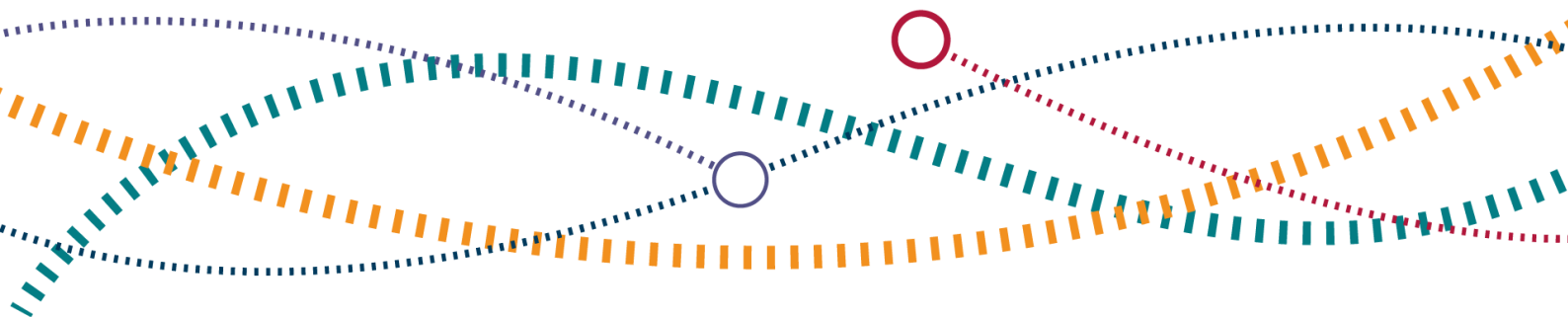




Strategic Risk Chapters

Chapter 6b: Civil Engineering Assets

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SRC Civil Engineering Assets

ORR Strategy for Civil Engineering Assets

The integrity of Civil Engineering Assets ('Civils') is fundamental to safe railway operation. There are challenges in Civils' stewardship that are unique to this group of assets. Very many of the earthworks and structures in our railway infrastructure are over a hundred and fifty years old. They do not benefit from the resilience of assets designed to modern standards. Further, having lasted for numerous decades with little degradation, many assets are now near the end of their lifecycle. In these circumstances asset condition may deteriorate suddenly – particularly when subject to the pressures of climate change and increasing rail traffic. Failure can be hard to predict because of the vulnerability of these assets to sudden highly localised weather events – regardless of asset condition.

On 12th August 2020, a passenger train was derailed near Carmont in Aberdeenshire leading to the deaths of three people. The train had struck material washed out from a drain onto the track following intense convective rainfall. This tragic event illustrated the challenges of managing civil assets safely at a time when our climate is changing.

ORR's strategy for regulating the risk arising from Civils assets is to promote optimal integrity of these assets, in order to minimise precursors to catastrophic failure. However, we recognise that for the legacy infrastructure there are no quick, reasonably practicable routes to modern thresholds of resilience. Our focus, in the interim, is to achieve the best understanding of the consequences of failure so that mitigation can be appropriately prioritised and implemented. We take a balanced approach, conscious of the potential for significant disruption arising from precautionary measures.

We will:

- Support the rail sector to embed learning from the Carmont derailment, encompassing: better understanding of how assets behave in extreme weather; recognising the importance of better water management to the safe operation of rail networks; seeking more accurate and granular weather forecasting and real-time information to enable a framework of balanced; targeted mitigations whenever assets may be vulnerable to failure.
- Engage with the industry to ensure increasing understanding of the relationship between asset condition, consequences of failure and control of risk. For duty

holders whose asset knowledge is still variable – there must be improvements in the quality of asset information.

