RAIU

Railway Accident Investigation Unit

Investigation Report R2010-003

Derailment of an on track machine at Limerick Junction Station

on the Dublin to Cork Line

3rd of July 2009

Document History

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Function of the Railway Accident Investigation Unit

The Railway Accident Investigation Unit (RAIU) is a functionally independent investigation unit within the Railway Safety Commission (RSC). The purpose of an investigation by the RAIU is to improve railway safety by establishing, in so far as possible, the cause or causes of an accident or incident with a view to making recommendations for the avoidance of accidents in the future, or otherwise for the improvement of railway safety. It is not the purpose of an investigation to attribute blame or liability.

The RAIU's investigations are carried out in accordance with the Railway Safety Act 2005 and European railway safety directive 2004/49/EC.

Any enquiries about this report should be sent to:

RAIU
Trident House
Blackrock
County Dublin
Ireland

Executive Summary

At approximately 04.50 hours on the 3rd of July 2009 a train consisting of two coupled On Track Machines, ballast regulator 703 and tamping machine 743, was travelling from a work site on the Dublin side of Limerick Junction Station to the Limerick Junction Sidings. For the final part of the movement unit 703 was leading. The leading left wheel of unit 703 did not follow the route the number 27A points were set for, it travelled over the top of the left switch rail of the points and along the stock rail before derailing.

The immediate cause of the accident was:

- The derailment of the wheels as a result of the wheels taking diverging routes on the track due to the poor interface created by degraded condition of the switch rail and the wheel profile.

The causal factors identified were:

- The poor condition of the number 27A points;
- The flange sharpness of the wheels on the leading wheelset of the On Track Machine.

The underlying factors were:

- The lack of measurement of the wheel profiles as part of the maintenance of the On Track Machine;
- The lack of measurement of the wheel profiles following previous derailments of the On Track Machine.

Recommendations

- Iarnród Éireann should put in place a formalised process to ensure that life expired points are removed from service, where this is not possible a risk assessment should be carried out and appropriate controls should be implemented to manage the risks identified;
- Iarnród Éireann should ensure On Track Machine maintenance personnel are trained and competent to examine the wheelsets.

Contents

1 Factual information

1.1 Parties involved

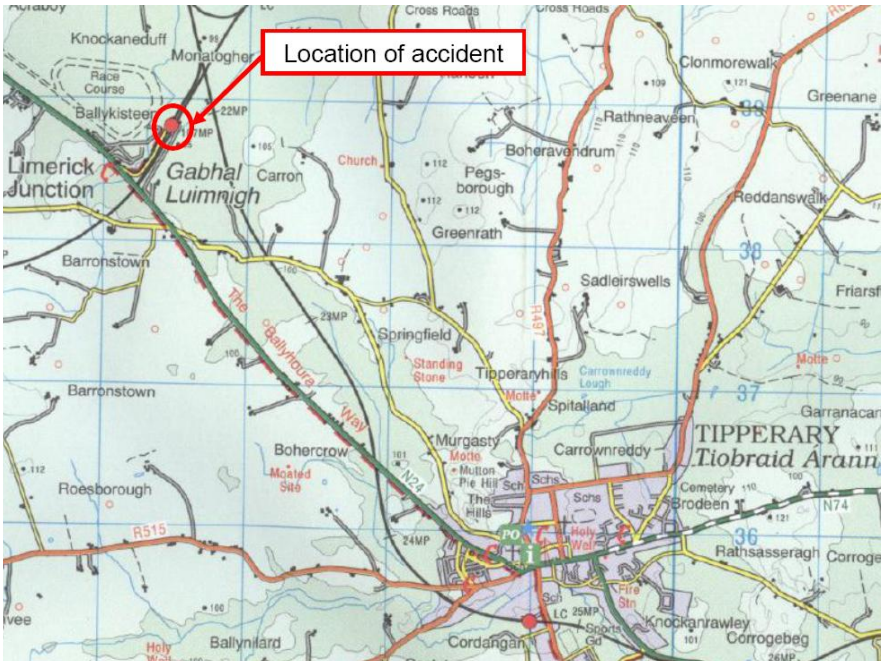
Iarnród Éireann (IÉ)[1] is the *railway undertaking*[2] that owns and operates mainline railway services in Ireland. IÉ is also the railway *infrastructure manager*.

