RAIB

Rail Accident Investigation Branch

Rail Accident Report

Derailment of a Docklands Light Railway train, near Deptford Bridge station, London 4 April 2008

Department for Transport

Report 16/2009
June 2009

This investigation was carried out in accordance with:

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

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Introduction

Preface

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

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

Key Definitions

3 A Docklands Light Railway (DLR) train consists of two cars coupled together. A car consists of two articulated coaches that are supported by three *bogies* and are permanently coupled together. The centre bogie supports both coaches. One end of the car is known as end 'A' and the other end is known as end 'B'.

4 This report makes use of the terms 'left' and 'right' rails. These terms are used in relation to the direction of travel of the train that derailed.

5 The DLR lines between Greenwich and Lewisham are known as the up and down Lewisham lines. The up line is normally used by trains travelling towards Greenwich station from Lewisham and the down line is normally used by trains in the opposite direction.

6 Appendices at the rear of this report contain the following glossaries:

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

Summary of the report

Key facts about the accident

7 At 05:22 hrs on 4 April 2008, the 05:19 hrs Docklands Light Railway service from Lewisham had just left Deptford Bridge station, travelling towards Greenwich, when it struck a *drilling jig* that had been left on the track and became derailed (Figure 1).

8 There were no injuries to the 59 persons on board the train.

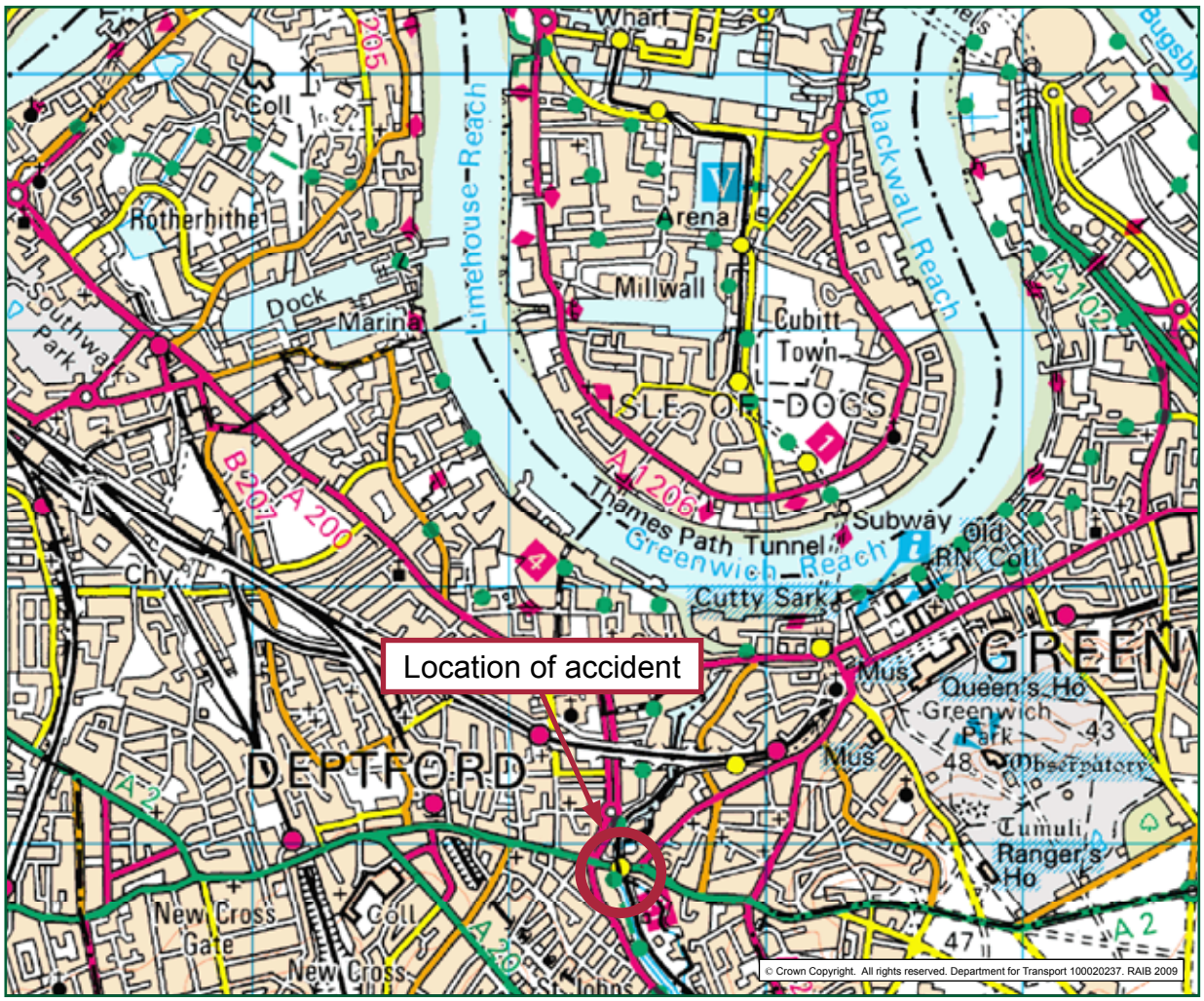

Figure 1: Extract from Ordnance Survey map showing location of accident

Immediate cause, causal and contributory factors

9 The immediate cause of the accident was that the DLR train struck a drilling jig that had been left across the running rail, and derailed.

10 Causal factors were:

- the *Person In Charge Of Work*, (PICOW) and the other drillers did not realise that the drilling jig had been left at site across a running rail;
- there was no procedure requiring a systematic check that all equipment representing a derailment risk was accounted for;
- the PICOW did not undertake a systematic and adequate check of the work site; and
- the site working lights were switched off before items on the track were cleared, leaving the area in darkness.

11 The following factors were contributory:

- the PICOW involved was not adequately supervised or monitored when undertaking his duties;
- the senior PICOW did not undertake any formal monitoring and auditing of the PICOWs; and
- the drilling jig was not conspicuous in poor lighting.

Recommendations

12 Recommendations can be found in paragraph 278. They relate to the following areas:

- Five recommendations have been made to Serco Docklands. These cover the areas of:
  - reviews of its competency management system, its operational safety management systems, its current rules and procedures; and
  - identifying safety process indicators.
- Four recommendations have been made to Docklands Light Railway Ltd. These cover the areas of:
  - the implementation of processes to improve visibility of equipment representing a derailment risk;
  - modification to control centre systems;
  - the role of sweep trains; and
  - the production of a DLR common rule book and procedures.
- Two recommendations have been made to Carillion JM Ltd. These cover the areas of:
  - the role of the senior PICOW; and
  - method statements being up-to-date for the work being carried out.

The Accident

Summary of the accident

13 At 05:22 hrs on 4 April 2008, the 05:19 hrs Docklands Light Railway service from Lewisham had just left Deptford Bridge station, travelling towards Greenwich on the up line (paragraph 5), when it struck an object on the track and became derailed by the second axle of the first bogie. The front of the train came to rest 88 metres after hitting the object (Figure 2).

14 The train, which was the first train of the day from Lewisham, was under the control of its on-board computer (automatic mode of operation). The object on the track was found to be a steel drilling jig that had been in use during engineering activities earlier that morning.

15 There were no injuries to the 59 persons on board the train and all were evacuated safely back to Deptford Bridge station.

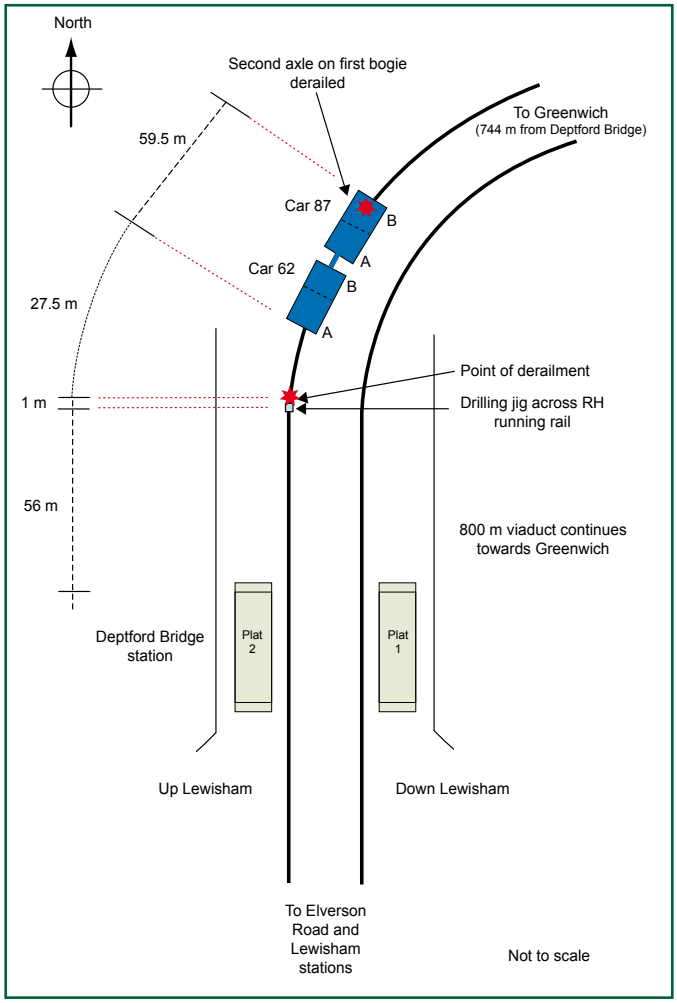

Figure 2: Diagram of the location of the accident north of Deptford Bridge station (A and B refer to the ends of each car [paragraph 3])

The parties involved

16 Docklands Light Railway Ltd is part of Transport for London (TfL) and owns the assets of the railway with the exception of the infrastructure within the concessionaires' areas. Docklands Light Railway Ltd oversees the operation of the railway and plans for the future development of the railway to meet the needs of the area. Docklands Light Railway Ltd manages the franchise and concessionaires' contracts to ensure that services are provided and the assets are maintained.

17 Serco Docklands has been the franchise operator for Docklands Light Railway Ltd since April 1997. Serco Docklands operates the whole of the railway and provides maintenance services for specific areas of the network. In May 2006, Serco Docklands was awarded a renewed seven year franchise.

18 Serco Docklands employed the *passenger service agent* on-board the train and the *control centre controller* involved in this accident. They also employed control centre supervisors and control centre technicians.

19 City Greenwich Lewisham Rail plc is a concessionaire. City Greenwich Lewisham Rail plc designed, financed, built and maintains the Lewisham extension. The extension is from Mudchute station (in the north) to Lewisham station in the south.

20 City Greenwich Lewisham Rail plc approved the method statement for the work that was undertaken on the evening of 3 April 2008. City Greenwich Lewisham Rail plc employed a *control room operator* at their Norman Road headquarters.

21 Light Rail Group contractors, a non-integrated joint venture between John Mowlem Construction plc, MBK Rail Link Construction Ltd and Nishimatsu Construction Co Ltd was formed for the specific purpose of constructing the Lewisham extension of the Docklands Light Railway on behalf of City Greenwich Lewisham Rail plc. Work commenced on the construction of the extension in October 1996.

22 The construction project was completed in December 1999. Carillion JM Ltd acquired Mowlem in February 2005 and assumed all responsibilities for the Mowlem part of the construction entity of Light Rail Group contractors. This involved carrying out maintenance and remedial work on the Lewisham extension infrastructure.

