RAIB
Rail Accident Investigation Branch

Rail Accident Report

Derailment at Cromore, Northern Ireland
14 April 2007

Department for Transport

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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

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

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

3 Access was freely given by Northern Ireland Railways and Sperry Rail International Ltd to their staff, data and records in connection with the investigation.

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

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

Summary of the report

Key facts about the accident

5 At about 01:00 hrs on Saturday 14 April 2007, a Northern Ireland Railways (NIR) *ultrasonic test* train became derailed near Cromore, Antrim, while travelling at about 49 mph (77 km/h).

6 The train consisted of a locomotive and a single ultrasonic test vehicle. All four wheels of the test vehicle were derailed. There was some damage to the track and to the test vehicle. No-one was hurt.

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

Immediate cause, causal and contributory factors, severity of consequences

7 The immediate cause of the accident was *wheel unloading* resulting from violent *pitching* oscillation caused by *cyclic top* in the track.

8 The following were causal factors in the derailment:

a. the train was travelling at too high a speed, arising from errors in the *Weekly Operating Notice*;

b. the *Approval Certificate* for the test vehicle was not circulated to the appropriate people within NIR; and

c. the *Special Operating Instruction* covering the operation of the test vehicle on NIR was not issued to the relevant staff before the ultrasonic test runs of April 2007 began.

9 The following factors were contributory to the derailment:

a. the condition of the track on the Portrush branch;

b. the staffing levels in the Compliance Department of NIR; and

c. the suspension of the test vehicle was stiff and undamped and therefore sensitive to small inputs from track irregularities.

10 The following factors contributed to the severity of the consequences of the derailment:

a. the guard of the train was not in a position to react quickly to the derailment because he was not travelling in the rear cab of the locomotive; and

b. the Sperry staff travelling in the rear cab were unaware of how to stop the train in an emergency, and were unable to attract the attention of the driver.

Underlying cause

11 The underlying cause of the accident was the lack of systematic processes within NIR for the preparation and issue of the Weekly Operating Notice and Special Operating Instructions.

Recommendations

12 Recommendations can be found in paragraph 123. They relate to the following areas:

- improvements in the process for preparing and issuing the Weekly Operating Notice and Special Operating Instructions;
- modifications to the suspension of the ultrasonic test vehicle;
- briefing given to people travelling in the rear cabs of locomotives and trains, and to the facilities for communication between the front and rear cabs of locomotives;
- provision of correct information on vehicle weight; and
- standards for track maintenance on NIR.

The Accident

Summary of the accident

13 At about 01:00 hrs on Saturday 14 April 2007, a Northern Ireland Railways (NIR) ultrasonic test train, running from Portrush to Coleraine, had just passed the level crossing at Cromore, Antrim, when the test vehicle became derailed.

14 The train, comprising diesel electric locomotive no. 8113 and an ultrasonic test vehicle, SRS241, had finished testing for the night and was travelling at a speed of about 49 mph (79 km/h). As the train approached the level crossing the test vehicle began to bounce violently and all its wheels derailed to the left (in the direction of travel), 113 m after passing over the crossing. The train remained coupled and was brought to a stand by the driver 400 m beyond the point of derailment.

15 No-one was injured in this accident. The underside of the test vehicle was severely damaged, and there was minor damage to the track.

The parties involved

16 The railway and the train were operated by NIR, which is an operating arm of the Northern Ireland Transport Holding Company. The train crew were NIR employees.

17 The ultrasonic test vehicle was owned by Sperry Rail International Ltd (Sperry), and was being operated under contract to NIR to check the rails of the NIR system for flaws. For this purpose employees of Sperry travelled with the train to operate the equipment on the test vehicle.

Location

18 The derailment occurred near milepost 64¾ (measured from zero at Belfast (York Road)) on the single track branch line from Coleraine to Portrush, which is 6 miles (9.7 km) long. The point of derailment is close to the disused station at Cromore, 2¾ miles (4.4 km) from the terminus at Portrush (Figure 1).

19 The branch is operated in accordance with the NIR *Electric Token Block Regulations*, although the signal box at Portrush is normally closed and is only opened for special events and for trains, such as the ultrasonic test train, which require the locomotive to *run round* the train before the return journey.

External circumstances

20 The weather at the time of the accident was clear and dry. Weather conditions played no part in the derailment.

The Train

21 The train consisted of diesel-electric locomotive number 8113 'Belfast and County Down', which was built by General Motors (GM) in 1984, and Sperry test vehicle SRS 241 (Figure 2).

22 The test vehicle was built for Sperry International by Cometi of Italy in 2006. The lower portion is a Cometi 'CMT T15' type four wheel flat wagon with rubber suspension units, and has a wheelbase of 2.5 m and an overall length of 5.92 m (Figure 3).

23 Built onto the flat wagon is a body which consists of a steel shell of similar construction and dimensions to a shipping container, with a single hinged door at the left-hand end of each side.

24 The interior of the vehicle contains ultrasonic test equipment, a one cubic metre water tank, and a generating set for powering the test equipment. The vehicle is air conditioned, to maintain the test equipment at an even temperature. There are no seats or windows because it is not designed for people to ride in.

Figure 2: The train after the derailment

Figure 3: The Sperry ultrasonic test vehicle after the derailment

The Track

25 The track on the Portrush branch is laid with second-hand *flat-bottom rail* on concrete sleepers. This rail was originally bolted together in 60 foot lengths but when laid on the Portrush branch it was *cropped and welded* to form *continuous welded rail* (CWR). Further details of the track and the history of it can be found in paragraphs 37 - 43.

Events preceding the accident

26 The ultrasonic test vehicle, which had previously worked on the NIR system in 2006 (paragraphs 52 – 71), began its second recording programme over the NIR network on Tuesday 10 April 2007. Most of the network was covered in the next three days. The plan for Friday 13 April involved leaving Adelaide depot, Belfast, at 23:30 hrs and running via Bleach Green (where testing began) to Coleraine, then over the branch line to Portrush, running round and returning, not testing, to Coleraine where the test vehicle would be stabled at 05:00 hrs before testing the line to Londonderry the next night.

27 This programme was slightly modified by a supplement to the Weekly Operating Notice (WON) (paragraphs 73 – 77) which brought forward the timings so that the train left Adelaide at 20:05 hrs, there was to be a short stop at Magherabeg for meal purposes and to allow other trains to pass, and the duty would terminate at Coleraine at 01:45 hrs.

