



Strategy for regulation of health and safety risks - chapter 6a: Track and Lineside

Strategy for Track & Lineside

Track and lineside asset integrity is fundamental to safe railway operation (see appendix 1). Whilst management of both assets is improving, overall the management of the track asset is at a more mature management stage than that of lineside. Recent trends in the management of track assets are positive, and significant work is ongoing to improve the management of the lineside asset. Whilst this is welcome, the adequacy of the industry's arrangements for safe stewardship of the track and lineside assets remains an ORR priority due to the potential for a catastrophic event. Further, many of the risk control measures for both assets are vulnerable due to their reliance on human interventions and judgements.

ORR's strategy for regulating the risk arising from the track and lineside assets is based on the analysis of duty-holders' performance, inspection, and investigation findings. In particular we want the industry to improve the reliability of its risk control arrangements.

We will do this by:

- Engaging with the industry to encourage the development of an increasing understanding of the relationship between risk, control, responsibilities, competence and assurance;
- Setting an expectation that improved intelligence about risk prevention and mitigation is translated into effective practical delivery of change ;
- Pushing the industry to apply the hierarchy of risk control with elimination of risk at source through the principles of safety by design at scheme and component level;
- Encouraging the industry to improve engineering knowledge and innovation so that there is a move towards further engineering control of track related risks and a reduction in the reliance on human systems;
- Promote the importance of improved understanding of track asset condition, consequence of failure and appropriate mitigation in order to deliver a suitably balanced approach to the management of track, between renewal, maintenance and inspection; that take account of resource constraints.
- Pushing the industry to develop and implement a pragmatic proactive approach to improving the management of the lineside asset, in particular vegetation, whilst managing day to day risks.
- Focusing on how the industry is increasing the consistency of implementation of risk- based company control frameworks, through an ever improving understanding of risk control effectiveness linked to assurance activity.

We will continue to give specific attention to ensuring that Network Rail continues to manage the high risk area of Switches & Crossings (S&C) effectively. We will promote improved arrangements for all infrastructure managers to consider track and lineside interface risks within their asset management activities and encourage them to work with other rail industry duty-holders to manage wider system risk.

Note: Chapter 6b covers the risks from earthworks and structures that supports the track.

Summary

1. Many of the headline measures for track asset performance particularly for Network Rail and London Underground are at 'best ever' or 'near to best ever' levels. Both have achieved a notable reduction in the volume of rail defects and broken rails since 2014. However, the on-going challenges associated with significant growth and change, combined with constrained resource, potentially makes these gains vulnerable.
2. In comparison with the track asset it is noticeable that the lineside asset information and performance data is significantly less comprehensive and reliable. This makes understanding the performance of the lineside asset and demonstrating the impact of any improvements more challenging.
3. The adequacy of the industry's arrangements for managing the integrity of the track and lineside assets remains an ORR priority because of the potential for a catastrophic event should the track fail and trees or animals obstruct the line and the vulnerable nature of risk control arrangements which are sensitive to a range of influences affecting the quality of risk control implementation.
4. The industry has inspection, maintenance and renewal arrangements in place to manage track deterioration. In the context of an aging and increasingly heavily used asset keeping the correct balance between these three elements remains essential to deliver sustainable safety and train performance.
5. Ineffective or inadequate renewal and maintenance arrangements can lead to failures and present precursors to catastrophic train accidents. Fortunately these events are infrequent, but, as illustrated at Potters Bar in 2002 and Grayrigg in 2007, of high consequence. More recent derailments illustrate the consequences of failed track that in slightly different circumstances could have resulted in a catastrophic outcome.
6. Our inspection and investigation findings from track and lineside related incidents show that risk management arrangements are heavily reliant on knowledge, competence and expertise of individuals and that centrally developed strategies and procedures are not implemented consistently. There are very few leading performance indicators to identify potential problems with risk controls before control is lost, or reliably indicate whether the risk control processes are effective.
7. We note and encourage recent developments and improvements in Network Rail and London Underground's approach to: component design to reduce the risk of human failure; an increasingly clear risk-based framework and the introduction and continued development of automated inspection techniques to improve asset condition understanding.

8. A high proportion of track risk control measures continue to have a lower degree of effectiveness. Many sit towards the bottom of the hierarchy of control, chiefly because of a high reliance on the consistent application of human judgement and activity. The industry should continue to challenge itself to better understand where improvements can be made in its risk control arrangements, including competence and monitoring, so as to increase risk control reliability.

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Introduction

1. The track asset forms a critical part of the transport system due to its primary function of providing safe support and guidance to rail vehicles. Its integrity has a direct impact on safety throughout its lifecycle, from design to renewal. The provision and maintenance of safe and resilient track is therefore a primary element of the effective and safe operation of any railway. Ensuring on-going integrity is a key risk control; infrastructure managers should have renewal, refurbishment and maintenance arrangements in place to manage track deterioration risk in order to reduce the likelihood of failure.

2. Track asset is made up of plain line and switch and crossings (S&C). Plain line consists solely of fixed rails set a fixed distance apart; S&C consists of movable rails (driven by point operating equipment) that allow trains to move from one plain line to another.

3. Lineside assets are the vegetation on either side of the railway tracks up to the railway boundary, the physical railway boundary and access points.

4. To give some sense of scale, Network Rail has approximately 32,000 kilometres of plain line track and 17,900 S&C units in running lines; supplemented by some 1,500 kilometres of plain line track and 4,100 S&C units in sidings. On London Underground the concentration and accessibility of the track poses different problems with 45% (429 kilometres) of the 954 track kilometres below ground, the majority of that in deep tube single bore tunnels. London Underground has around 1,800 S&C units, mostly operating within stretches of track operating at slower speeds.

5. Both plain line and S&C are made up of a number of track related components, including rails, sleepers, fastenings, ballast, formation and drainage. Rails can be continuous welded rail (CWR) or jointed. They are attached to sleepers formed from concrete, steel or timber. Rails can also be directly fastened onto longitudinal timbers or concrete slabs in non-ballasted track construction. Each component, when managed correctly (both individually and as part of the track system) contributes to securing a safe railway that reduces the risk of derailment, collision, injury and death.

6. On the mainline network, the average age of overall track assets has increased since the mid 1990's, albeit with some marked differences between individual routes in both age profile and trend. Modern components often have a longer life than those that they are replacing. Rail, in contrast to other track assets, is the only component where the average age has reduced, principally due to the aggressive rail changing policy in the aftermath of the Hatfield derailment in 2000¹.

7. Main line rail traffic has increased by approximately 60% since 1995 and although levelling off for a period during the second half of the 2000's, has again begun to increase. The London Underground network continues to see significant traffic levels; trains travelling over 470 million miles per year and in peak times, up to one train every 90 seconds on the some lines.