23 Carillion JM Ltd wrote the method statement for the work that was undertaken near Deptford Bridge station on the evening of 3 April.

24 Carillion JM Ltd employed the PICOW involved in the accident. The PICOW had come from Derryard Construction Ltd as an agency worker.

25 Quality Site Testing Ltd was sub-contracted by Carillion JM Ltd to undertake the drilling works in the Deptford Bridge area. Quality Site Testing Ltd employed two drillers involved in the accident. Another of the drillers, who also operated the drilling jig, had been contracted by Quality Site Testing Ltd through Coyle Personnel plc, an agency.

26 Docklands Light Railway Ltd, Serco Docklands, City Greenwich Lewisham Rail plc, Carillion JM Ltd and Quality Site Testing Ltd freely co-operated with the investigation.

Location

27 The accident took place on the up (Lewisham) line between Deptford Bridge station and Greenwich station (Figure 2). At this location the track is level and constructed on an 800 m long viaduct, approximately 7 m above ground level. The viaduct has wooden fencing (at track level) on both sides which is approximately 1.8 m tall.

External circumstances

28 At the time of the accident at 05:22 hrs, the weather was dry and it was dark.

The DLR driverless system

29 The entire DLR network operates as a driverless system.

30 The railway utilises a fully automatic train control system, which is monitored by the permanently staffed control centre at Poplar. The signalling system is based on the *moving block* (Seltrac) system developed by Alcatel (Canada). It works on the principle of controlling the separation between trains and so permits a very intensive train service to be operated.

31 Trains are constantly monitored by the vehicle control computer system, which compares the position of each train with a stored schedule. The train's on-board computer constantly communicates with the central computer and if this transmission is broken the train will stop until given authorisation to continue. Information is passed to the train to open its doors on the platform side together with the required information to continue with adjustments in speed to maintain the schedule.

32 The system is equipped with Automatic Train Protection, a mode of operation in which the train runs in its own safety zone which no other train can enter. The system also regulates the maximum speed that the train may operate on any section of the track. The highest normal speed on the railway is 80 km/h. A train running under these conditions is described as being in Automatic Train Operation (ATO) mode.

33 A passenger service agent normally undertakes revenue and ticket duties on-board the trains. He can also drive trains in a manual mode, with all the protection of Automatic Train Protection. In this mode, the passenger service agent drives from the *lead emergency driving position*. This is a control position at the front of the train that allows the passenger service agent an unrestricted view of the line ahead. If the passenger service agent attempted to over speed or depart when a route had not been set, the train's control system would automatically apply the emergency brakes preventing further movement.

34 If the signalling system fails completely, trains may be driven in *emergency shunt* mode, which limits speed to 20 km/h. This may only be used when instructed by the control centre controller, who gives authority for movement to the passenger service agent.

35 The control centre controller has a complete overview of the entire railway and control of all the signalling and points, which he can operate via the system management centre computer system.

36 The control centre controller can also send commands to the train's on-board computer (located on every train) by inputting commands to the vehicle control computer system (such as reduced speeds and increased braking rates).

The sweep procedure

37 The Serco Docklands operating procedure that was current at the time of the accident stated that '*sweep* trains' were to run before the commencement of passenger services each day and therefore run without any passengers on-board. Sweep trains should run in ATO mode, but should travel at a predefined reduced speed that is set by the control centre controller. A passenger service agent should travel at the front of the train in the lead emergency driving position. If any obstructions on the track are seen by the passenger service agent, he should immediately operate the emergency stop button on the console and bring the train to a stop. This was in accordance with Serco Docklands operational procedure, SOP/M-3.11, Issue F.

Events preceding the accident

38 Between 01:15 hrs and approximately 04:00 hrs, engineering work was carried out involving the up line of the viaduct just north of Deptford Bridge station.

39 At approximately 04:05 hrs, the passenger service agent who was due to operate train 87/62[1] signed on for duty at Poplar depot. At 04:44 hrs, while walking towards Poplar station, he undertook a radio check with the control centre controller. On reaching Poplar station at 04:50 hrs, the passenger service agent boarded train 87/62 at platform 3. While undertaking his initial setup duties he received a call from the control centre controller giving him his instructions.

40 The instruction given by the control centre controller was that the passenger service agent should operate his train as a sweep train from Poplar to Lewisham and **also** on the return journey. The passenger service agent responded to the instruction by stating that he would sweep from Poplar to Lewisham. However, he said that he would operate the train in normal ATO mode for the return from Lewisham. The control centre controller did not correct the passenger service agent or re-iterate that he should be sweeping back from Lewisham.

41 A further instruction from the control centre controller informed the passenger service agent that his train would stop short at Elverson Road station (due to an indication to the control centre controller that the line was possibly blocked ahead) and that when it did, the passenger service agent should contact the control centre controller for further instructions.

42 At 04:55 hrs, train 87/62 departed from Poplar station. The passenger service agent was travelling at the A end of car 62 in the lead emergency driving position and observing the track ahead. When the train arrived at Elverson Road station at 05:12 hrs, the train stopped and the passenger service agent contacted the control centre controller for further instructions.

[1] Train 87/62 was made up of two cars.

43 The further instructions from the control centre controller were that the passenger service agent should:

- select emergency shunt and proceed to Lewisham platform 6; and
- select ATO at Lewisham.

44 The passenger service agent repeated the instructions and confirmed his understanding that normal ATO was to be selected at Lewisham for the return journey. The control centre controller listened to this and terminated the conversation. At no time during this final conversation was the instruction to sweep back from Lewisham reiterated by the control centre controller to the passenger service agent.

45 The passenger service agent selected emergency shunt and drove train 87/62 to Lewisham station. At Lewisham, the passenger service agent selected normal ATO and reboarded the train at the B end of car 87 (the leading car of the train now facing towards Greenwich). The passenger service agent stood at the second set of doors and undertook his door duties as normal. He did not stand or sit at the front of the train in the lead emergency driving position to observe the track ahead.

46 At 05:19 hrs, train 87/62 left Lewisham station under normal ATO control. Three minutes later, the train arrived in the up platform at Deptford Bridge station. Closed Circuit Television (CCTV) cameras at the station showed that passengers got onto the train.

Events during the accident

47 At 05:22:43 hrs, the train departed from Deptford Bridge station and accelerated northwards towards Greenwich.

48 At 05:22:53 hrs, the train hit an obstruction on the right-hand running rail and, after travelling a further metre, the second axle of the first bogie derailed.

49 The passenger service agent, on feeling the train moving violently up and down, inserted his door key into the door control panel and turned the key to inhibit the train movement. This applied the emergency brakes on the train.

50 The train was travelling at approximately 37 km/h. This was higher than the speed restriction that should have applied to this section of track at the time (paragraph 70).

51 The train travelled 87 metres after derailing, and came to a stand at 05:23:05 hrs.

52 The train's emergency brakes were applied 5 seconds (54 metres) after the train hit the obstruction. The train took 7 seconds (34 metres) to stop after the brakes applied.

53 The obstruction on the track was found to be a steel drilling jig that had been in use during engineering activities the previous night.

54 The location of the drilling jig (before it was hit by the train) was 56 metres north of platform no.2, placed across the right-hand running rail.

55 The train derailed towards the left of the running rail (in the direction of travel). The derailed wheels did not infringe or damage the *derailment containment* shown in Figure 3.

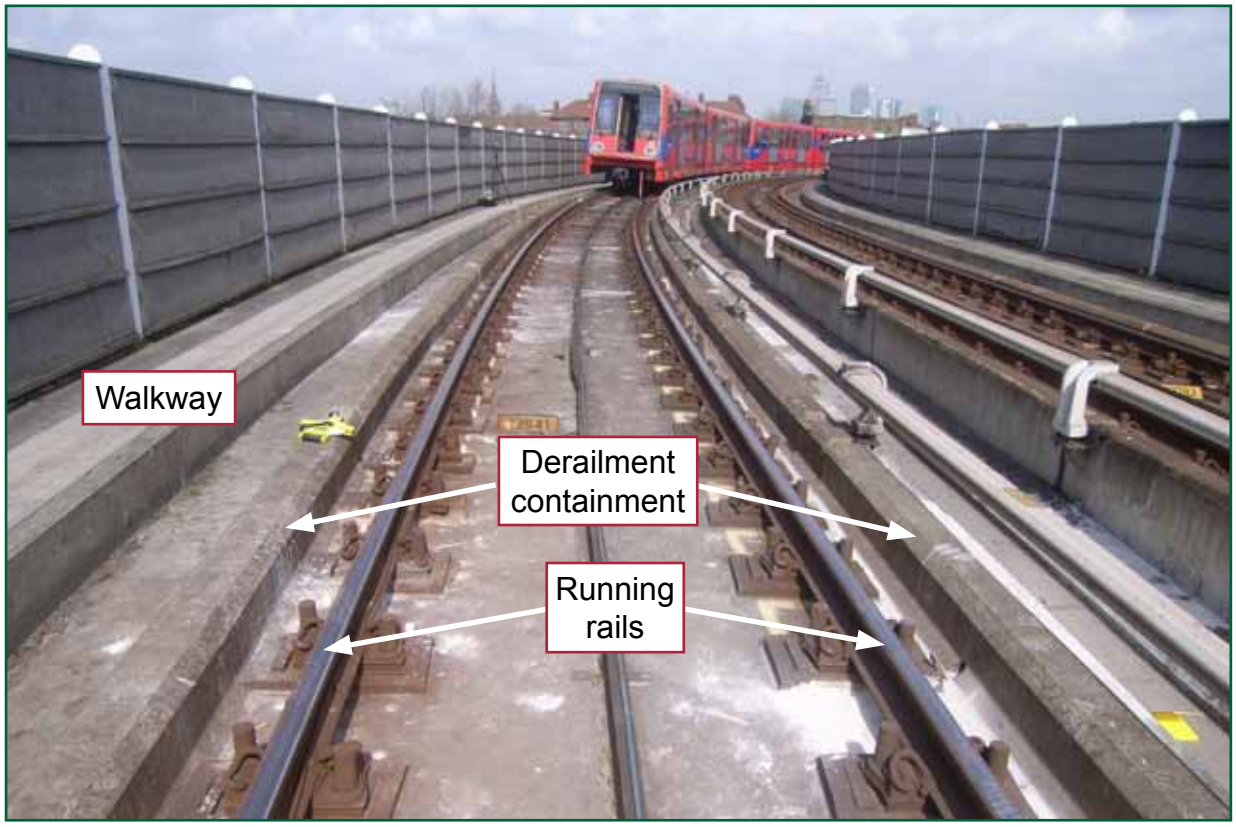

Figure 3: The Lewisham extension showing running rails and concrete derailment containment

Events following the accident

56 When the train had stopped, the passenger service agent immediately called the control centre controller to report the situation. He was advised to move the passengers back into car 62, which was the nearest to Deptford Bridge station, which he did.

57 At 05:23:27 hrs, 22 seconds after the derailed train stopped, a train on the opposite line, travelling towards Lewisham, passed by the derailed train. The passenger service agent on this train was unaware of the situation on train 87/62.

58 At 05:40 hrs, two members of Serco Docklands staff (who had been instructed by the control centre controller) arrived at Deptford Bridge station and confirmed to the passenger service agent and also the control centre controller that the train had been derailed.

