rapid disorientation that occurred as the coach lurched in complete darkness. The Panel was told that some passengers had used their mobile phones in order to give some light.

7.7.2 Emergency Lighting Installations in Other Coaches
7.7.2.1 The Panel was shown the system of emergency lighting that has been installed in vestibules and passenger saloons during a major
refurbishment of Mark IV coaches owned by HSBC Rail and operated by GNER on the East Coast Main Line. The system consists of a number of semi-autonomous units containing power conditioning equipment, a battery and LED light sources. Each unit is charged by means of a connection to the lighting circuit which powers the main ceiling lighting and the LEDs switch on automatically if the power to the lighting circuit goes off. The level of illumination which is provided is fairly low but it is sufficient to allow passengers to avoid disorientation and to be able to identify their escape route. With fully charged batteries, the units will operate for several hours.

7.7.2.2 The Panel was also shown a number of other recent designs of low power consumption emergency lighting systems having similar characteristics.

7.7.3 Safety Information Cards

7.7.3.1 Safety information cards that describe the means of escape from the train are provided by FGW adjacent to seats. Passengers told the Panel that the train staff had made announcements drawing their attention to these cards and urging passengers to read them. More details of the comments made by the passengers in respect of these cards appear in Section 9 of this report.

7.7.4 The Use of Light Sticks

7.7.4.1 FGW installed light sticks in the passenger accommodation of their trains in 2002/2003. They are fitted to the end partitions and the intermediate partitions of the passenger saloons. They consist of two chemicals within a clear flexible polymer tube. One of the chemicals is contained within an inner glass tube, which breaks when the polymer tube is bent, allowing the chemicals to mix, and producing a glow that lasts for several hours. In the FGW application the light sticks are contained in pairs in holders and the action of pulling them out of the holder breaks the inner glass tube. The holder itself is photo-luminescent so that it can easily be located in the dark.

7.7.4.2 A number of passengers told the Panel that they found the light sticks very useful in allowing them to find an escape route from the coaches. More details of the comments made by the passengers in respect of these light sticks appear in Section 9 of this report.

7.7.5 Escape via the Saloon/Vestibule Doors

7.7.5.1 As a result of a recommendation following the Ladbroke Grove accident, the saloon/vestibule sliding doors of HSTs operated by FGW have been fitted with a large removable polycarbonate glazing panel. When this panel is pushed into the vestibule area by a person within the saloon, an aperture is created through which the person can access the vestibule. Thus escape is possible even if the coach is lying on its side and door power has been lost such
that the sliding door cannot be opened automatically and owing to the weight of the door assembly holding it closed, cannot be opened manually. In order to push out the removable panel, it is first necessary to remove an elastomer retaining strip which runs around its periphery and is accessed via a ring pull. A sign on the door leaf indicates to the user how to do this.

7.7.5.2 A saloon/vestibule door assembly is required by Railway Group Standards to withstand a considerable force in normal use. It was not possible to find a design that is compatible with both this requirement and the ability to remove the polycarbonate panel using a level of force which a passenger might reasonably be expected to be capable of exerting. Hence a formal derogation to the standard was sought in order to allow the break-through facility to be installed. It was granted on the basis that the risk reduction from fitting the facility outweighs the increased risk of a person falling or being thrown through it in normal use.

7.7.5.3 By courtesy of HSBC Rail, the operation of the device was demonstrated to the Panel at their vehicle roll-over rig. During the demonstration, the glazing panel was removed without difficulty.

7.7.5.4 During his post-accident inspection of the coaches at Crewe, the Principal Engineer found that two of the saloon/vestibule doors in the train had their retaining strips removed but the polycarbonate panel was fully in place. A further door had its retaining strip removed but the polycarbonate panel was still in the door, though displaced at the bottom. He had noted that none of the push-out panels in the train had been removed by passengers or crew. However the passengers' statements that he examined did not mention any difficulty in removing the glazing panel. One statement described how a passenger had removed the retaining strip but rescuers then arrived in the vestibule and opened the door, rendering it unnecessary for the panel to be pushed out.

7.7.5.5 Most of the passengers interviewed by the Panel who had a need to move into a vestibule from a saloon reported no difficulty in doing so but they were not able to remember whether they had needed to slide the door or whether it was already open. However, one passenger who was in coach E, which was on its side, said that he had not seen the instruction regarding use of the removable panel so was not aware of this facility even though he had looked at the safety information card on his way to London by train. He said that he had attempted to open the door against the force of gravity and had got it half way open, despite the physical difficulty of getting sufficient leverage with the coach on its side, as further described in Section 9 of this report.

7.7.6 Escape via the Windows

7.7.6.1 The passenger, referred to in the preceding paragraph, reported significant problems in breaking windows in order to escape from
coach E. He told the Panel that despite realising the difficulty of escape from a window of a coach which was on its side, he attempted to break the window because he assumed that all other vehicles of the train were still coupled and also on their sides, thus not permitting escape via the gangway. He understood the necessity to use the hammer provided in FGW’s coaches (Appendix G, Fig. 14) and found that the green glow from the photoluminescent materials at the hammer location made them easy to locate. He knew from personal experience of the need to hit the window in the corner and successfully broke the inner pane of glass but broke the hammer in an unsuccessful attempt to break the outer pane. A second hammer broke when he tried in vain to break the inner pane of another window, as further described in Section 9 of this report.

7.7.6.2 The Principal Engineer reported that in his examination of the coaches, he had found a total of three windows where the inner pane of glass had been broken by being hit with a hammer but where the window was still intact such that it could not have been used for emergency egress.

7.7.6.3 During the Panel’s visit to HSBC Rail’s roll-over rig, the coach was rolled to various angles. With the coach rolled onto its side, the Panel was able to experience at first hand the difficulty of reaching up to a window, breaking it, removing the glass and then attempting to climb through the window aperture in order to exit the coach.

7.7.6.4 The Panel also saw a demonstration of a window breaking device which uses spring-loaded chisels impacting the edge of the panes of glass. The chisels are released by the action of a passenger pulling a handle. The device avoids any difficulty associated with the use of a hammer.

7.7.7 Post-Accident Investigation of the Strength of Window Breaking Hammers

7.7.7.1 Interfleet Technology Limited (ITL), on behalf of FGW, carried out post-accident investigations on the strength of the hammers. They tested unused hammers recovered from their storage positions in the coaches involved in the accident and hammers from the stock of spares held by FGW. They concluded that there was no difference in performance between the hammers that had been carried on the coaches and those from stock. There was no indication therefore that the hammers carried on this particular train had abnormal characteristics.

7.7.7.2 Static and dynamic load tests on the hammers were carried out in testing machines. ITL compared the measured dynamic failure loads with existing data on the forces which humans can exert on a metal plate using a fist, elbow or knee and found that in all three cases this force was considerably higher than the measured failure load of the hammer. ITL therefore concluded that the force a
person can exert on a hammer is greater than the force required to break it.

7.7.7.3 ITL also invited a number of volunteers to attempt to break the hammers by repeatedly striking a metal plate. Three out of the ten hammers were broken by the volunteers, although one of the three had been pre-cooled in a freezer and was thus not representative of the condition of a hammer in normal use. From these tests, ITL again concluded that the force that a person can exert on such a hammer can be beyond its breaking strength. They noted that this was the case even in a non-stressful situation. Under severe stress, a person would almost certainly be capable of exerting even higher forces.

7.7.7.4 ITL also noted that the window breaking test results supplied by the hammer manufacturer were on 4mm and 5mm thick panes, whereas those in HSTs have at least one pane that is 6mm thick. The report recommended that FGW review their hammer specification and compare it to the likely applied forces and usage of the hammer in an incident.

7.7.7.5 The Panel is not aware of any national or international standards relating to the strength of hammers for use in railway vehicles.

7.8 Relevant Research

7.8.1 RSSB’s Programme

7.8.1.1 The RSSB is currently managing, on behalf of the UK railway industry, a programme of safety research on vehicle design and operation. This research has to a large degree been prompted by recommendations resulting from recent serious rail accidents at Ladbroke Grove, Hatfield and Great Heck. The aims and achievements of the research were described to the Panel by RSSB specialists in traction and rolling stock and in human factors. Their evidence was supplemented by documentation giving synopses and status reports on the various projects.

7.8.2 Research into Improving Resistance to Derailment following Collision with an Object on the Track

7.8.2.1 RSSB project T189 Optimal Design of Obstacle Deflectors and Lifeguards deals with the effectiveness of obstacle deflectors and lifeguards in minimising the consequences of collisions with an object on the track, particularly at level crossings. The research has concluded that little can be done to improve the effectiveness of the currently specified design of obstacle deflector, given the practical limitations on its size and strength. Work on lifeguards is ongoing. Completion of the project is planned for autumn 2005.

7.8.2.2 RSSB project T305 Behaviour of Trains Hitting Deformable Objects at Level Crossings will be reported in the form of a university thesis.
Its objective is to investigate how best to model a large obstruction, such as a road tanker, in a realistic way such that the effect of its being impacted by a train can be correctly assessed. The results will feed into the work described in project T118 (7.8.3). Completion of the project is planned for summer 2005.

**7.8.3 Research into Whole Train Dynamics**

7.8.3.1 RSSB project T118 *Whole Train Dynamic Behaviour in Collisions and Improving Crashworthiness* aims to establish how energy is absorbed in collisions and by the subsequent behaviour of the train. It will look at requirements for keeping vehicles upright and in line and at the influence of couplers and bogie retention, with the objective of improving crashworthiness without prejudicing vehicle life cycle costs, performance or capacity. Work began in January 2005. Completion of phase 1 of the project, which covers a review of past work, identification of accident scenarios and justification of the phase 2 work is planned for summer 2005. The timescale for phase 2, which covers detailed assessment of vehicle behaviour, studies of the effectiveness of potential improvements etc, depends on what is agreed with stakeholders following phase 1, but is expected to be 18-24 months following phase 1 completion.

**7.8.4 Research into Driving Cab Design**

7.8.4.1 RSSB project T190 *Optimising Driving Cab Design for Driver Protection In a Collision* is looking at the effectiveness of a wide range of design features, such as the provision of a safe cell within which the driver’s survival space is maintained and the provision of seat belts and/or air bags. It has identified potential improvements and the degree of extra protection that they afford but the cost implications have not yet been evaluated. However, at the time of the accident at Ufton, the planned research did not consider measures to prevent the entry of debris into driving cabs. This has now been included. Completion of the project is planned for summer 2005.

**7.8.5 Research into Prevention of Fuel Spillage**

7.8.5.1 RSSB project T120 *Review of Measures to Reduce Risk from Passenger Train Fuel Tanks* is complete. It looked at a number of measures to reduce the risk of fire from the escape of diesel fuel. The location of the tanks in less vulnerable positions and the provision of sacrificial panels to prevent atomisation of fuel were found to be viable for new vehicles but neither of them was found to be viable for retrofitting to existing vehicles.

7.8.5.2 Requirements relating to the positioning of fuel tanks have been included in Railway Group Standard GM/RT2120 Issue 2 April 2004 *Requirements for the Control of Risks Arising from Fires on Railway Vehicles.*
7.8.6 Research into the Effect of Vehicle Interior Design on Harm to Passengers and Staff in Accidents

7.8.6.1 RSSB project T310 Review of Crashworthiness of Rail Vehicles in Recent Accidents aims to improve the understanding of the causes of injury by detailed examination of the circumstances of fourteen recent accidents. It will examine the particular features of each accident in order to establish those that appear to be the major contributors to injuries. Data collection for accidents prior to the Ufton accident is complete but it has been decided to defer the analysis so that data from Ufton can be included. Completion of the project is planned for summer 2005.

7.8.6.2 RSSB project T066 Identification and Quantification of Injuries in Railway Vehicles During Accidents is complete. It identified and categorised injury levels in accidents and used this information to develop a database of injuries in terms of severity and tolerability. It assessed the suitability of current anatomical test devices (ATDs) ie the use of test dummies, for studying injuries in railway accidents. It concluded that current designs cannot assess all of the typical types of injury suffered in railway accidents. It also recommended changes to currently accepted injury criteria and the development of a more suitable ATD.

7.8.6.3 RSSB project T201 Improving the Design of Seats and Tables to Minimise Passenger Injuries builds on the output from T066. An improved ATD is being used as part of a study of the effect on the abdominal loads of seat/table design and of the wearing of a lap type seat belt. The work will then be extended to cover three point seat belts, such as those fitted in cars. Completion of the project is planned for summer 2005.

7.8.6.4 RSSB’s Rolling Stock Specialist told the Panel that there is a particular problem in respect of the use of seat belts in a situation where there is in-line seating and some passengers are wearing seat belts and some are not. With the aid of a diagram (Appendix F, Fig. 10), he explained that the current philosophy in seat design is to make the seat such that it progressively collapses if the passenger is thrown towards it in an accident (Appendix F, Fig. 10a). This reduces the deceleration and hence the force experienced by the passenger as a result of the impact with the seat.

7.8.6.5 He said that if a three-point seat belt is fitted to that seat, it is necessary for the seat to have sufficient strength to withstand the double loading imposed on it by the seat belted passenger and by a passenger seated behind who is not wearing the seat belt. This makes the seat more difficult to design in respect of progressive collapse. Thus there is a conflict between the need to protect the passenger who is wearing a seat belt and to protect the one who is not. He also pointed out that even with such a seat belt there is a
danger of the passenger’s head contacting the seat in front (Appendix F, Fig. 10b), and that with a lap strap alone, the action of being thrown forward can put severe stress on the neck (Appendix F, Fig. 10c).

7.8.6.6 The Rolling Stock Specialist also told the Panel that experience in Finland of service operation of a train in which three vehicles were fitted with seat belts had shown that only about 5% of the passengers had used them.

7.8.7 Research into Human Behaviour and Evacuation Requirements in the Period Immediately following an Accident

7.8.7.1 RSSB project T121 Communications for Effective Passenger Behaviour Immediately Following an Incident examines how passengers currently behave in accidents, what behaviour should be encouraged and what communications equipment and staff training is required to achieve this. It follows on from work on communications technology, which was prompted by a recommendation of the Inquiry into the Ladbroke Grove accident. This work concluded that it was necessary to take a holistic view of the situation that applies after an accident, leading to an understanding of the wide range of factors that need to be taken into account before deciding on the most appropriate communications technology to employ. Completion of the project is planned for summer 2005.

7.8.7.2 RSSB project T122 Human Factors and Injury Information to be Collected During Accident Investigations is complete. It responded to a recommendation of the inquiry into the Ladbroke Grove accident. It looked at best practice in related UK industries and abroad, as well as information from accidents in the UK. The report has been shared with the Rail Accident Investigation Branch. Since the Ufton accident, human factors specialists from Cranfield University have been commissioned to interview passengers. This work will draw on the results of project T122.

7.8.7.3 RSSB project T052 Snap Wands and Low Location Marking Systems for Emergency Lighting on Passenger Vehicles is complete. It looked at the advantages and effectiveness of providing emergency lighting by provision of snap wands (light sticks) or airline style floor level lighting in the vehicle aisle. It found no clear-cut case on a cost/benefit basis for fitting or not fitting snap wands and that floor level lighting may be justified for new vehicles if factors such as passenger perception are taken into account. It also concluded that retrofitting this form of emergency lighting to existing vehicles is not justified on safety grounds alone.

7.8.7.4 RSSB project T314 Requirements for Emergency Lighting on Passenger Rail Vehicles aims at identifying international best practice. It also aims, via workshops with participants from a range of industries, at identifying relevant scenarios and associated
lighting requirements with a view to informing current UK standards and contributing to emerging European standards. The work has concluded that there is no case for mandating emergency lighting on a cost/safety benefit basis. Completion of the project is planned for summer 2005.

7.8.7.5 Three RSSB projects have looked at improvements to the safety signs within passenger vehicles, including signs relating to means of evacuation. These projects are:

(a) T052a Improvements to Safety Signage on Passenger Trains which is complete.

(b) T246 Development of Common Passenger Safety Signs which is complete.

(c) T422 Completing Passenger Train Safety Signage to Improve Legibility and Comprehension which is ongoing. Completion of the project is planned for summer 2005.

7.8.7.6 The development of the signs involves extensive testing to ensure that they are visible to, and understood by, passengers. The work results in a set of safety signs that are suitable for manufacturing from photo-luminescent materials. A process was designed to assist in the development of new signs that are required as a result of the introduction of any new safety related hardware intended for use by passengers. All the completed signs and the development process are readily available to all train operators via ATOC.

7.8.7.7 RSSB project T052c Signage and Illumination of Emergency Door Release Mechanisms in Passenger Vehicles is complete. It looked at how the correct use of this facility could be encouraged. It concluded that passengers’ comprehension of how to operate the release mechanism could be improved by using a mixture of pictograms and text. A set of pictograms was developed. It also concluded that photo-luminescent signs and marking of the release mechanism would provide the best solution for illumination.

7.8.7.8 RSSB project T424 Requirements for Train Windows on Passenger Vehicles will examine, from first principles, the apparently conflicting requirements of containment of the passengers and crew within the vehicle during an accident and the ability to break the window so as to provide a route for post-accident evacuation. The specification for the work is complete and tenders have been invited. By studying accident data, the research will examine the associated balance of risk in order to determine the most appropriate strategy. It will look at the strength of different types of windows designed for containment and as a means of emergency egress. The work will incorporate, if appropriate, the development of performance specifications for window breaking devices, including ‘hammerless’ systems, in situations where emergency egress via windows is required. Project completion is planned for spring 2006.
Two RSSB projects, both of which are complete, have looked at egress via windows or escape hatches. These are:

(a) T052e Windows and Hatches for Emergency Egress from Railway Carriages (7.8.7.10).

(b) T129 Design Study for Emergency Exit on Mk III Vehicle Windows (7.8.7.11).

The first project, T052e, looked at the use of removable windows of the types used abroad. It found that these had some advantages over breakable windows but also some disadvantages. It concluded that the overall risk is not reduced by the use of removable windows when compared with windows requiring a hammer to break them. It suggested further research into ‘hammer-less’ methods of escaping via windows. The project also looked at the provision of escape hatches. It found that whilst there were some circumstances where they could be of benefit, they would introduce a number of additional hazards. It concluded that there was no overall safety benefit to be gained from their use.

The second project, T129, looked at a particular design of sliding plug window that might be applied to HST coaches and concluded that its use was feasible. However it was considered that any proposal to implement such a device should await completion of project T424, the more general study into the role of windows (7.8.7.8).

RSSB project T052b Hammers for Breaking Carriage Windows Prior to Emergency Egress is complete. It reviewed the types of hammer used both in the UK and abroad with the objective of identifying best practice. An associated set of pictograms was developed and it was also recommended that the signing and the marking of the equipment should be photo-luminescent.

Lessons from Previous Accidents

The research work described in Section 7.8 was, to a considerable degree, driven by recommendations made as a result of recent serious accidents. The majority of these recommendations were not specific to a particular type of vehicle. However, there were two which concerned HST coaches in particular and which are relevant here.

Recommendation 53 of the Ladbroke Grove Public Inquiry report states ...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 retrofitting. The Industry Inquiry made a similar recommendation (recommendation 11.3).
7.9.3 The Panel understands that the Industry’s response to the recommendations was to include this specific issue in the remit for research project T118, as described in 7.8.3 of this report.

7.9.4 Recommendation 59 of the Public Inquiry report states, *The enhancement of the security ... of tables in HSTs should be considered, subject to an assessment of feasibility, costs and benefits, with a view to possible retrofitting.* HSE has monitored progress on implementation of this recommendation and their relevant report, *Progress from action holders July 2002* states, the Porterbrook-led study on tables and the design for the enhancement of table security has been completed. *This has already been incorporated in the refurbishment on the Midland Mainline fleet and enhancement to the table security on other vehicles will be incorporated as part of any future refurbishment work on these fleets. Industry regards this recommendation as completed.* The report continues, *HSC accepts that the action taken is adequate and regards the recommendation as completed.* (HSC is the Health and Safety Commission.)

7.9.5 The Panel understands that the enhancement has not been applied to the HSTs operated by FGW, which have not been refurbished since completion of the study led by Porterbrook.

8. The Rescue Operation

8.1 Actions of On-Train Staff

8.1.1 Train Manager A had joined the train at Paddington and estimated that there were between 200 and 220 passengers in the standard class accommodation in coaches A to E inclusive. He was standing in the vestibule at the front end of coach B2 when the derailment occurred. Although there was heavy deceleration and the coach yawed and tilted before coming to rest (Appendix G, Fig. 8), he was unhurt. His first reaction was to take down some light sticks and hand them out to the passengers. He then proceeded to make his way to the rear of the train, via coaches B2, B1 and A in succession. His progress was difficult owing to all three coaches leaning over at various angles. He did what he could to calm and reassure the passengers as he walked back.