8. The track asset life is influenced by, amongst other things: the amount of traffic loading; the type of asset; and level of intervention (renewal, refurbishment, maintenance). Increases in rail traffic as the railway moves towards the 24 hour railway will increase the rate of track wear, and reduce the amount of access available for inspection, maintenance, and renewal.

9. ORR also regulates:

- around 200 Heritage and tourist railways which operate at a maximum speed of 25mph and have track ranging from 0.4 to 61 kilometres.
- 7 tramway systems which are a form of light rail operating in a variety of environments including on street running, segregated street running and off street running. Whilst off-street sections have characteristics common with the mainline railway, segregated and street running sections have specific design requirements.
- Light rail systems, such as Tyne & Wear Metro and Glasgow Subway

The Law

10. The Health and Safety at Work etc. Act 1974 is the overarching health and safety legislation relevant to managing the safety of person using the track asset. The general duties under sections 2 and 3 require infrastructure managers to do what is reasonably practicable to secure the health, safety and wellbeing of employees and others. This includes having in place appropriate arrangements to ensure the safe passage of trains. There are a number of statutory instruments made under HSWA that expand on these general principles and deal more particularly with the management of risk arising from trains travelling on track. Most significantly, 'Railways and Other Guided Transport Systems (Safety) Regulations 2006' (ROGS).

11. ROGS gives duties to, amongst others, infrastructure managers, who in the context of the track asset are those responsible for developing, maintaining and managing the track so that it can be used for operating a rail vehicle. Regulations 3 and 4 require infrastructure

¹ Passenger train derailment at Hatfield, 17 October 2000;

managers to establish a safety management system that meets the requirements of regulations 5 or 6, and hold a safety authorisation.

12. Regulation 19 of ROGs sets out very explicit duties around carrying out suitable and sufficient risk assessments, and putting in place measures to ensure the safe operation of the transport system. Regulation 4 of the Management of Health and Safety at Work Regulations remains relevant, setting out the principles of prevention that must be applied through the 'hierarchy of risk control'².

13. The Railway Safety (Miscellaneous Provisions) Regulations 1997 places responsibility on the infrastructure manager for the railway's boundary measures, based on the principle of preventing unauthorised access to the tracks by people or animals.

14. Increasingly relevant to the track asset as the railway continues to evolve, are the requirements of the Railways (Interoperability) Regulations 2011 and the associated infrastructure technical specifications for interoperability; and the principles of 'Health and Safety by Design' discussed in chapter 12.

15. We have published 'Principles for health and safety on the railway' to help duty-holders understand our expectations for the high level health and safety outcomes that should be achieved by the railway (the principles) when complying with railway related health and safety legislation. Principles 2.4 and 2.5 – Track and Clearances for trains - are most relevant to this chapter.

Track and Lineside Integrity & Risk Profile

Track

16. There is a risk of train derailment should the track system lose its integrity. Track integrity is sensitive to the adequacy of a company's arrangements to manage condition, and the volume (usually measured in equated million gross tonnes) and speed of rail traffic. Whilst the risk is greater for the S&C, there are some key features common to both plain line and S&C that can initiate derailments.

17. The principal derailment risks relating to track asset are:

- track geometry faults (including twist, cyclic top)
- S&C faults
- track buckle
- loss of rail integrity (including broken rail, rolling contact fatigue (RCF), rail defect)
- gauge spread
- broken fishplates

18. Asset condition is maintained through a mixture of renewal, refurbishment and maintenance, all underpinned by inspection. All are dependent on continued human intervention to the right quality, at the right time and in the right location. Should the incorrect balance be delivered, or should there be under-delivery without adequate adjustment to other aspects, track condition will decline due to environmental factors and the passage of

² Taking steps to reduce risk by taking preventative measures in order of priority: elimination, substitution, engineering control, administrative controls, personal protective equipment (HSE).

trains. This leads to an increased risk of failure and potential derailment. There have been derailments, including Gloucester³, Primrose Hill/Camden and Heworth⁴ where sufficient action was not taken to prevent deterioration and this ultimately led to a train derailment.

19. Track integrity can impact on, and be impacted by other railway engineering disciplines. For example: the run on/off approaches to under-bridges can increase the risk of voiding and imposed load on the rail; embankment condition can influence the quality of track geometry, and the lack of suitable drainage infrastructure impact on the quality of track drainage provision. The position of the track in relation to other railway assets can have a significant impact on railway safety: the maintenance of suitable clearance between track and platform and other structures; track alignment and overhead wires or third/fourth rail, and the impact of track geometry profile on level crossing profile and surfaces. (See Interface chapter 5 for further information).

Lineside

20. There is a risk of train derailment through poor management of the lineside asset. The principal derailment risks relating to the lineside asset are:

- trains striking fallen trees and other objects placed on the line
- animals on the line

21. Poorly maintained vegetation can also obscure sighting at signals, user worked level crossings, and reduce visibility and clear access for the safety of workers on or near the line. Poorly maintained boundary measures also increase the likelihood of trespass incidents and theft of assets. (See Interface chapter 5 for further information).

22. Inspection processes to provide accurate knowledge of lineside vegetation makeup and condition, land use and fencing condition is a fundamental to understanding the lineside risk profile. This then enables management of the lineside asset to:

- maintain an appropriate vegetation profile
- provide effective boundary fencing, through renewal and maintenance programmes.

23. For both track and lineside the consequences of derailment will be dependent on a number of factors, including speed, location, environment (number of lines, embankment, cutting, bridge etc.), surrounding topography and train type (freight / passenger) and rolling stock type. Elements of these factors will be dependent on circumstances and chance, but they determine the seriousness of the outcome (whether there is potential for collision, for example). Despite this uncertainty the clearly foreseeable consequence is multiple fatalities. Likelihood can be kept very low if the correct control measures are in place.

Mainline – Network Rail

24. As the largest infrastructure manager regulated by ORR, Network Rail has made concentrated efforts to improve its stewardship of the track asset from the position inherited

³ Freight train derailment near Gloucester 15 October 2013

⁴ Derailment of a freight train at Heworth, Tyne and Wear, 23 October 2014

from Railtrack. The Hatfield derailment in 2000⁵ when four people were killed illustrated the inadequacies of Railtrack and their contractors' arrangements. The aftermath revealed an unacceptable deterioration in track condition due to underinvestment resulting in the imposition of approximately 850 emergency speed restrictions. Network Rail itself has also had to learn the lessons from fatal accidents due to track faults: failed stretcher bars at S&C at Potters Bar in 2002, when Railtrack were in administration and at Grayrigg in 2007.