59 At 05:53 hrs, the detrainment of the passengers began. All the passengers climbed down a small evacuation ladder from the train to the walkway and walked back towards Deptford Bridge station platform. By 06:03 hrs, all passengers were clear of the train.

60 The derailed train was re-railed at 14:15 hrs and the recovery of the re-railed train 87/62 was completed by 00:30 hrs on 5 April.

Consequences of the accident

61 There were no injuries to the passengers or the passenger service agent on board.

62 There was extensive damage to the track fixings that the derailed wheels had run over. The train also received damage to its underside including stopcocks that were displaced, impact damage to the main air reservoir and damage to other wheels that had ridden over the drilling jig.

63 The main part of the drilling jig was found lying across the *low running rail* in between cars 87 and 62. The remaining part of the jig came to rest under the B end of car 62, i.e. the third coach of the complete train. The damaged drilling jig can be seen in Figure 4.

Figure 4: Drilling jig (damaged as a result of the derailment) shown in its operating position with two drilling guide holes showing on the front edge

64 The drilling jig is a fabricated steel tool which provides location and guidance for drilling one or more holes in precise relationship to a fixed point. A detailed description of why the jig was being used is given in paragraphs 68 to 78.

The Investigation

Investigation process and sources of evidence

65 The incident was notified to the RAIB by Serco Docklands at 07:10 hrs on 4 April 2008.

66 The RAIB attended the accident site on the 4 April and initiated a full investigation.

67 The main sources of evidence used in this investigation were:

- witness interviews and discussions with managers and other staff regarding safety management systems, operational procedures and training;
- data derived from both DLR cars On Train Data Recording (OTDR) systems;
- voice tape recordings from the Serco Docklands control centre;
- CCTV downloads;
- vehicle control computer and system management centre computer system data analysis;
- photographs and measurements from the site;
- site testing of DLR trains stopping distances and visibility tests (for objects on the track) at Deptford Bridge station;
- control centre site observations during vehicle control computer *re-boots* and control centre controllers' handover; and
- review of Serco Docklands and Alcatel documentation.

Key Information

Background

Track defects

68 In the autumn of 2001 defects (cracked *grout pads*) were discovered in the track restraint system on parts of the Lewisham extension and a programme to widen the grout pads was carried out. By the end of 2002 it was believed by City Greenwich Lewisham Rail plc that the defects had been repaired.

69 In the spring of 2003, after a particularly hot period of weather, snapped holding down bolts were discovered in the track restraint system. The failing bolts were found to be on the *high rail* on tight curves.

70 Since then, Carillion JM Ltd in cooperation with City Greenwich Lewisham Rail plc and Serco Docklands have managed the issue by monitoring the track fixings on a regular basis, and have replaced any failed bolts. As a precaution, Serco Docklands have placed a temporary speed restriction of 30 km/h on the relevant section of the viaduct, that includes the curve north of Deptford Bridge station, and *tie bars* have also been installed.

71 Strain gauge monitoring of bolts was also undertaken and the cause of the failure was investigated to establish potential solutions.

72 Carillion JM Ltd sourced suitable replacement track fixings from Pandrol.

73 Installation of the replacement track fixings had been programmed to make maximum use of the *possessions* which had been planned for works to upgrade the system to accommodate longer trains throughout the summer of 2008.

Remedial works on the Lewisham extension

74 Work started on the Lewisham extension with the drilling of holes for the new fixings in mid March 2008. This included the clearing of the concrete surface between the existing rail *baseplates* and the drilling of four holes, by the use of a drilling jig, in preparation for installing the new Pandrol system.

75 The drilling work was undertaken in accordance with a Carillion JM Ltd method statement (approved by City Greenwich Lewisham Rail plc), a Permit to Work and PICOW briefing sheets dated 04/04/08.

76 The method statement stated that a rail trolley mounted drilling jig would be used and that more than one hole would be drilled at the same time. However, to make it easier to get the equipment to and from the site of work, the design of the drilling jig was subsequently modified, but the method statement was not.

77 The actual drilling jig used was not a rail trolley mounted jig, but a handheld steel jig that was placed over the running rail and levelled. The four holes were then drilled one by one with a handheld drill.

78 The drilling jig required two persons to lift it and position it across the running rail.

Actions of the engineering staff using the drilling jig

79 At 23:00 hrs on 3 April 2008, three Quality Site Testing Ltd drillers and the Carillion JM Ltd PICOW met at City Greenwich Lewisham Rail plc headquarters at Norman Road to sign on with the City Greenwich Lewisham Rail plc Control Room operator and to discuss that evening's work.

80 At approximately 00:30 hrs, the drillers and the PICOW arrived at Deptford Bridge station. The PICOW checked that the drillers had their track certification with them and their correct high visibility clothing on, but he did not brief them on any safety or site matters. The PICOW received a radio call at 01:15 hrs from the City Greenwich Lewisham Rail plc control stating that the track electrical power supply was now off and it was safe to begin work.

81 The team then unloaded their equipment onto platform 2. This involved the use of the public lifts, as the railway is approximately 7 m above ground level.

82 Before work commences, the PICOW should carry out a test of the rails to check that the track power supply is switched off. On this evening, the PICOW did not check that the electricity had been turned off.

83 The equipment that they were using included petrol generators which powered the various drills, and also flood lights mounted on a tripod. This tripod was set up on the west side of the up line, and the lights connected to one of the generators. These lights illuminated the work that involved the drilling jig.

84 Between 01:15 hrs and 03:51 hrs on 4 April, the team carried out drilling work for the new baseplate holes in an area approximately 55 m north of Deptford Bridge station on the up line. A diamond driller worked alone initially on the left-hand rail 50 metres north of the main drilling activities and the two other drillers worked as a team using the drilling jig. The PICOW did not take part in any of the work.

85 At 03:51 hrs, the PICOW requested that the three drillers begin to pack up their equipment and immediately began to check that the site was clear. The generators were then switched off. This included the generator that was powering the flood lights.

86 As part of his check, the PICOW walked northwards (and away from all three drillers) in the right-hand side part of the *four foot* (next to the low rail of the up line) to where the diamond driller had initially been, and also to an area of track containing tie bars. His only illumination was the headlamp on his safety hard hat. The PICOW then returned, walking in the left-hand part of the four foot (next to the high rail) and checking that side of the line. By the time the PICOW reached where the drilling had been done, the drillers had placed all of their tools on the walkway. However, the drilling jig was still in place across the low running rail and a small levelling tool was in place on the concrete derailment containment wall next to the jig. These items were not removed from the site.

87 At 03:53 hrs, CCTV evidence shows that a driller arrived on the platform carrying the floodlights and the tripod. These were placed next to the doors of the passenger lift before the driller returned to the work area off the end of the platform ramp.

88 At 03:55 hrs, the PICOW and one of the drillers who had been using the jig arrived on the platform. The PICOW was carrying large water containers and the driller was pushing a wheelbarrow containing a generator and other tools. The two made their way towards the lift and at 03:56 hrs both entered the lift.

89 Neither man returned to the platform or the work area at any other time that morning. At this point in time, the two other drillers were still on the track, and were clearing their tools and equipment onto the platform.

90 At 04:02 hrs two drillers carrying tools walked along the platform and entered the lift. These two drillers did not return to the platform or work area at any other time that morning.

91 When all the team was together again at road level at 04:10 hrs, the PICOW confirmed with the team that the track was clear. The PICOW radioed to City Greenwich Lewisham Rail plc control to confirm that the track was clear of people and tools.

92 The drillers and the PICOW continued packing up their van and drove back to City Greenwich Lewisham Rail plc headquarters to unload some tools and sign off. The Quality Site Testing Ltd drillers finally drove back to their meeting place at Canary Wharf to unload the remaining tools and equipment. When they unloaded the van at both locations, they did not notice that the drilling jig was missing.

Railway operations

93 Serco Docklands has an Operations Manual (ref: DRS2008_DOCLIB_16522). This manual contains operational procedures that instruct the relevant staff on how the railway should be operated.

Railway control

94 When the Lewisham extension was commissioned in December 1999, it was operated from Serco Docklands Poplar control centre. City Greenwich Lewisham Rail plc also had their own control room at their Norman Road headquarters. This latter control room managed the interface between the PICOWs working on the Lewisham extension infrastructure and the Serco Dockland's control centre technician.

95 The control room arrangements are summarised in Table 1.

Functions	Control Room	Resource (on a typical night shift)
Control and signalling of trains	Serco Docklands, Poplar	Control Centre Controller x2 Control Centre Supervisor x1
Power supply (whole system)	Serco Docklands, Poplar	Control Centre Technician x1
Interface with PICOWs on Lewisham extension	City Greenwich Lewisham Rail plc, Norman Road	Control Centre Manager x1

Table 1: Control room arrangements for Serco Docklands and City Greenwich Lewisham Rail plc

96 During *engineering hours* (and as required), train traction power to the Lewisham extension was switched off by the Serco Docklands control centre technician and handed over 'as one complete isolated section' to the City Greenwich Lewisham Rail plc controller despite the extension being split into three isolation areas. Operational procedures existed which addressed these three areas as a single section, in line with the operational requirement at the time. There were no procedures for any isolations of any part of the Lewisham extension.

97 In addition, PICOWs working on the Serco Docklands part of the railway (i.e. not on the Lewisham extension) would contact the Serco Docklands control centre technician directly to book on and off for work. On the Lewisham extension (i.e. the City Greenwich Lewisham Rail plc part), PICOWs would book on and off with the City Greenwich Lewisham Rail plc controller based at Norman Road. This controller would, when all PICOWs had booked off with him, liaise directly with the Serco Docklands control centre technician to inform him that the track was clear and current could be switched on again.

98 This process was recorded on a City Greenwich Lewisham Rail plc infrastructure handover certificate which was faxed between the two controllers at the start and end of engineering hours.

The sweep train procedure

99 When the DLR was first opened in 1987, trains did not run at weekends and, during the week, the last trains would run at approximately 21:00 hrs. This meant that engineering hours were long and weekend work on the track was also possible.

100 At that time, the first train of the day operated as a 'sweep train' to check that the line was unobstructed. This train was run before the commencement of passenger services and therefore ran without any passengers on board (paragraph 37).

101 The ongoing development of the Docklands Light Railway had led to an increase in passenger services with the running of earlier trains in the morning and later trains at night. This had the result of restricting the total daily engineering hours period to between 01:00 hrs until 04:00 hrs (typically).

102 At approximately the same time (1995) that the new Alcatel signalling system was commissioned, the operation of the sweep train changed. The sweep train became a normal scheduled service train carrying passengers. This was not in accordance with the operational procedure SOP/M-3.11, Issue F which was still current at the time of the accident on 4 April 2008.

103 Serco Docklands management produced a change paper (and a limited risk assessment) dated 24 January 2006 to discuss and propose a change to the operational procedure to bring it in line with the actual operation of sweep trains on the railway. This was presented to the Serco Docklands executive members but was not ratified for reasons that remain unclear.

104 However, the change paper was rejected by the Rules and Procedures committee in January 2006 (no reasons for its rejection were minuted) and resubmitted in December 2007. The paper was again rejected (due to formatting issues) but not resubmitted for the further two meetings of January and February 2008 (these meetings were the last such meetings before the derailment).