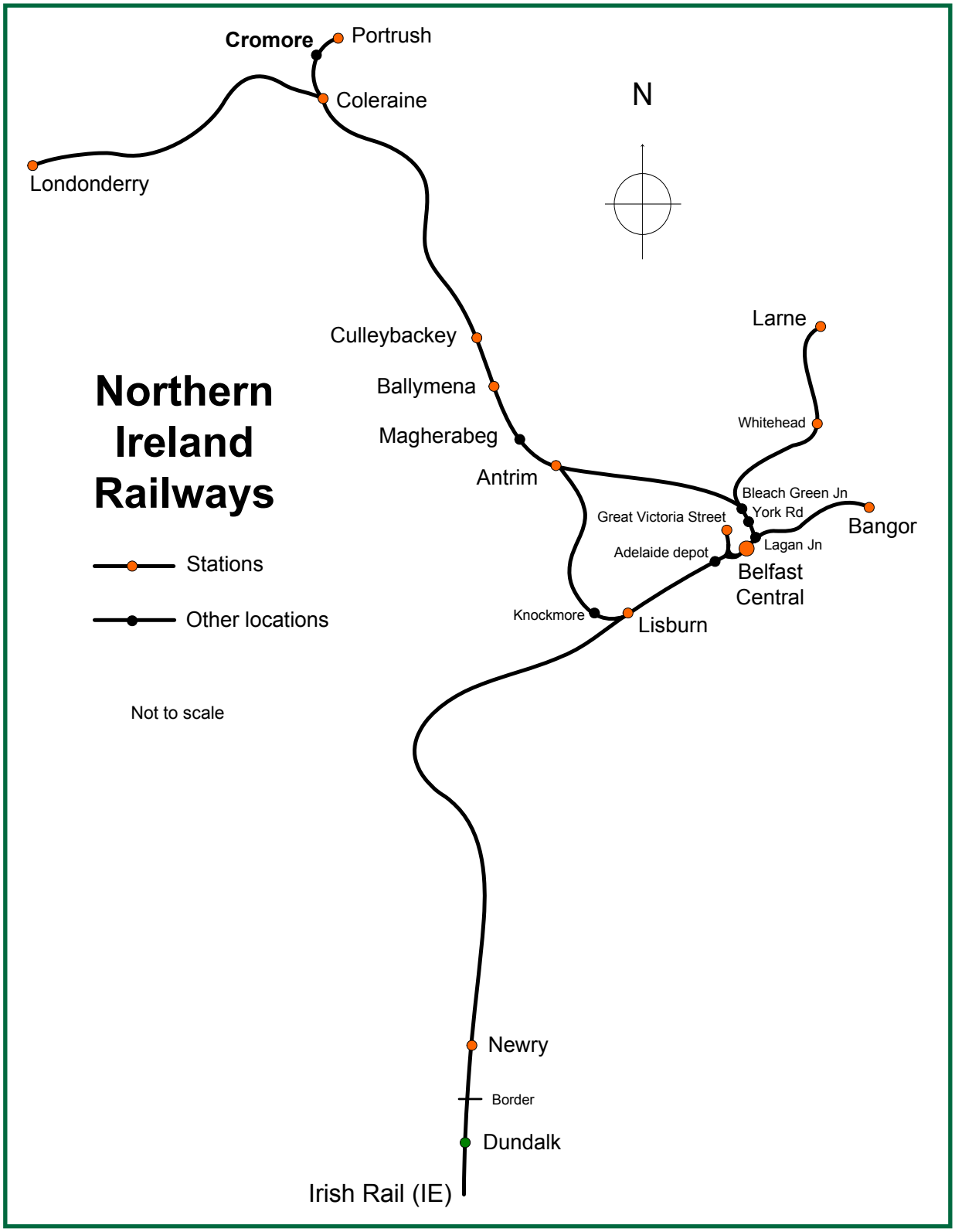

Figure 4: System map of Northern Ireland Railways showing locations mentioned in the text

28 The revised timings were followed quite closely, except that the meal break was taken at Antrim rather than Magherabeg because better facilities were available. The train reached Portrush 15 minutes early at 00:10 hrs, and after the locomotive had run round the test vehicle, it left Portrush at 00:48 hrs.

29 The driver was accompanied in the cab by a NIR traction inspector, who was acting as guard for the train. Also in the cab was a NIR permanent way inspector who was responsible for overseeing the ultrasonic testing and ensuring that the test runs went smoothly. There were three Sperry employees travelling with the vehicle, riding in the rear cab of the locomotive.

Events during the accident

30 The departure from Portrush was uneventful. As the train approached Cromore it was travelling at about 49 mph (77 km/h), when the Sperry employees in the rear cab saw the test vehicle bouncing violently. It steadied briefly, and then derailed. One of the Sperry staff tried to use the locomotive's horn to attract the attention of the train crew, but without success.

31 At about the same time the driver and the guard became aware of a rumbling noise. They both looked out of the cab windows, and looking back could see a cloud of dust. The driver brought the train to a stop with an emergency brake application, and when the crew got out and examined the test vehicle they discovered that it was derailed all wheels to the left in the direction of travel (Figure 3).

Consequences of the accident

32 About 400 m of track was damaged, and the running gear of the Sperry vehicle was distorted and some pieces of the brake rigging were detached. The ultrasonic test probes, fixed between the wheels, were destroyed.

33 No-one was injured.

Events following the accident

34 The crew of the train contacted the signalman at Coleraine and the NIR control to inform them of the derailment. The emergency services were not called.

35 The locomotive was released at 12:20 hrs on Saturday 14 April. The test vehicle was lifted clear of the line by a crane on Sunday 15 April, and the line was re-opened with a 20 mph speed restriction past the derailment site at 14:55 hrs that day. The test vehicle was removed by road the following day.

The Investigation

36 The RAIB obtained evidence for this investigation from:

- examination of the train and the track on site by RAIB inspectors;
- evidence gathered at the scene, including the data recorder on the locomotive;
- interviews with staff;
- examination of the test vehicle at the premises of Sperry in Derby, England;
- calculations carried out to model the behaviour of the wagon suspension; and
- documents relating to the design, testing and approval of the vehicle obtained from NIR and Sperry.

Factual Information

Track on the Portrush branch

37 The Portrush branch is part of the *non-core network* of Northern Ireland Railways. The long-term funding of these lines has been uncertain for many years, and their future is still under review by the Department for Regional Development. This has meant that their continued operation has been in some doubt for a long period, and has severely restricted the amounts that successive Infrastructure Executives of NIR have been allowed to spend on maintenance and renewals.

38 By the late 1990s the Portrush branch track was in poor condition. At that time it consisted of *bullhead rail* on wooden sleepers. In 2000 the then Infrastructure Executive of NIR decided that if the line was to remain open there was no alternative to renewal of the track, and therefore initiated a project to relay the whole of the Portrush branch as economically as possible.

39 The chosen method was to use second-hand rail, which was available following the relaying of the Belfast – Lisburn main line with continuous welded rail (CWR). The 60 foot (18 m) lengths of rail removed from this line were new in the late 1970s, and had had sufficiently little wear to allow them to be re-used on a branch line. Serviceable lengths of rail were transported to the Portrush branch, where the ends were cropped to remove the bolt holes and the resulting 15 m lengths were *flash butt welded* together into 300 m strings, by a welder working in the *five-foot* of the existing track. This was the first time that NIR had used this technique, which (for comparison) is permitted on Network Rail (NR standard NR/SP/TRK/0011, section 5), but is rarely used because it is time-consuming and not normally cost-effective.