8.1.2 On arriving at his office situated at the trailing end of coach A, he collected a set of track circuit operating clips and a hand lamp, donned a high visibility jacket and climbed out of the train through a broken window on the cess side of the track. The coach was leaning at an angle of about 45 degrees towards the cess, consequent upon which he was not able to exit through the door, which was being held shut by ballast. He walked along the cess to the back of the rear power car, where he placed the track circuit operating clips across the rails in the Down Line. At this time, he
observed that passengers were evacuating coach A via a broken window, also on the cess side of the track.

8.1.3 He met Train Manager B who informed him that he had attempted to contact the signaller without success but that he had managed to advise Swindon Control of the accident.

8.1.4 Train Manager A described the arrival of the emergency services and the subsequent movement of the passengers to the local inn that had been established as the reception point. He was contacted by a manager from FGW who eventually transported him to Bristol and thence to his home station in Exeter where he finally booked off duty at 0215 hours on Sunday.

8.1.5 He confirmed that he had been trained in first aid and in the controlled evacuation of passengers from coaches in accident situations. He referred to the realism of the training, including the presence of artificial smoke in the latter case. He said that the locations of the light sticks in the coaches were clearly illuminated in the darkness. He was not aware of any passengers trying to break through the saloon/vestibule doors in the coaches or having difficulty in evacuating the train. He believed that no problems had been caused by falling luggage.

8.1.6 Train Manager B had also joined the train at Paddington and was standing towards the centre of coach G (Appendix G, Fig. 2), facing the rear of the train, at the time of the derailment. He was in the process of working his way forward checking tickets and having completed coach F, he was making his way through coach G towards coach H at the front of the train. He was thrown backwards and sustained bruising. On regaining his feet, he activated the light sticks, leaving them in their housings. He asked the passengers to remain in their seats until the emergency services arrived. There was no evidence of panic. He recollected that there were twelve passengers in coach F and between six and eight passengers in coach G. He was not aware of the number of passengers in coach H. All three coaches contained first class accommodation.

8.1.7 He exited from coach G through an external door and went to a nearby signal post telephone in order to contact the signaller but the telephone was dead owing to lineside cables being damaged during the derailment. He informed Swindon Control of the accident by means of his mobile telephone. According to the Control Log, his call was made at 1821 hrs.

8.1.8 He then spoke to Train Manager A who informed him that he had put down track circuit operating clips to protect the train. He noted that at about this time, the emergency services were beginning to arrive, with the fire brigade being the first that he saw.

8.1.9 Train Manager B assisted the passengers who were gathering on the Up Side of the line and then went to the Down side to give his
help with the evacuation of the passengers from coaches G and H, which was being done under the control of the emergency services. He observed that the passengers of coach F had exited via an external door. When satisfied that he was no longer required, he left the site after first speaking by telephone to his on-call manager and assuring him that he was generally unhurt.

8.1.10 He mentioned that there had been a slight smell of diesel oil but he was not especially concerned as he realised that the fuel did not easily ignite. He confirmed that he had received passenger evacuation and first aid training, which was periodically refreshed. He believed that some passengers had used hammers to break coach windows and was of the view that more hammers should be provided in each coach. In the early stages there had been only minimal lighting at the site of the accident, principally from the street lights of the nearby A4 road. He considered that the light sticks had been very helpful.

8.1.11 Train Manager B also mentioned that on leaving the train, he was initially unsure of the location of the derailment. He said that it would have been helpful had there been a sign at the level crossing clearly displaying its name. He suggested to the Panel that all level crossings should have conspicuous name signs.

8.1.12 At the time of the derailment, the Customer Host was working in the buffet in coach F (Appendix G, Fig. 5), which suffered very severe damage. She either struck, or was struck by, an unknown object and lost consciousness for a short time. She recollected receiving medical attention at the lineside and then having to wait for about one and a half hours before being transported to the hospital in Reading. She also recollected that there was only one passenger in the buffet area when the derailment occurred.

8.1.13 She mentioned that she had been trained in first aid but was waiting to undergo evacuation training. She suggested that all on-train staff should be issued with personal torches.

8.2 Off-Site Care of the Passengers

8.2.1 The Station Manager at Reading, who was the On-Call Manager for FGW, was advised of the accident by telephone at 1840 hrs. Collecting his ‘incident bag’ containing the various items that he would normally need in an emergency, he travelled to the site, arriving there at 2000 hrs. After reporting to the Rail Incident Officer (RIO) in the command vehicle, he first satisfied himself that the passengers at the reception point in the inn were receiving proper care and attention. He then went to the hotel where the passengers were assembling prior to boarding road transport, which was being arranged to convey them home. He estimated that there were already about 100 passengers there on his arrival. Assisted by the
police and an off-duty member of FGW’s staff who had been on the
train, he recorded the home contact details of the passengers. He
ensured that they were directed to the correct coaches and taxis for
their onward journeys and recollected that the last of the
passengers left the hotel at about 2130 hrs.

8.2.2 He was requested by the FGW Control Office to attend the hospital
in Reading in order to assist the passengers as they were released
by the accident and emergency department (A&E). He arrived at
the hospital at about 2200 hrs where he met two other staff from
FGW who had also been directed there to help out with arranging
transport home for the passengers. He confirmed that all the
passengers discharged by A&E were provided with taxis, the last
one departing by no later than 0100 hrs. The hospital transport
department gave him an assurance that they would arrange, in due
course, suitable transport for the few passengers who were
detained. An over-night stay in a hotel in Reading was offered to all
the passengers who were discharged from the hospital but none
took up the offer.

8.2.3 The On-Call Manager said the passenger behaviour was one of
calm at all times and that they were fully understanding of the
situation. He received no complaints. He believed that there was
adequate staff to deal promptly with issues as they arose. He
considered that his training had equipped him well to handle a
major emergency of this nature. Although he had not been
debriefed by a senior manager at the time he appeared before the
Panel, he was confident that there would be a formal debrief in the
near future. He suggested that FGW should include an element
focusing on hospital liaison in future training courses for dealing
with major accidents.

8.2.4 FGW’s Senior Manager responsible for stations confirmed that
arrangements had been made for eight coaches to take many of the
passengers from the local hotel by road to stations at Newbury,
Taunton, Exeter and Swindon. From these points, they were
provided with onward transport to their homes. He said that in
addition to the On-Call Manager, three other FGW managers
attended the hospital in Reading to assist with the care of the
injured passengers.

8.2.5 He described the follow-up actions taken by FGW once the
passengers were home, including the offer to them of counselling
and generally monitoring the return of the property that they had lost
in the accident. FGW had also established a dedicated telephone
line to deal with the passengers’ ensuing queries and concerns, as
well as a specific accident website. He was aware that directors of
FGW attended the accident and assisted with caring for the
passengers. He was firmly of the opinion that FGW’s staff had
performed well as a team, both during the hours of the emergency and in the after-care of the passengers.

8.3 The Emergency Services

8.3.1 From the evidence presented to the Panel, it was clear that the response to the accident of all the emergency services ie fire, ambulance, civil police and BTP, was both rapid and efficient. The details of the numbers of emergency personnel who attended the site together with the response times of the emergency services are shown in Appendix C.

8.3.2 The senior fire officer took overall charge of the rescue operation, supported by the ambulance and police services and also, where appropriate, by staff from FGW and Network Rail. Liaison meetings of the emergency services were held regularly during the rescue operation to ensure that the rescue efforts were being properly co-ordinated and progressing well.

8.3.3 Most of the passengers were quickly evacuated from the train with the assistance of the emergency services staff. The more severely injured passengers were conveyed to the hospital in Reading and a small number with lesser injuries to the hospital in Basingstoke. Of the passengers interviewed by the Panel, those who had been taken to hospital spoke very highly of the care and treatment that they had received. The police assisted with supervising the movement of the ‘walking wounded’ and uninjured passengers to the reception point and helping there with tending to their needs.

8.3.4 The RIO confirmed the efficiency of the response of the emergency services. Network Rail’s senior management, who attended the site, described the work of the emergency services as being excellent.

9. Personal Experiences of Passengers

9.1 The Interview Arrangements

9.1.1 The Panel interviewed eight passengers who were travelling in different parts of the train that had suffered varying degrees of damage during the course of the derailment. In this way, the Panel was able to obtain a broad spectrum of the passengers’ experiences.

9.1.2 Six of the passengers attended the Inquiry in London to give their evidence. The remaining two, a husband and his wife who was too ill to travel, were interviewed in their home. These two passengers are referred to as Passengers 1 and 2.
9.2 Passengers 1 and 2

9.2.1 Passengers 1 and 2 were travelling together in coach H, which came to rest still coupled and in line with the train formation but lying on the ballast on its left hand side (Appendix G, Figs. 2 and 3). Both passengers were sitting on the left hand side, at the rear of the coach and adjacent to a window. Passenger 1 was facing forwards and Passenger 2 was facing backwards, with a table between them. Coach H contained only two other passengers.

9.2.2 Both Passengers 1 and 2 thought that there had been heavy braking of the train some 2 to 3 seconds before what they believed was the impact of the train with the car. They described the juddering of the coach that shortly followed and then being plunged into darkness when the lighting failed. The adjacent window broke and the next recollection of Passenger 2 was that he was lying with his face on the ballast. Passenger 1 had no recollection of the events immediately after the failure of the lighting owing to her loss of consciousness. She was severely injured and was hospitalised, first in Reading and then in Oxford, for a total of almost two weeks following the accident. She has since received further treatment at a hospital nearer to her home.

9.2.3 Passenger 2 believed that Passenger 1 had been thrown forward against the table when the train violently decelerated and then suffered further injuries as a consequence of the window breaking as the coach tilted and its side scraped along the ballast. Passenger 2 suffered relatively minor injuries. He described how the emergency services arrived within what he thought to be about ten minutes after the accident. He recollected that two light sticks were used by another passenger in the coach to assist in the assessment of the injuries. He said that the emergency services were very efficient in firstly stabilising the condition of Passenger 1 and then evacuating her from the train for conveyance to the hospital.

9.2.4 Both passengers praised the Health Service in general and the hospital staff in particular. They were of the view that the follow-up attention by FGW had been good. Most of their belongings had since been returned to them by the BTP.

9.2.5 Passenger 2 said that on previous journeys he had made in FGW’s trains, he had ‘browsed through’ the safety information card that is located near the seats in every coach. Passenger 1 had not read the card.

9.2.6 Passenger 2 commented that seatbelts would not be practical in trains. Passenger 1 thought that she would wear one if they were fitted.
9.3  Passenger 3

9.3.1 Passenger 3 was travelling in the first class section of coach F which was severely damaged in the derailment (Appendix G, Fig. 5). He was an off-duty FGW employee who was sitting facing backwards and travelling with three friends. None of them suffered significant injury. He described the train’s heavy brake application and the subsequent course of the derailment, making particular reference to the ballast breaking the windows around him and his friends. With the main lighting having failed, he used the light sticks to good effect. He went through the saloon/vestibule door and exited the coach by jumping down from the external door onto the ballast. He initially tried to contact the signaller by means of a signal post telephone, which he found was not working owing to lineside cables being damaged during the derailment. On his third attempt, he contacted the telephone operator by dialling 999 on his mobile telephone and was informed that the emergency services were already on their way to the accident site.

9.3.2 Passenger 3 returned to coach F to help other passengers to exit, on completion of which he climbed into coach D to assist with the care of passengers there. With the aid of a light stick, he then led a group of passengers through the field adjoining the railway line to the roadway that passed over the level crossing. He said that during this time, the mood of the passengers was generally good.

9.3.3 He continued to walk with the passengers to the inn which had been established as the initial reception point and where first aid treatment was being administered. From the inn, the passengers were conveyed onwards to a local hotel, which was serving as the final clearing point. Passenger 3 also went to the hotel where he assisted a member of FGW’s on-call staff to take the passengers’ contact details and to organise road transport to take them to their homes.

9.4  Passengers 4 and 5

9.4.1 Passengers 4 and 5 were travelling together and were also in coach F. They were sitting opposite one another with a table between them. Including themselves, they thought that there were seven passengers in the seating section of the coach.

9.4.2 Passenger 4 was a regular traveller on FGW’s trains. He had read the safety information card on previous journeys and was fully aware of its content. Passenger 5 was an occasional traveller and was not conversant with the emergency procedures. They confirmed that on this and previous journeys, safety announcements were normally made via the train’s public address system.
9.4.3 They described the heavy braking of the train, immediately followed by the sound of an impact and the failure of the coach lighting. The window adjacent to their seats broke during the course of the derailment. Passenger 4 was hit on the head by what he thought was either an internal part of the coach or an item falling from a luggage rack. He suggested that the luggage racks would benefit from a design change that would hold articles more firmly in place.

9.4.4 Passenger 4 was concerned that the table where he was sitting had come loose in the derailment, trapping Passenger 5 in his seat. Fortunately, Passenger 5 was quickly freed with the help of Passenger 4.

9.4.5 They explained how they had exited the coach via the door to the vestibule and thence the external door to the ballast. They thought that the light sticks had been effective although they took the view that a form of installed emergency lighting would have been better. They estimated that the elapsed time from the moment of the derailment to their egress from the coach was ten minutes.

9.4.6 They were cared for by the emergency services, which arrived on the site shortly after they left the coach and they were also offered assistance by one of the Train Managers. They were conveyed to the hospital in Reading and following treatment, allowed to go home early the next morning.

9.5 Passenger 6

9.5.1 Passenger 6 was travelling in Coach E (Appendix G, Figs. 3 and 4), which separated from the train and came to rest on the Up Line, lying on its right hand side. He was travelling with his young daughter and her girl friend. They were sitting towards the front of the coach, on the left hand side, with Passenger 6 facing backwards and the two girls sitting opposite him, facing forwards. He and his daughter were both sitting adjacent to the window. There was a table between him and the two girls.

9.5.2 He described the violent shuddering that he associated with heavy braking of the train and spoke of his initial surprise as it was not a sensation that he had experienced before when travelling by train. He heard a bang and the lights in the coach went out, disorientating him. He felt that the coach had derailed and was tracking differently. There was a great deal of noise and sparks and then the coach rolled over onto its right hand side before stopping, leaving him hanging from the table. He was aware of the cries of other passengers and of some beginning to use their mobile telephones as sources of illumination.

9.5.3 He located his daughter and her friend. It was apparent that as the coach rolled onto its side, they had fallen through a window. They had both become trapped between the side of the coach and the
ballast. Sadly, his daughter was dead and her friend was badly injured.

9.5.4 Better lighting was provided shortly by another passenger (Passenger 7), who arrived with light sticks and who stayed with him until professional assistance arrived. The carriage had to be raised with the aid of air bags to secure the release of his daughter and her friend. He estimated that the operation to release his daughter’s friend took between 1½ and 2 hours and that a further hour elapsed before his daughter’s body was removed from the coach. Apart from the light sticks, the only other form of lighting inside the coach was that of a handheld torch.

9.5.5 Passenger 6 remained at the lineside with his daughter’s body until she was taken to a temporary mortuary established in the immediate vicinity of the site. At this time, a member of the BTP was assigned to look after his needs. His daughter’s body was eventually conveyed to the hospital in Reading.

9.5.6 He described the considerable distress caused to him by the length of time that he was left on the site, mostly alone, with his daughter’s body. Whilst expressing his understanding of the difficulties with mounting a major rescue operation, he believed that more attention should have been given to his welfare. He suggested to the Panel that each coach involved in a major accident has its own set of circumstances and each needs to be individually managed accordingly.

9.5.7 He spoke well of the help that he had subsequently been given by the Family Liaison Officer from Thames Valley Police and the support from the Devon and Cornwall Constabulary. He also said that he and his family, who later joined him at the hospital in Reading, had been well cared for by the hospital staff. FGW had also offered counselling to him and his family but he had not availed himself of the service.

9.5.8 On more general points, Passenger 6 said that he had not read the safety information card but he was aware of the safety announcements that had been made over the train’s public address system. Even though the announcements draw the passengers’ attention to the safety emergency card, his personal opinion was that they tend to be dismissive of the information because they do not think that an accident is ever going to happen. He was aware of the availability of light sticks but considered that their location in the coach was not evident when the main lighting failed, although he said that looking for them was not a priority for him at the time. He believed that the provision of effective emergency lighting was very important, as was the installation of seatbelts.

9.5.9 He questioned the non-fitment of laminated glass in the coach windows of FGW’s trains in the knowledge that laminated glass had been fitted in other trains following a previous accident. He was
also of the opinion that RSSB had been slow to conduct research emanating from previous accidents, with particular reference to the safety potential of seat belts.

9.6 Passenger 7

9.6.1 Passenger 7 was also travelling in coach E, in the company of his wife and sister. They were sitting on the left hand side at the rear of the coach. He and his wife were facing backwards and his sister was sitting opposite, facing forwards. There was a table between them. He noted that most of the seats in the coach were occupied.

9.6.2 He had read the safety information card during his journey to London from Exeter earlier in the day but believed the card that he was shown by the Panel differed to the one on the train. He said that the card that he had read made no reference to the facility for removing the glazing panel from the saloon/vestibule door if the door itself could not be opened in the emergency situation. On the other hand, the card had brought to his notice the existence of the light sticks in the coach. He also said that from his personal observations of his fellow passengers, few paid attention to either the cards or the safety information announcements.

9.6.3 He gave a very detailed and graphic account of the behaviour of the coach during the course of the derailment. He said that initially it felt as if the coach had jumped three or four times before starting to roll to the right hand side. He braced himself in his seat and held his wife. When the coach was at an angle of about 45 degrees, the lights went out. The coach then landed on its side and still moving fast, began to yaw. When it came to rest, he was aware of some murmuring but there was no shouting or other evidence of panic. Checking immediately on the condition of his wife and sister, he found that both, like himself, were uninjured. His sister had also managed to hold onto her seat when the coach rolled onto its side. He lowered them both from their now elevated positions onto the lower side of the coach. He then rang the police on 999 and gave them the basic details of the situation as he saw it.

9.6.4 He said the photo-luminescent strips indicating the emergency hammer positions were clearly distinguishable in the darkness. He activated two light sticks but stated they were useful only if held close to an object. He had experience of other light sticks used by the military that were more effective. He noted that other passengers were using their mobile telephones as lighting. He did not observe that any other light sticks were being used in the coach at this time.

9.6.5 His next action was to attempt to break a window on the upper side of the coach. In accordance with the instructions, he hit the window
in the corner and although the inner pane cracked, it did not fall out. He made a second attempt, at which time the hammer broke.

9.6.6 He referred to a smell of fuel in the coach and his suspicion that the coach could be foul of the adjoining line. He believed that there was urgency for the passengers to evacuate the coach. Moving with considerable difficulty towards the front end of the coach, he located a second hammer and two more light sticks. He made a second attempt to break a window at that end with the new hammer. This time the hammer broke on the first blow and the window stayed intact. In the case of both hammers, he recollected that the breakages had occurred in exactly the same place where the head of the hammer met the shaft.

9.6.7 Passenger 7 made an assessment of the injured passengers that he found at this end of the coach, including the two girls who were accompanying Passenger 6. At this stage, he realised that the coach E had parted from the train and that egress could be made through the opening in the end vestibule. Owing to the coach being on its side, he had great difficulty with opening the internal door of the coach, managing to get it only halfway. He was unaware of the pull-tab arrangement that allowed the glazing panel of the door to be pushed out of its frame. By this time, members of the emergency services had appeared outside of the coach and they assisted with opening the door fully and getting most of the passengers out.

9.6.8 He remained in the coach with Passenger 6 and one other passenger, helping to comfort one of the two girls who were trapped under the coach. He realised that the second girl was dead. He stayed there for approximately 1½ hours, waiting for medical attention to be given to the trapped girl. When giving his evidence to the Panel, he was critical of the time that this took. He said that eventually the coach was lifted by the fire brigade with the aid of airbags, which he assisted in positioning from inside the coach.

9.6.9 Whilst in the coach, Passenger 7 referred to the fact that he had found a male passenger who had fallen part way through a broken window and appeared to be dead, which was later confirmed.

9.6.10 The Panel was subsequently advised by the BTP that of the total of five passengers who died in the accident, two were known to have been sitting in coach E with the possibility that two others, who were thrown from the train, were also sitting there.

9.6.11 Passenger 7 finally gave an account of the assistance given to the passengers at the initial reception point in the inn and their subsequent conveyance to the eventual clearing point in a nearby hotel.
9.6.12 In summing up his evidence, he said that he would have expected there to have been more external contact with the passengers whilst they were trapped in the overturned coach. Until medical attention arrived, the sole contact had been with a fireman. He also described the lack of good emergency lighting as being a “massive disadvantage”. He was of the view that there should be visible exit signs in the coach, possibly with luminous directional arrows or strips, when the main lighting failed. He also pointed out that the safety information card related to a vehicle in its upright condition and that there was no reference to bracing for impact. He was concerned by the breakage of the hammers.