25. Network Rail has undertaken a number of steps to secure improvements in the safe management of track since it took over from Railtrack in October 2002:

- It has brought maintenance back in-house
- It has undertaken significant track renewal and refurbishment activity
- It has reviewed & enhanced process and introduced new intervention limits
- It has analysed the strengths and vulnerabilities of its control measures through use of bow tie analysis
- It has tried to bring greater clarity to its instructions and procedures through work to improve the standards process, the role based competency (RBC) programme and introduction of the integrated management system (IMS),⁶ the aim being to make a more explicit link between competence, intervention, and control of risk.
- It has made a clearer identification of roles and responsibilities and changed its competency management system to align with these roles and strip out 'unnecessary' competence requirements.

26. The characteristics, risk profile and performance of the track asset are discussed in detail in Appendix 1. Generally, track geometry and rail performance is improving, and in some cases, such as broken rails and serious rail defects, at historically low levels.

27. This improving performance is in some part due to increased investment following Hatfield, and new technology. The introduction of pedestrian and train borne ultrasonic test unit (UTU) Sperry ultrasonic rail testing equipment the recent addition of Eddy Current testing to more accurately identify Rolling Contact Fatigue (RCF) and automated inspection techniques such as plain line pattern recognition (PLPR) have brought consistent and reliable supplements to the existing train borne systems to measure track geometry. UTU and PLPR have also brought a worker safety dividend by reducing track workers exposure to moving trains.

28. Technological improvements are welcome, but the preponderance of risk controls still rely on human knowledge, skills and judgement. Network Rail has not yet fully embedded the role based competence management to realise the full potential of this programme targeted at improving consistency and reliability of people-based processes.

29. ORR continues to make the management of track assets a top priority for its work – despite historically 'best ever' lagging indicators – because:

⁵ Passenger train derailment at Hatfield on the east coast main line; October 2000

⁶ This work was previously being undertaken through the Business Critical Rules (BCR) programme which was discontinued in 2018 & replaced through their quality management system and the associated introduction of the IMS, continuation of the RBC programme and updating of the standards process.

- Rising traffic levels can increase the rate of asset degradation, particularly on older track forms.
- Increasing traffic levels also typically reduce access availability to deliver maintenance and renewal activity, and increase the impact of failures due to the more congested network.
- Reducing the level of planned renewal activity will place greater reliance on inspection and maintenance activities.
- These conditions are increasing pressures on staff and already vulnerable control measures.
- We find varied RM3 ratings whilst improving reveal inconsistent and not well developed management maturity.
- Under the Putting Passengers First programme there is a significant devolving of track asset management responsibilities to the newly formed Network Rail regions. Consequently there is a need to ensure that each region, as it takes up these devolved responsibilities, maintains the focus on safety management to ensure the gains made to date and the process of continuous improvement are sustained.

Taken together these factors are sufficient to cause ORR to have concerns about how sustainable recent improvements will prove to be. Developing more meaningful leading safety performance indicators would allow Network Rail to more reliably identify early, and before failure, areas of weakness that can then be addressed to support making current performance sustainable.

High Speed 1

30. In contrast to the mainline network, the 68 mile (109 km) long HS1 track infrastructure is relatively new: in operation in part from 2003 and along its entire route length since 2007. It is the first high-speed railway in the UK, which allows for maximum speeds of up to 300 kph (186 mph). The track is a mixture of ballasted and slab track, and is maintained in accordance with SNCF track standards, which formed the basis of the original design and installation. The basis of Track maintenance on HS1 is basic visual inspection and track geometry measurement (similar to the UK mainline) by track recording vehicles, however, the overall maintenance strategy is 'predict and prevent' as opposed to 'find and fix'. For this reason a significant amount of time and resource is applied to analysing and trending defect data. The overall approach to managing risk is very similar to UK mainline, with asset condition maintained through a mixture of renewal, refurbishment and maintenance.

31. Although the infrastructure is relatively new, the HS1 track assets are now ageing and a large proportion of assets are approaching mid-life. During a planned routine maintenance inspection by NR(HS) track patrollers in January 2018, two loose bolts were found on a front-facing swing-nose crossing. In March 2018, during additional monitoring inspections, track patrollers found conditions at the crossing had deteriorated and identified that four bolts were loose. This was the first event of its kind on the HS1 network and had the potential to derail a train.

32. The track maintenance regime has now moved from predominantly monitoring and light maintenance to heavier maintenance with robust inspection and maintenance remains important to ensuring the integrity of the asset.

Transport for London – London Underground

33. London Underground's (LU) engineering approach to reducing risk arising from its track asset is similar to Network Rail's; designing out risk and improving the identification of risk precursors and serious defects.

34. Following a rise during 2012 and 2013 LU has more recently seen a resumption of a downward trend in rail defect numbers. Since 2013 the vast majority of rail breaks have been in bullhead rail; primarily at joints.

35. Through significant investment in track renewals, aimed at designing out risk LU has replaced significant amounts of jointed bull head rail with continuous welded flat bottom rail on concrete sleepers or direct fix slab track, improving rail integrity and reducing overall risk.

36. London Underground has also introduced new monitoring and inspection techniques to improve its understanding of asset condition, including B-Scan ultrasonic testing and the automated track monitoring system (ATMS).

37. LUs longer-term move away from traditional jointed rails on wooden sleepers, to a more modern track configuration of flat bottomed continuous welded rail on concrete sleepers has also reduced the potential for gauge widening and track twist. Targeted improvement works also include BH to FB conversion works on hardwood sleepers where the sleepers and geometry have been assessed to be adequate.

38. Track quality continues to improve across all lines, the amount of track classed as 'most serious' reducing consistently since 2013/14. Track quality discrete fault numbers have also been falling consistently since early 2013/14.

39. The increased use of track recording vehicles and automated track monitoring systems provide greater understanding of how the track performs under load, allowing track geometry faults to be identified prior to visual identification. However, the resilience of the track recording vehicle is questionable as a result of obsolescence issues, and the future position of the ATMS is now at risk.

40. Recent high risk rail defects within High Performance (HP) rail steel, and in cab noise problems resulting from the installation of Pandrol Vanguard have raised some concern regarding the change management process employed by LU.

41. The changes in LU funding arrangements and potential to impact on renewals budgets; the maintenance modernisation programme which aims to reduce track maintenance budgets; and the ongoing transformation programme provide challenges to the management of the track asset moving forwards. This challenge may be more significant when combined with the aforementioned issues surrounding change management.

Trams & Light Railways

42. Tramways are more modern networks than other UK rail networks and purpose built. However, some networks also use heavy rail track sections inherited from previous urban railway operations. These rail sections are susceptible to the same risks as on the mainline although trams speeds are lower meaning that the track is over engineered for its use.

43. To supplement this chapter we have published a specific strategic chapter for tramways. It expands this chapter to highlight key issues relevant to how tramway practice may result in hazards that are different to those of the wider railway or metro systems.