Speed restrictions

105 The maximum speed of all trains is imposed by the vehicle control computer system and is dependant on where the train is on the system. If a temporary or permanent speed restriction is required over a certain area of track, then this data is entered by the control centre controller into the vehicle control computer systems. The train speed is then transmitted to the train's computer on its approach to the restricted speed track area.

106 Temporary speed restrictions may be required during an emergency situation or when a track engineer finds a fault in an area of track, and requires that trains running over that area have their speed reduced. This speed restriction may only last a short time and is usually activated by the person requesting it contacting the control centre controller directly. If the speed restriction is required to become more permanent, then the data is added to an 'Operational Restrictions List'.

107 The operational restrictions list is a document stored on a computer and is managed and controlled by a Serco Docklands systems engineer. He collates the speed restriction data (as well as other operational restrictions) and enters the data onto the list. The computer document was not made available to other persons through the information technology systems.

108 Before the accident, when a change to the operational restrictions list was made, a paper copy was brought to the control centre and attached to a notice board at the side of the room. This was the only copy that existed in the control room.

109 Once entered by the control centre, the operational restrictions list data was retained by the memory of the vehicle control computer systems until they had to be re-booted. When a re-boot happened, all the data from the operational restrictions list had to be re-input manually by the control centre controller. Re-boots were scheduled on a weekly basis for all three vehicle control computers, and following any software upgrade or work on the system.

110 The entry of the data into the vehicle control computer systems was usually via a keyboard/mouse interface. It was not easy to check the data that had been entered. The capture of the data on the vehicle control computer monitor screens was difficult; the operational restrictions list data was shown over many lines and pages of text and was extremely difficult to extract and check. For example, the entry of data, '45 km/h from track section 4687 to 4699' was displayed on the monitor as:

- 45 km/h from 4687 to 4688;
- 45 km/h from 4689 to 4691; and
- 45 km/h from 4692 to 4699.

This data would be displayed over various lines, interspersed between other lines of data and on different 'pages' of the screen display.

111 Operational restrictions list data that was being entered by the control centre controller was not being checked, either by the control centre controller or by a supervisor in the control centre.

Re-boots of the vehicle control computers pre and post accident

112 Before and directly after the accident, re-boots of all vehicle control computers were happening quite regularly because of software testing and for other operational reasons (Table 2). This meant that the control centre controller was continually re-entering the operational restrictions list data after every re-boot.

113 The following table shows the number of re-boots which occurred during March and April 2008:

	Vehicle control computer no.1	Vehicle control computer no.2 (incorporating Deptford Bridge to Lewisham station areas)	Vehicle control computer no.3
March 2008	12	13	9
April 2008	6	12	8

Table 2: Number of vehicle control centre re-boots in March and April 2008

114 The majority of re-boots (and hence the re-input of operational restrictions list data) happened between 03:00 hrs and 04:30 hrs. This was at one of the busiest times for the control centre controller. As well as re-entering and checking the operational restrictions list data, the control centre controller also had to give instructions to all passenger service agents that were coming on duty to undertake sweeps, liaise with the depot controller on trains that were being moved around the system from depots and generally co-ordinate the railway operations at the start of the morning passenger service.

115 The RAIB carried out an analysis of the vehicle control computer and system management centre data for 3 to 6 April 2008. The data analysis confirmed that there were a significant number of re-boots occurring during this period on all vehicle control computers, but not all of the correct speed restriction data was being entered (Table 3).

116 On 3 April, vehicle control computer no.2 (which controlled the Greenwich to Lewisham area) had been re-booted four times between 03:41 hrs and 10:17 hrs. On 4 April, the same vehicle control computer was re-booted at 04:31 hrs.

117 The data (ref: 0.37 and 0.38 of Table 3) showed that on the morning of 4 April 2008, there had been no speed restriction data entered for the area between Greenwich and Deptford Bridge stations. For this reason the maximum speed of train 87/62 was limited by the sweep speed input by the control centre controller at 04:35 hrs. This sweep speed was 40 km/h, which was 10 km/h higher than the speed restriction that should have been imposed.

Ref	Time and date in effect	Speed Restriction	Vehicle control computer no.	Was the speed restriction correctly entered on 3/4/08?	Was the speed restriction correctly entered on 4/4/08?	Was the speed restriction correctly entered on 5/4/08?	Was the speed restriction correctly entered on 6/4/08?
0.37	03/02/2004	Greenwich to Deptford Bridge Down Line **30 km/h** from track section 2774 to 2784	2	No	No	No	**Yes**
0.38	08/09/2003	Deptford Bridge to Greenwich Up Line **30 km/h** from track section 2934 - 2942	2	No	No	No	No
0.56	27/04/2005	Poplar to - Blackwall Down Line **45 km/h** from track section 4687 to 4699	3	Unknown	**Yes**	No	Unknown
0.58	02/09/2005	Shadwell to Bank Up Line **50 km/h** from track section 360 to track section 380	1	**Yes**	No	No	Unknown
0.6	28/11/2005	London City Extension - through all platforms. **40 km/h** for track sections as follows: WST, 4932 - 4935, 5116 - 5119. PDK, 4900 - 4904, 5082 - 5086. LCA, 4855 - 4859, 5037 - 5041. KGV, 4810 - 4818, 4991 - 4998.	3	Unknown	**Yes**	No	Unknown
0.62	02/10/2006	Royal Mint Street - Shadwell Down Line **40 km/h** from track section 148 to track section 151.	1	No	No	No	Unknown
0.65	01/02/2007	East India to Caning Town Down Line **35 km/h** from track section 4621 to track section 4639	3	Unknown	No	No	Unknown
0.68	16/11/2007	Shadwell to Tower Gateway Up line **20 km/h** from track section 543 to track section 544	1	**Yes**	No	No	Unknown
0.69	17/01/2008	Pudding Mill Lane to Stratford Between 1159 points and Stratford platforms, both lines. **20 km/h** on track sections 2002 - 2011 inclusive and 2357 - 2362 inclusive	2	No	No	No	**Yes**

Table 3: Analysis of operational restrictions list speed restriction data from vehicle control computers no. 1 to 3 between 3 and 6 April 2008.

Training and competence of the staff involved

Training of Serco Docklands staff

118 There is no dedicated training department at Serco Docklands. Training of Serco Docklands staff is done by full time members of staff (carrying out the training role and also their normal 'day' job) by training their colleagues in their own discipline. Those members of staff undertaking training responsibilities are required to hold relevant National Vocational Qualifications and are released from their other duties to undertake the training. This training is scheduled each year and the plan is programmed into work shift patterns i.e. rosters to ensure the appropriate release of trainers.

119 The quality of training was not monitored by management and the trainers were not audited. No evidence has been found of any active management reviews of the trainers, and the content and quality of the training was not checked by the management at Serco Docklands.

120 All staff involved in the accident were qualified, according to Serco Docklands standards, for the work they were undertaking and their certification was in order. None had been involved in any previous safety related incidents.

The passenger service agent

121 The passenger service agent had worked in this role for seven months. Before starting this role, the passenger service agent had undertaken a Serco Docklands training course.

122 The training course was an initial seven weeks, followed by a two week 'shadowing' period. The shadowing period consisted of the passenger service agent working with an experienced passenger service agent. Although a log of the shifts was recorded, no record was kept of the actual duties undertaken by the trainee passenger service agent. Because passenger service agents also have other duties not concerned with train operation, it may not have been possible to cover all operational situations during the shadowing period. There was no validation that the types of duties undertaken during his shadowing period reflected the content of the training.

123 There was no 'driving' simulation training provided for the trainees.

124 The passenger service agent had not done a sweep of the Lewisham extension during his training or at any time prior to the accident. He had been on board trains travelling over the extension, had undertaken revenue and ticket duties and occasionally been at the lead emergency driving position during peak hours when the trains were very busy. Night time runs on the Lewisham extension (after normal passenger services had stopped), for the purpose of training passenger service agents, had always been refused by City Greenwich Lewisham Rail plc. This was because of the extensive engineering work that was being carried out at the time.

125 The group of trainees that the passenger service agent had been trained with consisted of thirty two persons. Previous training groups had consisted of about eight trainees. However, the group of thirty two was divided into three groups for practical training but remained as one large group for the majority of classroom training.

126 Immediately before the day of the accident, the passenger service agent's work pattern had been:

- 3 April – off;
- 2 April – off;
- 1 April – 07:10 hrs to 14:19 hrs; and
- 10 March to 31 March – 3 weeks leave.

127 The passenger service agent's Fatigue Index value has been calculated as 7.9[2]. This value was based on his work shift and rest day pattern and indicates that the passenger service agent had not been exposed to a work pattern likely to cause abnormal fatigue. No other factors have been identified that are likely to have caused the passenger service agent to be fatigued or subject to unusual levels of stress or distraction.

128 Following the accident, the passenger service agent was *'for cause'* drug and alcohol screened, in accordance with his employer's post incident procedure. The results were negative.

The control centre controller

129 The control centre controller who was involved in the operation of train 87/62 had worked in the control centre at Poplar for sixteen years. He had past experience as a passenger service agent and also as a control centre supervisor.

130 Immediately before the day of the accident, the control centre controller's work pattern had been:

- 31 March to 3 April (4 night shifts) – 20:45 hrs to 05:45 hrs;
- 29 and 30 March – off;
- 27 and 28 March (2 late shifts) – 12:45 hrs to 20:45 hrs;
- 24 to 26 March (3 early shifts) – 05:45 hrs to 12:45 hrs; and
- 20 to 23 March – off.

131 The control centre controller's fatigue index value has been calculated as 45.9[2]. This value was based on his work shift and rest day pattern. This indicates a possibility that the control centre controller may have been at risk of fatigue. The control centre controller had been working his fourth consecutive night shift. Research by the Health and Safety Executive indicates that fatigue risk increases with successive night shifts and also during the period of between midnight and 06:00 hrs.

132 No other factors have been identified that are likely to have caused the control centre controller to be fatigued or subject to unusual levels of stress or distraction.

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[2] The potential for fatigue arising from the above work pattern has been assessed using the Health and Safety Executive (HSE) Fatigue and Risk Index Calculator (version 2.2) available from www.hse.gov.uk. The output from the fatigue index is a measure of the probability of high levels of sleepiness. This is expressed as a value of between 0 and 100. A fatigue index of 20.7 corresponds to the average work shift and rest pattern, assuming typical values for the job type and breaks factor. A 'benchmark' fatigue score of between 30-35 for day or early shifts and 40-45 for night shifts relates to the probability of a person suffering high levels of sleepiness. The value given is an average for the whole duty not hour by hour. ORR guidance entitled, 'Managing fatigue in safety critical work' , defines a night shift as a shift that usually starts between 22:00 hrs to 02:00 hrs and ends between 05:00 hrs to 08:00 hrs.

133 Following the accident, the control centre controller was 'for cause' drug and alcohol screened, in accordance with his employer's post-incident procedure. The results were negative.

The PICOW

134 The PICOW had worked in this role for two years. He had been trained as a PICOW by Serco Docklands.

135 The PICOW was employed by Carillion JM Ltd through Derryard Construction Ltd agency.

136 Immediately before the day of the accident, the PICOW's work pattern had been:

- 30 March to 3 April (5 night shifts) – 23:30 hrs to 05:30 hrs (each of 6 hrs);
- 28 and 29 March – off;
- 24 to 27 March (4 night shifts) – 23:30 hrs to 05:30 hrs (each of 6 hrs);
- 20 to 23 March – off; and
- 16 to 19 March (4 night shifts) – 23:30 hrs to 05:30 hrs (each of 6 hrs).