40 The rail that was used was flat-bottom, mainly CIE 50 kg/m section, but on the approach to the point of derailment near Cromore there is a length of about 60 m of BS113A rail, which is of very similar section and can safely be used alongside 50 kg/m rail.

41 The whole renewal operation was carried out during a twelve week closure of the Portrush branch in summer 2000. The time pressures inherent in this meant that it was not possible to carry out rail straightening. This was significant because the re-used rail had acquired a dip at each end because of the heavy traffic and limited maintenance it had experienced during its previous use on the Belfast – Lisburn line, and it proved impractical to eliminate this feature when the rail was cropped and welded. This resulted in there being a distinct dip at each weld.

42 From the time that it was relaid the track exhibited ‘hogging’, in which each 15 m rail length has a convex vertical profile between the welds at either end. NIR believe that this has got worse in the seven years since relaying, because the dip at the weld results in an increased dynamic load on the formation at this location each time a train passes, and leads to the crushing of ballast and loss of support at that spot, causing the dip to become more pronounced.

43 NIR have attempted to correct this effect by *tamping*, but these efforts have not been successful. The result of this is that the track geometry on the Portrush branch now exhibits cyclic top on a 15 m wavelength, for the whole length of the line, and as far as vehicle ride is concerned, it has similar characteristics to jointed track and is sometimes referred to as ‘virtual jointed’ track. The track near the point of derailment is shown in Figure 5 (the derailed train can be seen in the distance).

Figure 5: Track near point of derailment, showing cyclic top

Track geometry measurement

44 NIR uses the Irish Rail track recording car (TRC) for measuring track geometry on its network. The most recent run of the TRC over the Portrush branch before the derailment was on 27 August 2006. Output from the TRC is in paper form, and is sent to the District Engineer, who will also ride on the TRC during the recording run. At present NIR does not mandate any recognised standards for track maintenance (paragraph 47), and the District Engineers use their judgement in interpreting the output from the TRC and directing appropriate remedial work.

45 The TRC run over the Portrush branch in 2006 confirmed the presence of cyclic top along the whole route. Part of the trace covering the area of the derailment is at Figure 6. Distances on the trace are in miles and yards. It can be seen that the left and right top are closely matched, and exhibit peaks every 15 m, corresponding to the length of the cascaded rails that the branch is laid with.

46 Shortly after the TRC run this printout was reviewed by the Infrastructure Engineer (Track) and the District Engineer (North). The District Engineer (North) arranged for the line to be tamped during late 2006 to try and correct the cyclic top, but RAIB's site survey after the derailment showed that the track was in a similar condition to that which existed at the time of the TRC run in 2006.

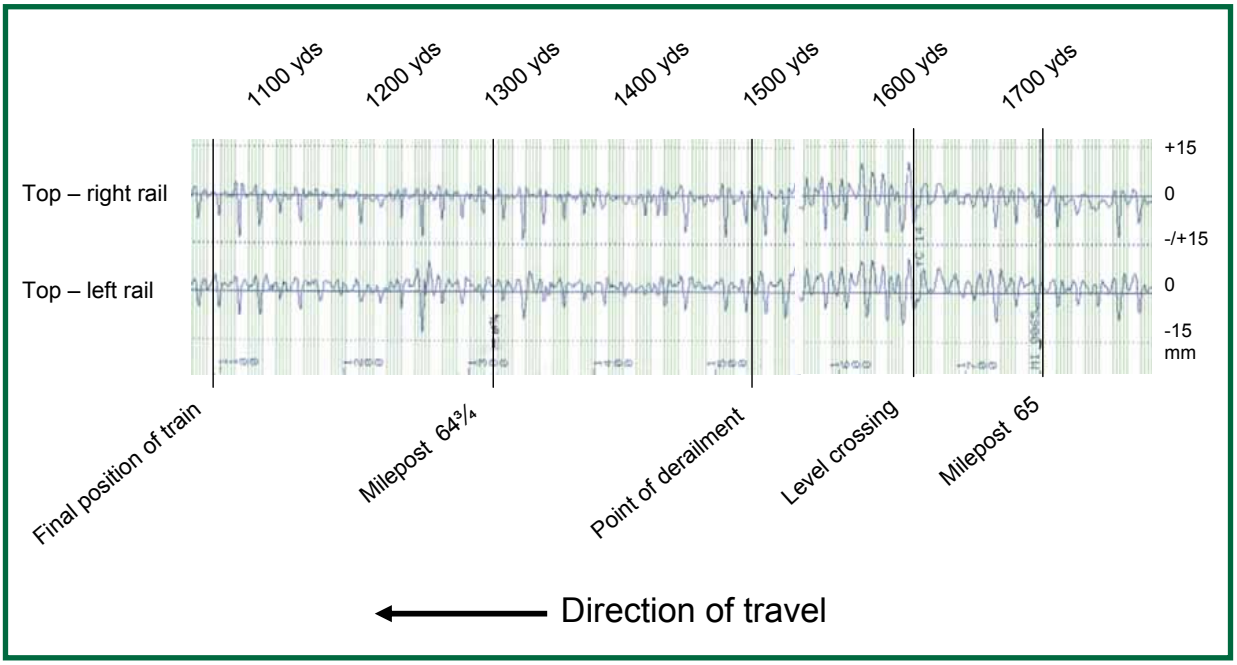

Figure 6: Track recording coach output for area of derailment on 26 August 2006

Track standards and cyclic top

47 NIR uses Railway Group Standards and Network Rail standards as the basis for its track design and maintenance, but does not mandate compliance with them, since they are based around GB standard gauge (1435 mm) and in this and in other ways are not entirely applicable to conditions in Northern Ireland. NIR is working towards adoption of its own suite of standards, in connection with the safety management system and certification required by the Railways (Safety Management) Regulations (Northern Ireland) 2006 which come into force, as far as NIR's operation is concerned, on 30 June 2008.

48 Cyclic top is particularly hazardous to short wheelbase four-wheel vehicles which may develop a pitching oscillation when they encounter it, as well as being prone to *hunting* (lateral oscillation of a wheelset- see Appendix B). However, the different suspension characteristics of bogie vehicles mean that they are less affected by cyclic top, and in most cases the worst consequence is a reduction in ride quality. There is no freight traffic at present on NIR, and all passenger services and NIR's own engineering trains consist of bogie vehicles, so the presence of cyclic top along the Portrush branch was not normally significant. For this reason, NIR did not consider the risk associated with cyclic top in their normal use of maintenance standards derived from Network Rail's practice.

Ultrasonic detection of rail defects

49 Detection of fatigue cracks before they reach critical size is a very important part of the maintenance regime for railway track. Ultrasonic crack detection techniques have been used by the railway industry for many years.

50 NIR has in the past used its own staff to carry out ultrasonic testing, with pedestrian operators using portable equipment pushed along the rail head.

51 The main drawback of using pedestrian operators for the detection of defects is the limited amount of track they can cover in a given time, and the high dependency on the competence and diligence of the operator.