Lloyd Rail is a privately owned company that operates *On Track Machines* (OTMs) on behalf of IÉ.

1.2 The accident

At approximately 04.50 hours (hrs) on the 3rd of July 2009, a train consisting of two OTMs, ballast regulator 703 (unit 703) and tamping machine 743 (unit 743), coupled together was travelling from a work site on the Dublin side of Limerick Junction Station to the Limerick Junction Sidings with unit 743 leading, see figure 1.

Figure 1 – Location Map



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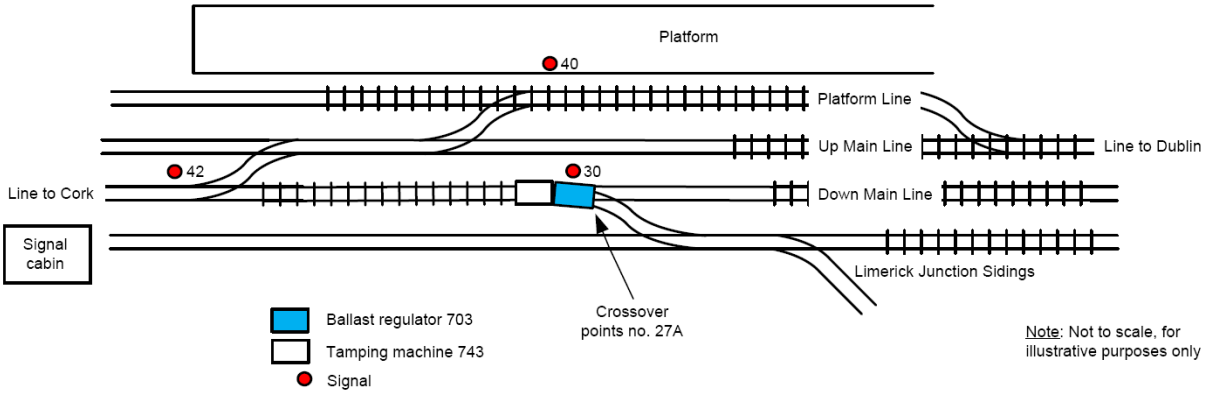
[1] All abbreviations are explained in the list of abbreviations.

[2] All terms in italics are explained in the glossary of terms.

The train entered Limerick Junction Station on the Platform Line, stopping at signal number (no.) 40. The train driver contacted the Signalman in the Limerick Junction South Signal Cabin and requested the route from the Platform Line to the Down Main Line. Once a *proceed aspect* was displayed the train travelled onto the Down Main Line and stopped with both OTMs on the Cork side of *disc signal* no. 42. Control of the movement was then taken by unit 703 to travel in the opposite direction along the Down Main Line. See figure 2 for the track layout.

Figure 2 – Site Layout



The route was set by the Signalman for the train to travel from the Down Main Line to the Limerick Junction Sidings past disc signals no. 42 and no. 30. A proceed aspect was given at disc signal no. 42 and the *points* were set to travel straight ahead on the Down Main Line. When the train arrived at disc signal no. 30 a proceed aspect was displayed and the route was set for the train to travel over the *crossover* at the no. 27A points into the Limerick Junction Sidings. The train travelled onto the no. 27A points and derailed, see photo 1.

Photo 1 – Derailed OTMs on no. 27A points

The leading left wheel of unit 703 did not follow the route that the no. 27A points were set for, it travelled over the top of the left *switch rail* of the points and along the *stock rail*, see figure 3 and photo 2.