137 The times shown above are approximate. No records of the actual working start and finish times of the PICOW (and other staff involved with the drilling work) were recorded by Carillion JM ltd.

138 The PICOW's fatigue index value has been calculated as 30.7[2]. This value was based on his work shift and rest day pattern and indicates that the PICOW had not been exposed to a work pattern likely to cause abnormal fatigue for a permanent night shift worker. No other factors have been identified that are likely to have caused the PICOW to be fatigued or subject to unusual levels of stress or distraction.

139 Following the accident, the PICOW was not 'for cause' drug and alcohol screened as he had already returned home following the end of his night shift.

140 There were three Carillion JM Ltd supervisors involved with this particular project (known as senior PICOWs) who could have checked the quality of the PICOW's work (paragraph 147). There is evidence that the checking of the PICOWs' work activities was carried out infrequently.

141 The surveillance and auditing of PICOWs by the senior PICOWs was not recorded and there were no specific procedures covering this activity.

The drilling team

142 The diamond driller was an experienced and qualified individual who had worked with Quality Site Testing Ltd for two years. The evening of 3 April was his second night of working at Deptford Bridge station. This driller had not been briefed by the PICOW on either of the two nights (paragraph 80).

143 The other two drillers were general labourers and had worked for Quality Site Testing Ltd for a couple of months each. Both had had previous experience as labourers on Network Rail and London Underground. One of the drillers was employed by Quality Site Testing Ltd through Coyle Personnel plc, an agency.

144 All the drilling team worked similar hours to those of the PICOW (paragraph 136) and their fatigue index value was similar to that of the PICOW.

145 Work related fatigue is not considered to have influenced the behaviour of the drilling team. No other fatigue or other work related factors have been identified that are likely to have adversely influenced the performance of the drilling team.

146 Following the accident, the drilling team was not 'for cause' drug and alcohol screened as they had already returned home following the end of their night shift.

The Senior PICOW

147 Senior PICOWs are employed directly by Carillion JM Ltd to manage and supervise PICOWs. However the role of the senior PICOW is not formally defined by Carillion JM Ltd in any procedure or job description.

148 Senior PICOWs undertake the standard PICOW training as delivered by Serco Docklands. There is no other training given to the senior PICOWs.

149 As well as having a general supervisory role, senior PICOWs also do some general administration work (e.g. signing of work progress and time sheets) and are expected to visit the work sites to oversee PICOW activities if time permits.

150 On the morning of 4 April, the senior PICOW on duty was working as a PICOW with another group near to Lewisham station. At some point during the shift, he visited the group of drillers and the PICOW at Deptford Bridge station to confirm work progress. He did not stay while the work at Deptford Bridge was finished and the tools were cleared from the track.

The train

151 An analysis of the OTDR from both cars comprising the train shows that the emergency brakes were applied 4 seconds after the train was derailed.

152 The OTDR confirms that the emergency brakes were applied as a result of an inhibit command. This may have come from either the passenger service agent activating his key in the door control panel or by a computer software fault code caused by one of the following:

- impact damage to a traction motor box on the outside of the train causing a propulsion failure;
- loss of the 'all doors closed' indication; or
- a dynamic brake failure.

153 The OTDR is unable to differentiate between the door control panel and the software codes creating the inhibit command. From further analysis of the OTDR, physical evidence from the train and witness evidence, it is believed that the actions of the passenger service agent in operating his key in the door control panel activated the trains emergency brakes.

154 Electronic data shows that power to the *conductor rail* was lost 5 seconds after the emergency brakes were applied and 2 seconds before the train came to a rest. A short circuit occurred (as the derailed train continued to travel forward) at some time before the traction power was lost. This resulted in the main *breakers* tripping and this was brought to the attention of the control centre technician through the power monitoring systems at the Serco Docklands control centre.

155 All DLR cars are fitted with internal CCTV cameras, with images recorded on-board each car.

156 A project to upgrade on-board CCTV was started in 2008 and was in progress at the time of the accident. This project allows images of live on-board cameras to be displayed at the control centre as well as being recorded.

157 Because the upgraded CCTV equipment had not been fully tested and commissioned, neither car involved in this accident recorded any CCTV images of the inside of the car before, during or after the accident.

Safety management

Method statements

158 The method statement for the drilling near Deptford Bridge was written by Carillion JM Ltd and approved by the client, City Greenwich Lewisham Rail plc, in accordance with their respective company procedures at the time of the accident. The method statement specified a rail trolley mounted drilling jig but in reality a handheld jig was used.

159 The infrastructure manager, Docklands Light Railway Ltd, did not approve the method statement but relied on City Greenwich Lewisham Rail plc and Serco Docklands to review and approve method statements on its behalf and on their respective parts of the infrastructure.

Breakdown of processes within Serco Docklands control centre

160 Paragraph 114 describes the workload of the control room staff at certain times during the night shift. Paragraph 110 describes the way in which control centre staff had to input operational restrictions list data into the vehicle control computers after every re-boot. The way in which data entry was undertaken was a consequence of the original design of the control centre system.

161 At the time of the accident at the Serco Docklands control centre in Poplar (and on a typical night shift) there would be one technician (control centre technician), two traffic controllers (control centre controllers) and one supervisor (control centre supervisor). The control centre technician operated the technician's controls. A depot control and two traffic control positions were shared between the two control centre controllers and the control centre supervisor. The control centre supervisor did not undertake a dedicated supervisory role but worked at one of the three control positions. There was no additional person or dedicated supervisor to oversee the actions of the control centre staff.

162 The RAIB reviewed the management arrangements associated with the control centre at Poplar. This highlighted the following factors as relevant to the breakdown in operational processes:

- although audits of Serco Docklands management systems were carried out regularly, they did not include verification of working practices at the control centre;
- there was no evidence of effective line management of the control room and systems;
- there was no systematic management review of safety performance in the control centre; and
- there was no process to identify measures of safety performance consistent with current good industry practice.

Risk assessment

163 The most recent risk assessment carried out on behalf of Serco Docklands was issued in November 2005 as part of the Serco Docklands Railway Safety Case and in support of its application for Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS) certification.

164 The derailment of a passenger train was seen as the sixth highest risk and contributed 5.3% of the total risk. This was calculated as 19.2% of the total individual passenger risk. Although the sixth highest risk, it was the highest *train accident risk* identified.

165 The risk assessment identified that:

> 'No derailment on the DLR has yet resulted in serious consequences but the potential for such an outcome is apparent, particularly if the derailed train fouls the adjacent line and is struck by a train running in the opposite direction'.

166 Consequently, Serco Docklands held a workshop to consider additional risk mitigation measures. In relation to derailment, four potential measures were identified. These were:

- additional derailment containment;
- motorway wire crash barrier containment;
- provision of a trip wire between lines to remove *code* if broken by a train; and
- guardrails.

167 The Serco Dockland's risk assessment concluded that,

> 'The design of the DLR does take account of derailment in more vulnerable locations and some derailment containment is provided[3]. In addition, the contribution made by faulty *permanent way* and rolling stock to derailment events means that careful maintenance of these items is a vital control measure. Serco Docklands recognises the potential seriousness of derailment incidents and ensures that the identified control measures are properly and conscientiously implemented. During the risk assessment workshop sessions, some additional control measures were identified for review (including further provision of derailment containment) and Serco Docklands will ensure that these measures are assessed and implemented when reasonably practicable to do so'.

168 Whilst there was derailment containment at the site of this accident, none of the additional measures had been implemented and no further review had been carried out by Serco Docklands after November 2005. Serco Docklands had no plans to do so at the time of the investigation.

169 The risk assessment did not identify the risk of overspeeding due to controller error. However, the risk had been identified in a *preliminary hazard analysis* for the Docklands Light Railway contract by Alcatel in 1995.

[3] The Docklands Light Railway uses derailment containment in certain areas (including the Lewisham extension) of its system to restrict the movement of a train that has been derailed. This is achieved by the provision of a concrete gulley and raised kerbs on either side of the running rails (Figure 3).

170 The mitigation identified in this preliminary hazard analysis was the 'correct implementation of procedures by the control room staff'. No technical measures were identified to prevent errors or to highlight that data had not been entered.

Reporting of the accident

171 Although the accident occurred at 05:22 hrs, the accident was not notified to the RAIB by Serco Docklands until 07:10 hrs. The late notification of the accident by Serco Docklands to the RAIB was contrary to the requirements laid down in the Railways (Accident Investigation and Reporting) Regulations 2005 (RAIR).

Previous occurrences of a similar character

172 There were four derailments of DLR trains on passenger lines during the 1990s: two in 1992 and two in 1995. None of these resulted in passenger injuries.

173 At 05:23 hrs on 6 December 2004, a DLR sweep train struck some metal troughing just off the end of Blackwall station on the down line. The passenger service agent had been travelling at the lead emergency driving position and was able to stop the train by pushing the emergency stop button on the console.

174 Contractors had been working in the area and a range of engineering items including lights, troughing and cables had been left next to the running rail.

175 The train incurred some damage but did not derail. An internal Serco Docklands investigation was initiated but the results of the report are unknown.

176 A similar incident occurred at 05:20 hrs on 13 January 2006, when a DLR sweep train struck some concrete slabs that had been placed across the track by vandals on the approach to Devons Road station on the up line. The passenger service agent had been travelling at the lead emergency driving position and was able to stop the train by pushing the emergency stop button on the console.

177 There was no damage to the train and it did not derail. Ten passengers walked from the train back to Devons Road station.

Recovery of the derailed train

178 During the recovery process, a partial, 'shuttle', service was run from Greenwich to Lewisham using the down line.

179 In normal circumstances, electrical power to the Lewisham extension was switched off during engineering hours by the Serco Docklands control centre technician and handed over 'as one section' to the City Greenwich Lewisham Rail plc controller (paragraph 96). Neither Serco Docklands or City Greenwich Lewisham Rail plc had procedures (normal or emergency) to cover a partial isolation of the Lewisham extension. For this reason the operating staff had devised a special working procedure to permit the operation of a shuttle service on the 'down line'.

180 At the cessation of the shuttle service, two members of staff from City Greenwich Lewisham Rail plc went trackside to begin the clearing of temporary fencing and the reconnection of the cables joining the conductor rails. Communication to the City Greenwich Lewisham Rail plc staff was being relayed, via their control room at Norman Road, from Serco Docklands control room at Poplar. At some point during the reconnection and while the messages were being relayed, the member of staff came into contact with the conductor rail and suffered burns to the hands and temporary blindness.

181 The electric shock incident is being investigated by the Office of Rail Regulation (ORR), the safety regulator, and also by an external organisation appointed by Serco Docklands.

Analysis

Identification of the immediate cause[4]

182 The immediate cause of the accident was that train 87/62 struck a drilling jig that had been left across the running rail, and derailed.

Identification of causal factors[5]

183 The drilling jig had been left across the right-hand running rail. Although the drilling jig was a heavy steel tool, neither the PICOW nor any of the drillers realised that it had been left at site. There were no checks when tools were removed from site or returned to the Quality Site Testing Ltd stores at Canary Wharf. Each of the drillers had assumed that their colleagues had removed the jig and placed it into a wheelbarrow for transporting to the lift at the station and subsequently into their works van. The staff not realising that the drilling jig had been left at site was a causal factor.