- Ensure that improved intelligence about likelihood and consequence of failure informs prioritised programmes of renewal to modern resilient designs – and underpins interim contingency arrangements to mitigate the effects of failure.
- Promote industry adoption of appropriate asset management regimes, balancing renewal, refurbishment, maintenance and inspection activities to maximise safe management of civils assets. Industry should continue to improve the completeness and accuracy of its asset information as necessary in order to optimise the effectiveness of those asset management regimes.
- Support the industry to improve engineering innovation so that there is a reduction in the reliance on human systems. This might include greater use of technological means of inspecting assets, and remote monitoring of asset condition to predict or report failure. It may also include increased adoption of more specific information to train crews during adverse weather.
- Engage with industry to secure a suitable systems engineering approach to the management of Civils assets – recognising the interfaces and dependencies with other asset disciplines (and outside parties) and the opportunities for improvement.

1. Introduction

1. Civils assets are fixed assets that facilitate the operation of a transport system. For the purposes of this strategic chapter, these assets include:
 - structures, such as bridges, tunnels, retaining walls, culverts, coastal, estuarine and river defences and ancillary structures (e.g. signal posts, electrification and telecoms structures);
 - earthworks, such as cuttings (soil and rock) and embankments;
 - operational property (buildings), such as stations, depots and train sheds (on mainline infrastructure); and
 - drainage systems, regardless of their physical location.
2. The characteristics and balance of Civils assets vary by duty holder. On London Underground, for example, a far greater proportion of the network consists of tunnels (around 45% of approximately 400 route km, 1000+ track km), and pumping systems are a far more significant component of drainage management due to the risk of flooding in sub-surface and deep tube sections of the network. High Speed 1 (HS1, the channel tunnel rail link), in contrast to the considerable average age of Civils assets on the mainline and London Underground networks, has very young assets, being newly built (opening in two stages in 2003 and 2007) and benefitting from modern design intelligence.
3. Failure of Civils assets can lead to train derailment due to obstruction of the line (for example, a landslide, masonry debris from a bridge or tunnel, or a fallen structure such as a signal post), or due to track faults (arising, for example from failure of the supporting embankment). Risks to individuals can also arise, for example from the failure of an ancillary structure or part of a bridge. The provision and maintenance of safe and resilient infrastructure is therefore a primary element of the effective, safe operation of any railway and ensuring its on-going integrity is a key risk control.
4. The relationship between the different asset groups is vital in ensuring a safe infrastructure. For example, culverts often provide important drainage to embankments, and deformation of an embankment often manifests itself initially as a track defect. An infrastructure system risk management approach is therefore needed to ensure that these assets are managed effectively, recognising the interfaces and dependencies.

5. Further, these assets are vulnerable to the influence of the actions of outside parties. Those actions are not always easily detectable, such as an outside party diverting drainage some distance away from the railway which results in unanticipated increased outfall onto the rail infrastructure. Even simple changes such as the direction in which a field is ploughed can change the flow of water on to the railway. In June 2019, for example, a cutting slope at Corby failed when flood water overspilling from two adjacent flood storage points (which has overfilled with water from a nearby brook) accumulated at its crest. In August 2016, a leaking water main contributed to the failure of part of a bridge at Barrow-upon-Soar, which collapsed and fell into the railway lines below. There was no obvious warning to the railway duty-holder of what was about to transpire.
6. The Rail Accident Investigation Branch (RAIB) carried out investigations into these and other incidents involving outside parties, and made recommendations aimed at improving duty holders' knowledge of third party actions and their consequences. It has proved very hard to give practical effect to the intent of those recommendations. ORR recognises the significance of outside party actions on the safe management of Civils assets whilst acknowledging the significant difficulties of mitigating their effects.
7. There are approximately 30,000 bridges and tunnels on the national railway network, a further 16,000 bridges and structures on LUL infrastructure, and a significant number on light and heritage railways. Network Rail also manages culverts greater than 450mm in diameter as structures; these assets number approximately 22,000. Management regimes, largely based around regular examination and assessment, are in place to minimise the risk of failure. However, risks can arise if effective action is not taken to address defects that are identified following examination or assessment. In addition, any backlog in examination delivery presents the risk that defects are not identified and addressed in a timely fashion.
8. An earthwork is defined on Network Rail-controlled infrastructure as a cutting, embankment or natural slope that is at least 3 metres high or, if less than 3m, one whose failure could pose an unacceptable risk to railway infrastructure. There are between 19,000 and 20,000km of earthworks on the national railway network. On LUL there are 235km of 'earth structures' (referring to those at least 1 metre high). There are significant numbers on light and heritage railways, including some ageing assets inherited from heavy rail. Earthworks are subject to a management regime based around regular examination or inspection. Earthworks are very susceptible to extremes of weather, in particular rainfall, which can quickly lead to the failure of previously stable slopes.