Figure 3 – Direction of travel of wheels

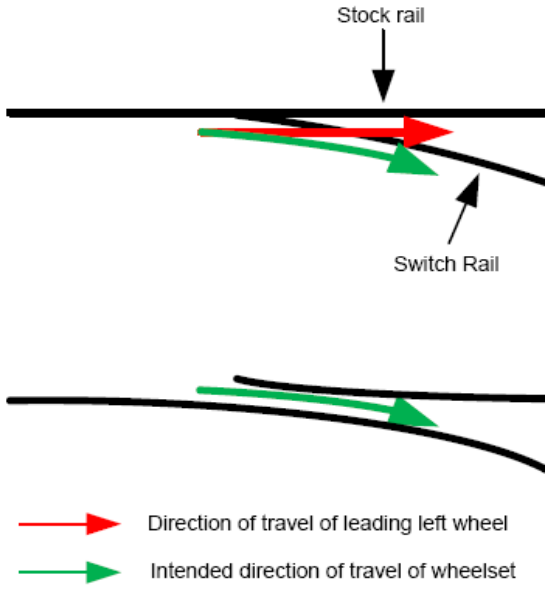


Photo 2 – Damaged switch rail

The right wheel of the leading *wheelset* of unit 703 and the second wheelset followed the correct route along the no. 27A points. The two wheels on the leading wheelset of unit 703 derailed as the route of the wheels diverged, see photos 3 and 4. The driver of unit 703 contacted the Signalman to let him know the train had derailed. The accident occurred during hours of darkness and the weather was dry.

Photo 3 – Left derailed wheel

Photo 4 – Right derailed wheel

1.3 Infrastructure

1.3.1 General description

Limerick Junction Station is located at 106 miles 1716 yards from Heuston Station on the Dublin to Cork line.

The track in Limerick Junction is jointed track on ballast with wooden *sleepers* and a combination of *bullhead rail* and *flatbottomed rail*.

1.3.2 Points

The crossover from the Down Main Line to the Limerick Junction Sidings consists of the no. 27A points at the main line end and the no. 27B points at the sidings end. Together these are referred to as the no. 27 points.

The no. 27A points are 90 pound (90 lb) bullhead rail points that were originally installed in 1947 and are operated mechanically by a wire connected to a lever controlled by the Signalman in the Limerick Junction South Signal Cabin. The no. 27A points are *trailing points* and they are usually kept in the *normal position* for movements travelling in the *down direction*.

The no. 27A points do not lock in position. The points are held in the normal position or the *reverse position* by the tension in the wire and the *catchlock* on the lever in the signal cabin.

A second crossover allowing access to the sidings was removed in 2008 due to poor condition. The crossover at the no. 40 signal was also replaced in 2008 due to poor condition.

The second *stretcher bar* at the no. 27A points was found to be bent after the derailment. It is not possible to determine whether the bar was bent before or during the accident.

The left switch in the direction of travel was found to be bent and broken following the accident, see photo 2.

1.3.3 Maintenance

Inspections are carried out by Patrol Gangers, Permanent Way Inspectors (PWIs), Assistant Divisional Engineers (ADEs) and Divisional Engineers (DEs). The inspection schedule for the track in Limerick Junction Station is detailed in table 1.

Table 1 – Track inspection schedule

Standard	Area	Carried out by	Frequency	Type of inspection
I-PWY-1307[3]	All track	Patrol ganger	Once a week	Visual
I-PWY-1107[4]	All track	PWI	2 monthly	Inspection car
			2 monthly	Cab of train
			4 monthly	Visual with Patrol ganger
			6 monthly	Track Recording Vehicle
	All track	Chief PWI	2 monthly	Inspection car
			6 monthly	Cab of train
			Once a year	Track Recording Vehicle
	All track	ADE	2 monthly	Inspection car
			6 monthly	Track Recording Vehicle
	All track	DE	6 monthly	Inspection car
			6 monthly	Visual from cab of train
I-PWY-1159[5]	Points	PWI	Once a year	Visual and gauge checks

The last inspection under I-PWY-1307 took place on the 29th of June 2009. There is no mention of the area of the no. 27A points in the records of this inspection.

The last inspection under I-PWY-1159 was carried out on the 25th of April 2009. The records for this inspection show the no. 27A points to have received a 30% rating out of a possible 100%. The rating is based on the summation of the condition ratings for items listed, see table 2. The tip of the left switch rail is recorded as being in poor condition and the switch is recorded as not being square. The points were considered by IÉ to be life expired.

[3] Iarnród Éireann (2006), I-PWY-1307, Standard for Track Patrolling.

[4] Iarnród Éireann (2006), I-PWY-1107, Track and Structures Inspection Requirements.

[5] Iarnród Éireann (2005), I-PWY-1159, The inspection, maintenance and assessment of the condition of points (Pointcare).