Heritage Railways

44. The heritage sector continues to grow in popularity and when normalised for its size, the potential for infrastructure failure is probably disproportionately greater than other networks. This is attributable to the age of the assets and the largely volunteer nature of its workforce. However, consequences are generally less severe due to the lower speeds prevailing and significantly lower traffic density.

45. The Heritage Railway Association has produced specific guidance for the planning, inspection, and maintenance of permanent way to support dutyholders manage track related risk. The guidance sets out the principles and requirements for Company specific standards, and each company has to determine standards appropriate to their operation.

46. Most heritage railways have installed used serviceable rail from the mainline and it may be nearing the end of its engineering design life (hence removal from the mainline). Checking management of track wear by the operators is a particular priority for us as a precursor to failure and subsequent derailment risk.

47. We find that some heritage railways do not have a sustainable renewal policy or funding available for large-scale rail renewal. There can be an absence of standards for track appropriate to their heritage use, as the mainline standards may no longer be appropriate. We expect heritage railways to have systems in place to monitor wear and staff competent to do so.

Challenges

48. There are a number of challenges that can restrict effective control of risk arising from track and lineside:

- **Reliability of controls:** Network Rail has developed a relatively mature set of standards and process that are capable of controlling risk of derailment due to loss of track integrity. Although automated inspection techniques are becoming more common, effectiveness of these controls is largely reliant on human application, judgement and intervention that sit towards the bottom of the hierarchy of risk control (e.g. not engineering based; and no fail to safety). We have evidence that these control measures can be poorly delivered at an operational level. Organisational culture, competence, and monitoring and review arrangements are fundamental to ensuring effective risk control. The move towards a risk based standards framework, and improved competence framework in the mainline network for example, has the

potential to increase the clarity and effectiveness of risk controls, if introduced and comprehensibly embedded so as to realise the potential benefits. We note there is action being taken to increase control effectiveness. Within plain line for example, inspection of key risks is increasingly reliable through use of automated inspection arrangements.

- **Monitoring arrangements:** The reliance on human judgement and intervention to implement risk controls increases the reliance on monitoring and review activity to provide confidence risk is controlled as intended. There is an absence of high quality tactical monitoring arrangements and leading indicators to identify potential problems or reliably indicate risk control effectiveness, before the asset fails.
- **Sustainable repairs:** Keeping the correct balance between maintenance and renewal activity is essential. The proportion of track geometry faults that are repeats – up to 60% in some instances – indicates that achieving sustainable repairs remains challenging in the environment of reducing renewal and refurbishment volume. In many instances, such as cyclic top and the most severe geometrical faults, maintenance interventions will only achieve short term fixes that will require repeated monitoring activity and interventions, acting as a distractor from other proactive work to prevent deterioration elsewhere.
- **Growth & increasing demand combined with constrained resource levels:** the on-going challenge of managing rail traffic growth, and resource constraints (in terms of people, reducing access & move towards a 24 hour railway on the mainline, and introduction of the ‘night tube’ on London Underground), equipment, renewal activity, refurbishment) to deliver a safe and efficient railway; resulting in reducing access for track maintenance & renewal activity leading to a greater reliance on the effective management of maintenance & renewal activity targeted at highest risk areas.
- **Granularity of data:** Network Rail’s recognised measures indicate that track asset performance at a national level is improving with some measures at ‘lowest ever’ values. This positive national performance is not reflected universally or consistently across Network Rail and potentially masks local performance challenges. There is a lack of easily accessible information at a granular level to provide visibility of track asset performance to monitor performance and allow effective targeting of finite resource. In Network Rail the roll out of the Track Integrated Geometry Engineers Report “TIGER” (commenced November 2019) will provide much improved granularity of data.
In Network Rail in comparison with the track asset the lineside asset information and performance data is significantly less comprehensive and reliable. This provides a challenge in understanding the performance of the lineside asset and demonstrating the impact of any improvements.
- **Interaction between track and freight vehicle:** particularly in relation to those vehicles that are more sensitive to track condition closer to intervention limits.
- **Interface with other disciplines** that can impact on track risk control effectiveness, and vice versa: structures, geotechnical structures, electrification overhead wires.

ORR priorities

49. Within each priority below, we reference the most relevant [Risk Management Maturity Model](#) (RM3) sub-criterion and level to illustrate the goal area we believe the industry should be moving towards.
50. Increasing understanding of the relationship between risk; control and its effectiveness; responsible role; competence; and assurance. Focus particularly on track geometry and S&C risk. (SP1 – Leadership: level (4) predictable; OC6 - Organisational culture: level (4) predictable & (5) excellent)
51. Move away from a standards based approach to one increasingly based on risk. (RCS2 - Management of asset: level (4) predictable)
52. Improved engineering control of risks and move towards elimination of risk at source rather than reliance on reactive human systems to secure adequate risk control; with a move to remote condition monitoring, automation, and further implementation of safety by design principles and innovation. (PI1-Risk assessment & management: levels (4) predictable & (5)excellent); RCS2 - Management of asset: level (4) predictable)
53. Better understanding of underlying asset condition and performance, to a granular level at local level; the risk presented; and the controls required and implemented until renewal or removal of the risk. A fundamental element of this approach is knowing the problem, and understanding and addressing the root cause rather than a symptom. Linked to need for a track maintenance strategy and supporting plans that set out the short, medium and long term goals and resources to deliver those goals delivering an informed balance between renewal and maintenance activity. (OC7 – Record Keeping: level (4) predictable and level (5) excellent; PI3 - Workload planning ; level (4) predictable); RCS2 - Management of asset: level (4) predictable)
54. Robust monitoring and review arrangements, with focus on developing leading indicators, and improvements in supervisory and monitoring arrangements at a tactical level. (MRA1 - Proactive monitoring arrangements level (4) predictable and level (5) excellent; MRA4 - Management review; MRA5 - Corrective action: all level (4), predictable)
55. At the time of writing this chapter the RM3 assessment of Network Rails track asset management was better than Network Rails overall assessed level, with track assessments typically in the standardised and predictable range. The assessed levels for the less mature area of the lineside asset were in the managed to standardised range.

ORR activities

56. **Risk Control Implementation:** Given the potential for multi-fatality events arising from track defects and lineside issues, we will continue to verify, through proactive inspection, the effective implementation of industry’s arrangements intended to manage risk associated with the track and lineside.
57. **Risk Control Implementation, S&C system:** We continue to identify the S&C system as a priority risk area due to its complexity, potential failure modes and reliance on individuals to control risk. We will continue to challenge the industry’s safe management of

S&C, including knowledge and understanding of the asset; design of risk control measures; efficacy of the inspection and maintenance arrangements to manage identified risks; and encourage its plans to reduce reliance on human intervention to secure adequate risk control through automation and safety by design.

58. **Investigation:** We will investigate selected incidents to identify lessons to be learned in the management of track and lineside risk, and to ensure suitable corrective actions are identified and acted upon.