9. Drainage systems have an important role in facilitating the stability of earthworks and the track formation. Their effective maintenance is an important element in maintaining a safe infrastructure. Drainage systems on the national network are often referred to as 'secondary assets', since their failure does not directly result in a risk to the railway, being manifested in a track twist or cutting failure, for example. This can lead to them incorrectly being considered as less critical asset group and has been reflected in the comparative neglect of drainage assets on Network Rail-controlled infrastructure until recently. On LUL infrastructure, 'Pumps and Drainage' plays a prominent role particularly in respect of the London Underground deep tunnel section of the network which has approximately 360 km of the 500+ km total of track drains.
10. In recent years, ORR has devoted more of its work effort to ensuring the effective management of ancillary structures due to an increase in the number of incidents on the mainline network involving such assets. These number in the hundreds of thousands and include the following asset types (not exhaustive):
 - Advertising hoardings;
 - Lighting columns;
 - Overhead Line Equipment (OLE) masts and supports;
 - Radio telecoms masts and equipment supports;
 - Raised walkways;
 - Signal gantries, cantilevers and portals; and
 - Signal structures (including straight posts and signalling equipment platforms).
11. There are 17 major and 2,500 other stations and 8,200 commercial properties on the national network, with a further 270 stations on LUL and others on the light rail and heritage networks. This operational property is also subject to a management regime based around regular inspection, examination and assessment.

2. Safety risks

12. The primary safety risk associated with Civils assets is that their failure could lead to the derailment of a train. Depending upon the nature and location of the derailment, this could result in multiple fatalities. A failed structure could directly derail a train, as could parts of a structure falling onto the track and obstructing the line. In the case of earthworks, derailment could be caused by track deformation resulting from embankment failure, or obstruction of the line in the case of cutting or drainage failure. This was sadly demonstrated at Carmont in August 2020, when a train struck drainage material that had been washed onto the track and derailed, resulting the deaths of three people.
13. Civils assets can also pose risks to individual passengers or members of the public. For example parts of structures may fall off and strike people or vehicles in the vicinity, as could failed signal posts or lighting columns. Overbridges may also fail beneath vehicles. In addition, there may be risks to individuals associated with the use of pedestrian footbridges and other structures at stations. The collapse of a gable end wall at Northwich station in 2020, which resulted in 13 tons of material falling to the platform (but fortunately no injuries) indicates the potential for serious consequences in the event of failure of assets in this group, as does an electrical incident at Godinton substation in 2018 which was in part caused by water leaking into the building.
14. Appendix one contains safety risk data showing trends in safety performance of Civils assets in greater detail.
15. The most significant factors when considering the nature of risk in the population of Civils assets are:
 - The age of the assets – the majority of Civils assets on the mainline and LUL networks were constructed before 1900;
 - Many assets are at or near the limits of their design life – and could be susceptible to rapid deterioration;
 - The legacy of pioneering efforts – we have inherited a large asset population built without benefit of current understanding - so it is not likely to be as resilient as modern designs;
 - Construction details have sometimes been lost so there is uncertainty about composition, drainage arrangements, and materials;