The Sperry project

52 NIR had a relatively small number of people able to carry out ultrasonic inspection as pedestrian operators, and increasing traffic was limiting their access to the network. By 2006 there was a considerable backlog of rail inspection, and NIR were seeking a more efficient method of carrying it out. The NIR Infrastructure Engineer (Track), after reviewing the options available, approached Sperry Rail International.

53 Network Rail and its predecessors have used Sperry equipment, both pedestrian operated and vehicle mounted, in Great Britain for many years. Once a defect has been detected by vehicle-mounted equipment, a technician can then visit the site and assess the severity of the defect. The vehicle-borne equipment is mounted in test trains made up of adapted passenger coaches. It was not practicable for one of these to be further adapted for use with the Irish track gauge (which is 1600 mm (5'3"), while the GB standard gauge is 1435 mm (4'8½")), but Sperry offered a purpose-built vehicle of a type which had been used elsewhere in the world and was readily adaptable to a variety of different gauges.

54 Sperry had been using a four wheel wagon, built on a Cometi underfame, for some three years. This vehicle, SRS240, has a body built to the restricted loading gauge of the London Underground tube system. It had been used on the railway systems of countries including Norway, Sweden, Finland and Spain without any problems with the ride of the vehicle.

55 The Sperry vehicle which was involved in the accident, SRS241, was built in 2006. It used a similar underframe to SRS240, but was fitted with a main line size body which could accommodate more test equipment.

56 The equipment associated with this vehicle uses Global Positioning Satellite (GPS) technology and track mileage data to locate the position of defects identified by ultrasonic probes mounted below the floor of the vehicle, between the wheels. It had the potential to test the whole NIR system in a series of runs carried out over a period of one week.

57 As the vehicle had not previously been used on NIR it was necessary for it to be formally assessed and approved, to ensure that operation of the vehicle did not import risk to the NIR system. NIR has a process for doing this for vehicles that are to be used on its network by a 'guest' operator (ref. N/ME/007 issue 1, December 2004). The use of the Sperry test vehicle was within the scope of this process, so when the vehicle was first brought to Northern Ireland in 2006, NIR made plans for it to be approved as laid down in N/ME/007. An 'Approval to Test' certificate (NIR/SR/001) was issued on 8 August 2006, authorising testing of the vehicle over the whole NIR network, subject to certain speed restrictions.

58 The initial information which Sperry provided to NIR indicated that the vehicle was designed to run at 50 mph (80 km/h) when in transit, and at up to 30 mph (50 km/h) when recording. This was based on experience with the SRS240 vehicle in other countries, because SRS241 itself was newly built and had only had commissioning runs at low speed on a heritage railway in England before being re-wheeled from 1435 mm to 1600 mm gauge. At the first planning meeting held by NIR, on 26 July 2006, these speeds were accepted. However, the NIR Operations Standards Manager raised the concern, in an e-mail to the Infrastructure Engineer (Track) dated 3 August, that the Sperry vehicle had a rigid body and a short wheelbase, and its speed might need to be restricted on some sections of the network.

59 The Infrastructure Engineer (Track) decided that, as NIR had no previous experience of the vehicle, its speed should be restricted to 30 mph on the sections of the network laid with jointed track or 'virtual' jointed track (paragraph 43), and these were specified on the 'Approval to Test' certificate.

60 A test plan was prepared, in the form of special operating instruction R/OP/SOI/002, dated 9 August 2006, which specified that the maximum permissible speed should be 30 mph on the sections Whitehead – Larne, Culleybackey – Coleraine – Londonderry, Coleraine – Portrush and Lisburn – Antrim. A speed of 50 mph was permitted on other sections.

61 This document also specified the dates that testing could take place, and that no other traffic would be permitted on the same line or on an adjacent line.

62 Testing under these conditions took place on 9/10 August 2006. When running at 50 mph on sections of CWR, the NIR engineer travelling in the rear cab of the locomotive observed the vehicle to oscillate at rail joints, in a way which gave him cause for concern. NIR therefore restricted the speed of the vehicle to 40 mph on CWR for the rest of the test programme.

63 Following this test Sperry added additional weight to the vehicle, in an attempt to improve the ride, although NIR were not made aware of this at the time.

64 A satisfactory test run was carried out on 23 August, and on 24 August the Approval Group met and agreed that the 'Approval to Test' certificate could now be converted to an 'Approval to Operate' certificate (NIR/SR/002), and this was issued, valid until 24 September 2007.

65 The 'Approval to Operate' certificate specified the speeds at which the vehicle could operate on each section of the NIR network, in the light of the tests that had been carried out. The vehicle was limited to a general maximum speed of 40 mph when not testing, and on the Portrush branch it was further limited to 30 mph when not testing, and 20 mph when testing (see table, Appendix D).

66 The Operations Standards Manager then prepared a Special Operating Instruction (SOI), based on the information gathered during testing and the conditions set out on the 'Approval to Operate' certificate. This document, R/OPI/SOI/004, was issued in 2006, although by the time it was ready the Sperry vehicle had already tested the NIR lines from Belfast to Newry, Bangor and Larne and had been sent south to work on the Irish Rail network. It came back to NIR in late September 2006 and tested from the border to Newry and from Coleraine to Belfast. Operating problems prevented the testing of the Portrush branch. NIR agreed with Sperry that the vehicle would return to NIR every six months. The Operations Standards Manager intended that the SOI would be issued on each occasion the vehicle came to NIR to provide a ready reference for the group of staff who would be working with the vehicle.

67 In March 2007 Sperry contacted NIR to arrange for the next round of recordings, based on the agreed six-monthly frequency. The District Engineer (South) for NIR was made responsible for making arrangements on behalf of the permanent way department and for liaison with Sperry before and during the visit of the ultrasonic test vehicle.

68 NIR planned that the recording runs would take place in the second week in April. To complete the arrangements and prepare the information that would appear in the weekly operating notice (WON), a meeting was held in late March or early April (the exact date was not recorded). The Infrastructure Engineer (Track), the District Engineer (South), the Planning Manager and the permanent way supervisor who was to travel with the test vehicle were present at this meeting, with the Planning Manager representing the Operations department.

69 Since it had not been tested in 2006, the Portrush branch was to be given priority on this visit of the test vehicle. The Planning Manager was uncertain about the speeds that had been used for generating the *paths* in which the test vehicle was to run and asked the District Engineer (South) what speed the test vehicle was authorised to run at.

70 The District Engineer (South) wrote down on the draft timings tabled at the meeting: "Speeds for Sperry Welded non testing 50 mph testing 30 mph, Jointed non testing 30 mph testing 15-20 mph". These figures were from his memory of the first tests done in August 2006 and information given by Sperry in their initial presentation of the vehicle. He had seen neither the Approval to Operate Certificate for the test vehicle, nor the SOI prepared in 2006.

71 The vehicle arrived in Northern Ireland on Friday 6 April and was unloaded at NIR's Adelaide depot in Belfast. Testing began on Tuesday 10 April, and continued each night until Friday.

72 The normal crew for the test vehicle was two Sperry staff, a chief operator and an operator. On the day of the accident the Sperry Rail operations manager was also present to watch the operation of the vehicle.