Table 2 – Results of inspection under I-PWY-1159

Check	**Result**	**Rating**
Track gauge within range of -0 millimetres (mm) to +5mm of design gauge	1615 mm	0
Condition of timbers	Poor	0
Chair/*baseplate* screws and fastening devices secure	Fair	5
Gauge plate stop wear (maximum 2 mm)	Fair	7
Chair/baseplate gall or timber indentation (not greater than 3 mm)	Poor	0
Stock rail bolts correctly tightened	Poor	0
Switch side wear	Fair	6
Switch tip damage (maximum 7 mm deep and 200 mm long)	Left side – Poor Right side - Good	5
Switch crossing condition	Fair	7
Sleeper packing required	Required	0
Total Rating		30/100

At the previous inspection of the no. 27A points under I-PWY-1159 on the 9th of April 2008 the points received a 28% rating. No records are available for the inspections carried out by the PWI, Chief PWI, ADE and DE under standard I-PWY-1107. Additional inspections were reported by IÉ as having been carried out on the no. 27A points, however, no records were retained for these inspections.

1.4 Signalling and communications

1.4.1 General description

The signalling in Limerick Junction Station is *mechanically controlled signalling*. Control is split between the Limerick Junction North and South Signal Cabins. Both signal cabins are operated through mechanical levers.

The signalling system in Limerick Junction Station was due to be replaced at the end of October 2007. As part of this work, the existing no. 30 signal and no. 27 points were due to be removed. There have been delays with the implementation of this project. New points had been delivered for use as part of the re-signalling scheme and several other sets of points in Limerick Junction that were *life expired* had been replaced. A plan was in place to replace the no. 27A points with a set that had been ordered for the re-signalling of Limerick Junction, which would require adjustment of the signalling layout. Drawings had been completed in June 2008, however, approval had not yet been granted for the change.

Communication between the signalman in Limerick Junction North Cabin and train drivers is over an open channel radio system referred to as mode C. This provides communication between the signal cabins and train radios. Train drivers communicate with the signalman in Limerick Junction South Cabin by *signalpost telephone*.

1.4.2 Signal no. 30

Permission to access the Limerick Junction Sidings is given by shunt signal no. 30. The signal is controlled from the Limerick Junction South Signal Cabin. The signal detects the position of one of the switches of the points mechanically in order to give an Off aspect. The signal was in the Off position following the derailment, indicating that the OTMs had the signal to proceed.

No issues were identified relating to the signalling system that may have contributed to the derailment.

1.5 Traction and rolling stock

1.5.1 General description

Unit 703 is a USP-400 *ballast regulator* manufactured by Plasser and Theurer in 1994, see photo 5. It has a mass of 35,430 kilograms (kg) and is 21.52 metres (m) long. There is a driving cab at each end of unit 703 with the driving position situated on the right hand side. There is a mobile radio unit on the vehicle. Unit 703 has three wheelsets, two of which are powered. The wheelset that derailed is not powered. There is no event recorder fitted to unit 703.

Unit 743 is a *tamping machine* manufactured by Plasser and Theurer in 1999, see photo 6. It has a mass of 62,040 kg and is 24.1 m long. There are two driving cabs, for travel in either direction. Unit 743 has five wheelsets, two of which are powered. There is no event recorder fitted to unit 743.

Photo 5 – Unit 703

Photo 6 – Unit 743

1.5.2 Maintenance

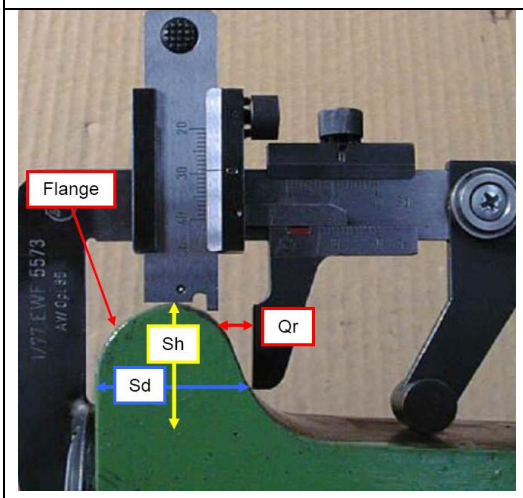
The OTMs are due to undergo maintenance inspections daily before commencing operation, 4 weekly (PM1), 12 weekly (PM2), 24 weekly (PM3) and annually (PM4).