- Both mainline and LUL networks have experienced significant increases in traffic levels (until the coronavirus pandemic) and, thus, increases in the loadings to which the assets are subjected;
 - These are assets that are perceived to have very long life-cycles, so have historically been 'sweated' and not always subjected to appropriate inspection and maintenance regimes;
 - Initiating failures may be hard to detect visually, and may be in hidden parts of structures and earthworks;
 - Vegetation growth on structures and buildings may weaken them and also obstruct indicators of failures if not removed;
 - Earthworks, in particular, are vulnerable to high rainfall during extreme weather events, and river bridges are susceptible to scour – but predicting the location of such failures is very difficult and unsafe conditions can arise rapidly; and
 - Extreme weather events are becoming more frequent and more severe, as a result of climate change.
16. ORR's enforcement history is a useful indicator of priority risk areas. Our enforcement on Civils assets has, in the last decade, all been on Network Rail controlled infrastructure. Following the failure of a bridge over the River Crane near Feltham in November 2009 we served an Improvement Notice regarding visual inspection of structures. That has been followed by several other Notices designed to improve the efficacy of examination and inspection of earthworks and structures. Good risk assessment and safety management requires accurate information about asset condition.
17. Following a series of derailments of passenger trains in the unusually wet summer of 2012 ORR carried out enforcement with a slightly different emphasis. Recognising that earthworks could not quickly be brought up to modern, resilient design standards we required Network Rail to focus on the consequences of asset failure so that it could target contingency arrangements for extreme weather in a prioritised, risk-based way. This has been our philosophy: to optimise mitigation of risk where elimination is not reasonably practicable.
18. Although there have been comparable numbers of earthworks failures before and after ORR's Improvement Notice in 2012 there have been far fewer derailments. In fact, until the derailment and subsequent collision of a passenger train at Hunton Bridge tunnel near Watford on 16 September 2016 there had been no derailments

since the response to ORR enforcement, indicating greatly improved management of the consequences of failure. This relatively good safety record was achieved despite increasingly extreme weather conditions arising from climate change.

19. However, the fatal derailment at Carmont in 2020, which resulted in three deaths, sadly brought this period to an end (although it should be noted that this was caused by washed out drainage material, rather than an earthwork failure.) After the accident, Network Rail commissioned two task forces, one led by Lord Robert Mair focusing on earthworks and drainage, the other led by Dame Julia Slingo focusing on weather forecasting. The implementation of the recommendations of these reports, and those arising from the RAIB investigation, is a priority for both Network Rail and ORR.
20. Safety risks associated with ancillary structures were highlighted following an incident in November 2014, when a simple signal post fell across the tracks at Newbury, obstructing one line and partially obstructing another. A train on the partially obstructed line struck the signal's junction indicators. The post was found to be badly corroded near its base. Investigation found that accumulated ballast around the base had not been cleared during routine examinations to enable all parts of the structure to be viewed. Examination reports also lacked detail and internal corrosion appears to have been a factor. Following this incident, ORR became aware of a number of other failures of ancillary structures and has worked with Network Rail to improve their management of these assets.

3. The Law

21. Health and safety legislation relevant to the management of Civils assets includes the following:
- Health and Safety at Work etc. Act 1974
 - Management of Health and Safety at Work Regulations 1999
 - Construction (Design and Management) Regulations 2015
 - Railways and Other Guided Transport Systems (Safety) Regulations 2006 (for mainline railway undertakings)
22. These pieces of legislation place duties on duty-holders to reduce risks to their employees, other workers, passengers and members of the public, so far as is reasonably practicable. Risk assessment and management requirements also apply to the control of risks posed by Civils assets. The Construction (Design and Management) Regulations (CDM) impose duties on those constructing, repairing and maintaining any structure (which includes drainage and earthworks).