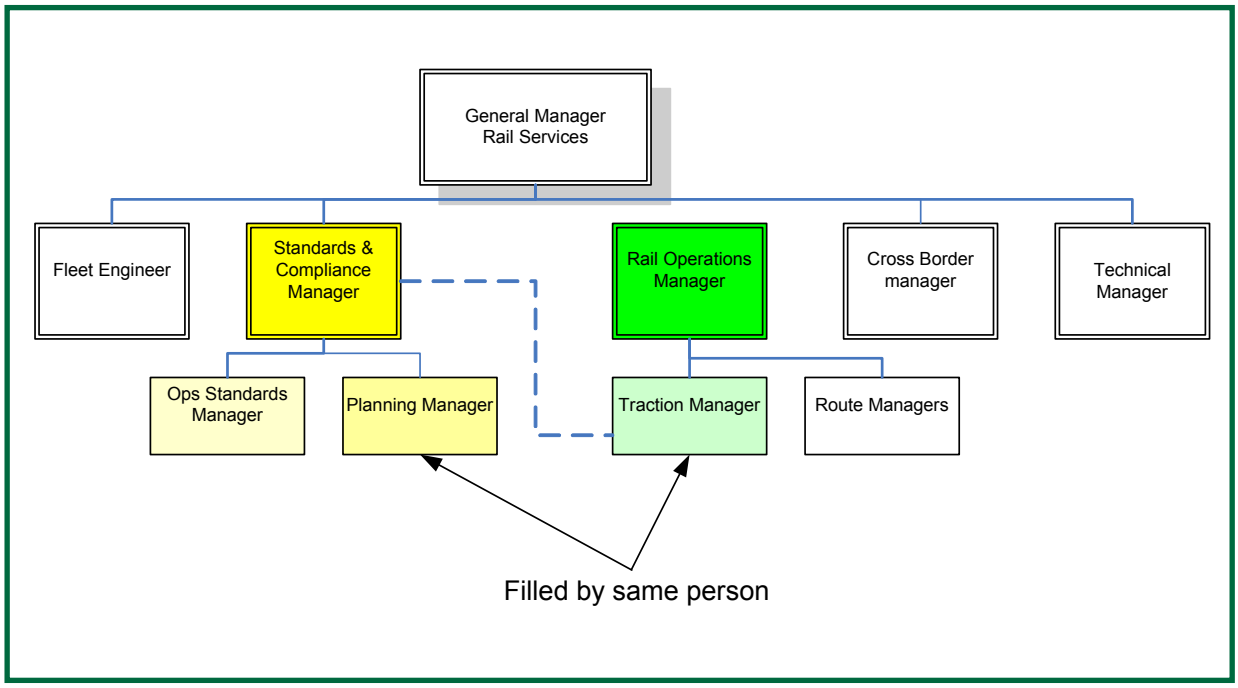

Figure 7: Organisation chart for NIR Operations and Engineering departments

The Weekly Operating Notice

73 The WON included information on temporary speed restrictions, special trains, party bookings and seat reservations, civil engineers trains, engineering possessions, and a list of operating instructions currently in force. WON 14 covered the period from 7 April to 14 April 2007. In the entries relating to the ultrasonic test trains, the timings for each day's run were given and the following information appeared: 'Speeds for Sperry Wagon on CWR: Non testing 50 mph, testing 30 mph. Speeds for Sperry Wagon on Jointed rail: Non testing 30 mph, testing 20 mph'. The supplement which was issued to modify the timings of the test train on 13 April repeated this information.

74 Figure 7 shows part of the organisation of the departments of NIR responsible for operations and standards. The Standards and Compliance Department produced all operating documents. At the time of the accident the arrangements for preparing the WON had existed for many years. Each notice commenced on a Saturday. On the Monday before that, a meeting was held in the Standards and Compliance Department, chaired by the Planning Manager, which was supposed to be attended by representatives from the Infrastructure and Operating Departments to agree the engineering work programme for the coming week. In practice, there was a low level of engineering activity and it had become customary for the Permanent Way Department to submit details of proposed works in writing rather than attend the meeting, and for the Planning Department to produce a draft WON on the Tuesday or Wednesday and circulate it for comment to a large number of individuals and departments. No response by Thursday was taken as agreement to the contents, and the final document on was issued on Thursday or Friday for commencement on Saturday.

75 The work of preparing the notice was done by the Planning Manager. He was unfamiliar with the Sperry vehicle and used the information provided by the District Engineer (South) as the basis for the whole entry in the WON (paragraph 70). At this time, within the Standards and Compliance Department the Planning Manager was also filling the post of Traction Manager in Rail Operations (see Figure 7) to which he had been appointed in December 2006: he was continuing with his duties as Planning Manager pending a reorganisation. The Operations Standards Manager was on leave at the time the planning for the visit of the Sperry vehicle took place, and his assistant was on long-term sick leave.

76 The Standards and Compliance Manager had been filling the role of Professional Head of Operations. However, he left the company at the beginning of April to take up a post elsewhere, and his duties as Professional Head fell on the Operations Manager. The Standards and Compliance Manager had received a copy of the Approval to Operate Certificate for the Sperry vehicle, but he had not circulated it within the Compliance Department.

77 WON 14 was circulated for comment in the normal manner, but no-one identified that the speeds shown for the ultrasonic test train did not correspond to those on the Approval to Operate Certificate or the Special Operating Instruction.

The Special Operating Instruction

78 The Operations Standards Manager had personal control of the Special Operating Instructions. He prepared them, and it was his practice to issue them as and when they were needed, with the intention that the relevant staff would each receive a copy of the instruction and it would be close at hand and/or fresh in their minds on the day it was required.

79 When the plans for the Sperry vehicle to run in 2007 were made, and the information for the WON went to the Planning Manager, the Operations Standards Manager was on holiday. He was therefore unaware of the presence of the Sperry vehicle until he returned to work the day before the derailment, and for this reason the Special Operating Instruction relating to the vehicle was not issued in time for its visit to NIR.

Previous occurrences of a similar character

80 A ballast regulator, being towed by a tamper, derailed at Trooperslane on the Belfast – Larne line of NIR on 23 April 2006. The RAIB has published a report on this incident (25/2007). This derailment was caused by a mechanical defect on the ballast regulator, but the investigation also found that the train was being driven at more than the maximum speed permitted for the ballast regulator, because the driver had not been given the appropriate training, due to a breakdown in competence management arrangements.

81 There were a large number of derailments of four-wheel short (10 foot (3 m)) wheelbase wagons on British Railways between 1960 and 1966, on *plain line* and involving trains travelling at 50 mph (80 km/h) or more. Derailments occurred when the peak lateral force between the wheel flange and the rail caused by hunting occurred at the same instant as the vertical load on that particular wheel was reduced to a minimum as a result of the reaction of the wagon suspension to a track irregularity.

82 The British Railways Board imposed a blanket speed restriction of 45 mph (72 km/h) on all trains containing short wheelbase wagons, and following this action the number of such derailments significantly decreased. Some short wheelbase vans subsequently had their suspension modified to make them suitable to run at higher speeds, but this was not wholly successful and the use of short wheelbase vehicles in commercial freight services was discontinued in the 1980s.