184 The PICOW began his check of the worksite whilst work was still being done and before all of the tools had been removed from the track. He first checked the running rail that the jig was still placed over while walking away from the drilling site to look at some tie bars. He returned, walking near to and checking the other running rail, to where the drilling had taken place. By this time, the drillers had moved all of their equipment (except the drilling jig) to the walkway area.

185 The PICOW then left the work site before all of the drillers had left the trackside. The PICOW did not carry out any further checks or return to the platform, the walkway or the track worksite at any other time, while the two remaining drillers cleared the last tools from the walkway and onto the platform. The PICOW not returning to the site of work was a causal factor.

186 When the PICOW requested that work was to stop, the generators supplying power to the tools and to the site lights were immediately turned off. This had the effect of plunging the site into darkness apart from light from the head torches fixed to the safety hats of the staff. The PICOW was not issued or equipped with a handheld torch. Because the work was being carried out in an area of elevated track on the viaduct, there were no other lights in the area (e.g. street lights or station lighting) that would have assisted in illuminating the railway. The lack of lighting when work stopped, and the PICOW began his checks, was a causal factor.

[4] The condition, event or behaviour that directly resulted in the occurrence.

[5] Any condition, event or behaviour that was necessary for the occurrence. Avoiding or eliminating any one of these factors would have prevented it happening.

Identification of contributory factors[6]

187 Senior PICOWs were not given training in supervisory duties, but were expected to monitor the PICOWs they were responsible for. However, because of other duties, monitoring of the PICOWs was an infrequent occurrence and was not recorded.

188 Although the senior PICOW on duty on 4 April did visit the PICOW and the drilling team at Deptford Bridge station, this did not constitute formal monitoring or supervision. It is possible that the existence of a routine and formal process for supervising and assessing the performance of the PICOW would have modified his behaviour thereby averting the accident. The absence of a formal process to supervise and assess PICOWs was a contributory factor.

189 Although the drilling jig was a heavy steel tool, it was of a similar colour to the running rail and the concrete trackbed. As a consequence, it was not conspicuous, especially under low lighting conditions, and was missed by the drillers and the PICOW. This lack of conspicuity was a contributory factor.

Consequence analysis

190 The following sections analyse different factors that may have affected the consequences of the derailment.

The control centre system

191 Train 87/62 was travelling at 37 km/h when it derailed. This was 7 km/h higher than the 30 km/h speed restriction that should have been entered by the control centre controller following the re-boot of vehicle control computer no.2 at 04:31 hrs on the 4 April.

192 The control centre controller had not entered the operational restrictions list data into the vehicle control computer no.2. Any data that had been entered into any of the three vehicle control computers had not been checked against the operational restrictions list document either by the control centre controller or a supervisor. The poor design of the system meant that data had to be entered into the vehicle control computers every time that the system was re-booted. This occurred frequently and caused increased workload for the control centre controllers. Despite the importance of this task, it was sometimes omitted by the controllers and not checked by the supervisors.

193 This omission resulted in the train derailing at a higher speed than would otherwise have been the case. This higher speed influenced the consequence of the derailment.

The position of the passenger service agent on-board the train

194 The passenger service agent on-board train 87/62 was not at the lead emergency driving position during the derailment. He was standing at the second set of doors of the B end of car 87.

[6] Any condition, event or behaviour that affected or sustained the occurrence, or exacerbated the outcome. Eliminating one or more of these factors would not have prevented the occurrence but their presence made it more likely, or changed the outcome.

195 If the passenger service agent had either been sitting or standing at the lead emergency driving position, he would have been able to see approximately 15 to 20 metres ahead of him at a speed of 30 km/h[7]. At a speed of 30 km/h, the emergency braking distance was 22.3 metres. The braking distance was therefore greater than the distance that could be viewed by the passenger service agent.

196 It is probable that had the passenger service agent been at the lead emergency driving position, he would not have seen the drilling jig in time to avert the derailment but he would have been able to activate the emergency brakes as soon as the train began to move violently as it derailed. Had the passenger service agent done this, the train would have stopped more quickly thereby reducing the risk to passengers on the train.

197 If the passenger service agent had been at the rear of the two car train or had been disabled as a result of the accident (and assuming that track power was not lost) the train might have continued to travel forwards. Even though an axle of the first bogie had been derailed, the train would still have been propelled (via the traction motors in car 62) until it hit an item of railway infrastructure (e.g. a station platform ramp). This could have resulted in serious injuries to the passengers on board.

198 Although the passenger service agent is permitted to travel at any position on the train (for their normal revenue and customer service activities), if the passenger service agent is at the rear of a train that has derailed, the consequences following a derailment may be increased. A passenger service agent at the rear of a train may be unaware that the train has derailed for the following reasons:

- they may not be able to see or hear that the train has derailed;
- they may not feel any vibration from the train that has derailed; and
- there are no 'gangway connections' between cars on the DLR to enable noise to travel between them.

199 With the ongoing introduction of three car DLR trains, the total length of the train has been increased. If three cars were coupled together (running as a six coach articulated train) and derailed with the passenger service agent in the rear coach, the time taken for the passenger service agent to become aware of a derailment is likely to be increased.

Training and safety critical communications

200 Both the passenger service agent and the control centre controller had been trained by Serco Docklands to undertake safety critical communications. This involved the use of the phonetic alphabet and repeating back the message to the person giving the instruction so as to ensure a complete understanding. Despite their training, the passenger service agent and the control centre controller did not come to a complete understanding during their conversations about the need for a sweep on the return journey.

[7] This data was collected during testing in the area of Deptford Bridge station at approximately the same time in the morning as the accident occurred.

201 Witness evidence suggests that the control centre controller was under the impression that he had instructed the passenger service agent to sweep in both directions on the Lewisham extension. However, the passenger service agent was under the impression that he should not be carrying out a sweep on the return journey from Lewisham.

202 The training of the passenger service agent involved in the accident included duties involved with the operation of a sweep train. Because of the number of trainees, the practical element of this part of the training could not be done on the Lewisham extension in normal operating hours and was not possible at other times owing to the refusal by City Greenwich Lewisham Rail plc to allow trains onto the extension in engineering hours because of extensive works in progress.

203 Following the passenger service agent's training and during the shadowing period (paragraph 122), the passenger service agent did carry out one single sweep train duty. However, this duty was not on the Lewisham extension but on another part of the system.

204 It was not mandatory that a passenger service agent should carry out any sweep train duties during his shadowing period. His training and experience had meant that he was accustomed to carrying out sweep duties in one direction only, with sweeping in the other direction being done by a different train. The traffic pattern on the Lewisham line, however involved the same train carrying out the sweep in both directions. The passenger service agent not doing a sweep of the Lewisham extension during his training or shadowing period contributed to his confusion about the procedure to be applied.

205 This lack of training combined with poor communications with the control centre controller resulted in the passenger service agent not being at the lead emergency driving position on the return journey. Had he been at this location it is unlikely that he would have seen the obstruction on the track because of the poor lighting conditions. However, he would have been able to operate the emergency stop button immediately on impact so reducing the time that elapsed between the derailment and application of the brakes.

206 A lack of training, poor communications and the absence of a clear understanding between the passenger service agent and the control centre controller contributed to the severity of the outcome.

Underlying factors[8]

Underlying factors linked to the causation of the derailment

207 The Carillion JM Ltd method statement had been reviewed and approved by the client organisation, City Greenwich Lewisham Rail plc. For its part, the infrastructure manager, Docklands Light Railway Ltd, did not review method statements but attempted to assure themselves that City Greenwich Lewisham Rail plc were competent to undertake reviews and approvals of method statements. They did this by carrying out regular audits of City Greenwich Lewisham Rail plc's safety and competence management systems. No concerns had been raised as a consequence of these audits.

[8] Any factors associated with the overall management systems, organisational arrangements or the regulatory structure.

Underlying factors linked to operational irregularities

208 In paragraphs 118, 119 and 125, deficiencies were identified in Serco Docklands training systems. These included:

- no dedicated training resource;
- the limited ability to deal with a large number of trainees at the same time;
- inadequate management of training systems and staff involved; and
- absence of audit or management review of training and competence management systems.

209 These deficiencies contributed to the incorrect implementation of the sweep procedure by the passenger service agent.

210 Paragraph 192 identifies deficiencies in the implementation of safety related procedures in the control centre.

211 At the time of the derailment at Deptford the management team at Serco Docklands was unaware of the safety issues related to the training of operational staff and the poor implementation of control centre procedures. The company did have audit and safety review processes in place but these had not extended to include the implementation of operational procedures, the training of passenger service agents and control centre supervision. Had they done so it is likely that the problems would have been identified and corrective actions could have been taken.

212 The inadequate scope of management systems to monitor safety performance could have been avoided had a systematic process been implemented to identify appropriate 'process safety indicators'[9] and management systems to give early warning of system failures before the accident occurred.

213 The RAIB considers that the effective management of safety on the DLR would benefit from the adoption of a performance measurement model similar to that outlined in the HSG 254[10] guidance. However, the development of suitable process safety indicators is conditional on a thorough understanding of risk and control measures.

Observations[11]

Serco Docklands policy on operation of the first train of the day

214 Serco Docklands documented policy on the operation of the first train of the day was based on the concept of an empty 'sweep train'. It is not clear how this process was intended to control the risks associated with starting up the system in the mornings. As currently configured, the sweep train is unlikely to be able to stop short of an obstruction that a passenger service agent observes on the track ahead.

[9] A 'process safety indicator' can be seen as broadly equivalent to a key performance indicator (KPI). However a process safety indicator is focussed on measuring those aspects of system performance that affect on the safety of a process.

[10] HSG 254, Developing process safety indicators, HSE Publications, October 2006 (http://www.hse.gov.uk/pubns/books/hsg254.htm).

[11] An element discovered as part of the investigation that did not have a direct or indirect effect on the outcome of the accident but does deserve scrutiny.

215 However, for reasons it has not been possible to discover, the concept of the empty sweep train was abandoned in about 1995 and the practice that applied at the time of the accident can be summarised as follows:

- the first train in each direction on every line operated at a reduced speed (40 km/h);
- the passenger service agent was required to be at the lead emergency driving position to look out for obstructions and to apply the emergency brakes if necessary; and
- the sweep trains were permitted to carry passengers.

216 This investigation has found no evidence that the above practice, and in particular the conveyance of passengers, had been subject to a formal risk assessment. The conveyance of passengers on the sweep train was contrary to Serco Dockland's operating procedure at the time of the accident (paragraph 103).

Method statement

217 The method statement used by the PICOW (City Greenwich Lewisham Rail plc method statement E5763/07 issue 03) stated that a rail trolley mounted jig would be used.

218 The actual drilling jig used was not a rail trolley mounted jig, but a handheld steel jig that was placed over the running rails. The difference in the description of the jigs was not identified by the PICOW or by those who had written and approved the method statement, which included the review of the document by City Greenwich Lewisham Rail plc.

The PICOW

219 The PICOW checked that the drillers had their track certification with them and their correct high visibility clothing on but he did not brief them on any safety or site matters.

220 Witness evidence revealed that the PICOW only gave a full safety brief on the first day that the drilling work commenced at Deptford Bridge. This was approximately two weeks before the day of the accident.