4. Network Rail overview

23. Many railway structures on Network Rail infrastructure are from the Victorian era and were built from materials whose quality was poorer and more variable than modern construction materials. Most earthworks also date from when the railways were originally constructed. At that time, geotechnical knowledge was largely empirical and earthworks are frequently over steep in their design. However, earthworks and other structures can still continue to provide a suitable degree of safety integrity and performance provided they are subject to effective management arrangements. The main measures for ensuring adequate risk control are:
- robust asset management policies and processes that deliver best practice in the management of Civils assets; and
 - Implementation of a robust inspection, maintenance (including preventative maintenance), refurbishment and renewal regime that is based on adequate knowledge of the type of structure and its behaviour, condition and capability.
24. Safety of Civils assets is largely managed by Network Rail through a suite of Asset Policies and related engineering standards, which lay down the asset management principles described above. Additional standards detail the actions to be taken in the event of adverse or extreme weather, which can negatively affect the performance of Civils assets. Compliance with these standards presents a challenge to Network Rail as a devolved organisation. The central Technical Authority seeks to support and guide Regions to achieve requirements, but ensuring effective implementation is the responsibility of individual Regions.
25. Improving the resilience of civils assets on the railway has become increasingly important, given the impact of climate change on weather conditions (see appendix one for more details.) In recent years, Regions have developed Weather Resilience and Climate Change Adaptation (WRCCA) action plans aimed at reducing the impact of extreme weather. Effective implementation of these plans is critical if they are to have a significant practical impact.
26. ORR inspections over a number of years have found varied, inconsistent degrees of compliance with relevant policies and standards across the network. We also find correspondingly variable levels of management maturity, as measured by our use of the Risk Management Maturity Model (RM3). Network Rail must focus on ensuring consistently effective, reliable implementation of asset management requirements – and on being able to demonstrate that by meaningful assurance.

5. Network Rail Asset Management

27. At the time of writing, Network Rail does not hold a complete inventory of all its Civils assets. Drainage asset registers are incomplete in some routes, despite several years of work intended to complete them. Regions have committed to complete their drainage asset registers by the end of March 2023. The continued delay in compiling this information introduces a risk that this may delay the process of inspecting, maintaining and renewing those assets which are already known about.
28. Further, the report produced for Network Rail following the Carmont accident by Lord Robert Mair highlighted the importance of effective installation and management of drainage assets. In particular, the report stressed the importance of dedicated, competent drainage management teams within the Regions. ORR has for a number of years been seeking similar improvements to drainage asset management. These recommendations are therefore supported, and we continue to push Network Rail for evidence of their effective implementation.
29. Network Rail's asset management arrangements for Civils assets are based around a regime of examination, assessment and evaluation; leading to corrective actions to remedy any defects that are identified. In most regions, most of these examinations are carried out by contractors, the exception being North West and Central (NW&C) and Eastern Regions, which have both brought at least some of this work in-house. Completing examinations, assessments and evaluations on schedule is a major challenge for Network Rail, which has incurred significant examination and assessment backlogs, primarily affecting structures. Resolving this backlog and putting in place arrangements for longer term compliance is a key priority for ORR, and continues to be the subject of regulatory interventions.
30. Within the structures portfolio, the examination of tenanted arches presents specific challenges in some Regions. These have been exacerbated by the sale of space within arches to the Arch Company. Recent improved co-operation between Network Rail and Arch Co has seen improved planning and delivery of examinations in some Regions, but this is not consistent across the Network and examination backlogs remain a significant concern. However, progress is now being made towards eliminating those backlogs and placing the examination of tenanted arches on a more sustainable footing for the future.
31. ORR is aware of weaknesses in Network Rail's evaluation of defects that are identified following examinations and assessments. In some instances, ineffective evaluations have led to no action being taken, or action that is inadequate or

inappropriate to resolve those defects, ultimately resulting in the failure of an asset. Network Rail has acknowledged the shortcomings in its evaluation processes, and has taken action in recent years to address them. This process remains ongoing.

32. Fundamental to many of the difficulties described above is the lack of an integrated database to enable civils assets to be managed as a system. Network Rail had planned to implement a new database – the Civils Asset Management Solution (CSAMS) – but this was not delivered. Work is now underway as part of Network Rail's Intelligent Infrastructure Programme to deliver an improved system, and ORR will continue to monitor its implementation.
33. Hidden shafts in railway tunnels present a risk to both the railway and any structures that may be built above them in the event of a failure. A significant programme to identify hidden tunnel shafts was recently completed by Network Rail, but progress towards assessing the risk associated with those shafts and implementing mitigation measures has stalled. ORR is seeking properly defined plans for the delivery of these activities, within reasonable timescales, so that any risks associated with these shafts is mitigated.
34. Network Rail's renewals plans have at times been affected by financial constraints on the regions. This has led to a significant number of planned structures and earthworks renewals being deferred or downgraded to refurbishment or maintenance. In these cases, Network Rail states that a risk-based process should be used to identify which renewals to defer, and risk assessments should be carried out to identify any mitigation measures that should be put in place at deferred sites. ORR continues to require that appropriate decisions have been made and risk control measures are in place as necessary.
35. Network Rail must find an appropriate balance between renewal, refurbishment, maintenance and inspection activities – based on good understanding of asset condition and the likelihood and consequences of failure. It must also ensure it implements appropriate interim risk mitigation measures.