9.7 Passenger 8

9.7.1 Passenger 8 was travelling in coach A, which had come to rest still coupled and in line but leaning at an angle of about 45 degrees (Appendix G, Figs.7 and 8). He was seated facing forwards and there was no table in front of him. He said that he had not read the safety information card. He estimated that there were about thirty passengers in the coach and he believed that none had suffered injury as a result of the derailment.

9.7.2 Passenger 8 described the coach apparently “lifting and gently twisting” after the impact and before coming to rest. He had no impression of excessive deceleration forces. In the ensuing darkness, he used his own torch until the light sticks were found. He said that his torch, which emitted a beam, was more effective than a light stick, which simply gave off a glow.

9.7.3 He recollected the Train Manager coming through the coach and a window being broken, either by a passenger using a hammer from within the coach or the emergency services breaking through from outside. After about 15 to 20 minutes from the time of the accident, the passengers started to leave the coach through the broken window. He said that there were some jagged pieces of glass around the edge of the frame, which caused minor cuts to some of the passengers during egress. He thought that it took about 20 minutes to get all the passengers out through the one window. He remembered that the weather was initially dry but later turned to a fairly heavy drizzle.

9.7.4 Passenger 8 finally outlined the activity in the local inn and hotel. In his view, the emergency services had done an excellent job. He also said that the follow-up care by FGW had been both helpful and supportive. He suggested that emergency floor lighting in the coach would have been of considerable benefit in the evacuation process.
10. **The Recovery Operation**

10.1 **Establishment and Operation of the Accident Command Structure**

10.1.1 **On the Site**

10.1.1.1 Network Rail’s Mobile Operations Manager (MOM) for the Reading Area was shortly due to commence his turn of duty when he was advised of the accident at 1832 hrs via his pager. He went immediately to the site, arriving there at 1846 hrs, by which time the emergency services were already in attendance. In consultation with Network Rail’s Control Office in Swindon, he formally took up the role of RIO. At 1901 hrs he checked and received confirmation from the signaller in Reading Signalling Centre that both the Up and Down Lines had been protected. He referred to there being a problem with the railway internal telephones, so he used his mobile telephone for communication.

10.1.1.2 He confirmed that Gold Control was established in the Control Office in Swindon. In his capacity as RIO he said that he operated as Silver Control and that other staff from Network Rail, who were deputed to assist him on the site, were in the role of Bronze Control. He saw his role as being principally one of liaison between Gold Control and the emergency services, which were working under the direction of the fire brigade’s senior officer.

10.1.1.3 He referred to a number of events that occurred during the time that he was on duty. He noted that at 1904 hrs he was asked to raise the half barriers by the fire brigade’s senior officer, that Network Rail’s Incident Command Vehicle arrived on the site at 1930 hrs and that at 2010 hrs the level crossing data logger was removed by an inspector from the HSE. Later during his shift as RIO, he received advice that AEAT’s derailment investigation team was on its way to the site and he said that on its arrival, he fully briefed the team members of the situation. He informed Gold Control of these events but he did not start to record his own log on the site until midnight.

10.1.1.4 The RIO expressed concern that he was not involved with the initial hourly liaison meetings that were held on the site. He believed that Network Rail’s senior management on the site, although not part of the formal accident command structure, had attended the meetings. From his perspective, there was consequently some lack of communication, at least in the early stages of the rescue operation, between the emergency services and the command structure that he represented. He said that he was generally concerned with the considerable number of managers who were on the site and the effect that they had upon the discharge of his duties.
10.1.1.5 He did not become involved with the welfare of the passengers as he believed that this was not part of his role and he was confident that they were being well cared for by the emergency services.

10.1.1.6 He said that he had acted as RIO on five or six previous occasions but none had been of the magnitude of this one. He confirmed that he received refresher training in the duties of the RIO on a biennial basis. He also confirmed that he had received a de-brief of the events of his shift as RIO since returning to normal duties.

10.1.1.7 He left the site at 0830 hrs on Sunday after formally handing over his responsibilities as RIO to his successor.

10.1.1.8 The RIO’s principal assistant was a Signaller Manager, based at Reading, who had also been contacted by the Control Office in Swindon shortly after the accident and asked to attend the site. He arrived there at about the same time as the RIO and adopted the role of Bronze in the accident command structure. Although he had previous experience of acting as a RIO, his certificate of competence for the role had expired in 2003. This however did not restrict him from assuming the duties of Bronze.

10.1.1.9 The Signaller Manager said that he had checked that the railway lines had been protected and that he also checked the two emergency telephones at the level crossing, neither of which was working. He described the general assistance that he rendered by way of escorting visiting personnel to the site, including senior managers of Network Rail and AEAT’s derailment investigation team.

10.1.1.10 He supported the comment made to the Panel by the RIO with regard to the formal accident command structure being circumvented for a few hours during the late Saturday evening. He said that one of Network Rail’s senior managers, who is a director in the company, appeared to personally organise aspects of the recovery operation without recourse to the RIO. Included in these actions was the instruction for a second Incident Command Vehicle to come to the site from Doncaster, which the Signaller Manager believed was unnecessary. In the event, the vehicle was not utilised during the relatively short time that it was on the site. Also, in his view, the particular director had held progress meetings with the senior officers of the fire services and the police, to the exclusion of the RIO. He said that the uncertainty regarding the responsibility for control and communication was resolved when he eventually expressed his concerns to the director.

10.1.1.11 The second RIO on the site was another MOM for the Reading area. After receiving a briefing from the first RIO, he formally took up his duties at 0740 hrs on Sunday. He described the activities on the site and his liaison with the representatives of the HSE, the BTP and FGW. He said that the first road crane arrived at 1000 hrs but there was a delay with its entry onto the site as the police were still
carrying out a ‘fingertip’ search along the track. He said the emergency telephones at the level crossing together with another local railway telephone were not working but considered that this was a result of the damage sustained by the cable troughing during the derailment.

10.1.1.12 He told the Panel that he did not believe that AEAT’s derailment investigation team encountered any problems with carrying out their survey. He confirmed that there were senior managers from both Network Rail and FGW on the site during his turn of duty.

10.1.1.13 He considered that his training as a RIO had satisfactorily equipped him for the task. His last refresher course had been three months earlier. He had not been formally debriefed since the accident and felt that such an exercise would be helpful. In essence he said that he had experienced no problems with discharging the duties of RIO, which he handed over to the next manager to take up the role at 1830 hrs on Sunday.

10.1.2 In the Control Office

10.1.2.1 The Route Senior On-Call Manager was in Bristol at the time he was advised via his pager of the accident and he went to the Control Office in Swindon, arriving there at 2100 hrs. He assumed the role of Gold in the accident command structure and generally dealt with the numerous communications in support of the RIO on the site. He confirmed that he had sought and had received assurance that the Up and Down Lines had been protected. He liaised closely with the parallel command structure established by FGW. He stated that as long as the site was deemed to be concerned with the rescue operation, it was under the control of the emergency services but that the status changed at 0700 hrs on Sunday, approximately twelve hours after the accident, when it became a recovery operation.

10.1.2.2 He was informed by Network Rail’s National Control Centre that a second Incident Command Vehicle had been despatched from Doncaster. He did not think that the RIO had been aware at the time that it had been ordered to the site. After its arrival, he spent some time finding hotel accommodation for the staff that accompanied the vehicle.

10.1.2.3 He confirmed with the Reading Area On-Call Manager that the signaller in the Signalling Centre should be screened for alcohol and drugs. He expressed his concern to the Panel at the subsequent delay that occurred, within Network Rail’s organisation, in advising the test results to the signaller’s manager.

10.1.2.4 He believed that there was a period when there was some confusion regarding the effective functioning of the command structure on the site, although he did not think that it had impacted adversely in any way upon the rescue operation, which was under
the control of the emergency services at the time. Although he was
aware the RIO had been placed in control of the site of a major
accident for the first time, he knew that the Signaller Manager, who
was assisting the RIO, was very experienced and would provide
any support that became necessary. In his capacity as Gold
Control, he had not received training relating to a major accident.

10.2 Attendance on Site of Network Rail’s Senior Management

10.2.1 Network Rail’s Director of Operations and Customer Services told
the Panel that on arrival on the site some two hours after the
accident, his assessment of the situation was that the RIO would
have difficulty in coping with the demands upon him, at least in the
eyear stages of the rescue operation. After making contact with the
RIO, the Director therefore gave his immediate support to the
rescue work, especially in ensuring continuous and close liaison
with the emergency services.

10.2.2 Whilst accepting that there was a risk his involvement could have
created the impression that the RIO’s responsibilities were being
compromised, he told the Panel that he did not believe that this had
been the case. He recollected that the RIO had attended the formal
communications meetings on the site but possibly that he had not
been involved in some informal meetings. He said that he had been
in touch with both Network Rail’s National Control Office and the
Swindon Control Office whilst making his way to the site but once
there, his contacts with Gold Control had been through the RIO.

10.2.3 The Director confirmed that he had ordered the Incident Command
Vehicle to come to the site from Doncaster. Calling upon his
experience on other accident sites, he was aware that it would take
a week to clear the site at Ufton and he believed that a second
vehicle to supplement the facility already there would be helpful. He
was not involved in the decision to return the vehicle to Doncaster
without it being deployed on the site.

10.2.4 He left the site at 0245 hrs on Sunday, returning later in the day to
give his assistance with the preparations for bringing the cranes
onto the site, including the construction of a temporary roadway for
the large capacity crane. He said that progress with the work for
the recovery was not proceeding as quickly as he expected and he
believed that his managerial actions were positive in accelerating
the arrangements. He returned to the site on Monday and again on
Friday of the week following the accident, when he continued to
give his personal support to the recovery operation

10.2.5 Commenting upon the role of the RIO, he said that in terms of
management seniority, the RIO at Ufton was very junior when
compared with the officers in charge of the emergency services. He
believed that this could have made for some difficulties in site
liaison. He was of the opinion that there was a need to upgrade Network Rail’s command structure when a major accident occurs. He affirmed that this is a matter that is receiving current attention within the company, with the seniority and the requirements of the role of the RIO being reconsidered and a concomitant training package being developed.

10.2.6 The Director asserted that the response and organisation of the rescue work of the emergency services were excellent.

10.3 Attendance on Site of AEAT’s Derailment Investigation Team

10.3.1 AEAT’s Principal Derailment Investigator told the Panel that he was in London on the Saturday evening when the derailment occurred. As soon as he became aware of the accident, he contacted Network Rail’s Control Office in Swindon to enquire whether or not the derailment investigation team was required to attend the site. He made the telephone call at 2215 hrs. He was informed that the team was not required and consequently he took no further action.

10.3.2 Two hours later, he was surprised to receive a call from the same Control Office requesting the attendance of the team. He immediately alerted the members of the team who were in Derby, following which he travelled to the accident site, arriving there at 0130 hrs. The other team members arrived with their equipment at 0445 hrs and the work for the investigation, which included a full survey of the track in the area of the level crossing, was commenced. Interspersed with appropriate periods of rest, the team continued to attend the site until the following Tuesday afternoon, when their work was completed.

10.3.3 The Route Senior On-Call Manager, who was acting in the capacity of Gold in the accident command structure, was unable to shed any light on the negative response to the telephone call from the Principal Derailment Investigator. He said that he was contacted at about 2330 hrs by Network Rail’s Route Director, who informed him that a full investigation of the derailment was necessary. He confirmed that he had arranged accordingly.

10.4 Clearance of the Derailed Vehicles

10.4.1 A Supervisor from English, Welsh and Scottish Railway Ltd told the Panel that he arrived on the site within half an hour of the accident occurring. He made his appraisal of the situation and reported to his Regional Engineer, who put into motion the necessary arrangements for heavy lifting equipment and road transport vehicles to attend the site. The lifting of the derailed coaches and power cars was carried out with a crane having a maximum lift capacity of 1,000 tonnes (Appendix G, Fig. 15).
10.4.2 The lifting of the detached bogies was completed with a smaller capacity crane on the Monday following the derailment. Once the jib of the large crane had been erected and the crane made ready for work, the main operation for the lifting of the derailed vehicles and placing them onto road low-loaders commenced on the Tuesday. The lifting operation proceeded smoothly with the last of the derailed vehicles being removed from the site on the Thursday evening. The capacity of the large crane was such that it had to be re-positioned only once during the whole lifting operation, considerably facilitating the recovery work and enabling the site to be cleared of the derailed vehicles in three days.

10.5 Restoration of the Infrastructure

10.5.1 Network Rail’s Track Renewals Manager made his first visit to the site on Wednesday of the week following the derailment, at the time when the derailed vehicles were in the process of being lifted and conveyed away. He made his appraisal of the infrastructure repair and renewal work needing to be done (Appendix D).

10.5.2 He said that the first operation to be completed was the repair of 60 metres of track in the Up Line to allow access to the site for the engineering trains. This work was completed on the day after his site visit. With all the derailed vehicles having been removed from the site, the main operation for the complete renewal of 400 metres of track in the Down Line was able to be started on Friday. The work went well and was completed ahead of schedule by mid-day on Monday of the following week. Train services were resumed on the following day with a speed restriction applying to the newly laid track. The line speed was returned to normal two days later.

10.5.3 He explained that the facing points into the Down Goods Loop and the damaged length of the loop itself were not included in the renewal work but that these facilities would be reinstated at a later date (4.3.10).

10.5.4 The Track Renewals Manager said that the pre-cast concrete units forming the roadway over the level crossing had suffered only minimal damage in the derailment. None needed to be replaced but a few had to be repositioned slightly. There had been cable damage, and repair and renewal work was necessary in respect of treadles and track circuits. He also explained that the ballast had been treated with a bio-degradable chemical during the course of the track renewal work in order to neutralise the spilled diesel fuel.

11. Staff Training, Competence and Fitness for Duty

11.1 All the train crew were experienced staff, having the necessary competencies for their jobs and being fit for duty. Although the
Driver was killed in the accident, the download of the OTMR showed that all his actions for the control of the train during the journey from Paddington to Ufton AHB level crossing were completely normal and strictly in accordance with the requirements and restrictions of the route. The two Train Managers had received the appropriate training for their work, including first aid and emergency evacuation of passengers. The Customer Host had been trained in first aid but was waiting to undergo evacuation training.

11.2 The RIOs were competent, fit for duty and had been trained in the requirements and responsibilities of the post. They had undergone refresher training according to a two yearly cycle. Although experienced in carrying out the duties of a RIO, they had not previously been involved in an accident of the magnitude of Ufton.

11.3 The Signaller responsible for the route on which the accident occurred is subject to continuous assessment of his competence by his Signaller Manager.

11.4 The Signaller was screened for drugs and alcohol in accordance with the standard procedure. The result of the screening was negative.

11.5 The Driver was also tested for drugs and alcohol in the post-mortem examination. The results were negative.

12. Weather and Environment

12.1 The weather was dry at the time of the accident but soon afterwards turned to rain, described by witnesses as being a drizzle varying in intensity from light to heavy. It was referred to as being unpleasant but there was no suggestion that it had hindered the rescue operation.

12.2 The derailment was in a rural situation with open fields on either side of the railway line. The normally busy A4 road ran parallel to the line and just a short distance away. There was direct access from the A4 to the line along the minor road passing over the level crossing. A wide space on the Up side of the line enabled the vehicles of the emergency services to drive from the level crossing almost right up to the derailed train.

12.3 The existence of the local inn proved of considerable advantage in respect of providing the facilities for the initial reception of the passengers, many of whom walked there from the accident site. Minor cuts and bruises were dealt with at the inn. This was complemented by a hotel, a short vehicle ride away, which served as the clearing point for passengers before commencing their journeys home.
12.4 An area of land close to the level crossing and belonging to a garden nursery provided the assembly area for the passengers before they were taken under supervision to the inn. In due course, the space was utilised for the establishment of the accident site control centre, together with refreshment and hygiene services.

13. Factors for Consideration

13.1 Infrastructure and Train

13.1.1 Maintenance Condition

13.1.1.1 The survey undertaken by AEAT following the derailment, together with the record of the most recent run of the Track Recording Vehicle made before the derailment, clearly indicated that the track leading up to the point where the train derailed was in good condition. The track from the point of derailment to the facing points forming the connection into the Down Goods Loop was similarly in good condition and the points were correctly set.

13.1.1.2 The AHB and the signalling equipment were all in good condition and operated correctly for the passage of the train. The emergency telephone functioned in accordance with its design. The pre-cast concrete units forming the roadway over the level crossing were similarly in good condition.

13.1.1.3 There were no problems with the condition of the train that could have influenced the derailment.

13.1.1.4 Taking into account all the evidence, the Panel was satisfied that there was no aspect of the condition of either the infrastructure or the train that contributed to the derailment or to the severity of its consequences.

13.1.2 The Pre-Cast Concrete Road Units

13.1.2.1 The Panel noted the comment of AEAT’s Principal Derailment Investigator to the effect that the disposition of the different types of pre-cast concrete road unit in the four-foot could have had a critical influence on the behaviour of the leading wheelset. He said that the climbing of its right hand wheel onto the road surface at the point where the units reverted to the steel framed design led to the loss of the inherent corrective steering mechanism which might otherwise have re-railed the leading wheelset.

13.1.2.2 The Panel sought the advice of Network Rail on the reason for there being two types of pre-cast concrete units in the level crossing at Ufton. The Panel was informed that the first units to be laid in the UK were in a level crossing near Swindon in 1971. They were of the type in which the concrete was contained in a steel tray, which formed a vertical steel edge to the unit, as was the case with some
of the units at Ufton. Up to this time, the normal form of the road surface over a level crossing was tarmac with check rails.

13.1.2.3 The first installation was successful and the pre-cast concrete unit became the standard for road level crossings throughout the railway system in the UK. There were modifications in the succeeding years, the biggest being the elimination of the steel frame, which was giving rise to track circuiting problems as a result of the accumulation of road debris and winter road salt in the gap between the unit and the rail. The design of the unit was changed to one of polymer concrete, which did not require a frame and was electrically non-conducting.

13.1.2.4 At Ufton, some of the original steel framed units, as they became worn over the years, were replaced with the newer polymer concrete units. This accounted for the mix of units found in the level crossing.

13.1.2.5 The Panel does not consider that the replacement of steel framed units in level crossings should be accelerated beyond that occasioned by normal wear and tear. However it does consider that in circumstances where there is a mix of units and they have to be taken up to enable the track to receive maintenance attention, it would sensible for the units in the four-foot to be re-laid with all the steel framed units at the running-on end. It is appreciated that this re-arrangement of the units may require consequent alterations to the road markings.

13.2 Level Crossing Safety

13.2.1 Risk Assessment – General Considerations

13.2.1.1 It is recognised that level crossings present a unique set of risks to the railway system and to users. Trains, road vehicles, pedestrians and railway personnel share a single space and effective systems are therefore needed to maintain separation and safety.

13.2.1.2 Incidents at level crossings contribute to, or are a precursor to, collisions and derailments, which can result in death and major injury to crossing users, passengers and railway personnel. It is estimated that level crossings account for 23% of the current train accident risk on Network Rail.

13.2.1.3 For as long as level crossings exist, it is not possible to eliminate all risk. It is therefore essential that the railway has an effective system to identify the risks at level crossings and apply suitable risk control measures.

13.2.1.4 Network Rail’s method of assessing risk at AHB level crossings has been built up over time and has been the subject of improvement in the light of new information. The model is a quantitative one and encourages an objective assessment to inform decision-making.
13.2.1.5 The intolerable and broadly acceptable regions set for use currently with the risk assessment model appears to the Panel to be appropriate in the light of present circumstances. The model concentrates possible improvement actions on the risks that are assessed to lie between these regions. The Panel also supports the objective assessment of the safety benefit to be derived from proposed improvement actions and their associated costs as an aid to the decision-making process.

13.2.1.6 The Panel therefore considers that the general methodology adopted by Network Rail to control AHB level crossing risk is appropriate.

13.2.2 Risk Assessment – Ufton

13.2.2.1 The Panel is satisfied that the specific risk assessment carried out for Ufton level crossing in July 2004 was done correctly to the current standards required by Network Rail.

13.2.3 Risk Assessment – Improvements to the Process

13.2.3.1 Although the Panel's view is that the general methodology adopted by Network Rail to control level crossing risk is appropriate, it considers that further improvements should be made to the AHB level crossing risk model so that it is more representative of the railway and its attendant risk.