59. **Learning Lessons:** We will ensure that the industry properly and proportionately implements RAIB recommendations; and ORR investigation findings and inspection action points; doing so through inspection programmes and where necessary formal enforcement.

60. **Enablers:** Within the main line railway, Items 57 to 59 below are closely related to the development, roll out, and implementation of the work to improve the standards process, the role based competency (RBC) programme and introduction of the integrated management system (IMS),⁷ the aim being to make a more explicit link between competence, intervention, and control of risk. . We consider these activities to be enablers to assist the more effective management of the track asset, in terms of safety, performance, and reliability.

61. **Control reliability:** The industry should apply the principles of the hierarchy of risk control and 'safety by design' as set out in chapter 12 of our strategy when planning new or modified track works or process⁸, at both a system and component level to avoid or reduce future hazards, by increasing control effectiveness and reducing dependence on human activity to achieve suitable levels of risk control. This should include developing new technologies that will reduce reliance on human judgment alone; and looking for opportunities to remove redundant assets where possible.

62. **Competence:** We will monitor the industry's activity to increase its focus on developing, maintaining, and assessing competence at all levels to allow it to grasp the full potential that its move from heavy reliance on prescriptive standards to a more risk based approach can provide.

63. **Monitoring / Indicators:** Push the industry to develop its monitoring arrangements by:

- Continuing to develop its lagging indicators so as to provide greater visibility of track and lineside performance and level of risk at a local level to allow more effective use of constrained resource to manage risk.
- Develop leading indicators, to complement its current suite of lagging indicators, to improve its monitoring arrangements to verify that the risk control system is operating as intended, or provide early warning that problems are starting to develop.

⁷ This work was previously being undertaken through the Business Critical Rules (BCR) programme which was discontinued in 2018 & replaced through their quality management system and the associated introduction of the IMS, continuation of the RBC programme and updating of the standards process.

⁸ Management, installation, inspection, maintenance, removal

- Developing its tactical assurance arrangements to provide confidence that risk control measures are being implemented to an adequate quality to secure reliable and consistent level of safety and asset performance.

64. **Maintenance balance:** Encourage the industry to move from a 'find and fix' to a 'predict and prevent' culture underpinned by appropriate knowledge of the assets and consequence of failure; leading to an increasingly proactive, effective and efficient management of the track and lineside assets through the provision of risk based maintenance, management and renewal plans.

65. **Tramways:** we describe our sector specific activities in the strategic chapter on Tramways.

66. **Heritage Railways:** We will continue to carry out inspection and investigations with track a priority. We will support the Heritage sector to implement their infrastructure inspection and maintenance guidance in a consistent manner.

Appendix 1: Characteristics of the Mainline – Network Rail

1. The RSSB Safety Risk Model⁹ defines the overall modelled risk on the railway. Whilst the risk of derailment from track failure is a small component of the overall risk, it remains important. The latest version (v8.5) published in March 2018 shows train accidents make up around 4.4% of all risk; derailments around a third of this (1.4% of all risk).

2. RSSB’s Train Accident Precursor Indicator Model (PIM) measures the underlying risk from train accidents by tracking changes in accident precursors (in the past 12 months) and is calibrated against the Safety Risk Model.¹⁰ The PIM indicates that long term risk associated with track equipment continues to broadly decline (Figure 1) making up around 3.4% of the total PIM score. As shown in Figure 2, three trends are particularly noticeable:

- S&C failure rate has risen slightly from the low of late 2016 and is now the highest risk precursor but has returned to a downward trend.
- The reported risk from track twist and geometry faults although rising slightly from a historic low of 2018/19 remains the 2nd lowest track equipment contributor
- Buckled rail performance shows the impact of the long hot summer in 2018
- However, it should be noted that PIM recorded performance is only based on the most serious track faults and doesn’t take into account wider track geometry fault performance and as such is sensitive to small changes due to the small data set.

Table 1 shows the relative PIM contribution from the principle track failure modes. As the PIM is a lagging indicator providing information on past performance, its use is limited as an indicator of future performance.

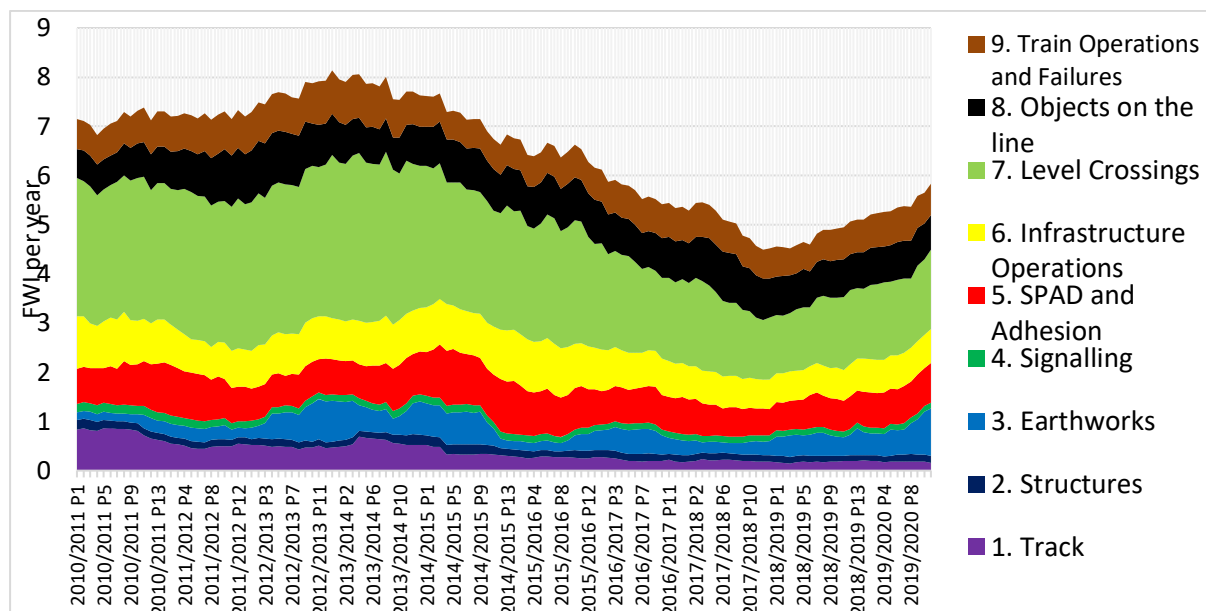


Figure 1: PIM – Total Risk, period 9 2019/20

⁹ SRM v8.5

¹⁰ <http://www.rssb.co.uk/risk-analysis-and-safety-reporting/risk-analysis/precursor-indicator-model>