221 The PICOW did not also carry out a test of the rails to check that the track power supply was switched off. This was a documented requirement of his role as a PICOW, and he was aware of this. He relied on the control centre manager at the City Greenwich Lewisham Rail plc control centre telling him that it was safe to go onto the track. The power off test is part of the training given to PICOWs and is a test to confirm that power is indeed switched off. None of the drillers challenged the PICOW that the test had not been carried out before they started work.

Serco Docklands and City Greenwich Lewisham Rail plc procedures

222 When the Lewisham extension was being built and City Greenwich Lewisham Rail plc became the concessionaire for the extension, certain contractual arrangements at the time required City Greenwich Lewisham Rail plc to set up its own control room. This was in addition to the Serco Docklands main control room at Poplar.

223 As a result, Serco Docklands and City Greenwich Lewisham Rail plc devised different operating procedures to cover communications between PICOWs and the control rooms (paragraph 97). This use of two different ways of working, although not inherently unsafe, could have led to confusion because the same staff worked on both sections of the system.

224 An agreed procedure existed defining how traction power to the Lewisham extension was to be switched off and how the extension was to be handed over, 'as one system', from Serco Docklands to City Greenwich Lewisham Rail plc. However, this procedure did not cater for a partial isolation of the Lewisham extension if one line, or part of one line, was to have the power turned off.

225 The electric shock accident which occurred during the recovery of the derailed train (paragraph 180) is still being investigated by the ORR.

Internal CCTV project

226 The primary purpose of on-board CCTV is passenger security and safety. Because upgraded equipment had not been fully tested and commissioned, neither car involved in this accident recorded any CCTV images of the inside of the car either before, during or after the accident. In certain circumstances the ability of the control centre to view 'real-time' images of inside the cars would assist them in managing an emergency situation.

227 CCTV is also useful for investigation purposes and in this case would have assisted an understanding of the forces involved with the derailment and the potential effect on the passengers on board. These images may have also confirmed the actions of the passenger service agent in relation to the use of his key into the door control panel.

Derailment containment

228 DLR is equipped with derailment containment systems in certain areas. Although there was derailment containment on the Lewisham extension, derailment containment is not widespread throughout the DLR system.

229 The derailment containment on the DLR is by the presence of concrete gulleys and raised kerbs. There is no system (either trainborne or trackside) that detects that the train is derailed and could either:

- automatically apply the train's emergency brakes;
- switch off power to the track that the train is on;
- switch off power to the other tracks next to the derailed train; or
- inform the control centre controller of the derailment.

However, systems exist which will indirectly detect most, but not all, derailments. These systems include:

- damage to the signalling transmission cable;
- damage to the conductor rail; and
- failure to reach a certain position (which is captured within the signalling software systems).

230 The consequences of a train being derailed and becoming foul of another running line and therefore not 'contained' include the risk of a secondary collision[12]. This risk can be exacerbated on a driverless railway if the derailment is not detected and the train continues to travel forward. This particular risk was recognised by Serco Docklands in their systemwide risk assessment, as was the need to review whether any additional measures were required.

[12] A secondary collision is a possible collision directly following the initial accident/derailment of the train.

231 The Serco Docklands Safety Case had identified the need for a review to look at measures to manage the risk of a secondary collision following a derailment. At the time of the investigation no action had been taken.

The Railways (Accident Investigation and Reporting) Regulations 2005

232 The late notification of the accident by Serco Docklands to the RAIB was contrary to the requirements laid down in the RAIR regulations.

Conclusions

Immediate cause

233 The immediate cause of the accident was that train 87/62 struck a drilling jig that had been left across the running rail, and derailed.

Causal factors

234 Causal factors were:

- the PICOW and the other drillers did not realise that the drilling jig had been left at site across a running rail (paragraph 183);
- there was no procedure requiring a systematic check that all equipment representing a derailment risk was accounted for (paragraph 183);
- the PICOW did not undertake a systematic and adequate check of the work site (paragraph 184); and
- the site working lights were switched off before items on the track were cleared, leaving the area in darkness (paragraph 186).

Contributory factors

235 Contributory factors were:

- the PICOW involved was not adequately supervised or monitored when undertaking his duties (paragraph 187, Recommendation 2);
- the senior PICOW did not undertake any formal monitoring and auditing of the PICOWs (paragraph 188, Recommendation 2); and
- the drilling jig was not conspicuous in poor lighting (paragraph 189, Recommendation 1).

Other factors affecting the consequence

236 The following factors resulted in the train travelling faster than the temporary speed restriction that should have been in place:

- the design of the control centre system required the entry of speed restriction data every time that the vehicle control computers were re-booted (paragraph 191, Recommendation 3); and
- a breakdown in the operational processes within the control centre relating to speed restrictions owing to high workload, inadequate supervision and the design of the control centre systems (paragraphs 192 and 273).

237 The following factors resulted in the passenger service agent not being in the lead emergency driving position and not carrying out the sweep procedure:

- despite their training, the passenger service agent and the control centre controller did not come to a complete understanding during their radio communications (paragraphs 200 and 272); and
- the training and mentoring of the passenger service agent did not provide him with experience of undertaking a sweep of the Lewisham extension (paragraph 202, Recommendation 4).

Underlying[13] factors

238 The underlying management factors were:

Linked to the operational irregularities:

- inadequate systems for monitoring and reviewing safety performance and for monitoring compliance with rules and procedures (paragraph 211, Recommendations 5 and 6);
- Serco Docklands did not provide adequate training resource and only limited management review of the training (paragraph 208, Recommendation 4); and
- the absence of Serco Docklands management systems to systematically identify safety process indicators (paragraph 213, Recommendation 7).

Additional observations

239 Serco Docklands had not properly identified the purpose of operating a sweep train and the risks it was intended to control, and had no formal risk assessment in support of its policy for the operation of the first train of the day (paragraphs 214 and 216, Recommendation 8).

240 The method statement for the work did not describe the correct type of drilling jig used (paragraph 217, Recommendation 9).

241 The PICOW did not give a safety brief to the drilling staff on 3 April and on other previous night shifts (paragraph 219).

242 The PICOW did not carry out a test of the rails to check that the track power supply had been switched off (paragraph 221).

243 Serco Docklands and City Greenwich Lewisham Rail plc procedures for the operation of Lewisham extension were not aligned (paragraph 223, Recommendation 10).

244 At the time of the accident the 'on-board' CCTV project was not fully commissioned and consequently no internal images were recorded (paragraph 226).

[13] Any factors associated with the overall management systems, organisational arrangements or the regulatory structure.

245 Serco Docklands did not fully assess the reasonable practicability of additional measures to contain and/or detect derailment at high risk locations on the DLR system (despite the need for a review being identified in the systemwide risk assessment) (paragraph 231, Recommendation 11).

246 Serco Docklands were slow to notify the RAIB of the accident contrary to the requirements of the RAIR regulations (paragraphs 232 and 277).

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

Docklands Light Railway Ltd

247 Docklands Light Railway Ltd is managing a process in consultation with Serco Docklands and City Greenwich Lewisham Rail plc leading to the achievement of a 'common rule book' for application by all parties on the DLR which will align procedures for communications and electrical isolations and other operational matters.

248 Docklands Light Railway Ltd have also commissioned, in partnership with Serco Docklands, a review of the Systemwide Risk Assessment by an independent specialist organisation.

249 The 'on-board CCTV' project that was in progress at the time of the accident is still being progressed and is not fully commissioned. When completed, this project will allow the images of live 'on-board' cameras to be displayed at the control centre as well as being recorded.

Serco Docklands

250 Following the accident, Serco Docklands control manager issued a temporary instruction to recipients of the operations manual: if sweep trains were to be the first scheduled passenger service, then the speed of the train should be set at 30 km/h.

251 At the May 2008 Serco Docklands Rules and Procedures committee meeting, the change paper associated with the sweep change was accepted and a new operational procedure for sweep trains (ref: SOP/M-3.11, Issue G) was published bringing the procedure in line with the actual operation of the railway.

252 Serco Docklands issued the new operational procedure for sweep trains in July 2008. As of 19 November 2008, all relevant staff have been briefed on the new procedure. However, the investigation found witness evidence that some members of Serco Docklands staff were unaware that a new sweep procedure had been issued and the changes incorporated within it.

253 Serco Docklands have updated its method statement and risk assessment guidance to include specific mention that the visibility and sources of illumination for the final check, as well as registers of appropriate equipment, are to be included in the relevant documentation.

254 Serco Docklands have modified its PICOW training course to stress the importance of checking that the track is clear of obstructions, and how this can be accomplished correctly.

255 Serco Docklands have also employed four additional control room controllers who have now completed their training. This will allow control centre supervisors to undertake their supervisory roles. An additional control centre technician has also been employed for certain shifts at the control centre.

256 Serco Docklands is proposing to reduce the length of night shifts at the control centre from 12 hrs down to 8 hrs in order to reduce the risk of fatigue.

257 A dedicated member of Serco Docklands staff is reviewing the process of possessions on the Lewisham extension.

City Greenwich Lewisham Rail plc

258 Following the accident, and after the issue of the RAIB preliminary examination report and the initial Serco Docklands investigation, City Greenwich Lewisham Rail plc reviewed its safety risk register. Following the December 2008 annual review of the Register, City Greenwich Lewisham Rail plc is incorporating the results into its 2009 Safety Improvement Plan.

259 All City Greenwich Lewisham Rail plc control room staff and key managers have attended safety-critical communications training by an external company.

260 All City Greenwich Lewisham Rail plc staff, including PICOWs, supervisors and control room staff have been briefed on the importance of safety-critical communications, and on the renewed vigilance needed when clearing the trackside site.

261 City Greenwich Lewisham Rail plc have adopted the same audit regime as Serco Docklands to review randomly-sampled safety critical communications against objective criteria.

262 City Greenwich Lewisham Rail plc have reissued its method statement/risk assessment template to include a specific requirement to assess derailment risk (following works) as 'High/Medium/Low' and to assess and specify precautions (additional to the provision of a PICOW) comparable to the assessed risk. Such assessments will additionally be reviewed by the City Greenwich Lewisham Rail plc manager who approves the method statement.

263 City Greenwich Lewisham Rail plc's Safety Improvement Plan for 2009 includes an increased level (quantity) of site checks of its subcontractors to confirm:

- compliance with rules and procedures; and
- correct working to method statements.

264 City Greenwich Lewisham Rail plc has also re-briefed its relevant staff on the company's reporting obligations under RAIB and the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (RIDDOR) regulations and the correct processes for compliance.

Carillion JM Ltd and Quality Site Testing Ltd

265 Following the accident, Carillion JM Ltd modified its method statement to include actions to clear the site. The method statement now states:

> 'The supervisor is responsible for walking along the worksite and checking that it has been left safe and clean, with no loose items of plant or materials. He will check along the line of each rail as well as along the cable trough walkway line'.

The PICOW is now required to be briefed by Carillion JM Ltd site management on method statements and risk assessments and signs that he has read and understands them.

266 Carillion JM Ltd also modified its 'Risk Assessment & Control Pro-forma' (ref: RA/10B) for the work, and added a new requirement stating, '...that the PICOW (and other supervisors) use large handheld torches to sweep the site and to walk along each rail and cable trough to ensure all work site swept'. It also requires metal units to be painted a visible colour.