13.2.3.2 The nature of the railway system in the UK is such that many track and lineside features are encountered along the route. Generally, these present no risk to the safe passage of trains but their presence can become a dangerous consequential factor if a train should become derailed. At Ufton, the facing points changed a simple derailment, in relative terms, into a catastrophic one.

13.2.3.3 It is not practical to eliminate the track and lineside features of the railway in the UK. The best that can be done is to attempt to ensure that collisions and derailments generally are minimised and to mitigate the consequences in the relatively rare instance of a derailment occurring. A number of actions are possible in relation to caring for the safety of passengers and crew in a derailed train and these are dealt with in Section 13.3 of this report.

13.2.3.4 The proximity of the points at Ufton altered the risk presented by the level crossing but the model did not take this into account. The Panel considers that the process should be modified so that the proximity of track and lineside features is included as a factor in the risk model for AHB level crossings. Furthermore, their proximity can increase risk at all level crossings and therefore the Panel is of the view that this should be taken into account when undertaking any level crossing risk assessment.

13.2.3.5 Network Rail's first and preferred option is to close a level crossing. The Panel, however, has a concern that consideration of closure is
not specifically mandated as an option in the risk assessment process. It considers that Network Rail should give a higher priority to seeking closure in pursuit of their stated preferred option.

13.2.4 Collision Risk at AHB Level Crossings – General Considerations

13.2.4.1 The AHB type of level crossing was developed and authorised for use in specific circumstances where the line speed does not exceed 100mph and where the road conditions are suitable. It should be clearly understood that there is a fundamental difference between AHB level crossings and manually operated level crossings with full barriers or gates.

13.2.4.2 The AHB level crossing is designed specifically to minimise delays to road users whilst providing a level of protection to the railway to allow trains to pass over the crossing. There is no protection afforded by the railway signalling system and the signaller has no means of observing the operation of the crossing. Once the level crossing closure sequence has operated correctly, safety at AHB installations depends totally upon the discipline of the road users. The road is closed for the minimum time, typically 30 seconds, which can increase to a minute or two if another train is coming in the opposite direction.

13.2.4.3 It is an essential feature of the design of an AHB level crossing that it is operated automatically by the approach of the train very shortly, just a few seconds, before the train arrives at the crossing. This is specifically to minimise the delay to road users who otherwise might be tempted to ignore the warning lights and zigzag around the barriers. A consequence of this design criterion is that once the train has initiated the crossing sequence, it is not likely that the train driver will be able to avoid a collision even if he can see that the crossing is obstructed. It will also probably be too late for the signaller, even if warned of an obstruction, to take action to stop the train before it reaches the crossing.

13.2.4.4 At a manually operated crossing with full barriers or gates, the railway maintains control over road access to the crossing at all times. When trains are required to pass over the crossing, a signaller operates the barriers or gates to completely fence off the road in sufficient time so that a train travelling at the permitted line speed incurs no delay. When the crossing is seen to be completely closed and free of any obstruction, either by direct observation or by the use of CCTV surveillance, the signaller operates signals to permit the train to pass over the crossing. The road remains totally fenced off to road users until the train is seen to have completely cleared the crossing and then the signaller reopens the crossing to road users. The road is closed for several minutes at a time, typically three to five minutes per train and it can be closed for up to six to ten minutes if another train is coming in the opposite direction.
13.2.4.5 If an AHB level crossing were to be interlocked with the signalling system in an attempt to provide some measure of protection from a collision on the crossing, the road closure time for each operation would be extended from typically 30 seconds to between three and five minutes, or possibly longer. This would be necessary in order to provide adequate time and distance for trains running at the permitted line speed to stop clear of an AHB level crossing if it is obstructed. It would require the provision of signals interlocked with the crossing controls and located at a considerable distance from the crossing. Even if this were implemented, there would still be a significant period of time after a train had passed the protecting signals and before it arrived at the crossing when a road user, frustrated by the significant delay, might attempt to zigzag around the barriers and obstruct the crossing.

13.2.4.6 If the ‘strike-in’ point were to be moved further away from the level crossing, this would allow more time for a slow moving road vehicle to get clear but might again encourage the impatient user to zigzag.

13.2.4.7 Neither of the alterations to the arrangements at an AHB level crossing referred to in the two preceding paragraphs would yield a net safety benefit and they would nullify the aim of minimising the delays to road users.

13.2.4.8 The Panel has considered how the risk to road and rail users at AHB level crossings might be reduced by either reducing the probability of a collision with an obstruction and/or mitigating the consequences by reducing the speed at which a collision might occur. The Panel has taken into account:

(a) That closure is the safest option.
(b) That conversion to fully manually operated crossings with gates or barriers reduces the risk of collision but that conversion is costly and road delays become significant.
(c) That the whole life cost of a bridge may not be significantly greater than that of a conversion.
(d) That in employing the AHB method of level crossing protection and therefore minimising long road delays:
   - The AHB level crossing design philosophy must be fundamentally different from a manually operated crossing.
   - The train is unlikely to be able to stop after the automatic closure sequence has been initiated and that the closure sequence must start irrespective of whether the crossing is occupied at that moment.
   - A means of escape for road users must be provided and that this inevitably provides a means for irregular entry at any time.
- Moving the ‘strike-in’ point to provide more warning time is likely to make matters worse by inconveniencing road users and encouraging the impatient to zigzag, although it does give more time for a stalled or slow vehicle to clear the crossing.

- However distant from the crossing the ‘strike-in’ point is moved to provide for more warning time, there remains the potential for the crossing to become obstructed at any moment up to the time the train arrives.

- Interlocking the crossing controls with the signalling system has the same effect as moving the ‘strike-in’ point and that mixing the design philosophies of the AHB level crossing and the manually operated crossing will make matters worse.

- There is a role for improvements to the warning lights and for predictor technology, median strips and enforcement cameras.

- There will always be the opportunity for wilful acts of obstruction.

- Reductions in line speed would mitigate the consequences of collisions but would impact upon the line capacity.

- Obstacle detectors could reduce the collision speed but research is required to establish a practical system and to balance the risk of collision against the probability of false alarms.

13.2.5 Complete Abolition of AHB Level Crossings

13.2.5.1 Although the consequences of striking the car were in this case very severe, few accidents of this magnitude have occurred at AHBs. In the last 40 years’ history of the automatic level crossing in the UK, there have been only two accidents of similar severity on AHB level crossings, or on crossings operating on a similar principle. These were at Hixon and Lockington. Eighteen years passed between the Hixon and Lockington accidents and another 18 years passed between Lockington and Ufton. This type of accident leading to major injuries and fatalities of train passengers is therefore very rare, although collisions resulting in major injury and fatalities to road users are more common.

13.2.5.2 The Panel considers that the policy adopted by Network Rail, of case by case risk assessment taking into account the risk to all users and using cost/benefit analysis to assess potential safety improvements, is an appropriate way of determining required actions at individual AHBs. It does not consider that the events at Ufton justify their complete abolition.
13.2.5.3 It should be noted that even if all AHB level crossings were to be abolished, in a situation where a person chooses to undertake the deliberate act of placing a vehicle on a crossing in the path of a train, there are opportunities at over 4,000 user worked crossings where this can be done.

13.2.6 Closure of AHB Level Crossings by Extinguishing Rights of Way

13.2.6.1 Network Rail’s stated policy in reducing the risks associated with level crossings, and its preferred first option in support of this policy, is closure. Network Rail maintains a list of level crossings where opportunities exist for closure. Ufton was not on the list at the time of the accident.

13.2.6.2 The Panel considers that this list should continue to be kept under regular and frequent review, at least annually, as part of the annual risk assessment for automatic crossings. Previous experience of progressing level crossing closures indicates that the closure procedure may be both difficult and protracted and the legislation is complex. The expertise to implement crossing closure proposals successfully is hard won and easily lost. The Panel considers therefore that Network Rail should create a dedicated team of management and engineering personnel to provide a single focal point in order to ensure that Network Rail’s policy on level crossing closure is translated into practical implementation.

13.2.6.3 In the specific case of Ufton, the level crossing is on a minor road where road traffic is light. A suitable alternative access via Tyle Mill to the A4 from Ufton Nervet exists within a reasonable distance. The Panel therefore considers that Ufton is a possible candidate for closure and potential ways of achieving that end should be investigated in support of Network Rail’s level crossing policy. The map of the locality in Appendix L illustrates the alternative road route.

13.2.7 Closure of AHB Level Crossings by other Means

13.2.7.1 Where extinguishing the right of way is not feasible, alternative solutions to upgrading the level crossing, for example by the provision of a bridge, should be considered.

13.2.7.2 Decisions on the adoption or otherwise of safety initiatives examined as part of the risk assessment process depend in part on their associated implementation cost. Network Rail informed the Panel that a CCTV supervised manually operated level crossing, often regarded as an appropriate conversion of an AHB level crossing, typically costs £1m or more. The Panel understands that the road over the railway bridge provided in 2002 to allow the abolition of Hixon AHB level crossing cost approximately £1.6m, excluding the purchase price of the land.
13.2.7.3 The Panel notes that the estimated comparative costs of these two options are not significantly different. A further consideration is that whilst a level crossing continues to exist, there are relatively frequent ongoing maintenance and renewal costs in comparison to those for a bridge. Moreover, a bridge avoids delays to road traffic.

13.2.7.4 It appears to the Panel that the elimination of an AHB level crossing by the provision of a bridge, as opposed to converting to a CCTV supervised manually operated crossing with full barriers, should merit greater consideration as part of the assessment of the action to be taken where considerable expenditure is justified by safety considerations. The Panel acknowledges that the provision of bridges in place of level crossings requires the active co-operation of the relevant road and planning authorities and other parties but nevertheless considers that such opportunities should be vigorously pursued.

13.2.8 Moving the 'Strike-In' Point and/or Interlocking with Signals

13.2.8.1 It has been suggested that the 'strike-in' point should be moved further away from the crossing to provide for a longer warning time and/or that the crossing controls should be interlocked with the railway signalling system. Both of these actions would nullify the purpose of the AHB and are likely to encourage disregard of the road warning lights and zigzagging. They are not supported by the Panel.

13.2.9 Elimination of AHB Level Crossings on High Speed Lines

13.2.9.1 A collision at a level crossing, at any speed, has the potential to derail a train. The lower the collision speed, the lower the consequences are likely to be, although some risk of a serious accident will always remain.

13.2.9.2 No level crossings of any type are permitted on lines where the line speed exceeds 125mph. AHB level crossings are permitted by HSE Railway Safety Principles and Guidance only on lines where the speed does not exceed 100mph.

13.2.9.3 If all the AHB level crossings on 100mph lines were to be closed or converted, this would remove 31 of the 458 AHB crossings that existed at the time of the accident. If AHB level crossings on lines at, for example, 70mph and above were not permitted, this would mean that 281 of the 458 AHB level crossings would have to be closed or converted. If a lower limit of, for example, 30mph (48km/h) were to be adopted, this would mean that 441 of the existing 458 AHB level crossings would have to be closed or converted.

13.2.9.4 Major train accidents at AHB level crossings are very rare and some risk would remain, particularly for road users, even if the permitted speed were to be as low as 30mph. Moreover, the figures in the preceding paragraph indicate that in order to obtain a significant
reduction in overall risk by confining AHB level crossings to lower speed lines, the number requiring to be closed or converted to manually operated crossings, and hence the associated cost, would be very high. The Panel therefore does not consider that there should be any change in the current HSE requirements governing the line speed up to which AHB level crossings may be provided.

13.2.10 Imposition of Line Speed Restrictions

13.2.10.1 An alternative to abolition or conversion of these AHB level crossings would be the imposition of local line speed restrictions for all trains traversing the crossings to, for example, either the 70mph or 30mph limit discussed above. Such speed restrictions would have a significant impact on the availability of train paths and timekeeping and it would be necessary to amend the train timetables. At a time when use of the UK rail network is at its highest level for 50 years and still rising, it is not in the interests of rail passengers to implement actions that would reduce the capacity of the network and cause users to transfer to road. Line speed reductions are not therefore supported by the Panel.

13.2.11 Obstacle Detection at AHB Level Crossings

13.2.11.1 The Level Crossing Engineer said that it would be feasible to provide a suitable form of obstacle detector to provide warning of an obstruction on an AHB level crossing. The proponents of this idea envisage that if an obstacle were to be detected, then the signalling system or another parallel system could be used to stop the train before it enters the crossing. Unfortunately, because the crossing can be obstructed at any time up to the arrival of the train, the best that can be achieved with the use of obstacle detectors, whilst maintaining the aim to minimise delays to road users, is a reduction in the train speed at a potential collision.

13.2.11.2 Any form of obstacle detector device, if introduced, must be highly reliable in its ability to detect obstacles and must not cause false detections. This would include the detection of a vehicle legitimately traversing the crossing just as the crossing closing sequence is initiated. As a consequence of such a false detection, trains would be subjected to unnecessary emergency braking action and stress would be caused to the train driver.

13.2.11.3 Further research work is required to establish if a reliable form of obstacle detector can be incorporated into a safe and practical warning system for use at AHB level crossings on Network Rail. This research is supported by the Panel.

13.2.12 Emergency Telephone

13.2.12.1 The PETS was described in Section 6.6. It connects with the signaller at a continuously staffed monitoring point. It provides the facility for contact to be made with the signaller by members of the public needing to warn of an emergency situation that may have
arisen on the crossing, for persons wishing to use the crossing with animals and for the drivers of slow moving vehicles with exceptionally long loads that may not be able to traverse the crossing within the normal warning time. On receipt of such advice, the signaller, if traffic conditions permit, operates signals on the approach to an AHB level crossing in order to stop trains.

13.2.12.2 At Ufton, despite the best endeavours of the policeman who witnessed the accident to prevent the collision by quickly going to the emergency telephone to give warning of the car on the crossing, it was too late for the signaller to be able to do anything to stop the train. There was nothing more the policeman could or should have done to try and prevent the accident. Neither the train driver, nor the signaller at Reading Signalling Centre, even if the emergency call had got through to him, could have taken any effective action to prevent the accident in the time that was available.

13.2.12.3 The policeman was not aware that after lifting the telephone handset, it was necessary to press the illuminated call button before he could be connected to the signaller. Nor in the urgency of the moment did he see the illuminated instruction informing users of the correct procedure to be followed to call the signaller. In the event, the telephone design feature that causes the illumination of the user instruction label to be dimmed when the handset is lifted meant that it was almost impossible in the dark to read the instruction label, once the telephone handset has been lifted.

13.2.12.4 The Panel considers that action is necessary to prevent a recurrence of this problem. The system operation and design should be reviewed in a holistic manner, taking into account human factors, environmental and technical issues in order to determine the most appropriate approach, and the system should be modified accordingly.

13.2.13 Other Design Improvements at AHB Level Crossings

13.2.13.1 The AHB level crossing has been proved over many years and in various countries to be an effective means of managing the road/rail interface. It is especially suited to localities typified by Ufton where the environment is rural and the road traffic is relatively light. The arrangement has also been proved to be safe, providing that road users obey the road traffic rules and that no one uses the crossing with deliberate intent to cause a collision.

13.2.13.2 The previous fatal accidents at automatic crossings at Hixon and Lockington resulted in a number of improvements in the design and layout of the crossing equipment to make the AHB level crossing plainly visible and capable of reliable and correct use by the road user.

13.2.13.3 It is a fact that the vast majority of level crossing incidents and accidents are caused by the wilful actions or errors of road users.
In the case of AHB level crossings, common abuse by road users involves ignoring the warning lights and hoping to ‘beat’ the barriers across the crossing or zigzagging around the barriers hoping to ‘beat’ the train before it gets to the crossing. Both actions are fraught with danger.

13.2.13.4 Although the AHB level crossing with its red flashing warning lights and the customary road signs warning of a crossing ahead has been in existence for over 40 years and is therefore no longer a rarity, some road users either do not see the flashing lights or approach the crossing at too high a speed and fail to stop at the stop line. Design improvements are being directed at eradicating both of these behaviours.

13.2.13.5 Consideration is also being given to improvements that will attempt to overcome the wilful disregard of the red warning lights. These include the employment of predictor technology in order to introduce constant warning times so that all trains arrive at the crossing in the same time cycle as well as yellow box road markings and red light violation cameras, which will enable legal enforcement action. Trials will be conducted with median strips in order to enforce lane discipline and discourage zigzagging.

13.2.13.6 Improvements are also either in hand or proposed to make the flashing red warning lights and the red lights on the barriers booms brighter and more arresting to the eye.

13.2.13.7 Other improvements are directed at increasing the reliability of the operation of the barrier machines themselves, in this case principally to avoid the delays and costs caused to the railway if the barriers should fail.

13.2.13.8 The Panel fully endorses all of these actions.

13.2.14 Level Crossing Name Display

13.2.14.1 One Train Manager referred to the fact that he was not aware of the exact locality of the accident and felt that it would be helpful if the name of the level crossing had been prominently displayed.

13.2.14.2 It was a recommendation following the Hixon accident that AHB level crossings should have the crossing name displayed at the crossing. Unfortunately there was no uniform standard mandated by BR and the former Regions therefore adopted practices that varied and suited their existing traditions. In the case of the former Western Region, the AHB level crossing name can usually be found stencilled in black on the barrier machine cases each side of the crossing. This is how the name is displayed at Ufton. Other Regions adopted a policy of attaching a nameplate to each barrier pedestal. Despite the Regional variations, the Panel considers the existing situation to be acceptable.
13.2.15  Level Crossing Research and the Role of NLXSG

13.2.15.1 The Panel has learned of the substantial amount of research work currently being undertaken or proposed into level crossing safety and also of the work of the NLXSG. A further recent development has been the creation of a working party of NLXSG specifically to carry out a review of level crossing safety. The Panel welcomes this initiative.

13.2.15.2 The following aspects will be examined by the working party:

(a) Level crossing legislation
(b) HSE Railway Safety Principles and Guidance, Part 2  
   Section E, Guidance on Level Crossings
(c) Level crossing risk
(d) Land use
(e) Driving tests
(f) Closure of crossings
(g) Review of previous level crossing studies

13.2.15.3 The working party is seeking commitment for the active involvement in this work from interested parties including the Department for Transport, the HSE, the Police and representatives of the road authorities as well as the relevant railway authorities. The Panel regards this involvement as most important since level crossing risk and accidents at level crossings are not solely a matter for the railway. It should be a joint responsibility of the road and rail authorities with the active involvement and co-operation of all relevant parties, together with a willingness to seek and fund solutions to the problems of the road/rail interface.

13.2.15.4 A similar issue was raised in the formal inquiry into the accident at Great Heck on 28 February 2001. Recommendation 16.2.1 of the report suggested that the then Railtrack, the Highways Agency and local road authorities should develop processes to ensure appropriate participation in the assessment of mutual safety risks and sharing of results. The Panel understands from RSSB that a study of such processes has been completed and evidence is emerging of a more co-operative approach.

13.2.15.5 This type of co-operative approach is required if the public, as represented by both the road user and the rail passenger, are to be provided with safe and cost effective solutions for the prevention of accidents at level crossings. It is the Panel’s view that Network Rail is best placed to take the lead role for ensuring co-ordinated action to address level crossing risk.
13.3 Train Behaviour

13.3.1 The Mechanism of the Derailment and the Influence of Leading Vehicle Front End Design

13.3.1.1 There is strong evidence to suggest that the mechanism of initial derailment was the trapping of a component of the motor car beneath the leading axle gear case and/or traction motor and consequent relief of wheel load, leading to flange climb at the left hand wheel. The exact nature of the car component could not be definitively established but AEAT’s Team Leader concluded that it was likely to be the engine block.

13.3.1.2 The Team Leader’s view was that the shape of the power car nose led to the car being pushed downward and that a forward mounted obstacle deflector to current design requirements would have substantially reduced the likelihood of derailment. However, current Railway Group Standards do not require obstacle deflectors to be fitted to vehicles, like HST power cars, that have axleloads greater than 17 tonnes.

13.3.1.3 The Panel is not aware of any previous derailments of such vehicles where it has been concluded that an obstacle deflector would have been likely to prevent that derailment. Nevertheless the Ufton accident demonstrated that a high axleload is not a defence against derailment if a sufficiently large and robust object becomes trapped beneath an axle assembly.

13.3.1.4 The Panel considers therefore that the exemption from the requirement to fit obstacle deflectors to new-build leading vehicles, which applies when the axleload is more than 17 tonnes, should be reviewed. In respect of HST power cars, the Panel is aware that the practicability of the retrofitting of any item of equipment required to carry substantial loads will depend on the design of the existing structure. It is also aware that the residual life of the vehicles still in service may be limited, even though no replacement is currently on order.