Lloyd Rail carry out the daily inspections and forward the daily inspection sheets to IÉ. IÉ do not retain copies of these records. Lloyd Rail maintain a copy of these inspections. According to the inspection sheet for that shift, there were no faults noted with the unit 703 at the beginning of the work. No difficulties were found with the operation of unit 703 during the work.

The 24 weekly and annual inspections include checking the wheel profile. The wheel profile inspections were found not to have been carried out. The maintenance instructions did not clearly state that measurement of the profiles was required, the IÉ staff responsible for the maintenance of the OTMs were not trained to measure the wheel profiles. The records of the last inspection, which was completed on the 25th of June 2009, indicated that only a visual inspection of the wheel profiles was carried out as part of the maintenance. Full PM4 inspections were completed on the 25th of February 2009, the 17th of November 2008 and the 22nd of February 2008, the checklists for these inspections have no entry against the checking of the wheel profiles indicating that they were not carried out. The wheels on unit 703 were last re-profiled on the 13th and 14th of January 2003.

No defined wheel profile was available for the Regulator. General minimum acceptable limits for *flange* dimensions[6] have been set by IÉ for any wheel profile used on the network, beyond these limits the wheel must either be re-profiled or scrapped, see table 3. The wheel profiles for the wheelsets on unit 703 were checked following the derailment. The leading wheelset was found not to meet the minimum acceptable limits for wheel profiles on the IÉ network, see table 3.

Table 3 – Wheel Profile Flange Service Limits

Wheel Profile Flange Measurements	Requirement	Left Wheel	Right Wheel
	Flange thickness, Sd: Greater than 24 mm.	27.666 mm	25.229 mm
	Flange height, Sh: Less than 38 mm.	30.326 mm	30.415 mm
	Flange sharpness, Qr: Greater than 6.5 mm.	5.396 mm	3.760 mm

[6] Iarnród Éireann (2007), Wagon Instruction No. 23, Wheel examination for rail vehicles.

The distance between the backs of wheels on the same axle, referred to as the *back to back dimension*, is 1525 mm with a tolerance of +0 mm and -2 mm on the IÉ network. There is no mention of checking this dimension in the maintenance documents. Following the derailment, the back to back dimension for the derailed wheelset was measured as 1523 mm, which is within the required tolerance.

1.6 Operations

The maximum speed through Limerick Junction Station is 40 kilometres per hour (km/h) due to the condition of the track and signalling. The maximum speed in the Limerick Junction Sidings is 8 km/h.

The Limerick Junction Sidings are normally used for the storage of OTMs, spare locomotives, cement trains and empty test trains.

The OTMs are owned by IÉ and were operated by Lloyd Rail.

The competency of the OTM operators was found to be in date. The competency of the staff operating the OTMs was not found to have contributed to the accident.

The movements of the train through Limerick Junction Station could be observed on the station Closed Circuit Television footage. It was possible to confirm that the train was not travelling at excessive speed leading up to and at the time of the derailment.

1.7 Fatalities, injuries and material damage

1.7.1 Fatalities and injuries

There were no fatalities or injuries.

1.7.2 Infrastructure damage

The tip of the left switch rail of the no. 27A points was bent and broken, the second stretcher bar was bent and four chairs were damaged.

1.7.3 Traction and rolling stock damage

There was no damage to the OTMs.

1.8 History of accidents

1.8.1 Derailments involving the no. 27 points

The previous derailments involving the no. 27 points were:

- Derailment of locomotive 147 at the no. 27B points on the 5th of May 2009 – Locomotive 147 derailed leaving Limerick Junction Sidings while it was propelling an empty train. Gauge checks were carried out on the no. 27A points, no issues were found with the no. 27A points;

- Derailment of locomotive 117 at the no. 27B points on the 30th of November 2007 - The locomotive derailed as it was called past a signal when it was not showing a proceed aspect. The IÉ investigation report[7] issued a recommendation to 'review the condition of the no. 27 points in the interim before the rationalisation and re-signalling project is complete'. No records of a review of the condition of the no. 27 points over and above the normal checks required under the IÉ standards were available;

- Derailment of wagon 30251 at the no. 27A points on the 21st of November 2003 – The leading bogie of the first wagon derailed when the wheelset took two diverging routes.