Analysis

Identification of the immediate cause

83 There were no defects in the vehicle which could have caused or contributed to the derailment. The presence of cyclic top in the track was clear from the RAIB's survey of the track 200 m on the approach to the point of derailment, made immediately after the derailment. It was also evident from the TRC output from a test run which took place eight months before the derailment.

84 Witnesses saw the vehicle "bouncing" as the train approached Cromore. The wagon then appeared to steady momentarily, probably because any hunting motion stopped when the left-hand wheel flanges climbed onto the rail head, before derailing.

85 Calculations showed that the test vehicle was likely to be prone to excitation by cyclic top at speeds above 40 mph (65 km/h). The short wheelbase of the vehicle meant that it was also dynamically unstable and hence prone to hunting, and this combined with the pitching induced by the cyclic top would make the wheels likely to run off the rails when the speed rose to the point where the vehicle's response to the vertical excitation resulted in unloading of the wheels.

86 The immediate cause of the derailment was wheel unloading due to excitation caused by cyclic top input from the track.

Identification of causal and contributory factors

Speed of the train

87 The train was travelling at about 49 mph (77 km/h) at the time of the accident, as recorded by the OTDR of the locomotive. The driver had understood from the WON and the supplement, which he had been issued with (paragraph 73), that the appropriate maximum speed on CWR when not testing was 50 mph, and he was controlling the speed of the train accordingly. The track on the Portrush branch was technically CWR. However, because of the way it had been laid, in terms of vehicle ride it performed in the same way as jointed track (paragraph 43). For this reason the maximum speed which had been authorised in the Approval to Operate Certificate and SOI for the Sperry wagon on the Portrush branch was 30 mph (paragraph 64).

88 Because the wagon suspension was liable to excitation at speeds over 40 mph (65 km/h) (paragraph 85), the speed of the train was a causal factor in the derailment. The excessive speed arose directly from the error in the WON.

Weekly Operating Notice

89 The WON had been prepared by the Planning Manager, who was also acting as Traction Manager (paragraph 75). The system of sending out the draft WON for comment to a large number of departments, depots and individuals (paragraph 74), regardless of the sources of the information in it, meant that there was no 'ownership' of the document and it was rare for any comments to be received. In practice the check on the accuracy of the information in the WON was not effective in identifying errors and conflicts in the published plans.

90 The errors in the WON arose because the Planning Manager prepared it using incorrect information supplied at a planning meeting (paragraph 70) without reference to the appropriate documents (the Approval to Operate certificate, or the SOI), and this information was not checked at any stage of the process because there was no mechanism for doing so at the time. The errors led directly to the excessive speed of the train and were a causal factor in the derailment (**Recommendation 1**).

Special Operating Instruction

91 The SOI relating to the Sperry wagon had not been issued. That this had not been done would not have been immediately obvious to anyone checking the reference on the Approval to Operate Certificate, which was posted in the vehicle, because this incorrectly referenced R/OP/OPI/004, a standard operating instruction which is permanently in force on NIR and is identified as such on the last page of each WON: it is concerned with defect reporting. However, the Approval to Operate Certificate had not been widely circulated, and it is unlikely that any NIR staff had seen the copy posted inside the vehicle as only Sperry staff had any reason to enter it.

92 The Approval to Operate Certificate had not been circulated within the Standards and Compliance Department. The reasons for this were related to a breakdown in communications and relationships within the department around the time of the departure of the Standards and Compliance Manager. It is unlikely that this was a factor in the issuing of the SOI, which did not happen because the Operations Standards Manager was on leave at the time that the plans for the visit of the Sperry vehicle in 2007 were made. However, if the Planning Manager had received a copy of the Approval to Operate Certificate, he would have been able to check it against the information provided by the infrastructure department for the WON, although there was no procedure in force at the time that required him to do this.

93 If the SOI had been issued, the Planning Manager would have been able to use the information in it when he was preparing the WON, and the driver would have had two accurate sources of information about the maximum speed for the train. It is likely that the derailment would not have occurred.

94 The non-issue of the SOI and the failure to circulate the Approval to Operate Certificate were causal factors in the derailment (**Recommendation 2**).

Compliance Department

95 The Standards and Compliance Department was short of staff at the time of the accident, as described in paragraph 75. This was a probable contributory factor in the derailment. This has been recognised by NIR and appropriate action taken to reorganise the department and put in place appropriate procedures for covering staff absences.

Wagon suspension

96 The suspension of the test vehicle was designed for use in works trains travelling at low speed. It is relatively stiff and has no damping. Because of this the wagon will ride roughly on any track which is not of the highest quality, and because of its short wheelbase it will pitch heavily in response to small vertical inputs arising from rail joints and variations in top level.

97 If these inputs are regular (as with cyclic top), and close to the natural frequency of the suspension or one of its *harmonic frequencies*, pitching may develop to the point where the wheels will significantly unload and the wagon appears to bounce.

98 As the wagon had such a short wheelbase, the design of the suspension meant that the wagon was highly sensitive to irregularities in the track, and liable to excitation by cyclic top when travelling at more than 40 mph. This had been recognised in the speed limits that NIR had set out for the wagon, although these were exceeded on 14 April. The design of the suspension was therefore a contributory factor in the derailment (**Recommendation 3**).

Condition of the track

99 The track had been relaid with cyclic top present, and subsequent maintenance had not reduced this: the condition had probably become worse in the seven years since renewal took place (paragraph 42).

100 The need to operate the Sperry vehicle at a reduced speed over the Portrush branch had been identified during the approval process, and if the speed on the journey on 14 April had been limited to 30 mph (50 km/h) the derailment is not likely to have occurred. However, the speed limit was exceeded, and in those circumstances the condition of the track was a contributory factor in the derailment that occurred.

Identification of underlying cause

101 NIR is a small organisation in railway terms, with less than 900 staff. The management culture of NIR relies heavily on personal relationships, and the company's procedures and processes are often less formal and structured than is the case in larger systems.

102 The circulation of documents relating to the Sperry vehicle and the preparation of the WON for the week which included 13/14 April are two examples of how the lack of effective procedures and the consequent breakdown in communications led to inaccuracies in safety critical information being conveyed to operational staff.

103 There were staff shortages and breakdowns in communication which contributed to the situation which developed, but the lack of defined and documented processes for the production and issue of operating documents was the underlying cause of the derailment (**Recommendations 1 and 2**).

Severity of consequences

104 After the wagon had derailed, the three members of Sperry staff who were travelling in the rear cab were unable to take any action to alert the driver (other than sounding the horn at the rear of the locomotive, which the driver was unable to hear) or stop the train, because they had no means of communicating with the front cab, and they had not been briefed on how to apply the brakes in an emergency (which is done by operating the emergency brake control on the back wall of the cab, behind the driver's seat).