13.3.1.5 Nevertheless, the Panel considers it appropriate to examine what can be done in order to improve the resistance to derailment of HST power cars following a collision of this kind. This should include consideration of the practicality of fitting an obstacle deflector and/or of modifying the front end shape so as to reduce the tendency to push an object downwards, thereby reducing the probability that it will pass beneath the leading bogie rather than being swept aside. The Panel considers that such improvements, if practical, should be incorporated into all power cars undergoing refurbishment as part of a life extension programme.

13.3.2 Coupler Behaviour

13.3.2.1 A number of couplers were subjected to very high forces as a result of the movements of the vehicle bodies. The Panel is satisfied that
the failures of the couplers were the result of the forces being beyond their designed load capacity rather than any defect in their manufacture. Parting of couplers was also a feature of the Hatfield accident of 17 October 2000 and led to a recommendation (Recommendation 9.1) that the coupler strength criteria should be reviewed.

13.3.2.2 At Ufton, there were a number of cases where, although the vehicles remained coupled, considerable roll angles developed between them. The ‘Alliance’ type of coupler offers little resistance to relative roll of vehicles and the Team Leader considered that although there are practicable limits to the forces and moments which couplers can resist, an alternative design of coupler might have helped to keep the train in line.

13.3.2.3 RSSB research project T118 specifically addresses the role of couplers in keeping vehicles upright and in line and evidence from the Ufton accident is being fed into that research. The Panel considers it appropriate to await the outcome of that work before any judgement is made as to whether action should be taken to improve the effectiveness of HST couplers, or to amend the requirements relating to couplers in general. However, it is concerned at the length of the timescale for the completion of the work.

13.3.3 Bogie Retention

13.3.3.1 The Team Leader’s view was that whilst the accident would have been less serious if the coach bogies had been retained, the longitudinal forces generated as the bogies dug into the ballast were beyond what the body to bogie connection could sustain. This would have exceeded the levels specified in current standards.

13.3.3.2 The generation of high longitudinal forces as a result of the bogies digging into the ballast was also a feature of the Hatfield accident. The inquiry recommended (Recommendation 9.4) a review of the body to bogie connection design loads specified in the standards and if appropriate, retrospective modification of vehicles.

13.3.3.3 The Team Leader considered that the lack of vertical restraint between the coach bodies and their bogies was not a significant factor in the bogies becoming detached at Ufton. However, the severe damage to coach F illustrated how dangerous loose bogies can be. The industry inquiry into the Ladbroke Grove accident of 5 October 1999 recommended (Recommendation 11.3) that the net safety benefit and reasonable practicability of fitting bogie retention devices to Mk3 coaches, which include HST coaches, should be investigated. This was prompted by a view that the extent of derailment and roll over of the leading HST vehicles at Ladbroke Grove would have been reduced if the bogies of the leading four HST vehicles had not become detached. The subsequent public inquiry made a similar recommendation (Recommendation 53).
13.3.3.4 The response of the railway industry to these recommendations has been to address these issues in RSSB project T118, which, in addition to the subject of couplers discussed in Section 13.3.2 of this report, is examining the role of bogie retention in whole train dynamic behaviour in collisions. The Panel considers it appropriate to await the outcome of that work before any judgement is made as to whether action should be taken to improve bogie retention arrangements on HST coaches or to amend the requirements relating to bogie retention in general. However, it is concerned at the length of the timescale for the completion of the work.

13.3.4 The Structural Performance of the Coach Bodies

13.3.4.1 The Panel considers that the Team Leader’s reconstruction of the course of events following the arrival of the leading power car at the facing points is plausible but notes his caution in saying that the scenario is no more than the probable course of events, given the destruction of the track and consequent lack of detailed evidence. Nevertheless it is clear that the severe damage to coaches F and D resulted from contact with loose bogies.

13.3.4.2 The Team Leader’s view was that the lateral and/or vertical forces imparted to the structure of coaches F and D, which were applied towards the centre of the coaches, were beyond what a rail vehicle body could be expected to survive. He concluded that corrosion was not a significant factor in the behaviour of coach F. One of the recommendations (Recommendation 9.5) of the Inquiry into the Hatfield accident was to give consideration to increasing the strength of coach roofs but to implement this only if it could be demonstrated to be cost effective. The Panel understands that this issue is being addressed as part of RSSB project T118.

13.3.4.3 The Team Leader also concluded that it is impractical to retain underframe equipment in circumstances where bogies become embedded and the body/bogie connection fails.

13.3.4.4 Apart from coaches F and D, the body shells of the coaches remained substantially intact, although there was some localised deformation of body sides and in one case, of the coach floor. As has been the case on a number of other occasions, the accident demonstrated the robustness of HST coaches. Coaches H and E rolled onto their sides without compromising interior survival space. There was no significant distortion of the vehicle ends, although the Team Leader commented that despite the severity of the accident, the compressive loads that were generated were insufficient to have activated crumple zones in the coaches, had they been so equipped.

13.3.4.5 Given the view that the damage to coaches F and D and the loss of underframe equipment were unavoidable, the Panel does not consider that the performance of the coach structures, other than in respect of windows and bogie retention, raises any new issues to
be considered as part of vehicle design or any reasons for modifying the structure of HST coaches.

13.3.5 Cab Design for Driver Protection

13.3.5.1 Fatalities resulting from ingress of large amounts of ballast and debris into a driving cab are rare. However the Ufton accident was the second such instance within a short period, a similar fatality having occurred in the accident at Great Heck on 28 February 2001, although in that case the ingress was via a windscreen. It is not clear what forces were exerted on the door pillar as the power car fell onto its side at Ufton but it is likely that if the door had remained closed, the Driver would have survived, as the structure of the cab remained substantially intact. The Panel understands that since the accident the scope of the current RSSB-led research into driving cab design has been extended to cover the question of how best to secure the cab doors in the closed position in such circumstances.

13.3.6 Fuel Tank Design and Location

13.3.6.1 There was extensive spillage of fuel in the accident but this occurred sufficiently slowly to prevent atomisation and the consequent risk of fire. The research led by RSSB has pointed to precautionary measures, which should be taken for new vehicles but has found no justification for retrofitting to existing vehicles. The Panel considers that there is no reason to alter that conclusion as a result of the Ufton accident.

13.3.7 The Design of Seats and Tables

13.3.7.1 AEAT’s Principal Engineer concluded that the damage to seats and tables was the result of their being impacted by passengers or of structural intrusion and that none had come adrift as a direct result of the deceleration of the coaches.

13.3.7.2 When subjected to impact loading from passengers, there were a number of aspects of the seat behaviour which were unsatisfactory and which could have increased the degree of passenger injury as compared with a seat designed in accordance with current best practice. The behaviour of many of the table fixings was also unsatisfactory in the respect that although the tearing out of the fixings might cushion the impact felt by a passenger, it is not desirable that the tables should come loose in an accident and become potentially dangerous missiles. The exposure of the protruding metal brackets also increased the risk of injury to the passengers.

13.3.7.3 RSSB project T201, which is using the improved ATD as part of a study to look at the effect of seat and table design on abdominal injuries, is still in progress. The Panel understands that data from the Ufton accident is being fed into this work. In view of this ongoing research, the Panel considers it would be premature to make any judgement now as to whether action should be taken to
improve the performance of HST seats or to amend the requirements relating to seats and tables in general. However, the accident again demonstrated, as at Ladbroke Grove, the problems associated with table security in HSTs. The Panel therefore endorses the decision, arising out of the Ladbroke Grove recommendation, to incorporate enhanced table security as part of any refurbishment work on HSTs.

13.3.8 Retention of Passengers in Their Seats During an Accident

13.3.8.1 The Panel considers that if there had been an effective arrangement for restraining passengers in their seats, the fatalities resulting from ejection or partial ejection of seated passengers through the toughened glass windows would have been avoided, although the risk of injury to the arms and upper body of passengers sitting next to a window would have remained. The evidence of passengers indicated that in a situation where a vehicle rolls onto its side or rolls over completely, the containment provided by the seat/table is not sufficient to enable all passengers to remain in their seats.

13.3.8.2 Section 6.4 of ATOC Standard AV/ST 9001 Vehicle Interior Crashworthiness requires that, seats shall be fitted with armrests wherever possible to resist lateral movements of the occupants. This requirement was not in force at the time HST seats were designed, and the Panel considers that it would be very difficult to design a seat capable of holding passengers when a vehicle rolls onto its side. Effective longitudinal restraint of passengers in their seats would have prevented them being thrown forward against seats, tables or other internal fittings liable to cause injury, or against other passengers.

13.3.8.3 The Panel heard evidence regarding the potential fitting of seat belts. It is satisfied that, if worn, they would almost certainly have provided the necessary restraint to prevent ejection through windows. However, in the exercise carried out in Finland, the percentage usage of seat belts in service operation was very low. The Panel was also advised that in a collision there are disadvantages associated with the use of seat belts with in-line seating. These arise from the difficulty of preventing the wearer’s head from contacting the seat in front and from the need to safeguard passengers choosing not to wear a seat belt in an environment where their use is not compulsory.

13.3.8.4 There is also the further consideration of whether, in a case where there is significant structural intrusion, it is desirable that passengers are secured in their seats and thus cannot be thrown clear of the area where there is loss of survival space.

13.3.8.5 In a situation where passengers sit face to face across a table, there is a clear advantage in preventing one passenger being projected into another. Seat belts could be beneficial in this...
respect, although a table that is able to cushion impact loading may
be an alternative means of arresting the motion of the forward
facing passenger.

13.3.8.6 The issue of whether it is appropriate to fit seat belts in trains is a
complex one, involving not only the mechanics of how the human
body can best be protected in an accident but also issues of public
perception of danger and personal preference, which will influence
the percentage usage of seat belts if they are fitted. The Panel
notes that there may be a safety disbenefit in a situation where
seats are designed to withstand the loadings imposed by seat belts
but where the belts are little used and also in a situation where a
seat belt is worn and there is significant structural intrusion.

13.3.8.7 The Panel notes the current research work, which uses an ATD to
determine how abdominal loads are influenced by seat/table design
and by the use of seat belts. It understands that the outcome of this
work will be combined with data on all causes of injury in recent
accidents. This information will be used to look at whether the
provision of seat belts could be a beneficial element of an integrated
internal design concept, including consideration of the use of
laminated glass, which minimises the overall risk to passengers. If
the provision of seat belts is shown to offer such a benefit, the
percentage usage that would be required in order to realise it will be
determined.

13.3.8.8 If when taking into account the cost of the fitting and maintenance,
the analysis shows a worthwhile benefit at a percentage usage of
seat belts that appears attainable, the Panel considers that the
research should be followed up by an in-service trial. The objective
of the trial would be to determine whether the level of long-term
usage necessary to justify the provision of seat belts could be
sustained.

13.3.8.9 The Panel takes the view that this information should be used in
conjunction with an examination of associated issues, such as
enforcement and the action to be taken in respect of standing
passengers, so as to determine whether the fitting of seat belts is
reasonably practicable.

13.3.9 Safety Information

13.3.9.1 The Panel considers that a common design for safety information
signs on all trains is desirable and commends the development and
availability to all train operators of a fully tested set of photo-
luminescent standard signs.

13.3.9.2 Photo-luminescent marking of the emergency hammer positions
helped passengers to locate them in the dark. Research led by
RSSB has pointed to the value of photo-luminescent marking in
assisting passengers to locate emergency hammers and
emergency door release mechanisms. The Panel considers that
there should be a general requirement for photo-luminescent marking to be applied to emergency equipment as a complement to the use of photo-luminescent signs.

13.3.9.3 The safety information cards provided at seats by FGW were of value to those passengers who had read them prior to the accident, although not all had done so. Such safety information cards are more likely to be read by passengers than similar information posted in the vestibules, as is the practice with some train operators. The Panel takes the view that train operators should provide safety information that passengers can read at their seats where this is practicable, recognising that this may not always be the case, as for example, on the commuter railway.

13.3.9.4 The Panel notes that the safety information cards provided on the train were not up to date in respect of the facility for removing the glazing panel from the saloon/vestibule door in the emergency situation. However, it has been reassured by FGW that the cards on all of their HSTs have since been brought up to date.

13.3.10 Emergency Lighting

13.3.10.1 A number of witnesses said that the absence of lighting in the vehicles accentuated the problems which they faced in a situation where they were experiencing considerable distress and disorientation following the derailment. The light sticks alleviated this to some degree and the Panel considers that they should be provided wherever emergency lighting is not available, even though RSSB project T052 did not indicate a clear case for mandating their use. The Panel understands that whilst light sticks more powerful than those used by FGW are commercially available, there is a trade-off between the brightness and the duration of the illumination which light sticks provide. The Panel was advised that FGW took these factors into account when choosing the type of light stick to be fitted in their trains.

13.3.10.2 Recent advances in technology now allow the fitting of compact and robust emergency lighting units which charge from the normal lighting circuits, have their own batteries and can be arranged to illuminate whenever the lighting voltage is lost. These factors make them virtually immune to problems of cable damage or loss of main vehicle batteries in an accident. Hitherto, lighting standards have concentrated on load shedding so as to preserve some lighting in a situation where battery charging power is lost and true emergency lighting, in the sense of lighting which will function when the normal lighting is totally inoperative, has not been specified.

13.3.10.3 RSSB project T314 concluded that there is no case for mandating emergency lighting on a cost/safety benefit basis. However, the Panel considers that this is too narrow a view. Whilst it is not possible to measure in financial terms the additional distress experienced by passengers as a result of the lack of any lighting,
the Panel considers that it is no longer acceptable, when suitable emergency lighting hardware is available at modest cost, that the emergency lighting standards applied in public buildings should not apply similarly to trains.

13.3.10.4 The Panel considers that provision of emergency lighting should be made a mandatory requirement both for new vehicles and for vehicles undergoing major internal refurbishment.

13.3.11 **Windows**

13.3.11.1 The Principal Engineer concluded that laminated windows would have been much more likely to prevent ejection from the coaches than the toughened windows fitted to HSTs. The current Railway Group Standard applicable to new vehicles requires that laminated glass should be fitted at all windows except those designated for emergency egress. However, retro-fitting of existing rolling stock is not required. ATOC Standard AV/ST 9001 contains a similar window specification and requires that it should be applied both to new vehicles and, where reasonably practicable, to vehicles undergoing modifications that affect their crashworthiness. The Panel understands that this latter qualification includes a situation where windows are being replaced on a systematic basis as part of a refurbishment programme.

13.3.11.2 Ufton is the third relatively recent serious accident in which there have been fatalities as a result of ejection through windows. Fatalities occurred at Southall on 19 September 1997 and at Potters Bar on 10 May 2002. At Southall a HST coach turned onto its side and slid along an adjacent track in a similar way to coach E at Ufton. At Potters Bar the circumstances were unusual in that facing points guided the trailing bogie of a vehicle such that it took the turnout route, whereas the leading bogie did not. This caused violent yawing of the vehicle, which subsequently rolled completely over. However, the Ufton accident has demonstrated that such complete rolling of a vehicle can also occur as a result of a train coming out of line under the action of compressive forces even in the absence of a heavy collision and that, as at Southall, the turning of a vehicle onto its side can cause passengers to fall onto windows.

13.3.11.3 The inquiries into the Southall and Potters Bar accidents made no recommendations regarding possible replacement of toughened glass by laminated glass in the windows of existing vehicles. In view of the events at Ufton, the Panel considers that this issue should be addressed. It is aware that a decision as to whether or not to retrofit existing vehicles must take into account their likely residual life. The Panel considers therefore that a requirement to retrofit laminated windows to vehicles should be linked to major refurbishment, since this is normally done only where the owner envisages that the vehicle has a substantial residual life.
13.3.11.4 The Panel notes that RSSB project T424, which is looking at the balance of risk in respect of retaining some toughened windows for emergency egress purposes, is not yet complete. It considers that this work should be accelerated, so that retrofitting of windows to vehicles undergoing refurbishment is not delayed by uncertainty regarding the number and disposition of toughened windows that should be retained.

13.3.12 Devices for Breaking Windows

13.3.12.1 Two window hammers were broken by a passenger as he attempted to break a window. Subsequent tests commissioned by FGW showed that the hammers fitted in their coaches, whilst strong enough to break the windows when correctly used, were not sufficiently strong to withstand the forces that a determined passenger could reasonably be expected to impart to them. FGW is not the only train operator using this type of hammer.

13.3.12.2 Three windows that were still intact showed signs of their inner panes having been struck with a hammer. It is not clear whether the passengers who did this understood that the window is double glazed and that it is necessary to use the hammer to claw out enough of the glass of the inner pane to allow a clear strike at the outer pane. The signs which indicated how to use the hammer did not make this clear. Such problems would be avoided by a window breaking system which eliminates the need for hammers.

13.3.12.3 The Panel is of the opinion that it is preferable to provide a device that avoids the need for passengers to use a hammer to break toughened glass windows. However, it notes the ongoing work in RSSB project T424 and is of the opinion that it would be premature to recommend such a system prior to completion of that work. Nevertheless it considers that urgent action should be taken, where hammers are provided, to ensure that they are of sufficient strength to withstand the loads imposed by the user and that he has clear information as to how to break all the glass and remove it from the window frame. The Panel considers that the scope of project T424 should be extended to include this work.

13.3.13 The Actions of the Train Driver

13.3.13.1 The Panel is satisfied that the train was being driven in a correct manner.

13.3.13.2 There is conflicting evidence regarding the moment when the Driver applied the emergency brakes. The Driver Manager concluded, on the basis that the brake relay bouncing began at the moment of collision with the motor car, that the Driver braked one quarter of a second before the collision. AEAT's Team Leader, using a different method, concluded that the Driver had braked between one and two seconds after the collision. The latter figure would be consistent
with the relays beginning to bounce when the front power car reached the turnout.

13.3.13.3 The Panel is unable to determine the precise location at which the Driver applied the brake. However, given the low level of illumination at the crossing, it considers it probable that the Driver did not see the car until the very last moment and that even if the AEAT analysis is correct, the shock of the collision could have caused him to take a second or so to apply the brake. The Panel concludes that there is no evidence to indicate that the Driver could have done more to reduce the speed of the train or to mitigate the effect of the derailment.

13.3.14 The Condition of the OTMR

13.3.14.1 The OTMR, despite the fault on two of the channels and the absence of certain information as a result of its being in the rear power car, gave valuable information in respect of the way the train was being driven and of the detailed events at the time of the accident. However, the unit was one fitted for trial purposes and therefore not covered by the normal planned preventative maintenance regime.

13.3.14.2 The speed compensation which is available in order to adjust for wheel wear was set to the ‘new wheel’ diameter, although the wheels from which the speed signal was taken were smaller than this. This is consistent with the Driver Manager’s conclusion that the speed being recorded was higher than the actual train speed. The Panel accepts his conclusion.

13.3.14.3 The Panel understands that there is an ongoing programme to fit OTMRs to all the power cars of the HSTs operated by FGW. This work is due to be completed by the end of 2005 and the units will be included in the vehicle maintenance regime as they are fitted. On this basis, the Panel is satisfied that there is no need for further action by FGW over and above that already planned.

13.4 The Rescue

13.4.1 Train Staff

13.4.1.1 It was fortunate that apart from some minor bruising, both the Train Managers were unhurt during the accident. In the immediate aftermath, they behaved in a calm and responsible manner as they did what they could to comfort the passengers, although it was apparent that they did not manage to check on the situation in all of the accessible coaches. After attending to the immediate priority for the protection of the train, they assisted with the evacuation of the passengers from the coaches and generally ensured that the passengers subsequently received appropriate care and attention before they were taken from the accident site.
13.4.2 Evacuation of the Passengers

13.4.2.1 Taking into account the severe nature of the derailment, the evacuation of the passengers generally proceeded well. The failure of the internal lighting in the coaches, coupled with the fact that the derailment occurred in open countryside with the only external lighting coming from the street lights of a distant main road, seriously exacerbated the situation. However, the light sticks that were activated by the train crew and some of the passengers were helpful in the provision of limited illumination. Where it was possible, the passengers exited either through the external door of a coach or through the open end of the vestibule where coaches had separated from one another. Where these means of egress were not available, the passengers exited via windows.

13.4.2.2 The difficulties that did occur with the evacuation applied mainly to the coaches in the centre of the train that had broken loose from the train formation and had rolled and/or yawed before coming to rest at substantial angles to the vertical, including one lying completely on its side. Most of the casualties occurred in these coaches, which coupled with the inclined attitude of the coaches and the serious damage that they had sustained, led to inevitable delays with extricating the passengers. Nevertheless, the emergency services dealt with the evacuation from these coaches as expeditiously as possible.

13.4.3 Care of the Passengers

13.4.3.1 All those passengers who were able to walk, including those who had suffered minor cuts and bruises, were conducted in groups to the local inn which was situated at a distance of approximately 300 metres from the accident site and which was serving as the initial reception point. Their injuries were tended there by paramedics.