6. Adverse weather arrangements on Network Rail infrastructure

36. In response to enforcement activity by ORR, Network Rail has developed improved arrangements for identifying earthworks slopes considered to be vulnerable to failure during adverse weather. The increased number of slopes listed on these 'at risk' registers presents a very significant risk management challenge to Network Rail during adverse weather. Network Rail is exploring the use of technology, such as remote monitoring, to help manage these risks and reduce reliance on the use of site watchmen or operational restrictions on the running of trains. Progress has been slow, but completion of a trial following ORR pressure has resulted in this technology now being used more widely across the Network. Management of critical drainage systems, also key in minimising the risk of failure, has also been the subject of ORR enforcement action.
37. As well the impact on earthworks, adverse weather can also cause scour damage to structures, as was demonstrated by an incident at Lamington viaduct in Scotland on 31 December 2015. A train reported a dip in the track when passing over the viaduct, and subsequent investigation revealed serious damage to the structure due to scour. This incident led to a wider review of the arrangements for management of scour and monitoring during extreme weather in England and Wales. Work is ongoing to reduce risk at the highest risk structures.
38. It is vital that Network Rail continues to refine the effectiveness of its response to extreme weather. There is considerable scope for the adoption of technological means to monitor the condition of earthworks and structures; to monitor ground saturation; to measure flow rates in water courses; and to identify localised high rainfall. There is also potential to use drivers' advisory systems and signalling technology to make warnings, speed restrictions and closures more specific and targeted. The importance of such contingency arrangements grows more important as renewal to modern resilience has been constrained and as climate change makes extreme weather events more frequent.
39. The outputs of the task forces led by Dame Julia Slingo and Lord Robert Mair, as well as RAIB's and the industry's own investigations into the Carmont derailment have led to a wide-ranging programme to achieve improvements in many of the areas outlined here. ORR will be relentless in holding Network Rail to account to deliver these plans.

7. Ancillary structures on Network Rail infrastructure

40. Prior to the failure at Newbury (paragraph 20); ancillary structures were not subject to active management by Network Rail. Reliance was instead being largely placed on annual visual examinations reporting by exception on a 'line of route' basis. These have been shown to be of limited effectiveness, unless a defect has been identified, there is no report on the condition of the structure (other than to say that it has been examined.) The investigation into the Newbury failure identified that the bases of posts were not routinely being cleared of ballast or other obstructions to enable examination of the entire post, nor were such hidden elements being recorded as unexamined.
41. In recognition of these issues, Network Rail made changes to its examination regime in respect of ancillary structures, requiring more detailed reports for each structure. The new arrangements are also expected to require condition scoring for these assets, splitting them into three sections, each of which is required to be scored separately. However, implementation of the new regime met with delays, largely as a result of financial and resourcing concerns within the routes and, to an extent, the examination contractors.

Network Rail Operational Property (Buildings)

42. Safety management arrangements for Network Rail's Operational Property (Buildings) estate has in the past lagged behind that being achieved in other disciplines. However, progress has been made in completing up to date assessments for these assets; and a programme of hidden critical element (HCE) examinations is now complete.
43. However, an incident at Northwich station in May 2020, in which the gable end wall of a building collapsed and deposited 13 tons of material onto the platform, has raised concerns about the effectiveness of the management regime for station buildings. More specifically, the damage to the building by the longstanding presence of vegetation growth suggests that Network Rail will need to revisit their arrangements for vegetation management at buildings and other structures.