267 Carillion JM Ltd has provided all PICOWs with a large handheld torch and also magnetic lights are now fixed to the viaduct balustrade in the works area at Deptford Bridge station. These magnetic lights are switched on during engineering activities.

268 Carillion JM Ltd's site management team is now required to monitor PICOW briefings on an 'ad hoc' basis.

269 Carillion JM Ltd has implemented a system of safety tours on an on-going basis. Carillion JM Ltd Directors' safety tours commenced in June 2008 as the work activity increased.

270 Quality Site Testing Ltd have painted the drilling jig with a view to it being seen in poor lighting conditions.

271 Quality Site Testing Ltd have developed a daily check list for the equipment and tools taken to site and also identifying the person responsible for each item. This list has to be signed by both the Quality Site Testing Ltd employee and the PICOW when it has been confirmed that all the equipment and tools taken to site have been returned to the platform from which access to the work site was gained.

Completed actions which address factors in the report so avoiding the need for the RAIB to issue a recommendation

Serco Docklands

272 Serco Docklands have undertaken a re-brief of all control centre controllers and passenger service agents on safety critical communications and audits are in place to monitor the control centre on a regular basis. An external company has also been employed to deliver safety-critical communications training to all control room staff and new and existing passenger service agents. This external company is also reviewing Serco Docklands communications training material to ensure it meets industry best practice.

273 Serco Docklands have developed a checklist to capture the routine control centre controller activities, including the application of the operational restrictions list data into the vehicle control computers, and the control centre controllers sign off that the data has been entered correctly. This checklist is checked and countersigned by the control centre supervisor. During the following shift handover, both outgoing and incoming control centre supervisors confirm that all restrictions are in place and both sign the checklist.

274 The checklist is now retained by the control centre manager and regular audits of the checklist are being undertaken. Serco Docklands is also in the process of transferring the responsibility for the operational restrictions list from a systems engineer to the control centre manager.

275 Serco Docklands have allowed controlled electronic access to the operational restrictions list for all control centre staff for both current and archive lists (as well as a hard copy in the control centre). The operational restrictions list is also sent to City Greenwich Lewisham Rail plc for information.

276 In the light of these actions addressing the factors identified in paragraphs 108 and 236 the RAIB has decided not to issue further recommendations to address these factors.

277 The RAIB has also written to Serco Docklands to remind them of its duties under the RAIR regulations in respect of the timely reporting of the accident to the RAIB.

Recommendations

278 The following safety recommendations are made[14]:

Recommendations to address causal and contributory factors

1 Docklands Light Railway Ltd should implement arrangements to require that all organisations contracted to work on DLR infrastructure and stations should implement measures to improve the visibility of equipment representing a derailment risk when used at night (paragraph 235).

2 Carillion JM Ltd should clarify the role of the senior PICOW to provide them with guidance on the method, nature and extent of the supervision of PICOWs that they are required to carry out (paragraph 235)

Recommendations to address factors affecting the consequence

3 Docklands Light Railway Ltd, in consultation with Serco Docklands, should introduce modifications to the control system to remove the need for controllers to manually enter temporary speed restrictions after the re-booting of the system(s) and to simplify the checking of the correct speed restriction data (paragraph 236).

4 Serco Docklands should review its competency management system and the way in which it is currently delivering training to passenger service agents and control centre controllers. The objective of this review shall be to assess the adequacy of existing arrangements (including resources available for training and the methods of delivery) and to identify ways of improving the overall levels of competence. Serco Docklands should take suitable actions to implement the findings of the review (paragraph 237).

continued

[14] Those identified in the recommendations, have a general and ongoing obligation to comply with health and safety legislation and need to take these recommendations into account in ensuring the safety of their employees and others.

Additionally, for the purposes of regulation 12(1) of the Railways (Accident Investigation and Reporting) Regulations 2005, these recommendations are addressed to the Office of Rail Regulation to enable it to carry out its duties under regulation 12(2) to:

(a) ensure that recommendations are duly considered and where appropriate acted upon; and

(b) report back to RAIB details of any implementation measures, or the reasons why no implementation measures are being taken.

Copies of both the regulations and the accompanying guidance notes (paragraphs 167 to 171) can be found on RAIB's web site at www.RAIB.gov.uk.

Recommendations to address underlying factors

5 Serco Docklands should undertake a review of its management arrangements for the monitoring, audit and review of activities at the level of operational and engineering staff. The findings of this review should be translated into effective corrective actions where appropriate (paragraph 238).

6 Serco Docklands should undertake an in-depth assessment of the adequacy of the current rules and procedures and implement improvements as appropriate. This assessment should encompass:

- the level of compliance with existing rules and procedures;
- identification of activities currently being undertaken that are not addressed by existing procedures;
- the interface with concessionaires (linked to Recommendation 9); and
- management systems to ensure compliance (e.g. audits).

(paragraph 238)

7 Serco Docklands should thoroughly and comprehensively identify safety process indicators covering the entire scope of its operation and implement suitable management arrangements covering the collection of data, monitoring and subsequent review. The guidance contained in HSG 254 in relation to leading and lagging performance indicators should be taken into account (paragraph 238).

Recommendations to address other matters observed during the investigation

8 Serco Docklands should review what risks a sweep train is intended to reduce, and in the light of this review should revise the adequacy of the mitigation measures linked to the operation of the first train of the day. This should include an assessment of the appropriateness of a range of possible measures including:

- operation of sweep trains with no passengers;
- better lighting around the trackside to enable sighting of obstructions (trainborne and/or trackside); and
- reduction of the speed of sweep trains.

(paragraph 239)

9 Carillion JM Ltd should review its process for maintaining method statements as the design and project evolves. The process should include a check that the method statement states the actual tools and plant being used (paragraph 240).

continued

10 Docklands Light Railway Ltd should review and amend the current contractual and working arrangements with the objective of ensuring that Serco Docklands and City Greenwich Lewisham Rail plc (and further DLR concessionaires) work to one common rule book and coherent operating procedures (paragraph 243).

11 Docklands Light Railway Ltd should undertake an assessment of the risk and possible mitigation measures associated with derailments and secondary collisions. This should assess the reasonable practicability of a range of measures including:

- additional derailment containment at high risk locations; and
- derailment detection (trainborne and/or trackside).

This assessment should include consideration of the impact of increased train traffic, increased passenger loadings and the operation of more and longer trains (paragraph 245).

Appendices

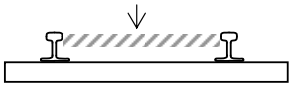
Appendix A - Glossary of abbreviations and acronyms

ATO	Automatic Train Operation
CCTV	Closed Circuit Television
DLR	Docklands Light Railway
ORR	Office of Rail Regulation
OTDR	On Train Data Recorder
PICOW	Person In Charge Of Work
RAIB	Rail Accident Investigation Branch
RAIR	The Railways (Accident Investigation and Reporting) Regulations 2005
ROGS	Railways and Other Guided Transport Systems (Safety) Regulations 2006

Appendix B - Glossary of terms

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

Baseplate(s)	A cast or rolled steel support for running rails.
Bogie	A metal frame equipped with two or three wheelsets and able to rotate freely in plan, used in pairs under rail vehicles to improve ride quality and better distribute forces to the track.*
Breaker(s)	A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit.
Code	Data that is transmitted wirelessly and constantly between the DLR train and the control centre (vehicle control computers) via a cable that is laid in the four foot.
Conductor Rail	An additional rail, generally of a unique section, used to convey and enable collection of electrical traction current at track level. Conductor rail systems carry voltages of the order of 600 - 1000 Volts, generally DC. The DLR system uses one conductor rail located outside the running rail which is supported on brackets. The conductor rail is protected and covered by insulated material and the train uses *shoegear* that picks up the power from underneath the conductor rail.
Control centre controller	A person who monitors and controls the railway operations of the DLR from the Serco Docklands control centre.
Control room operator	A City Greenwich Lewisham Rail plc employee who monitors the Lewisham extension during engineering hours and liaises directly with the Serco Docklands control centre in respect of track power and when the line is clear of engineering staff.
Derailment Containment	The physical measures put in place to guide a derailed train safely along the railway until it comes to rest.*
Drilling Jig	A fabricated steel tool which provides location and guidance for drilling one or more holes in precise relationship to a fixed point.
Emergency Shunt	A manual mode of driving the DLR trains whereby the passenger service agent operates a joystick which draws electricity to power the motors to drive the train either forward or reverse. The train is restricted to a maximum of 20 km/h.
Engineering Hours	On DLR, the period of time from when the traction current is switched off to the time the traction current is switched back on.
'for cause' screened	All those directly involved with an accident or incident should be 'for cause' screened for the presence of alcohol or drugs in line with either Railway Group Standard GE/RT/8070 or current industry good practice.

Four Foot	The area between the two running rails of a standard gauge railway. The actual dimension of this space is 1435 mm (4' 8½").* 
Grout Pads	A pad that sits underneath the baseplate and on top of the concrete trackbed. The grout pad is formed from liquid grout that is poured into formwork and sets. Once the grout pad is 'cured' the track fixing bolts can be torqued to the specified level.
High Rail	The outer running rail of a curved portion of a track, sometimes applied irrespective of the relative heights of the rails.*
Lead emergency driving position (emergency driving position)	The position in which the passenger service agent would travel at the front of the train. The passenger service agent would be looking ahead to see if there were any obstructions on the track. He could stop the train by operating the emergency stop button on the console.
Low Rail	The inner running rail of a curved portion of a track, sometimes applied irrespective of the relative heights of the two running rails.*
Moving Block	As opposed to fixed block where the signals are fixed trackside and only one train is allowed in one block at one time, moving block allows trains to travel closer together with a resultant greater capacity, less trackside equipment is used and there are less maintenance costs.
Passenger service agent	A person who travels on every DLR train, normally undertaking ticket and revenue duties. This person can also be requested to drive the train, when required and also carry out a 'sweep' of the track if necessary.
Permanent Way	The track, complete with ancillary installations such as rails, sleepers, ballast, as well as lineside fencing and lineside signs.*
Person in charge of work	A person who is responsible for a team of staff that go trackside during engineering hours. The PICOW should give the staff a safety brief and is also responsible for ensuring that the track is clear when their work is completed.
Possession	A period of time during which one or more tracks are blocked to trains to permit work to be safely carried out on or near the line.*
Preliminary hazard analysis	Preliminary hazard analysis is performed to identify possible hazards that could be created by the system being designed. This information can then be used to reduce the severity or build-in safeguards against the effects of the identified hazards.
Re-boot (vehicle control computer)	Booting or re-booting is a bootstrapping process that starts operating systems when the user turns on a computer system. A boot sequence is the initial set of operations that the computer performs when it is switched on.

Shoegear	Equipment carried by a train and used for current collection on third rail systems. Shoegear comprises a cast iron shoe that is usually mounted on an insulating beam attached to the side of the bogies, close to rail level.*
Sweep	A passenger service agent will check that the line ahead of the moving train is clear of obstructions by being at the lead emergency driving position and looking ahead. This train is known as the 'sweep' train and the action of the passenger service agent is known as 'sweeping'.
Tie Bar	An adjustable metal bar normally constructed with an insulated section in the middle, fixed between gauge rails to restore and maintain track gauge.*
Train Accident Risk	The risk from an accident that has been caused by the train (e.g. derailment of the train).

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