13.4.3.2 FGW staff, who attended both the initial and the secondary reception points, did what they could in the difficult circumstances to ensure that the passengers were made as comfortable as possible. Their personal details were recorded, telephone facilities were made available and reassurances were given, as far as possible, regarding the return of their luggage and personal effects. Every effort was made to organise alternative transport for them, with the result that the last of the passengers left the reception points on their homeward journeys a little over three hours after the accident had occurred.
13.4.3.3 FGW staff similarly attended the Royal Berkshire Hospital in Reading and gave their assistance as required to the passengers as they were discharged. With particular regard to follow-up action, FGW has offered counselling services to all the passengers.

13.4.3.4 The evidence presented to the Panel gave a clear and strong picture that FGW had displayed every concern for the well-being of the passengers and that a great deal of time and attention was given to this very important aspect of the accident.

13.4.4 The Emergency Services

13.4.4.1 After being alerted to the accident, all the emergency services arrived on the site within a very short timescale (Appendix C). With few exceptions, their work was praised equally by the passengers and by the staff of the railway organisations who attended the site.

13.4.4.2 The emergency services are to be congratulated on the speed, care and efficiency in which they performed their various and difficult tasks.

13.5 The Passengers

13.5.1 Reactions

13.5.1.1 Based on the evidence presented to the Inquiry by the passengers who attended for interview together with other staff who were involved with the rescue on the site, the Panel was left in no doubt that the passengers behaved in an exemplary manner. There was no panic despite the extreme circumstances of the accident.

13.5.1.2 Pending the arrival of the emergency services, the passengers comforted one another and did their best to help those who had been injured. Where possible, they looked for means of egress from the coaches, with some passengers adopting a leading role in the guidance of others. When the emergency services arrived on the site, the passengers displayed commendable patience during the rescue operation.

13.5.2 Observations and Suggestions

13.5.2.1 The passengers who were interviewed in the Inquiry had very different experiences of the derailment, principally as a consequence of where they were seated in the train. At one end of the scale, Passenger 8, who was travelling in coach A, described the course of the derailment as being fairly gentle and that he had not personally experienced any great distress or shock as the coach abruptly slowed and came to rest. At the other end of the scale, Passengers 6 and 7, who were travelling in coach E, experienced violent shuddering and bouncing of the coach as it broke away from the train formation and rolled onto its side. What all the passengers had in common was the difficulty caused by the failure of the coach.
lighting, which added considerably to their initial disorientation and uncertainty regarding their own situation and that of others around them.

13.5.2.2 The passengers made a number of observations and suggestions regarding safety that were helpful to the Panel when consideration was being given to the lessons to be learned from the accident and when the recommendations were being formulated. Among these comments were positive statements about the value of the light sticks, tempered with a suggestion that there are more effective ones available in the market place. It was also suggested that a form of installed emergency lighting would be better. The failure of two hammers during an attempt to break coach windows received critical comment.

13.5.2.3 Most passengers acknowledged that they had not read the safety information cards which are readily available in each coach. Some passengers made the additional comment that they had not observed any other passengers reading them. They made these comments at the same time as accepting that they had been requested to read the cards via announcements over the train’s internal public address system at every station stop. It was apparent that the general reluctance to read the cards stemmed from a conviction that an accident would never happen.

13.5.2.4 One passenger drew the Panel’s attention to the fact that the safety information card, which he had taken the time to study, omitted any reference to the ‘burst through’ panel in the vestibule door. The Panel was made aware by FGW that this omission occurred as a result of outdated cards being left on the train and that the situation was being rectified with immediate effect.

13.5.2.5 Other suggestions that were made by the passengers related to the fitting of laminated glass in coach windows, accident training for train staff and the provision of seat belts. Three passengers out of the eight who were interviewed volunteered comments upon the last feature, with varying views on the benefit to be gained.

13.5.2.6 The Panel acknowledges the valuable assistance given to the investigation by the passengers who attended the Inquiry.

13.6 The Recovery

13.6.1 Protection of the Line

13.6.1.1 The Panel notes that Train Manager A, after exiting the train through a broken window in coach A, had placed track circuit operating clips on the Down Line behind the rear power car. This action was in accordance with the correct procedure.

13.6.1.2 The Panel is concerned that no attempt was made to similarly operate the track circuit in the Up Line. The Panel considers that in
the prevailing circumstances, this would have been the appropriate safety action to take. It was fortunate that there was no train approaching the level crossing in the Up direction at the time.

13.6.1.3 Train Manager B had attempted to contact the Signaller by means of a signal-post telephone without success but alternatively had advised the Control Office in Swindon of the details of the accident via his mobile telephone. The RIO, after his arrival on the site, subsequently received confirmation from Reading Signalling Centre that both lines had been protected.

13.6.2 Silver Control

13.6.2.1 From the evidence presented to the Panel by the first RIO, it was clear that he felt that his position in the formal accident command structure was compromised to a degree by the actions of senior Network Rail management who attended the site. He felt that he had been excluded, at least in the early stages of the rescue operation, from the liaison meetings with the emergency services. He believed that his place had been taken by senior management. He also believed that other arrangements for the wider recovery operation had been made by senior management without prior consultation with him.

13.6.2.2 The RIO told the Panel that he had never before been involved in such a serious accident as that at Ufton, although he had acted in the capacity of RIO on more minor incidents in the past. He acknowledged that he had been very ably supported at Ufton by a more experienced RIO, whose certificate of competence for the post had expired but who was able to act in the role of Bronze in the accident command structure. The Panel also notes that the RIO had not started to record his actions and other relevant events in the official site log until midnight, six hours after the accident occurred.

13.6.2.3 The Panel understands the difficulties encountered by the RIO and is satisfied that he had performed his duties as well as he was able in the light of his limited experience. However, in consideration of the serious nature of the accident coupled with the seniority of the officers in charge of the emergency services, the Panel considers that it would have been appropriate for a Network Rail manager with more seniority and experience than a MOM to have undertaken the role of the RIO.

13.6.2.4 The Panel takes the view that there should be a fundamental review of the application of the command structure for major accidents, embracing not only the level of Silver but also Gold and Bronze. It is suggested that the review should include person specifications, training requirements and protocols for communication and documentation.
13.6.3 Gold Control

13.6.3.1 The Route Senior On-Call Manager assumed the role of Gold Control on his arrival at 2100 hrs in the Control Office. Network Rail confirmed that there are no written guidelines regarding the appointment of the person to the post but that it was the practice for the Route Senior On-Call Manager to undertake the role, as was the case on this occasion. The Panel also learned that the Route Senior On-Call Manager had received no training relating to the role of Gold Control in a major accident.

13.6.3.2 Although the Panel is of the opinion that Gold control functioned reasonably effectively, it considers that these issues should be covered by the review referred to in paragraph 13.6.2.4 of this report.

13.6.3.3 The Route Senior On-Call Manager believed that there was some early confusion in the operation of the control on the site but that this had not been to the detriment of the rescue or planned recovery operations in this accident. The Panel concurs with his view.

13.6.4 The Role of Senior Management

13.6.4.1 As to be expected in the event of a major accident such as that at Ufton, senior managers from Network Rail, together with senior managers from other involved organisations, attended the site to give their support to the local managers. It was evident that some of Network Rail’s local managers saw some aspects of the way in which this support was given as impacting adversely, albeit in a limited way, upon the formal accident command structure that they were responsible for operating.

13.6.4.2 The Panel understands the concerns of Network Rail’s local managers, at the same time appreciating that there was a Network Rail senior manager who took the view that the RIO in particular would have difficulty in dealing with all the demands that would be made of him. The senior manager therefore took action to give his support, especially in ensuring close liaison with the emergency services.

13.6.4.3 At Ufton, there were misunderstandings in the first few hours following the accident, which although not impeding in any way the work for the rescue that was in progress at the time, would have benefited from more prompt resolution. Whilst there can be no doubt that the presence of senior management at a major accident can be instrumental in providing the wider support that seniority brings to the task, in order to gain the maximum benefit it is important that the actions of senior management are properly integrated into the formal accident command structure.
13.6.5 Derailment Investigation

13.6.5.1 The Panel is concerned that initially there appeared to be uncertainty in Network Rail’s Control Office in Swindon regarding the requirement for AEAT’s derailment investigation team to attend the site, despite the obvious nature and severity of the accident. As it transpired, the delay was minimal and the Panel is satisfied that it had no effect upon the outcome of the investigation. Nevertheless, there was an apparent lack of understanding of the protocol in the Control Office and the Panel is of the opinion that Network Rail should take the opportunity to review the procedural arrangements for the attendance of derailment specialists at accident sites. Such a review might also usefully embrace the contractual arrangements.

13.6.6 Accident De-briefing

13.6.6.1 Although at the time when he attended the Inquiry, FGW’s On-Call Manager had not been de-briefed regarding the accident, the Panel was subsequently advised that he has since attended a full de-brief with his senior manager. When giving his evidence to the Panel, the On-Call Manager had anticipated that this was imminent.

13.6.6.2 The Panel was also provided with the notes of the formal de-briefs that were carried out by FGW with a number of their staff who were directly concerned in the aftermath of the accident. It was evident that these sessions were conducted in a very thorough and professional manner. The comments and recommendations made by the staff indicated that there were important lessons to be learned from the accident. At the strategic level, there were issues such as the need to clarify the role of FGW’s Incident Room and to identify more dedicated managers who could assume the role of Gold Control. At the tactical level, there were issues such as the need for a supply of spare batteries for mobile telephones to be made available on the site and for a review to be undertaken of the contents of the ‘incident bag’.

13.6.6.3 So far as Network Rail is concerned, the RIO advised the Panel that he had been de-briefed following his return to normal duties. Additionally, Network Rail provided the Panel with the notes of the full de-briefing meeting that had been conducted and chaired by the Route Director. As with FGW’s de-brief, this was an extremely thorough analysis of the events following the accident, broadly reviewing them in two separate parts ie the initial rescue and the subsequent recovery. In a very practical way, the review process considered those items that went well, those that went not so well and finally concluded with the actions that needed to be taken to ensure better preparedness in the future.

13.6.6.4 The Panel is in no doubt that both FGW and Network Rail were diligent in carrying out their respective de-briefing meetings and that valuable lessons had been learned from the accident.
13.6.7 Restoration of Infrastructure

13.6.7.1 The Panel noted that once the last of the derailed vehicles of the train had been cleared from the site, the commencement of the work for the renewal of the severely damaged track and signalling quickly followed and was eventually completed ahead of schedule. The priority was to open the Up and Down Lines for the running of normal traffic and accordingly the reinstatement of the connection into the Down Goods Loop was not included in the work at this time.

13.6.7.2 Network Rail gave detailed consideration to the present and future traffic needs for the Down Goods Loop before concluding that it was essential to reinstate it to its former length. In support of this conclusion, the Panel was provided with a copy of a paper prepared by Network Rail. There is a regular service of aggregates trains from the Mendips to London and the paper analysed the effect that the permanent loss of the facility to regulate these trains at Ufton would have upon the passenger traffic.

13.6.7.3 The paper demonstrated that the loss of the loop would constitute a significant impediment to the traffic flow over the route. This was borne out by the considerable increase in the delays that occurred in the weeks immediately following the derailment when the loop was not accessible.

13.6.7.4 Consideration was also given to shortening the Down Goods Loop by moving the connection further away from the level crossing. However, this option was not possible since an aggregates train, when hauled by two locomotives, occupies the entire length of the existing loop.

13.6.7.5 The new connection in the Down Line was subsequently laid into the track, in the same position that it occupied before the accident, during March 2005.

13.7 Staff Training, Competence and Fitness for Duty

13.7.1 The Panel is of the view that the evacuation and emergency response training given to the staff of FGW was very effective. The Panel considers that there could be benefits to be gained by communicating the details of the training to other train operators.

13.7.2 HSBC Rail’s roll-over rig, in which a coach can be inclined to any angle up to 90 degrees, was particularly helpful to the members of the Panel in understanding the difficulties faced by passengers inside of a coach that has rolled in an accident, in respect of both making their way through the coach to a door and in attempting to break and exit through a window. The Panel believes that there is the potential for such a facility to be used more widely than appears to be the case at present for the evacuation training of train crews.
13.7.3 With regard to the competence and fitness for duty of those staff directly concerned in the derailment ie the Driver, Train Managers, Customer Host and Signaller, they were all experienced staff possessing the necessary skills and knowledge to carry out the tasks involved in their work. The Panel is satisfied that the competence of the staff in their jobs and their fitness, both physical and mental, were appropriate for the performance of their duties.

13.7.4 The Train Managers displayed commendable composure in the emergency situation and did what they could to help and reassure the passengers.

13.8 Weather and Environment

13.8.1 At the time the train derailed, the weather was dry and had no effect upon the derailment. The drizzle that developed soon afterwards made for unpleasant conditions during the rescue operation but did not hamper the work.

13.8.2 Similarly, there were no environmental conditions that contributed to the derailment. The open vehicular access to the site, the availability of adjacent land for establishing a base for the accident control services and the proximity of an inn and a hotel, both of which acted as reception points for the passengers, were all instrumental in significantly facilitating the rescue and recovery operations.

14. Conclusion

14.1 Immediate Cause

14.1.1 The initial derailment occurred as a result of the train colliding with a motor car, causing the flange of the left hand wheel of the leading bogie of the front power car to climb over the left hand rail. The car had been driven on to the level crossing prior to the commencement of the closure sequence and had come to a stand. It was stationary at the time of impact.

14.1.2 The subsequent derailment of all the vehicles occurred when the train shortly afterwards reached facing points which caused the derailed left hand wheel to follow the left hand stock rail of the points pulling the trailing axle of the leading bogie, and then the bogies of all the following vehicles, into derailment.

14.2 Underlying Causes

14.2.1 The underlying causes are related to the behaviour of the driver of the motor car, which is outside of the scope of the remit for this inquiry.

14.2.2 A coroner’s inquest will be held into all the fatalities in the accident.
## 15. Recommendations

### 15.1 Level Crossings

#### 15.1.1 Closure

<table>
<thead>
<tr>
<th>Rec 1</th>
<th>Consideration should be given to the establishment of a team dedicated to the implementation of Network Rail’s stated level crossing strategy of giving priority to crossing closures. The team should bring vigour to a joint approach by the railway and road authorities to negotiating the extinguishing of rights of way to allow level crossings to be closed. Particular emphasis should be placed on locations where the line speed is high.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To ensure the implementation of Network Rail’s stated policy on level crossings.</td>
</tr>
<tr>
<td><strong>Responsibility</strong></td>
<td>Network Rail to lead with the support of the relevant road and planning authorities</td>
</tr>
<tr>
<td><strong>Timescale</strong></td>
<td>Formation of the team - immediate Progress of the level crossing programme - ongoing</td>
</tr>
<tr>
<td><strong>Ref.</strong></td>
<td>6.8.5, 13.2.3.5, 13.2.6.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rec 2</th>
<th>Where considerable expenditure is justified for safety reasons, vigorous consideration should be given to the provision of a bridge, rather than an upgrade to the crossing, thus allowing crossing closure whilst continuing to maintain the right of way.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To ensure that the primary focus for improvement action is on crossing closure rather than alternative forms of crossing control.</td>
</tr>
<tr>
<td><strong>Responsibility</strong></td>
<td>Network Rail</td>
</tr>
<tr>
<td><strong>Timescale</strong></td>
<td>Ongoing</td>
</tr>
<tr>
<td><strong>Ref.</strong></td>
<td>6.1.10, 13.2.7.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rec 3</th>
<th>Given that a suitable alternative road route exists via Tyle Mill, means of achieving the closure of Ufton level crossing should be investigated.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To remove the risk at this site in support of Network Rail’s stated level crossing policy.</td>
</tr>
<tr>
<td><strong>Responsibility</strong></td>
<td>Network Rail and the relevant road and planning authorities</td>
</tr>
<tr>
<td><strong>Timescale</strong></td>
<td>Six months</td>
</tr>
<tr>
<td><strong>Ref.</strong></td>
<td>6.8.5, 13.2.6.3</td>
</tr>
</tbody>
</table>
### 15.1.2 Risk Assessment

<table>
<thead>
<tr>
<th>Rec 4</th>
<th>The Network Rail level crossing risk assessment process should be revised so that the proximity of track and lineside features that could exacerbate the effect of a derailment is included as a factor.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To ensure that the risk assessment process considers the post-collision potential at level crossings.</td>
</tr>
<tr>
<td><strong>Responsibility</strong></td>
<td>Network Rail and RSSB</td>
</tr>
<tr>
<td><strong>Timescale</strong></td>
<td>Twelve months</td>
</tr>
<tr>
<td><strong>Ref.</strong></td>
<td>6.10.3, 13.2.3.4</td>
</tr>
</tbody>
</table>

### 15.1.3 Design Improvements

<table>
<thead>
<tr>
<th>Rec 5</th>
<th>Research should be undertaken to establish whether a practical system can be developed to detect and to warn train drivers of an obstruction at AHB level crossings.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To mitigate the consequences of a collision at a level crossing.</td>
</tr>
<tr>
<td><strong>Responsibility</strong></td>
<td>RSSB (to lead) and Network Rail</td>
</tr>
<tr>
<td><strong>Timescale</strong></td>
<td>Ongoing</td>
</tr>
<tr>
<td><strong>Ref.</strong></td>
<td>6.12.2, 13.2.11.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rec 6</th>
<th>The operation and design of the AHB level crossing emergency telephone system should be reviewed from a human factors, environmental and technical viewpoint and modified to promote successful contact with the signaller.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To ensure that from a user’s perspective, the telephone system operates in an intuitive manner when required to establish a call with the signaller in both routine and emergency situations.</td>
</tr>
<tr>
<td><strong>Responsibility</strong></td>
<td>Network Rail</td>
</tr>
<tr>
<td><strong>Timescale</strong></td>
<td>The review should be completed within six months and any necessary modification retrospectively applied within 12 months</td>
</tr>
<tr>
<td><strong>Ref.</strong></td>
<td>6.6.7, 13.2.12.4</td>
</tr>
</tbody>
</table>
### 15.1.4 Strategic Issues

<table>
<thead>
<tr>
<th>Rec 7</th>
<th>The work of the National Level Crossing Safety Group should be vigorously supported and given high priority for funding and resources.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To ensure that reasonably practicable proposals for reducing the risk at level crossings are developed in the shortest possible timescale.</td>
</tr>
<tr>
<td><strong>Responsibility</strong></td>
<td>Network Rail (to lead), RSSB, Department for Transport and the relevant road and planning authorities</td>
</tr>
<tr>
<td><strong>Timescale</strong></td>
<td>Immediate and then ongoing</td>
</tr>
<tr>
<td><strong>Ref.</strong></td>
<td>6.11, 13.2.15.3, 13.2.15.5</td>
</tr>
</tbody>
</table>

### 15.1.5 Road Surface

<table>
<thead>
<tr>
<th>Rec 8</th>
<th>Where there exists a random mix of steel framed concrete road units and polymer concrete (non-framed) road units in the four-foot of the track on a level crossing, there should be a policy that allows for the re-configuration of the units into a grouping of the former type of unit at the running-on end of the crossing followed by a grouping of the latter type of unit at the running-off end. The policy should be applied whenever the opportunity arises for such a re-configuration of the units in conjunction with their temporary removal from the track for other planned work on the crossing.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To reduce the likelihood that a wheelset will become completely derailed at a level crossing.</td>
</tr>
<tr>
<td><strong>Responsibility</strong></td>
<td>Network Rail</td>
</tr>
<tr>
<td><strong>Timescale</strong></td>
<td>As the opportunity arises</td>
</tr>
<tr>
<td><strong>Ref.</strong></td>
<td>4.2.1.3/4/5/7, 13.1.2.1/2/3/4/5</td>
</tr>
</tbody>
</table>
15.2 Trains
15.2.1 Reducing the Risk of Derailment

<table>
<thead>
<tr>
<th>Rec 9</th>
<th>The exemption for axleloads greater than 17 tonnes from the general requirement in Railway Group Standard GM/RT2100 to fit obstacle deflectors to new-build leading vehicles should be reviewed, taking into account the mechanism of derailment of the leading power car at Ufton.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To reduce the likelihood of derailment after striking an obstruction.</td>
</tr>
<tr>
<td><strong>Responsibility</strong></td>
<td>RSSB</td>
</tr>
<tr>
<td><strong>Timescale</strong></td>
<td>Six months</td>
</tr>
<tr>
<td><strong>Ref.</strong></td>
<td>7.2.1.3, 7.2.2, 13.3.1.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rec 10</th>
<th>The feasibility of modifying the front end shape of HST power cars and/or fitting an obstacle deflector in order to reduce the derailment risk following a collision with a large obstruction such as a motor vehicle should be investigated and implemented, if practicable, on power cars undergoing a life extension programme.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To reduce the likelihood of derailment after striking an obstruction.</td>
</tr>
<tr>
<td><strong>Responsibility</strong></td>
<td>Train Operators and Rolling Stock Leasing Companies</td>
</tr>
<tr>
<td><strong>Timescale</strong></td>
<td>Twelve months for the feasibility study and then implementation as appropriate.</td>
</tr>
<tr>
<td><strong>Ref.</strong></td>
<td>7.2.2, 13.3.1.5</td>
</tr>
</tbody>
</table>
### 15.2.2 Protection of Passengers and Crew

**Rec 11**

A programme of research should be pursued in order to assess:

(a) Whether there could be a net safety benefit in fitting seat belts in passenger vehicles.
(b) The percentage usage of the belts which would be required in order to realise a degree of safety benefit commensurate with the costs of fitting and maintaining the belts.
(c) Whether that percentage usage is achievable in long term service operation.