1.8.2 Derailments involving unit 703

The previous derailments involving unit 703 were:

- Derailment at YC106 BW points in Limerick Junction Sidings on the 6th of May 2009 – The OTM derailed at a set of hand operated points in the sidings. The wheel profiles on the OTM were not checked;
- Derailment at YC106 BW points in Limerick Junction Sidings on the 18th of July 2008 - The OTM derailed at a set of hand operated points in the sidings as the operator was not aware that the coupling to the second OTM should be slackened for the move. The wheel profiles on the OTM were not checked.

[7] Iarnród Éireann (2008), Report of the derailment of locomotive 117 at Limerick Junction on 30/11/2007

2 Analysis

2.1 No. 27A points

Following the derailment of unit 703 the condition of the track at the no. 27A points was found to be poor, the ballast required renewal, the second stretcher bar was bent, some of the special chairs were indented into the sleepers, the tip of the right switch was worn and the tip of the left switch rail was bent and broken. The damage to the left switch indicated that the flange of the wheel had travelled along the top of the switch rail, see photo 2. During the inspections of the no. 27A points on the 25th of April 2009 and on the 9th of April 2008, a rating of 30% and 28% were given to the points out of a possible 100%.

The points were considered to be life expired and due to be removed as part of a re-signalling scheme for Limerick Junction. The re-signalling project had been delayed several times since the original date of the end of October 2007 and plans from 2008 for the replacement of the no. 27 points had not yet been approved, resulting in the retention of the deteriorated points in service.

2.2 Wheel profile of OTM

The profile of the wheels on the leading wheelset of unit 703 did not meet minimum tolerances defined by IÉ for travel on the railway network as the flange sharpness was below 6.5 mm. Examination of the wheel profiles is required as part of the PM3 and PM4 inspections, however, the staff were not trained to verify the critical dimensions identified in wagon instruction no. 23 and at the last inspection only visual checks were carried out which are not sufficient to establish the acceptability of the wheel profile.

The profiles of the wheels on unit 703 were not checked following two derailments prior to the derailment on the 3rd of July 2009. Had the profiles been checked, unit 703 would have been removed from operation until the wheel with a profile below the acceptable limits for wheels on the IÉ network was re-profiled.

The combination of the condition of the no. 27A points as well as the wheel profile on the left leading wheel of unit 703 led to the left wheel climbing over the switch and the wheelset following a diverging that resulted in the derailment of unit 703.

3 Relevant actions already taken or in progress

As of the 8th of June 2010, IÉ had advised that the following actions had been taken in relation to the accident:

- Points no. 27A and 27B were renewed following approval in October 2009;
- OTM maintenance staff have been trained in wheel measurement;
- Procedures have been altered so that OTMs have their wheels measured as part of their annual service;
- All annual service sheets for OTMs have been amended to include wheel measurements and records are retained for audit and inspection purposes.

4 Conclusions

The no. 27A points were known to be in poor condition and had been due to be removed as part of the re-signalling of Limerick Junction. The delays with the re-signalling project meant that the points had stayed in situ allowing for a situation to develop where the derailment was possible. The wheel profile of the leading left wheel of the OTM did not meet the required dimensions as specified by IÉ as it had not undergone measurement as part of the maintenance and only visual inspections were being carried out. The wheel profile was also not checked following two prior derailments.

Immediate cause, causal factors and underlying factors

The immediate cause of the accident was:

- The derailment of the wheels as a result of the wheels taking diverging routes on the track due to the poor interface created by degraded condition of the switch rail and the wheel profile.

The causal factors identified were:

- The poor condition of the no. 27A points;
- The flange sharpness of the wheels on the leading wheelset of the OTM.

The underlying factors were:

- The lack of measurement of the wheel profiles as part of the maintenance of the OTM;
- The lack of measurement of the wheel profiles following previous derailments of the OTM.

5 Recommendations

Based on the conclusions it has been determined that recommendations[8] were warranted as identified below.

The no. 27 points in Limerick Junction Station were known to be in poor condition. Regardless of this, they were retained in use due to delays with the re-signalling scheme for Limerick Junction. This has led to the recommendation:

IÉ should put in place a formalised process to ensure that life expired points are removed from service, where this is not possible a risk assessment should be carried out and appropriate controls should be implemented to manage the risks identified.

The profile of the wheels on the OTMs was not checked as required in the maintenance documentation. This has led to the recommendation:

IÉ should ensure OTM maintenance personnel are trained and competent to examine wheelsets.