8. London Underground

44. London Underground manages Civils assets comprising over 16,000 bridges and structures, 350 km of tunnels and 235km earth structures (its 270 stations are managed separately). Many of the challenges are comparable to the mainline, in that the majority of the assets are over a hundred years old and degradation rates can be hard to measure when parts are hidden. The characteristics of the above-surface network are similar to the mainline as well, but drainage is of increased importance in the tube sections, where the risk of flooding and water seepage is ever-present.
45. Underpinning LUL's asset management has been a series of programmes completed around the start of the second decade of the 21st century to ensure LUL has a comprehensive picture of its assets and their structural stability and capacity. This is largely the result of the Analytical Asset programme (completed in April 2012), coupled with the results of the Drainage Hydraulic programme (completed August 2011). This led to the development of a risk-based framework of cyclical inspections to determine on-going asset condition and any consequent maintenance works. Alongside this a Civils Engineering programme to strengthen replace or renew has been similarly prioritised based on the outputs of the analytical assessment programme. This has led to targeted significant investment to recover a backlog of condition concerns.
46. London Underground has had the opportunity, during recent line extensions, to explore the design and construction of new Civils assets. It has developed new materials, processes and technologies to allow easy construction and improved future access and maintenance. As an example it has moved away from traditional construction 'in-situ' towards off-site fabrication that is then delivered to site and installed with minimal disruption. New construction has introduced standardised, modular parts – allowing scaling or expansion to accommodate future growth.
47. LUL's asset management philosophy is to view Civils engineering assets as part of the wider railway infrastructure 'system'. When considering safety risk LUL models the 'indirect' contribution of its assets as well as the more obvious direct risks – the effect of trains being stationary in tunnels, for example, for Civils assets affecting the flow of an evacuation route. Due to the density of passenger numbers, frequency of service and close proximity of assets, the impact of such disruption on LUL infrastructure is more acute than on other networks.
48. When thinking about the behaviour of its assets LUL employs the concept of 'asset abuse' to describe interrelationships. Thus Civils can impact on the performance of

non-Civils assets, for example when signalling and power assets are adversely affected by water ingress in a shallow brick tunnel, or when track support is compromised by earthwork deformation. Significant 'abuse' of Civils assets arises from external sources, e.g. road vehicle incursion. In recognition of this LUL is compiling a Third Party Asset Register.

49. ORR has recently begun exploring LUL's civils asset management arrangements in more detail. This has led to some concerns being identified in those arrangements, particularly in the context of continued constrained funding. The challenges to securing effective asset management will be explored and followed up in more detail in the coming years.

9. Tramways and Light Rail

50. Our primary focus in the tramways and light rail sector has been on the initial integrity of new operating systems within tramways and light rail, and how they are maintained. New infrastructure generally avoids features such as deep cuttings, wherever possible. The most problematic areas occur in relation to the legacy of heavy rail where Tramways and Light Rail routes incorporate existing assets such as cuttings, bridges and earthworks. Even there, so far as possible, our focus has been to ensure initial integrity. During construction phases of Manchester Metrolink, for example, 'inherited' viaducts were stripped back to the core, inspected and made good.
51. The information taken from safety management systems demonstrates certain operating assumptions, for example, inspection intervals, to ensure that tolerances are within a safe limit. If these operating assumptions are not followed, then the infrastructure can start to degrade. Inspections have shown that some tramway companies are not good at ensuring these operating assumptions are followed.
52. The selection of staff and maintaining their competence is a key factor in avoiding poor maintenance of assets and ensuring that the risks at the interface are kept low.
53. It is essential that tramways and light railways have appropriate standards for the inspection of their specific infrastructure, action levels and maintenance documentation. The use of standards from the mainline railway is often inappropriate for tramway and light rail components and using such standards unquestioningly can import risk.
54. There are few tunnel sections or other structures such as cuttings and embankments. bridges and other structures tend to be the responsibility of the highways authority, nevertheless some systems have extensive structures and access to appropriate inspection and maintenance contractors is required.
55. Whilst tramways and light rail sometimes feature similar infrastructure to mainline and metro railways – primarily non-street running parts of tram networks, often inherited from heavy rail – consequential risks are significantly different due to the ability of trams to stop more quickly should an obstruction or other derailment risk be encountered.