This information should form part of the input to a study to determine whether the fitting of seat belts is reasonably practicable.

<table>
<thead>
<tr>
<th>Objective</th>
<th>To reduce risk of injury to passengers in serious accidents.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responsibility</td>
<td>RSSB</td>
</tr>
<tr>
<td>Timescale</td>
<td>Twelve months</td>
</tr>
<tr>
<td>Ref.</td>
<td>7.5.8.2, 7.8.6.3/4/5/6, 13.3.8</td>
</tr>
</tbody>
</table>

**Rec 12**

The requirements in Railway Group Standard GM/RT2456 and ATOC Standard AV/ST9001 relating to the provision of laminated windows should be extended to cover vehicles undergoing major internal refurbishment. The RSSB research work on the provision of windows for emergency egress should be accelerated so that implementation of the requirements on vehicles undergoing major refurbishment is not delayed by lack of information on the optimum disposition of toughened and laminated windows.

<table>
<thead>
<tr>
<th>Objective</th>
<th>To reduce the risk of passengers or staff being ejected or partially ejected from vehicles or being injured by broken window glass or debris entering vehicles.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responsibility</td>
<td>RSSB</td>
</tr>
<tr>
<td>Timescale</td>
<td>Six months</td>
</tr>
<tr>
<td>Ref.</td>
<td>7.5.8, 7.8.7.8, 9.2.2, 9.4.3, 9.5.9, 13.3.11.</td>
</tr>
<tr>
<td>Rec 13</td>
<td>The programme for RSSB research project T118 should be reviewed so as to identify opportunities to bring forward the completion date of the work on the role of couplers and bogie retention in whole train dynamic behaviour in accidents.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>To promote the earliest possible implementation of any safety measures which are identified.</td>
</tr>
<tr>
<td><strong>Responsibility</strong></td>
<td>RSSB</td>
</tr>
<tr>
<td><strong>Timescale</strong></td>
<td>Two months</td>
</tr>
<tr>
<td><strong>Ref.</strong></td>
<td>4.2.4, 7.3.2, 7.3.3, 7.4, 13.3.2.3, 13.3.3.4</td>
</tr>
</tbody>
</table>

### 15.2.3 Emergency Procedures and Escape

<table>
<thead>
<tr>
<th>Rec 14</th>
<th>There should be a requirement to apply photoluminescent markings to emergency equipment so as to enable passengers to locate it in poor lighting conditions.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To promote effective use of emergency equipment by passengers.</td>
</tr>
<tr>
<td><strong>Responsibility</strong></td>
<td>Train Operating Companies</td>
</tr>
<tr>
<td><strong>Timescale</strong></td>
<td>Six months</td>
</tr>
<tr>
<td><strong>Ref.</strong></td>
<td>7.8.7.7, 9.6.4, 13.3.9.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rec 15</th>
<th>Safety information should be provided in the vicinity of passenger seats where it is practicable to do so.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To improve passengers’ understanding of the action to be taken in an emergency.</td>
</tr>
<tr>
<td><strong>Responsibility</strong></td>
<td>Train Operating Companies</td>
</tr>
<tr>
<td><strong>Timescale</strong></td>
<td>Six months</td>
</tr>
<tr>
<td><strong>Ref.</strong></td>
<td>9.4.2, 9.6.2, 13.3.9.3</td>
</tr>
</tbody>
</table>
Rec 16

Light sticks should be provided for the use of passengers in all trains where emergency lighting is not available.

Objective
To assist passengers and staff following an accident in darkness where no other lighting is available.

Responsibility
Train Operating Companies

Timescale
Six months

Ref.
9.3.1, 9.4.5, 9.5.4, 9.6.4, 13.3.10.1, 13.5.2.2

Rec 17

Provision of high integrity emergency lighting, which will function in a situation where the main lighting supply is lost, should be mandated for all new passenger vehicles and for those undergoing major internal refurbishment.

Objective
To assist passengers and staff by providing a guaranteed minimum level of lighting following an accident in darkness.

Responsibility
RSSB and Train Operating Companies

Timescale
Six months

Ref.
9.2.2, 9.3.1, 9.4.5, 9.5.8, 9.6.12, 13.3.10, 13.5.2.2

Rec 18

Where passengers are required to use a hammer to break toughened glass windows as part of a vehicle egress procedure, the hammer should be of sufficient strength to avoid it being broken by the action of the passenger. RSSB research project T424 should be extended to include an investigation into a suitable standard design or designs of hammer. Where windows are double glazed, the signing should clearly indicate this fact together with the appropriate action to be taken by the passenger in order to break and remove both panes of glass.

Objective
To allow rapid escape via windows in emergency.

Responsibility
RSSB

Timescale
Six months

Ref.
7.7.7, 9.6.5/6, 13.3.12, 13.5.2.2
### 15.3 Rescue and Recovery

#### 15.3.1 Training of On-Train Staff

<table>
<thead>
<tr>
<th>Rec 19</th>
<th>The responses of on-train staff when confronted with an accident should be reviewed, with particular emphasis on the evacuation of passengers from a derailed coach and the protection of the line. The lessons learned should be used as appropriate to reinforce the training programme together with ongoing exercises and briefings.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To ensure that the training programme comprehensively covers all the aspects of the safety of the passengers and the line and that on-train staff are prepared as well as possible for the real life situation.</td>
</tr>
<tr>
<td><strong>Responsibility</strong></td>
<td>FGW</td>
</tr>
<tr>
<td><strong>Timescale</strong></td>
<td>Three months</td>
</tr>
<tr>
<td><strong>Ref.</strong></td>
<td>8.1.1, 8.1.2, 13.4.1.1, 13.6.1.1, 13.6.1.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rec 20</th>
<th>Consideration should be given to the inclusion, in the emergency training module for on-train staff, the opportunity for them to visit a facility providing first hand experience of the conditions inside a rolled coach.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To enable on-train staff to gain a better understanding of the difficulties faced by passengers in a coach that has rolled in a derailment.</td>
</tr>
<tr>
<td><strong>Responsibility</strong></td>
<td>FGW and other Train Operating Companies</td>
</tr>
<tr>
<td><strong>Timescale</strong></td>
<td>Six months</td>
</tr>
<tr>
<td><strong>Ref.</strong></td>
<td>7.7.6.3, 13.7.2</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Rec 21</th>
<th>Consideration should be given to the emergency training of on-train staff, as currently practised by FGW, to determine if there are elements of the training that could usefully be transferred to other passenger train operators.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To promote the spread of best practice.</td>
</tr>
<tr>
<td><strong>Responsibility</strong></td>
<td>Train Operating Companies</td>
</tr>
<tr>
<td><strong>Timescale</strong></td>
<td>Six months</td>
</tr>
<tr>
<td><strong>Ref.</strong></td>
<td>8.1.5/10, 13.7.1</td>
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</tbody>
</table>
15.3.2 Procedures Following Accidents

<table>
<thead>
<tr>
<th>Rec 22</th>
<th>A review should be undertaken of the procedural arrangements with specialist investigation organisations in respect of the attendance of derailment and crash worthiness specialists at the site of a train accident.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To ensure that all the involved parties are clear about the requirements for the attendance of the specialists and that their arrival on the site is timely.</td>
</tr>
<tr>
<td><strong>Responsibility</strong></td>
<td>Network Rail</td>
</tr>
<tr>
<td><strong>Timescale</strong></td>
<td>Three months</td>
</tr>
<tr>
<td><strong>Ref.</strong></td>
<td>10.3.1/2/3, 13.6.5.1</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Rec 23</th>
<th>The present emergency command structure in Network Rail, at the three levels of Gold, Silver and Bronze, should be reviewed in respect of the way in which it is applied to major rail accidents. The review should consider all aspects of the requirements, especially the seniority, competence and experience of the appointees to the executive positions within the structure together with the communications between the different levels.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To promote efficient post-accident management.</td>
</tr>
<tr>
<td><strong>Responsibility</strong></td>
<td>Network Rail</td>
</tr>
<tr>
<td><strong>Timescale</strong></td>
<td>Three months</td>
</tr>
<tr>
<td><strong>Ref.</strong></td>
<td>10.1.1.4/5/8, 10.1.2.4, 13.6.2.2/3/4, 13.6.3.2, 13.6.4.1/2/3.</td>
</tr>
</tbody>
</table>
16. Appendices

A Witness Evidence

Written statements and reports provided by the witnesses and the oral evidence given at the Inquiry are held on record by the Rail Safety and Standards Board at their offices in Evergreen House, 160 Euston Road, London, NW1 2DX.

B Fatalities and Injuries

<table>
<thead>
<tr>
<th>Coach Designation</th>
<th>Fatal</th>
<th>Treated at Hospital</th>
<th>Treated by Paramedic</th>
<th>Attended Hospital Later</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>5</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>B1</td>
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<tr>
<td>B2</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>1</td>
<td>31</td>
<td>29</td>
<td>3</td>
</tr>
<tr>
<td>E</td>
<td>4</td>
<td>12</td>
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<td>3</td>
</tr>
<tr>
<td>F</td>
<td>0</td>
<td>5</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>G</td>
<td>0</td>
<td>6</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>H</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>71</td>
<td>68</td>
<td>8</td>
</tr>
</tbody>
</table>

The information detailed in the table above has been extracted by AEAT from 200 witness statements provided by the BTP.

The number of passengers treated by paramedics is lower than that for passengers treated at hospital. It is believed that a greater number of passengers will have received treatment on-site but this was not specifically mentioned in their statements.

The figures detailed in the ‘Attended Hospital Later’ column do not include those passengers who stated that they attended their General Practitioner for medical advice as a result of the accident.

Although they had seats in coach E, there is some doubt regarding the whereabouts, at the time of the accident, of two of the passengers who received fatal injuries (paragraph 9.6.10 refers).

The drivers of the train and the car also received fatal injuries.

C Emergency Services

In the critical four hours immediately after the derailment, the following equipment and personnel of the emergency services were involved in the rescue operation on the site:
(a) Police
British Transport Police 60 Officers
Thames Valley Police 120 Officers

(b) Fire Services
22 appliances with 84 crew members

(c) Ambulance and other Medical Services
13 doctors
23 paramedics
25 ambulances with 50 crew members

The response times were as follows (the accident occurred at 1812 hrs):
- The first fire services appliance arrived on the site at 1825 hrs.
- The first ambulance arrived on the site at 1831 hrs.
- The first officers of both police forces arrived on the site at 1835 hrs.

D Damage to Infrastructure

(a) Track
In the Down Line, the track required complete renewal from 43m 39c to 43m 57c ie a total length of 362 metres together with re-railing from 43m 57.5c to 43m 61.5c ie a total length of 80 metres.

In the Up Line, the track required re-sleepering from 43m 50c to 43m 53c ie a total length of 60 metres together with re-railing from 43m 46c to 43m 56.5c ie a total length of 211 metres.

In the Down Goods Loop, the track required complete renewal from 43m 45c to 43m 51c ie a total length of 120 metres.

New facing points No. 979A (S&C CV 13) were laid in to replace the connection from the Down Line to the Down Goods Loop.

(b) Signalling and Telecommunications
The following items of equipment required to be renewed:
- Signal No. R885 and its associated signal post telephone.
- Apparatus case No. M18 and all its associated components.
- The point machine and fittings for points No. 979A.
- 100 metres of surface concrete cable troughing and associated cabling.
- The Down Goods Loop ‘Limit of Shunt’ signal.
- The Up Line treadle located at signal No. R885.
• Lineside track circuit equipment for track circuits Nos. AK, AL, CJ and QF.
• The 25mph PRS indicator board for the Down Goods Loop points.
• A points battery pack.

E Damage to Rolling Stock

(a) Vehicle Structures and Equipment

Leading Power Car Vehicle number 43019

Severe abrasions down the left hand side of the body, with air intake grill badly damaged. Structural failure at top of left hand side leading door pillar of driver’s cab. Driver’s door missing. Lower part of GRP fairing on right hand side of the cab torn off. Front end of leading bogie frame, leading axle, traction motor and gear casing all severely abraded by ballast. Minor damage to both bogies. Fuel tank fractured in a number of places. Left hand lifeguard missing, right hand bent back. Trailing coupler head rotated approx 10 degrees clockwise.

Coach H First Class TF Vehicle number 41013

Scoring of entire length of left hand side, deep over rear two thirds of bodyside just above underframe level and tearing of bodyside skin over a length of 4 metres. Damage to underframe equipment and both bogies completely detached. Major damage to both bogies. Leading and trailing couplers twisted 10 and 20 degrees clockwise respectively.

Coach G First Class TF Vehicle number 41014

Trailing left hand corner door pushed into vestibule. Heavy longitudinal scoring and gross dent to rear left hand side of body. Localised crumple in rear corner of right hand bodyside. All underframe equipment torn off and both bogies completely detached. Major damage to both bogies. Leading and trailing couplers twisted 10 degrees anticlockwise and 20 degrees clockwise respectively.

Coach F Buffet First Class TRB Vehicle number 40206

Body bent almost double. Solebar, bodyside and approximately half of roof and floor structure torn away on right hand side following impact with loose bogie. Heavy scoring and tearing of bodyside on right hand side forward of point of penetration and general heavy impact damage to both bodysides. Bodyside panel seams split open where excessive body bending had occurred. Most of underframe equipment torn off and both bogies detached. Major damage to both bogies. Trailing coupler head lower knuckle fractured and head rotated 10 degrees clockwise.
Coach E  Standard Class TSD  Vehicle number 42018
Significant scraping down the right hand bodyside. Structural dents over one window frame. Most underframe equipment at leading end torn off and both bogies detached. Major damage to leading bogie, minor damage to trailing. Leading coupler twisted 10 degrees clockwise and lower shelf bracket broken. Trailing coupler knuckles fractured and bent open.

Coach D  Standard Class TS  Vehicle number 42022
Severe damage to the roof and bodyside towards leading left hand side, with left hand side of roof pushed down almost to floor level. Extensive scrape marks running diagonally along left bodyside. Most underframe equipment torn off and both bogies detached. Minor damage to leading bogie. Major damage to trailing bogie, with one primary spring missing. Leading and trailing couplers both twisted 90 degrees clockwise.

Coach B2  Standard Class TS  Vehicle number 42017
Damage to both sides of coach body and floor pushed up immediately behind leading bogie. Severe buckling and tearing at trailing left hand side of underframe. Most underframe equipment missing and both bogies detached, although trailing bogie still substantially under body. Major damage to both bogies. Fractured upper knuckle at leading coupler.

Coach B1  Standard Class TS  Vehicle number 42020
Minor damage to bodysides, underframe equipment and bogies. Centre pivots of both bogies partially detached. Major damage to leading bogie, minor damage to trailing. Leading and trailing couplers twisted 10 degrees clockwise and anticlockwise respectively.

Coach A  Standard Class TGS  Vehicle number 44006
Minor damage to left hand bodyside, underframe equipment and bogies. Minor damage to both bogies. Centre pivot of leading bogie partially detached.

Trailing Power Car  Vehicle number 43029
Minor damage only.

(b) Internal Fittings
Generally little damage except in areas of structural intrusion in coaches D and F. Some loose tables, seat base and seat back cushions in other coaches. Some fractures of the armrest castings of rear facing seats and lateral deformation of some armrests.
Fig. 1 Track and Signalling

Key
- Milepost
- Signal
- LOS Limit of Shunt
- AHB Emergency Telephone
- Milepost

Diagram showing track and signalling with key markers.

- Reading
- Westbury
- Up Westbury
- Down Westbury
- Overbridge Tyle Mill Rd
- 42m 67c
- Ufton Level Crossing (AHB)
- 43m 39c
- Limit of Shunt
- Milepost
- Signal
- LOS Limit of Shunt
- AHB Emergency Telephone

Additional annotations:
- Milepost
- Signal
- LOS Limit of Shunt
- AHB Emergency Telephone

The diagram illustrates the track layout and signalling points relevant to the Ufton Level Crossing incident.
Fig. 2  Disposition of Concrete Road Units and Flange Marks
F (cont.) Diagrams

Fig. 3  Gear Case and Traction Motor Arrangement

![Diagram of Gear Case and Traction Motor Arrangement]

Fig. 4  Definition of Yaw, Pitch and Roll Motions of Vehicle Bodies and Bogies

![Diagram illustrating yaw, pitch, and roll motions]

Formal Inquiry: Final Report: Ufton Level Crossing Passenger Train Collision with a Road Vehicle and Subsequent Derailment on 6 November 2004
F (cont.) Diagrams

Fig. 5 The progression of the accident from moment of impact with the car

(a) Estimated Position of Vehicles 6.5 Seconds After Impact With Car

(b) Estimated Position of Vehicles 7.9 Seconds After Impact With Car

(c) Estimated Position of Vehicles Between 7.9 & 8.8 Seconds After Impact With Car
F (cont.) Diagrams

Fig. 5 (cont.) The progression of the accident from moment of impact with the car.

- (d) Estimated Position of Vehicles 8.8 Seconds After Impact With Car
- (e) Estimated Position of Vehicles 11.3 Seconds After Impact With Car
Fig. 6  Final Position of Derailed Vehicles

Note:
All measurements are from the point of derailment (POD) on the level crossing.

Key

- Signal
- Bogie

Note: Colours of coaches and bogies correspond.
F (cont.) Diagrams

Fig. 7 Diagrammatic Representation of Relative Positions of Train and Car at Impact
F (cont.) Diagrams

Fig. 8 Coach Drawgear and Coupler Assembly
Fig. 9  Coach Centre Pivot Assembly
Fig. 10  The Behaviour of a Passenger Constrained by a Seat Belt Under High Longitudinal Deceleration

(a)  No seat belt
(b)  Three-point seat belt
(c)  Lap seat belt
Fig. 1  Leading Power Car (AEAT Photograph)

Fig. 2  Leading Power Car and Coaches H and G (FGW Photograph)
G (cont.) Photographs

Fig. 3  Coaches G, H and Leading Power Car on left. Coach E on right (AEAT Photograph)

Fig. 4  Coach H on left. Coach E on right (FGW Photograph)
G (cont.) Photographs

Fig. 5  Coach F (FGW Photograph)

Fig. 6  Coach D (FGW Photograph)
G (cont.) Photographs

Fig. 7  Coaches A and B1 (FGW Photograph)

Fig. 8  Rear Power Car and Coaches A, B1 and B2 (FGW Photograph)
G (cont.) Photographs

Fig. 9  Ufton Level Crossing (Network Rail Photographs)
(a) The position of advance crossing sign

(b) The position of ‘phone for permission to cross’ sign
G (cont.) Photographs
(c) Crossing with the barriers raised

(d) Crossing with the barriers lowered
G (cont.) Photographs

Fig. 10  Mazda 323 on Level Crossing During the Reconstruction of the Accident (Network Rail Photograph)

Note: For the purposes of the reconstruction of the accident, the car was driven by an officer of the BT Police.
FIG. 11 Damage to Concrete Road Units (AEAT Photograph)

Direction of travel

Right-hand rail

Flange climbs on top of crossing unit with metal face

Increasing damage to crossing unit on gauge-side of right-hand rail at Sleeper –3.
G (cont.) Photographs

Fig. 12   Typical Manually Operated Barrier Crossing
G (cont.) Photographs

Fig. 13 AHB Emergency Telephone (Network Rail Photographs)

(a) Illuminated backlight legend panel

(b) Illuminated Call button engraved ‘Press’
G (cont.) Photographs
Fig. 13 (cont.) AHB Emergency Telephone
(c) Legend details on the illuminated panel at the telephone at Ufton level crossing

Details of the Telephone
The telephone is supplied with a 75mm square LED backlight illuminated panel. A legend sheet is provided in which the instructions for telephone operation are provided. This legend sheet is visible only when the telephone case is open.
A sealed, illuminated tactile pushbutton engraved ‘Press’ is also provided.
G (cont.) Photographs

Fig. 14  Emergency Hammer (FGW Photograph)

Fig. 15  Heavy Lifting Crane (FGW Photograph)
H (cont.) Charts and Tables

Fig. 2 Crossing Flow Chart

![Flow Chart Image]

Source: Network Rail Code of Practice RT/E/C/11600 – Signalling & Operational Telecommunications – Page X18
### Numbers of Crossings According to Type

**Figures as at April 2003**

<table>
<thead>
<tr>
<th>Type of Crossing</th>
<th>Number of crossings</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHB (Automatic Half Barrier)</td>
<td>470</td>
</tr>
<tr>
<td>AOCL (Automatic open locally monitored)</td>
<td>140</td>
</tr>
<tr>
<td>ABCL (Automatic barrier locally monitored)</td>
<td>45</td>
</tr>
<tr>
<td>MG/B (Manual gate/barrier (including CCTV monitored crossings))</td>
<td>864</td>
</tr>
<tr>
<td>UWC+MWL (User worked with mini warning lights)</td>
<td>155</td>
</tr>
<tr>
<td>UWC+T (User worked with phone)</td>
<td>1617</td>
</tr>
<tr>
<td>UWC (User worked other)</td>
<td>2290</td>
</tr>
<tr>
<td>OC (Open crossings)</td>
<td>60</td>
</tr>
<tr>
<td>FP (Footpath crossings)</td>
<td>2546</td>
</tr>
</tbody>
</table>

**Source:** RSSB *Road Vehicle Level Crossings – Special Topic Report – January 2004*

### Numbers of AHBs at the Time of the Ufton Accident According to Line Speed

The following table gives a breakdown of AHB crossings on Network Rail infrastructure by line speed.