105 This meant that the wagon ran derailed for over 400 m, and therefore damage to the wagon and to the track was more extensive than it would have been if the train had been stopped immediately after the derailment occurred. If the brakes had been applied immediately, the train could have been stopped in approximately 280 m.

106 The guard had not been instructed to brief the Sperry staff about the controls and how to stop the train in an emergency. He was travelling in the front cab because he considered that he was carrying out the duties of a ballast guard on an engineering train, and was therefore required to travel in the front cab to instruct the driver concerning the movement of the train, as defined in the NIR/IE Rule Book, section B, clause 5.2. However, there was no need for such instructions while the train was returning to its stabling point, and in those circumstances he should have ridden in the rear cab as required by clause 5.1 of section B of the Rule Book.

107 During recording runs a permanent way inspector travelled in the rear cab to act as a communication channel between the Sperry crew and the guard, using two-way radios to pass messages about the appropriate speed for ultrasonic testing. These radios, however, were gathered together and put in the back cab once testing had finished for the day.

108 The absence of means of communication between the cabs, the lack of briefing for the staff in the rear cab, and the absence of the guard from the rear cab were factors in the severity of the consequences of the derailment (**Recommendations 4 and 5**).

Conclusions

Immediate cause

109 The immediate cause of the accident was wheel unloading resulting from violent pitching oscillation caused by cyclic top level variations in the track.

Causal factors

110 The following causal factors were identified:

a. the excessive speed of the train, arising from errors in the Weekly Operating Notice (paragraph 88, **Recommendation 1**);

b. the Approval to Operate Certificate for the Sperry vehicle was not circulated to appropriate people within NIR (paragraph 92, **Recommendation 2**);

c. the Special Operating Instruction covering the operation of the Sperry vehicle on NIR was not issued before the ultrasonic test runs of April 2007 began (paragraph 93, **Recommendation 2**).

Contributory factors

111 The following factors were considered to be contributory to the derailment:

a. the condition of the track on the Portrush branch (paragraph 100);

b. the staffing levels in the Compliance Department of NIR (paragraph 95);

c. the suspension of the Sperry vehicle was stiff and undamped and therefore sensitive to small inputs from track irregularities (paragraph 98, **Recommendation 3**).

112 The following factors contributed to the severity of the consequences of the derailment:

a. the guard was not travelling in the rear cab of the locomotive (paragraph 106);

b. the staff travelling in the rear cab were unaware of how to stop the train in an emergency and were unable to communicate with the driver to attract his attention (paragraph 107, **Recommendations 4, 5**).

Underlying cause

113 The underlying cause was the lack of systematic processes within NIR for the preparation and issue of the Weekly Operating Notice and Special Operating Instructions (paragraph 103, **Recommendations 1, 2**).

Additional observations

On-train data recorders

114 Locomotive 8113 was fitted with a Hasler type RT data recorder, which is an electro-mechanical device for recording speed only. It provides a record of speed over the last 2000 yards the locomotive has travelled, and then overwrites the data. At the time of the accident, there was no legal requirement in for trains in Northern Ireland to be fitted with data recorders.

115 The speed information was sufficient for this investigation. However, the absence of any recording of other parameters may hinder future investigations into accidents involving this class of locomotive.

116 The Railway Safety Regulations (Northern Ireland) 2007 (SR 2007 no. 47) require, by 31 December 2007, the fitting of data recorders to passenger trains to record the following information:

a. the speed of the train;

b. the application of the brakes and the application of power;

c. the indications displayed to the driver by any train protection system, automatic warning system and driver reminder appliance;

d. the actions of the driver to acknowledge and display any train protection system and any automatic warning system;

e. the actions of the driver to activate, deactivate and disable any driver reminder appliance; and

f. the time at which any of the data referred to in sub-paragraphs (a) to (e) above is recorded.

117 NIR intend to fit suitable recording equipment to the GM locomotives by the end of 2007.

Wagon weight

118 The maintenance handbook supplied by Cometi for the CMT T15 vehicle gives a tare weight of 5 500 daN[1] (equivalent to a mass of 5 606 kg), and a maximum weight of 10 000 daN (10 194 kg). The vehicle itself is labelled with a tare weight of 6 500 daN (6 626 kg) and a maximum weight of 11 000 daN (11 213 kg). The actual weight of the vehicle, as measured when it was being lifted after the derailment, was 13 500 kg, and it is estimated that the water and other equipment that is on board when testing is in progress would increase this to approximately 15 000 kg. Since the derailment Sperry have been advised by Cometi that the actual gross laden weight of the vehicle may be up to 16 000 kg.

119 The tare weight marked on the vehicle refers to the flat wagon as constructed by Cometi. As the body is permanently welded to the underframe, a revised tare weight which takes account of the body and fixed equipment should be marked on the vehicle. Both the tare and the maximum weights should be corrected to correspond with the actual state of the vehicle and its intended use (**Recommendation 6**).

1 1 daN = 1 dekaNewton, or 10 Newtons. This unit of weight is close to 1 kg in normal gravitational conditions.

Track standards

120 The lack of mandatory standards for track installation and maintenance on NIR was neither causal nor contributory to the accident at Cromore, because the risk of vehicle derailment above certain speeds was identified and assessed. However, this situation is not satisfactory for a railway undertaking on which trains run at up to 90 mph (146 km/h). The RAIB considers that NIR should ensure that appropriate standards are adopted and implemented according to a defined timescale. Such standards will be required by legislation from June 2008 (paragraph 47, R**ecommendation 7**).

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

121 Sperry have modified wagon SRS241 with softer rubber chevrons in the primary suspension, and the addition of hydraulic dampers. This work was done by the manufacturers, and calculations show that it should be beneficial to the ride of the vehicle and its response to cyclic inputs (**Recommendation 3**).

122 Immediately after the accident, NIR introduced a revised process for the production of the WON. The preparation process now begins two weeks before the commencement of the notice, rather than one. Representatives from all the departments which have an input to the notice are required to attend a meeting each week to agree the contents of the notice for the following week. The meeting attendees must then check the contents of the notice, and advise the planning manager that it is correct. The notice is then checked and signed off successively by the Operations Standards Manager and the Professional Head of Operations. If supplements are needed, they must be authorised by the professional head of the department which generates them (**Recommendation 1**).

Recommendations

123 The following safety recommendations are made[2]:

Recommendations to address causal and contributory factors

1 Northern Ireland Railways should revise their process for the preparation and issue of the Weekly Operating Notice (WON) so the process ensures that the information that it contains is accurate and complete (NIR report that they have already implemented this recommendation) (paragraphs 110a, 113, 122).

2 Northern Ireland Railways should revise their process for the preparation, issue and circulation of Special Operating Instructions (SOIs) to ensure that they are seen and acted upon by all relevant staff at the appropriate time (paragraph 110c).

3 Sperry Rail International should modify the suspension of the wagons that they use for ultrasonic testing to minimise their sensitivity to track irregularities including cyclic top (already complete) (paragraphs 111c, 121).

4 Northern Ireland Railways should revise their operating instructions to ensure that, where staff who are not qualified to act as guards travel unaccompanied in the rear cab of locomotives and trains, they are suitably briefed on action to be taken in case of emergency (paragraph 112b).