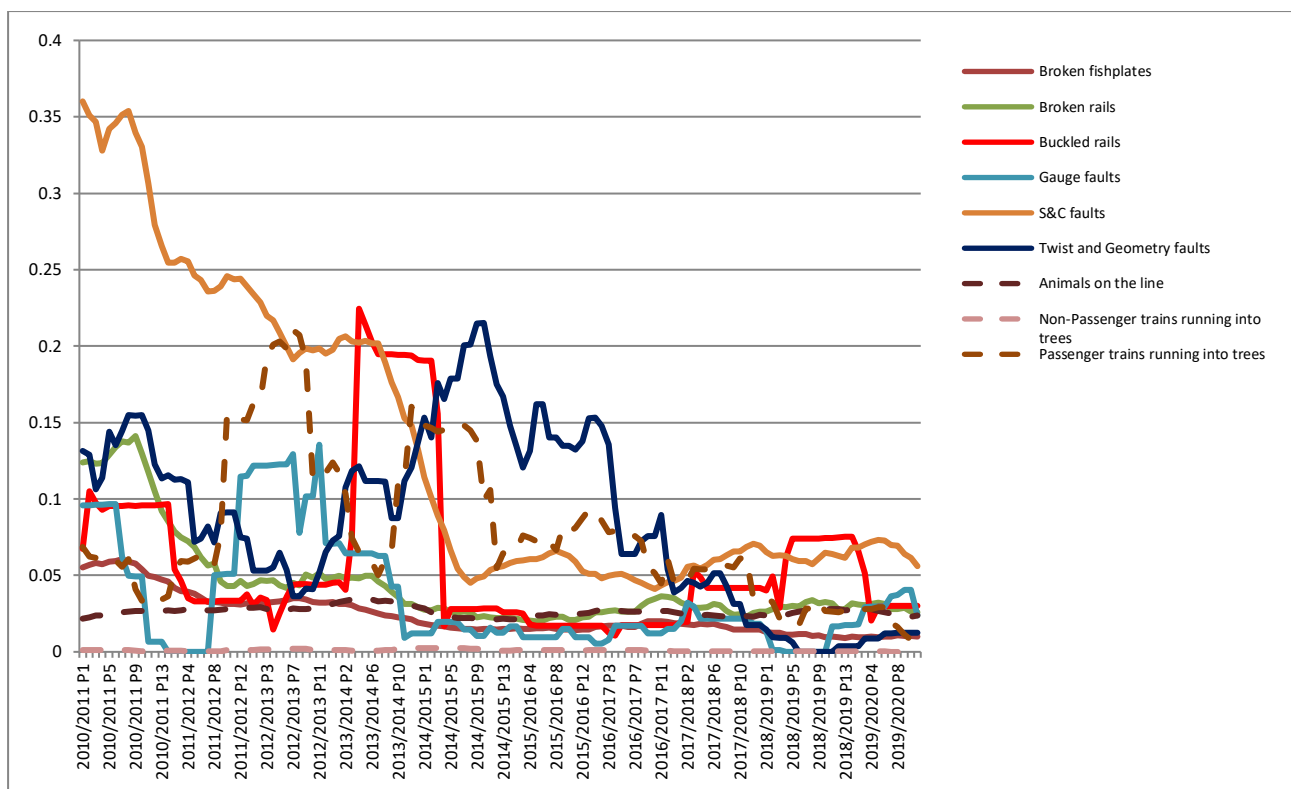


Figure 2: PIM Contribution, Track & Lineside; period 9 2019/20

Asset	Failure Mode	PIM precursor (FWI/vr)	Contribution to safety risk from track
Rail	Broken Rail	0.026	16.3
	Buckled Rail	0.03	19
	Broken fishplate	0.01	6.4
Sleepers	Gauge spread	0.024	14.9
Ballast	Track twist & geometry	0.012	7.9
S&C	S&C	0.056	35.5
Total Track			100%

Table 1: PIM Contribution from Track at period 11 2019/20; source: RSSB

3. Network Rail’s overall approach to risk reduction focuses on designing out risk, and improving risk pre-cursor and serious defect identification capability to allow earlier mitigation and repair.

4. Our inspection findings indicate that the mainline railway is managing immediate risk, but many of the controls are vulnerable relying on competent people doing the right things at the right times. This control vulnerability is shown in Network Rail’s own low assessment of the effectiveness of the majority of its control measure to manage track risk due to the reliance on workers implementing process correctly; which can be influenced by external factors such as access pressures and environmental conditions. There is a tendency to deliver some form of repair, rather than the structured review required to determine the most

suitable repair for the medium to long term. However work undertaken with Network Rail on risk based maintenance and targeting geometry management, in particular twist faults, SREs and repeat faults of these types has focussed Network Rail's attention on improving the quality of repairs undertaken. Current indications is that this is now showing improvements in track geometry management and associated KPIs. but these remain vulnerable to environmental factors such as the hot weather seen in summer 2018 and extreme wet periods that produced a deterioration in track geometry indicators.

5. Although Network Rail's track risk management has improved, more 'in-depth' arrangements such as enhanced monitoring, auditing and review, in particular at a local tactical level would allow better measurement of the effectiveness of the risk controls and act as a driver of improvement. This would in turn reduce these vulnerabilities. Within Network Rail, the level of compliance at a local level appeared to be influenced by the level of attention given to them by Network Rail Safety, Technical and Engineering (STE) or ORR.

Track and lineside performance

Track geometry

6. There has been a marked improvement in track quality performance at national level as measured by the 'good track geometry' and 'poor track geometry' indicators between 2000/01 and 2018/19. Track geometry performance worsened during the first half of CP4 before recovering and continuing to improve through CP5, although with regional variation. (See appendix 2). **Super red eighths** (SRE), the poorest classification of track geometry requiring immediate action, are also broadly trending downwards, as are repeat SREs (70% of total SRE numbers), but at a smaller rate. More recent performance indicates that further improvements may be harder to achieve, and recent gains are vulnerable.

7. Whilst not a direct safety indicator we monitor discrete track fault levels that require a response within a mandated timescale as they provide a useful precursor indicator to track condition. Repeat fault numbers provide an indication of repair effectiveness. Discrete fault numbers have seen a similar trend to poor track geometry: a significant reduction between 2000/01 and 2009/10 before levelling off and deteriorating in the first half of CP4. The improving trends achieved in the second half of CP4 has been overall maintained through CP5, the number of discrete track geometry faults now at an all-time low, around 20% less than at CP4 exit.

8. **Track twist** is a specific type of higher risk track geometry fault that is a common cause of derailment. Nationally total twist fault numbers reduced by 36% on CP4 exit at period 8 2019/20. After rising during 2011/12 to 2013/14, and following intervention by ORR, repeat twist fault numbers have decreased (at period 10 2016/17 repeat twist faults down 21% on CP4 exit), but with fluctuations performance remains variable, with the trend in CP6 going slightly upwards and now above Network Rail's CP5 flight path target. (Note Network Rail has not set flight path targets for CP 6.) Around 14% of twist faults continue to be repeat faults indicating that effective and sustained repair of this category of fault remains challenging.