[8] Recommendations shall be addressed to the safety authority and, where needed by reason of the character of the recommendation, to other bodies or authorities in the Member State or to other Member States. Member States and their safety authorities shall take the necessary measures to ensure that the safety recommendations issued by the investigating bodies are duly taken into consideration, and, where appropriate, acted upon. (Railway Safety Directive, 2004/49/EC)

6 Previous RAIU recommendations

No previous RAIU reports and their recommendations are relevant to this investigation.

7 Additional information

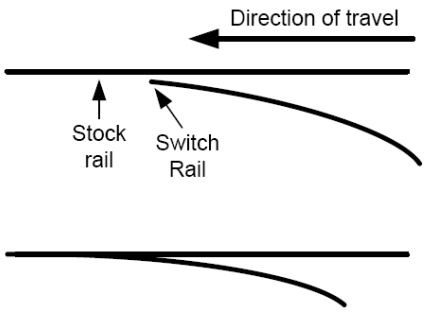
7.1 List of abbreviations

ADE	Assistant Divisional Engineer
DE	Divisional Engineer
Hrs	Hours
IÉ	Iarnród Éireann
Kg	Kilogram
Km/h	Kilometres per hour
lb	Pound
m	Metre
mm	Millimetre
No.	Number
OTM	On Track Machine
PWI	Permanent Way Inspector

7.2 Glossary of terms

Back to back dimension	The distance between the backs of wheels on the same axle.
Baseplate	A support for flatbottomed rail.
Bullhead rail	Rail with a similar shape for the top and the base of the rail.
Catchlock	A lock on a signal lever.
Causal factors	Any factor(s) necessary for an occurrence. Avoiding or eliminating any one of these factors would have prevented it happening.
Chair	A support for bullhead rail.
Contributory factors	Any factor(s) that affects, sustains or exacerbates the outcome of an occurrence. Eliminating one or more of these factor(s) would not have prevented the occurrence but their presence made it more likely, or changed the outcome.
Crossover	A section of track that allows movement between two railway lines with points at both ends.
Disc signal	Small shunt signal that rotates, displaying an red line horizontal or at 45 degrees to horizontal to indicate if a train has permission to pass the signal or not.
Down Main Line	The line on which trains normally travel away from Dublin.
Flatbottomed rail	Rail with a flat base.
	A metal plate fixed to the upper surface of a sleeper against a chair or

Gauge stop	baseplate to restrict outward lateral movement of the rail.
Immediate Cause	The situation, event or behaviour that directly results in the occurrence.
Infrastructure Manager	Organisation that is responsible for the maintenance of railway infrastructure.
Life expired asset	An asset for which the financial cost of keeping the asset part of the operational railway becomes uneconomic due to either the excessive maintenance activities required to keep it in safe operational use and/or due to operational restrictions and degraded working imposed as consequence of the degradation of the asset.
Mechanically controlled signalling	Signal control by mechanical means through the movement of levers to pull wires and adjust a signal.
Off	Term used for the position of a signal indicating that the signal is not at danger and the train can proceed.
On Track Machine	A rail vehicle used for the maintenance of the railway infrastructure.
Points	Section of track that moves to allow movement of a train from one line to another.
Railway Undertaking	Organisation that operates trains.
Rolling Stock	Rail vehicles.
Shunt signal	A signal that controls movements other than those controlled by the normal running signals.
Signalman	A person who controls the movement of rail vehicles from a signal cabin.
Signalpost telephone	A telephone on the positioned on the posts used for signals to allow communication with the signalman.
Stretcher bar	A bar fixed between the two switch rails of a set of points that maintains the distance between the switch rail.
Stock rail	The rail at a set of points that does not move.
Switch rail	Moveable part of the rail at a set of points.
Tamping machine	An OTM that lifts track and compacts ballast.
Track gauge	The distance between the rails measured at the running edge, which is a defined location on the rails, nominally 1600 mm.
Traction	Means of providing power to move rail vehicles.
Trailing points	Points over which movements normally occur in a direction where the tip of the switch rail is at the end of the movement, as illustrated.



Underlying factors	Any factor(s) associated with the overall management systems, organisational arrangements or the regulatory structure.
Up Main Line	The line on which trains normally travel towards Dublin.
Wheelset	Two wheels joined by the same axle.