<table>
<thead>
<tr>
<th>Speed</th>
<th>LNE</th>
<th>LNW</th>
<th>SC</th>
<th>SE</th>
<th>W</th>
<th>Grand Total</th>
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<tbody>
<tr>
<td>100</td>
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<td>3</td>
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<td></td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**Grand Total** | 189 | 23 | 28 | 173 | 45 | 458 |

**Source:** Network Rail

*Formal Inquiry: Final Report: Ufton Level Crossing Passenger Train Collision with a Road Vehicle and Subsequent Derailment on 6 November 2004*
**Fig. 5** Trains Striking Road Vehicles at Level Crossings

<table>
<thead>
<tr>
<th>Year</th>
<th>All crossings</th>
<th>AHB</th>
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<tbody>
<tr>
<td>1999</td>
<td>22</td>
<td>5</td>
</tr>
<tr>
<td>2000</td>
<td>17</td>
<td>6</td>
</tr>
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<td>17</td>
<td>4</td>
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<td>2002</td>
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<td>5</td>
</tr>
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<td>2003</td>
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<td>6</td>
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<tr>
<td>2004</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>110</td>
<td>29</td>
</tr>
</tbody>
</table>

Source: RSSB SMIS – November 2004

**Fig. 6** Derailments of Trains Striking Road Vehicles at Level Crossings

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Train Type</th>
<th>Fatalities</th>
<th>Major Injuries</th>
<th>Minor Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>08-Feb-92</td>
<td>Dimmocks Cote</td>
<td>Passenger</td>
<td>0</td>
<td>13</td>
<td>32</td>
</tr>
<tr>
<td>02-Apr-92</td>
<td>Mucking</td>
<td>Passenger</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>28-Nov-92</td>
<td>Wokingham Star Lane</td>
<td>Passenger</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<tr>
<td>21-Sep-94</td>
<td>Pitsea Gardeners</td>
<td>Passenger</td>
<td>1</td>
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<td>0</td>
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<tr>
<td>11-Mar-98</td>
<td>Swineshead</td>
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<td>Pooley Green</td>
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<td>15-Apr-02</td>
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<td>Passenger</td>
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<tr>
<td>07-Dec-02</td>
<td>Six Mile Bottom</td>
<td>Passenger</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>31-Jan-03</td>
<td>Fishbourne</td>
<td>Passenger</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>20-Sep-03</td>
<td>Chapel</td>
<td>Passenger</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: RSSB SMIS – November 2004
H (cont.) Charts and Tables

Fig. 7  Road Vehicle Occupant and Pedestrian Level Crossing Fatalities

![Graph showing trend in road vehicle fatalities, pedestrian fatalities, and total fatalities from 1992 to 2004.]

Source: RSSB Annual Safety Performance Report 2004

Fig. 8  International Comparisons

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Netherlands</td>
<td>155</td>
<td>10.3</td>
</tr>
<tr>
<td>Portugal</td>
<td>120</td>
<td>8.1</td>
</tr>
<tr>
<td>Belgium</td>
<td>73</td>
<td>6.1</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>4</td>
<td>5.4</td>
</tr>
<tr>
<td>Germany</td>
<td>456</td>
<td>3.4</td>
</tr>
<tr>
<td>France</td>
<td>262</td>
<td>2.6</td>
</tr>
<tr>
<td>Finland</td>
<td>53</td>
<td>2.0</td>
</tr>
<tr>
<td>Great Britain</td>
<td>45</td>
<td>1.1</td>
</tr>
<tr>
<td>Sweden</td>
<td>48</td>
<td>1.0</td>
</tr>
<tr>
<td>Ireland</td>
<td>2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Fig. 9   Suicides at Level Crossings

Suicides

Source:   RSSB SMIS – November 2004
Fig. 10  Managing Risk

Determine cost

Intolerable

MODIFY CROSSING

Evaluate level crossing user risks

ALARP

Cost benefit analysis

Gross Disproportion

ALARP SATISFIED

Cost Benefit Attractive

MODIFY CROSSING

Identify options to reduce risk

Identify options to reduce risk

Determine value to prevent fatality and safety benefit of each option

Determine value to prevent fatality and safety benefit of each option

Determine cost effective ways of reducing risks to tolerable levels

Modify crossing

Identify effective options to reduce risk

Identify effective options to reduce risk

Compare risks to criteria

Source: Network Rail
### Ufton Risk Assessment

#### Level Crossing Model Results

**Ufton**

**Automatic Half Barrier**

<table>
<thead>
<tr>
<th>Location</th>
<th>BHL 43m 39ch</th>
<th>Ufton Lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
<td>SU 616 688</td>
<td></td>
</tr>
<tr>
<td>Notes:</td>
<td>Abuse: Enter any additional information such as history of abuse, effect of any mitigation measures that have been installed. Default user abuse calculations. Approach: Foliage, Long &amp; straight from A4 road to level crossing but bend on the other side of crossing.</td>
<td></td>
</tr>
</tbody>
</table>

#### Frequency of Incidents

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Frequency of accident</th>
<th>Frequency of Derailment</th>
<th>Frequency of no Derailment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>1.28E-03</td>
<td>3.84E-06</td>
<td>1.28E-03</td>
</tr>
<tr>
<td>Van/Small lorry</td>
<td>9.59E-04</td>
<td>2.88E-06</td>
<td>9.56E-04</td>
</tr>
<tr>
<td>Bus</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
</tr>
<tr>
<td>HGV</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
</tr>
<tr>
<td>Cyclist</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
</tr>
<tr>
<td>Tractor</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
</tr>
</tbody>
</table>

#### Injury to public following collision with train

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Fatality</th>
<th>Serious Injury</th>
<th>Minor Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>1.03E-03</td>
<td>1.92E-04</td>
<td>6.41E-05</td>
</tr>
<tr>
<td>Van/Small lorry</td>
<td>7.67E-04</td>
<td>1.44E-04</td>
<td>4.79E-05</td>
</tr>
<tr>
<td>Bus</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
</tr>
<tr>
<td>HGV</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
</tr>
<tr>
<td>Cyclist/Motorcyclist</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
</tr>
<tr>
<td>Tractor</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
</tr>
<tr>
<td>Total Vehicle</td>
<td>1.79E-03</td>
<td>3.36E-04</td>
<td>1.12E-04</td>
</tr>
<tr>
<td>Pedestrian + Cycles + Motorcycle</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
</tr>
</tbody>
</table>
### Frequency of vehicle collision

**Annual frequency**

<table>
<thead>
<tr>
<th></th>
<th>Frequency of Vehicle Collisions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Derailment</td>
<td>6.72E-06</td>
</tr>
<tr>
<td></td>
<td>No Derailment</td>
<td>2.23E-03</td>
</tr>
</tbody>
</table>

### Injury to passengers following collision at level crossing

**Annual frequency**

<table>
<thead>
<tr>
<th></th>
<th>Fatality</th>
<th>Serious Injury</th>
<th>Minor Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Derailment</td>
<td>9.52E-06</td>
<td>1.38E-04</td>
<td>2.86E-04</td>
</tr>
<tr>
<td>No Derailment</td>
<td>1.58E-05</td>
<td>4.75E-05</td>
<td>9.49E-05</td>
</tr>
</tbody>
</table>

### Injury to staff following collision at level crossing

**Annual frequency**

<table>
<thead>
<tr>
<th></th>
<th>Fatality</th>
<th>Serious Injury</th>
<th>Minor Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Derailment</td>
<td>6.72E-06</td>
<td>1.34E-05</td>
<td>1.34E-05</td>
</tr>
<tr>
<td>No Derailment</td>
<td>2.23E-04</td>
<td>6.70E-04</td>
<td>1.34E-03</td>
</tr>
</tbody>
</table>

### Total Injury Following Crossing Accident

**Annual frequency**

<table>
<thead>
<tr>
<th></th>
<th>Fatality</th>
<th>Serious Injury</th>
<th>Minor Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle User</td>
<td>1.79E-03</td>
<td>3.36E-04</td>
<td>1.12E-04</td>
</tr>
<tr>
<td>Pedestrian + Cycle + Motorcycle</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
</tr>
<tr>
<td>Passenger</td>
<td>2.53E-05</td>
<td>1.86E-04</td>
<td>3.81E-04</td>
</tr>
<tr>
<td>Staff</td>
<td>2.30E-04</td>
<td>6.83E-04</td>
<td>1.35E-03</td>
</tr>
</tbody>
</table>

**Total Equivalent Fatalities** | 2.18E-03

### Individual Risk at Level Crossing for Regular User

<table>
<thead>
<tr>
<th></th>
<th>Risk</th>
<th>Risk 1 in ..</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Users</td>
<td>1.1E-05</td>
<td>88,000</td>
</tr>
<tr>
<td>Pedestrians</td>
<td>N/A</td>
<td>no pedestrians</td>
</tr>
<tr>
<td>Passengers</td>
<td>8.2E-09</td>
<td>120,000,000</td>
</tr>
<tr>
<td>Staff</td>
<td>1.3E-06</td>
<td>760,000</td>
</tr>
</tbody>
</table>
Automatic Level Crossing Model - Cost Benefit EXAMPLE

Supplement to Automatic Level Crossing User Guide

Date: 21 September 2004

Crossing Name

Ufton AHB – Using V3.1 model information obtained 8.7.04, Current Individual Risk of Fatality per year for (vehicle) user's is 1 in 88k.

Modification / upgrade description

CONVERT TO CCTV

Method

Assess whether risk is ‘intolerable’ (ie worse than 1 in 10,000)

1. Firstly where is the crossing against the ALARP criteria? If the risks are ‘intolerable’ then the risks must be reduced at all costs. Otherwise, cost benefit analysis can be used to support decision making.

| Individual Risk of Fatality per year for User |
|-----------------|-----------------|-----------------|
| Road User       | Pedestrian User  |                  |
| 1 in 10,000     | 1 in 100,000    | 1 in 1,000,000  |
| 10^{-4}         | 10^{-5}         | 10^{-6}         |
| Intolerable     | Risks are Tolerable Providing they are Reduced 'ALARP' |
| Tolerable       |                  |
| 1 in 88,000     | 1 in 100,000    | 1 in 1,000,000  |
| 2.18E-03 (0.00218) Eq. fats /yr | A |

Determine cost benefit of mitigation (for risks in ALARP region)

2. Run the base case risk assessment for the crossing as it is now. Record the equivalent fatalities per year:

3. Estimate the risk of the crossing after the upgrade / modification (equivalent fatalities per year).
4. Calculate the safety benefit of the upgrade / modification (equivalent fatalities per year) from (A) – (B):

\[(0.00218) - (0.000251) = 0.001929\]  

5. Record the number of years that the modification or upgrade will apply for:

<table>
<thead>
<tr>
<th>Years</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

6. Choose a suitable VPF (available from Railway Group Safety Plan – 2004/05 is £1.36M for single fatalities, to £3.81M for multiple fatality events or risks towards the upper limit of ALARP):

<table>
<thead>
<tr>
<th>VPF</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>£1.36M</td>
<td></td>
</tr>
</tbody>
</table>

7. Calculate safety benefit (in terms of £) of the upgrade / modification over its life from (C) x (D) x (E):

\[(0.001929) \times (25) \times (1,360,000) = £65,586\]  

8. Calculate the total cost of the upgrade / modification (include capital cost of equipment, and any maintenance or ongoing costs over the life):

<table>
<thead>
<tr>
<th>Cost</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>£1m</td>
<td></td>
</tr>
</tbody>
</table>

9. Compare the costs (G) with the safety benefits (F) (tick one):

- Costs are significantly less than safety benefits – project can be justified on cost benefit terms
- Costs are similar to safety benefits – project may be justified consider other factors
- Costs (G) are significantly greater than safety benefits (F) – project cannot be justified on cost benefit terms

<table>
<thead>
<tr>
<th>Costs</th>
<th>Yes</th>
</tr>
</thead>
</table>

**Conclusion**

In this case the estimated safety benefits (£65,586) are significantly lower than the costs of the up-grade (£1m) suggesting that conversion to CCTV is not justified although conversion to CCTV would have taken the ADL risk from 1 in 88k to 1 in 760k.
K Remit for NLXSG

To develop a level crossing awareness programme which, when developed, will ensure that:

1. Those responsible for the broad planning environment in which level crossings sit understand the road and railway safety risks.

2. Those who use level crossings on public highways understand the contribution they can make towards proper behaviour.

3. Those who provide level crossings are aware of their duties and responsibilities for correct operation of crossings.

4. Those who have responsibilities when there are usage violations can progress the successful prosecution of offenders.

In advancing awareness, the group will work within the concept of the USA “Operation Lifesaver”, to ensure education is not seen in isolation, but is a component of a control strategy including education, engineering and enforcement, and the group will support the development of a wider enabling strategy to permit this to happen.
(This page has been left intentionally blank)
<table>
<thead>
<tr>
<th>PROJECT TITLE</th>
<th>DESCRIPTION</th>
<th>STATUS AS AT NOVEMBER 2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic Level Crossing Risk Model</td>
<td>Development of a model to cover the risk at automatic level crossings (AOCL / ABCL / AHB).</td>
<td>Version three now in use by Network Rail</td>
</tr>
<tr>
<td>User Worked and Footpath Level Crossing Research</td>
<td>Understanding risk relating to user-worked and footpath level crossings by surveying 300 crossings, interviewing users and analysing accident data. Proposing improved risk control measures, incident reporting and data collection.</td>
<td>Published</td>
</tr>
<tr>
<td>Human factors risk at user worked crossings</td>
<td>Gaining a better understanding of human behaviour at user worked crossings and identifying contributory factors to risk at the crossings. Evaluating potential risk reduction measures.</td>
<td>Published</td>
</tr>
<tr>
<td>Wayside horns at level crossings</td>
<td>Establishing the best way to deliver audible warnings to crossing users should noise bans make it impossible to rely on horns operated by train drivers.</td>
<td>Stage one complete</td>
</tr>
<tr>
<td>Development of a universal level crossing risk tool</td>
<td>Developing a risk tool to encompass all crossings, including user worked crossings. This builds on the successful development and implementation of such a tool for automatic crossings.</td>
<td>Stage two about to start</td>
</tr>
<tr>
<td>Improving level crossing information systems</td>
<td>Improving Network Rail's national level crossing information database - ALRMS. Assessing user and stakeholder requirements, the strengths, weaknesses, and opportunities to upgrade the system, to manage level crossing risk better.</td>
<td>Stage two in development</td>
</tr>
<tr>
<td>Trials of median strips / lane separators at level crossings</td>
<td>Determining whether the provision of road median strips at the approaches to AHB level crossings would assist in the prevention of accidents caused by drivers violating the crossing controls.</td>
<td>Stage three in progress</td>
</tr>
</tbody>
</table>
### M (cont.) Level Crossing Research Projects

<table>
<thead>
<tr>
<th>PROJECT TITLE</th>
<th>DESCRIPTION</th>
<th>STATUS AS AT NOVEMBER 2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investigating level crossing upgrade costs in Britain and abroad</td>
<td>Investigating the costs of upgrading level crossings and how to achieve increased safety at crossings for lower cost. Comparing UK and overseas experience.</td>
<td>Final report due early December</td>
</tr>
<tr>
<td>Reducing the risk to motorists traversing user worked crossings on foot</td>
<td>Examining technical solutions, to risk reduction at user worked crossings. Users are currently required to traverse the crossing four times on foot to open and close gates.</td>
<td>Work started</td>
</tr>
<tr>
<td>Evaluating best practice deterrence and enforcement mechanisms at level crossings</td>
<td>Understanding best practice in the application of red light cameras, car number recognition, CCTV and other systems and fixed penalty regimes, as deterrent and enforcement mechanisms at level crossings.</td>
<td>To start in December</td>
</tr>
<tr>
<td>Understanding the risk at station and barrow crossings</td>
<td>Examining the requirements for the use of station and barrow crossings to traverse the track. Assessing current safety controls, and the scope of procedural or technical innovation to reduce risk.</td>
<td>To start in December / January</td>
</tr>
<tr>
<td>Modelling the economics of level crossing closures and conversions</td>
<td>Understanding the roadside and railside economics of crossings. Developing an economic model for making business cases for crossing closures or conversions to bridges over (or exceptionally, under) the railway.</td>
<td>To start in January</td>
</tr>
<tr>
<td>Improving road user and pedestrian behaviour at level crossings</td>
<td>Understanding offender, violator and error behaviour by road users and pedestrians at level crossings. Evaluating alternative technological remedies, such as signage, cameras, road markings and traffic calming.</td>
<td>To start in February</td>
</tr>
</tbody>
</table>
## Glossary of Terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>A&amp;E</td>
<td>Accident and Emergency</td>
</tr>
<tr>
<td>AEAT</td>
<td>AEA Technology Rail</td>
</tr>
<tr>
<td>AHB</td>
<td>Automatic Half Barrier</td>
</tr>
<tr>
<td>ALARP</td>
<td>As Low As Reasonably Practicable</td>
</tr>
<tr>
<td>ATD</td>
<td>Anatomical Test Device</td>
</tr>
<tr>
<td>ATOC</td>
<td>Association of Train Operating Companies</td>
</tr>
<tr>
<td>BR</td>
<td>British Rail</td>
</tr>
<tr>
<td>BTP</td>
<td>British Transport Police</td>
</tr>
<tr>
<td>CCTV</td>
<td>Closed Circuit Television</td>
</tr>
<tr>
<td>FGW</td>
<td>First Great Western</td>
</tr>
<tr>
<td>Four-foot</td>
<td>The space between the running rails of the track</td>
</tr>
<tr>
<td>GNER</td>
<td>Great North Eastern Railway</td>
</tr>
<tr>
<td>GRP</td>
<td>Glass Reinforced Polyester</td>
</tr>
<tr>
<td>HMRI</td>
<td>Her Majesty’s Railway Inspectorate</td>
</tr>
<tr>
<td>HSC</td>
<td>Health and Safety Commission</td>
</tr>
<tr>
<td>HSE</td>
<td>Heath and Safety Executive</td>
</tr>
<tr>
<td>HST</td>
<td>High Speed Train</td>
</tr>
<tr>
<td>ITL</td>
<td>Interfleet Technology Limited</td>
</tr>
<tr>
<td>kN</td>
<td>Kilonewton (One thousand Newtons)</td>
</tr>
<tr>
<td>LED</td>
<td>Light Emitting Diode</td>
</tr>
<tr>
<td>MJ</td>
<td>Megajoule (One million Joules)</td>
</tr>
<tr>
<td>MOM</td>
<td>Mobile Operations Manager</td>
</tr>
<tr>
<td>NLXSG</td>
<td>National Level Crossing Safety Group</td>
</tr>
<tr>
<td>OTMR</td>
<td>On-Train Monitoring Recorder</td>
</tr>
<tr>
<td>PETS</td>
<td>Public Emergency Telephone System</td>
</tr>
<tr>
<td>RIO</td>
<td>Rail Incident Officer</td>
</tr>
<tr>
<td>RSSB</td>
<td>Rail Safety and Standards Board</td>
</tr>
</tbody>
</table>