5 Northern Ireland Railways should assess the risk arising from the absence of communication between the front and rear cabs of locomotives and trains, and either provide suitable fixed equipment or make other appropriate arrangements to control such risk (paragraph 112b).

Recommendations to address other matters observed during the investigation

6 Sperry Rail International should revise the vehicle weight information that is marked on the ultrasonic test vehicle and shown in the maintenance documentation to accurately reflect the unladen and laden weights of the vehicle (paragraph 119).

7 Northern Ireland Railways should establish appropriate standards for track installation and maintenance throughout its network, define a timetable for the adoption of these standards, and implement them accordingly (paragraph 120).

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

Appendices

Glossary of abbreviations and acronyms — Appendix A

CIE	Coras Iompair Eireann
CWR	Continuous Welded Rail
GM	General Motors
GPS	Global Positioning System
NIR	Northern Ireland Railways
NR	Network Rail
RAIB	Rail Accident Investigation Branch
SOI	Special Operating Instruction
TRC	Track Recording Coach
WON	Weekly Operating Notice

Glossary of terms — Appendix B

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

Approval Certificate	Certificate confirming that a vehicle imported for use on the NIR network has been assessed as suitable for safe operation.
Bullhead rail	The former standard rail section in Britain, not now normally laid in as new.*
Continuous welded rail	A rail of length greater than 37 m (120') (or 55 m (180') in certain tunnels), produced by welding together standard rails, or track constructed from such rails.*
Cropped and welded	Rail, originally in 18 m (60') lengths, which has been shortened by removing the ends which were previously drilled for bolt holes, and welded together to created CWR.
Cyclic top	Regular vertical variations from the design level in one or both rails.
Electric token block regulations	Regulations for operating a signalling system for single lines based on the issuing of tokens to trains for each section. Only one token may be released at a time and trains may not enter the section without a valid token, ensuring that only one train may occupy each section at any one time.*
Five-foot	The area between the rails, in Ireland (cf 'four-foot' in Great Britain)
Flash butt weld	A welded joint between abutting rails, made by a flash (electrical) welding process.*
Flat-bottom rail	A rail section having a flat based rail foot or flange.*
Harmonic frequencies	A series of oscillations in which each oscillation has a frequency that is an integral multiple of the same basic frequency.
Hunting	A sometimes violent periodic lateral motion of a rail vehicle. The actual motion is due to the wheelset wandering from side to side using the small tolerance available between wheel flange and rail on each side. Normally the conical nature of the wheel and inclined rails act to centre the wheels on straight track.*
Non-core network	The NIR system north of Ballymena: the lines from Ballymena to Londonderry and Coleraine to Portrush.
Path	A route for a train that is defined in a timetable by the times the train will arrive, depart and pass various points along it.
Pitching	Rocking motion of a vehicle, back and forth parallel to the direction of travel.
Plain line	Track without switches and crossings.*
Run round	Moving a locomotive from one end of a train to the other, to enable the train to travel in the reverse direction.

Special Operating Instruction	On NIR, an instruction prepared to cover operation of a special vehicle, train or other event which is issued for a specific occasion or series of events.
Tamping	The operation of lifting the track and simultaneously compacting the ballast beneath the sleepers.*
Ultrasonic test	A method of detecting and assessing the size of rail defects by means of ultrasound.*
Weekly Operating Notice	On NIR, a publication issued weekly which lists temporary speed restrictions, details of special trains and timetables, engineering works, party travel bookings, additional operating instructions, and modifications to the Rule Book Appendix.
Wheel unloading	The reduction of the force applied to the rail by one or more wheels to very low or even small negative values, which can be caused by a number of different faults in the vehicle and the track.*

Key standards current at the time

Appendix C

N/ME/007 issue 1 Dec 2004	Northern Ireland Railways Approvals Process for Guest Operators Rolling Stock

Summary of Speed Information — Appendix D

The table below summarises the information about the speed of the Sperry vehicle that appeared in the various documents:

<table>
<tr><th>Document</th><th>Speed information</th></tr>
<tr><td>Approval to Test Certificate

NIR/SR/001</td><td>

Vehicle to be hauled by a locomotive subject to a maximum line speed of 50 mph with the exception of Whitehead to Larne, Lisburn to Antrim (via Knockmore), Culleybackey to Londonderry and Coleraine to Portrush where the maximum line speed must not exceed 30 mph.
During recording, vehicle speed must not exceed 30 mph

</td></tr>
<tr><td>Approval to Operate Certificate

NIR/SR/002</td><td>Vehicle to be hauled by a locomotive subject to maximum line speeds and recording speed as follows:
<table>
<tr><th>Line</th><th>Max Speed</th><th>Recording Speed</th></tr>
<tr><td>Belfast Central to Whitehead</td><td>40 mph</td><td>30 mph</td></tr>
<tr><td>Belfast Central to Culleybackey</td><td>40 mph</td><td>30 mph</td></tr>
<tr><td>Belfast Central to Bangor</td><td>40 mph</td><td>30 mph</td></tr>
<tr><td>Belfast Central to Cross Border/Newry</td><td>40 mph</td><td>30 mph</td></tr>
<tr><td>Culleybackey to Londonderry/Portrush</td><td>30 mph</td><td>20 mph</td></tr>
<tr><td>Whitehead to Larne</td><td>30 mph</td><td>20 mph</td></tr>
<tr><td>Lisburn to Antrim (via Knockmore)</td><td>30 mph</td><td>20 mph</td></tr>
</table>
</td></tr>
<tr><td>Special Operating Instruction

R/OP/SOI/004</td><td>WHEN RECORDING, THE MAXIMUM PERMISSIBLE SPEED ON ANY LINE IS 30 MPH
<table>
<tr><th>Locations Between</th><th>Maximum Speed (When NOT Recording)</th><th>Maximum Speed (When Recording)</th></tr>
<tr><td>Bangor – Border</td><td>40 mph</td><td>30 mph</td></tr>
<tr><td>Lagan Junction – Whitehead</td><td>40 mph</td><td>30 mph</td></tr>
<tr><td>Whitehead – Larne Harbour</td><td>30 mph</td><td>20 mph</td></tr>
<tr><td>Bleach Green Junction – Culleybackey</td><td>40 mph</td><td>30 mph</td></tr>
<tr><td>Culleybackey – Coleraine</td><td>30 mph</td><td>20 mph</td></tr>
<tr><td>Coleraine – Londonderry</td><td>30 mph</td><td>20 mph</td></tr>
<tr><td>Coleraine – Portrush</td><td>30 mph</td><td>20 mph</td></tr>
<tr><td>Lisburn – Antrim</td><td>30 mph</td><td>20 mph</td></tr>
</table>
</td></tr>
<tr><td>WON 14</td><td>Speeds for Sperry Wagon on CWR: Non testing 50 mph, testing 30 mph. Speeds for Sperry Wagon on Jointed rail: Non testing 30 mph, testing 20 mph</td></tr>
</table>

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