9. **Cyclic top** faults are a particular type of track geometry faults that increase the likelihood of freight train derailment. The level of risk is speed dependent and has potential

to increase in significance as the track formation ages or deteriorates for example due to poor drainage. Risk can be effectively controlled by imposing speed restrictions on freight vehicles until the fault is repaired. The effectiveness of using speed restrictions as a control rely on reliable asset performance information, correct application of process requirements, and accurate assessment of the quality of the repair. Since the middle of 2013/14, following intervention by Network Rail centre there has been a marked and sustained increase in speed restrictions associated with cyclic top, despite a decreasing trend in cyclic top sites, indicating improved and more reliable application of process. Network Rails development of a cyclic top predictor tool and provision of Abtus trolley cyclic top measuring equipment to the routes should help maintain and continue the improved performance.

10. **Combination faults**, where two or more different track faults occur together can increase the risk of derailment and potentially require earlier intervention than mandated timescales, based on an engineer's assessment of their combined impact. Similarly the risk of derailment can increase where the track, rail vehicle, and/or load is close to, at, or beyond allowable tolerances. The Cross Industry Freight Derailment Working Group¹¹ initiated by ORR has been formed to examine this system safety issue. Outputs from this group are now becoming operational and improving management of this risk.

11. Provision of **effective drainage** is a fundamental requirement in maintaining track in good condition; poor drainage is an underlying cause of track formation failure that will adversely affect track geometry, cause more rapid deterioration, and create a potential derailment risk. Until recently, Network Rail had neglected its drainage systems; it's recent creation and filling of a new 'Head of Drainage' is positive. There remains work to be done to deliver effective inspection and maintenance of all drainage assets. The output of the Integrated Drainage Project is a vehicle to make the necessary improvements.

S&C Integrity / guidance of train wheels through S&C systems

12. We treat S&C as a separate system within the track asset category. S&C presents a rail discontinuity to the rail vehicle wheels and this, combined with the increased dynamic forces on infrastructure and vehicle result in the vehicle being inherently less stable as it passes over S&C. As illustrated by the derailments at Potters Bar¹² and Grayrigg¹³ the consequences of failure can be high, and are potentially significantly higher than for other types of track related failure.

13. A key feature of S&C is that it should be managed as a system, combining both track and signalling asset knowledge. Designing and maintaining correct switch profile and position to the correct parameters prevents increased forces in the system that can result in degradation and un-commanded switch rail movements that ultimately can result in a train derailment.

14. The rail industry's current approach to managing risk at S&C is heavily reliant on human beings who implement the inspection and maintenance requirements of various

¹¹ <http://www.rssb.co.uk/risk-analysis-and-safety-reporting/accident-investigation-and-learning/tackling-freight-derailments>

¹² Passenger train derailment at Potters Bar on 10 May 2002, killing six passengers and one member of the public.

¹³ Passenger train derailment at Grayrigg on 23 February 2007, killing one passenger

standards. The industry recognises this and is developing engineering solutions to design out risk, increase the performance of crossings and improve the early identification of risk precursors and serious defects. Network Rail is increasingly moving to a risk based approach to managing and maintaining S&C based on an increasingly detailed understanding of their design, engineering science, and safety requirements. Complementing this approach Network Rail is in the early stages of developing automated S&C inspection equipment that, now at the field trial stage, would provide reliable and repeatable inspection data on a key derailment risk.

Track Buckle

15. The number of buckles that currently occurs on the main line network per year is principally linked to climatic conditions, as demonstrated by the rise in numbers of buckles in the hot summers of 2018 and 2019. As such the level of risk indicated by the PIM is driven by climatic conditions and the consequence of observed buckles.

16. Buckle risk control measures take on three elements: initial integrity delivered through correct stress free temperature and installation and subsequently maintained integrity during maintenance interventions; asset knowledge knowing the location of higher risk sites due to asset condition and environmental factors; and arrangements to monitor rail temperature and take appropriate action at the correct time. The latter two elements in particular rely on human intervention and application of process. Potential to improve effectiveness through remote monitoring has the capability to introduce an element of automation.

Rail integrity

17. Rail defects increase the likelihood of a rail breaking; similarly cracked or broken fishplates lead to the same outcome: an uncontrolled discontinuity in the rail running surface.

18. There has also been a notable reduction in the number of rail defects, broken fishplates and broken rails since 2000 when 952 broken rails were reported. In 2018 Network Rail had 95 broken rails, and represents a 90% reduction in 18 years at a time when traffic levels rose significantly.

19. These improvements are due to substantial and sustained improvements in rail management after the Hatfield derailment in October 2000, and includes a better understanding of causes, significant re-railing; improved site welding processes; improved and more frequent ultrasonic testing techniques (ultimately leading to the current train borne solution); and the introduction, and then tightening of intervention levels for rail joints.

20. Over CP4 and into CP5 we saw a continuing steady increase in heavy and severe **rolling contact fatigue** (RCF) across the network. This has been the result of changing standards; challenges around accurate visual identification and measurement; and reduced volumes of rail grinding in both S&C and plain line. Network Rail introduced in 2019 a new inspection regime based on eddy current testing processes. This is now operational across all routes and providing a more reliable, repeatable and accurate picture of RCF across the network.

21. Although the number of **rail breaks** due to foot corrosion and weld failure are falling, they form an increasing proportion of all rail breaks. In 2018 they accounted for around 35% of breaks. Conversely the proportion of breaks due to weld failure has dropped and in 2018 was around 15%. This shift is likely to be due to the aforementioned improvement in welding technique, but importantly partly due to the impact of localised deteriorating track geometry affecting support conditions and increasing intensive use of the rail.

Gauge

22. **Track Gauge** – the horizontal distance between the running edges of the track – is essential to deliver satisfactory track geometry and uniform rail wear, and ultimately to prevent derailment through gauge spread. Historically low levels of gauge faults were affected by the inclusion of tight gauge data since 2014/15.

23. **Tight gauge** is generally associated with construction activity, and initial quality of sleepers / bearers; or as a result of not properly controlled heavy maintenance or refurbishment activity. Whilst not likely to lead to a derailment event alone, tight gauge will potentially affect ride quality and train / rail interface leading to increased degradation of associated components.

24. **Wide gauge** is more associated with asset degradation, and is managed through track inspection and maintenance activity. Longitudinal timbers present a natural discontinuity in the track support system, when compared to sleepers, leading to potentially increased dynamic forces. This, combined with a construction form that can increase the risk of wide gauge and alignment defects can lead to the need for enhanced inspection and maintenance requirements involving other engineering disciplines to assess condition.

Lineside

25. The primary reason for managing vegetation to allow the safe passage of trains and prevent it physically obstructing the efficient management of other assets. There have been a number of derailments in the past 10 years due to trains striking fallen trees, and Network Rail state one of the main cause of signal failures is due to vegetation obscuring them. Network Rail continues to develop its understanding of its vegetation asset and work required to move away from its previously reactive approach to compliance with its new risk based requirements. All Network Rail routes now have in place long term funded plans to bring lineside vegetation into compliance with the company vegetation management standard.

26. RSSB report “Analysis of the risk from animals on the line – issue 2” (2014) concluded that the industry had reduced the risk arising from animal incursion through improvements in fence management, rules for reporting incidents, and robust train design. It identified that between 2003 and 2014 the number of animals accessing the line reduced by 40%; but in the same period there was a significant increase in the number of trains striking animals, the increase largely driven by increased deer strikes probably related to the rapid increase in deer numbers in recent decades. Since 2014 the number of trains striking animals has remained fairly constant at around 110-120/year. Passenger trains do derail when striking cattle, as illustrated at Letterston Junction (2012) and Godmersham (2015) where fencing management was poor, and can be fatal, as illustrated in Germany in 2012. Therefore accurate knowledge of land use and fencing condition remains a critical part in

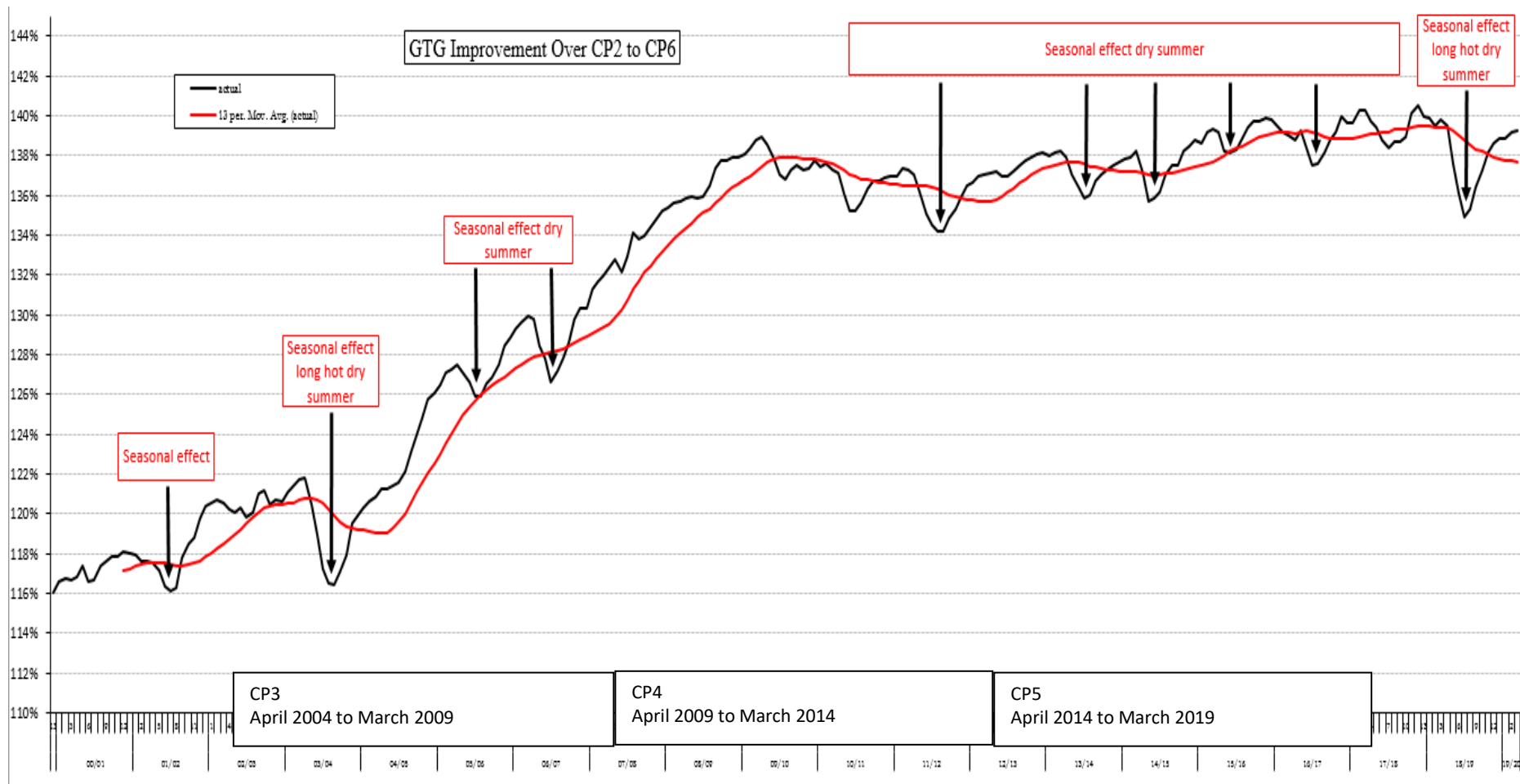
understanding any changing risk profile; and identifying changes in fencing type and level of effective maintenance to manage risk.

In comparison with the track asset it is noticeable that the lineside asset information and performance data is significantly less comprehensive and reliable. This makes understanding the performance of the lineside asset and demonstrating the impact of any improvements difficult. Network Rail are developing a more comprehensive focussed set of KPIs against which lineside performance (including safety) can be measured. Alongside this work is underway to improve the comprehensiveness and accuracy of the lineside asset database through use of hand held devices to record electronically asset information.

Appendix 2: Supporting Information

Network Rail: Good Track Geometry: Long Term Trend on Mainline Network

Network Rail: Poor Track Geometry: Long Term Trend on Mainline Network



Appendix 3: Glossary of terms

Glossary of terms	
Acronym	Definition
BCR	Business Critical Rules
CP	Control Period
CP1	April 1996 to March 2001
CP2	April 2001 to March 2004
CP3	April 2004 to March 2009
CP4	April 2009 to March 2014
CP5	April 2014 to March 2019
CP6	April 2019 to March 2024
CWR	Continuous welded rail
HS1	High Speed 1 railway line
HSE	Health and Safety Executive
FWI/yr	Fatalities and weighted injuries per year
LU	London Underground
NR	Network Rail
ORR	Office of Rail & Road
PLPR	Plain line pattern recognition (train)
PIM	Precursor indicator model
RCF	Rolling contact fatigue
RM3	Railway management maturity model
ROGs	Railways and Other Guided Transport Systems (Safety) Regulations 2006
RSSB	Railway Safety and Standards Board
S&C	Switches and crossings
SRE	Super red eighth
SRM	Safety risk model
STE	Safety, Technical and Engineering
UTU	Ultrasonic test unit



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