10. Heritage railways

56. Whilst the heritage sector creates the same sort of risk as other railways, the reduced line speed and generally lower frequency of traffic mitigate the severity of outcome. Conversely, the nature of the ageing infrastructure and the variable expertise of the volunteer workforce cause ORR to increase the priority we give to this area. We find that some heritage operators lack coherent safety management systems and this steers us towards a more proactive approach to the heritage sector than we might otherwise employ.
57. Many heritage railways operate on infrastructure that was previously closed down by British Rail and has been reinstated whilst others are of industrial origin – both standard and narrow gauge. The range of risks is similar to those of the mainline but the consequences are generally less severe. Serious incidents have occurred, though. In June and July of 2007, for example, a series of violent rainstorms resulted in severe damage to the Severn Valley Railway with numerous landslides, blocked and washed away lines. The railway was closed until April 2008. Investigations during repairs revealed that there were some 108 drainage culverts within the infrastructure; prior to the storms SVR had records of just 28.
58. Structures are a generally ageing asset and resources in the heritage sector to maintain and renew tunnels, embankments, cuttings and bridges can be very limited. Volunteers are at the heart of the heritage sector and many operate on a limited budget. Highly competent staff or contractors are needed to carry out the technical inspections required for structures. Inspection and maintenance regimes should be risk-based. As a minimum, we expect heritage operators to have a coherent inspection regime in place. We have seen evidence of good practice, such as North Yorkshire Moors' Railway's complete replacement of life-expired 145 year-old Bridge 30 near Goathland in 2010.
59. We apply the principles of the Risk Management Maturity Model (RM3) to this sector as with any other. The outcome of these inspections determine where our attention is focussed in future, although previous inspections suggests that the most effective means of intervention will be assistance to develop an effective safety management system.
60. The heritage sector continues to grow in popularity – ORR regulates some 215 self-contained railways above 15" gauge and one 10.25" gauge line. When normalised for its size, the risk of failure on heritage sector infrastructure is probably disproportionately greater than other networks; the consequences are, though,

mitigated by the characteristics of operations. ORR has been working with the Heritage sector to ensure that guidance specific to their needs is developed for infrastructure inspection and maintenance. Work is also planned to critically review the arrangements for civils asset management in the heritage sector in more detail – starting with the examination and maintenance of structures.

11. ORR Activity

61. ORR carries out a variety of inspection, investigation and liaison activities, with the aim of improving the management of Civils assets across all sectors of the railway industry. Although all sectors are subject to these activities, a significant emphasis has been placed on improving Network Rail's management of Civils assets. This was due to the relatively high residual risk in that sector when compared to other parts of the industry and to uncertainty about the extent of renewals activity that is affordable and deliverable. It means we have devoted more resource to influencing Network Rail in respect of Civils than all other duty holders combined. In doing so, ORR had regard to the devolved nature of Network Rail's organisation and carries out work with both the centre and the Regions.
62. Network Rail is still the most significant infrastructure manager nationally, and remains the focus of ORR activity. However, since 2021 ORR has begun to increase its scrutiny of Civils asset management by other duty holders, in particular LUL. This change in emphasis is expected to continue, with an additional increased focus on heritage railways and light rail.
63. ORR acknowledges the equilibrium that duty holders must strive to achieve between renewal, refurbishment, and maintenance activities, alongside work to monitor and mitigate the consequences of asset failure. Our strategy is to assist industry in achieving the most effective balance between these priorities, and thereby to achieve compliance with the law.
64. To achieve this ORR will:
 - (a) engage with the industry to ensure increasing understanding of the relationship between asset condition, consequences of failure and control of risk. For duty holders whose asset knowledge is still variable, there must be improvements in the quality of asset information. A firm knowledge of the asset base is a fundamental requirement of any asset management system and this must always be clearly established to enable further improvements to be made in the condition and capability of assets;
 - (b) support the industry in learning the lessons of the fatal derailment at Carmont. We will ensure that better appreciation of water behaviour underpins asset policies and extreme weather plans;

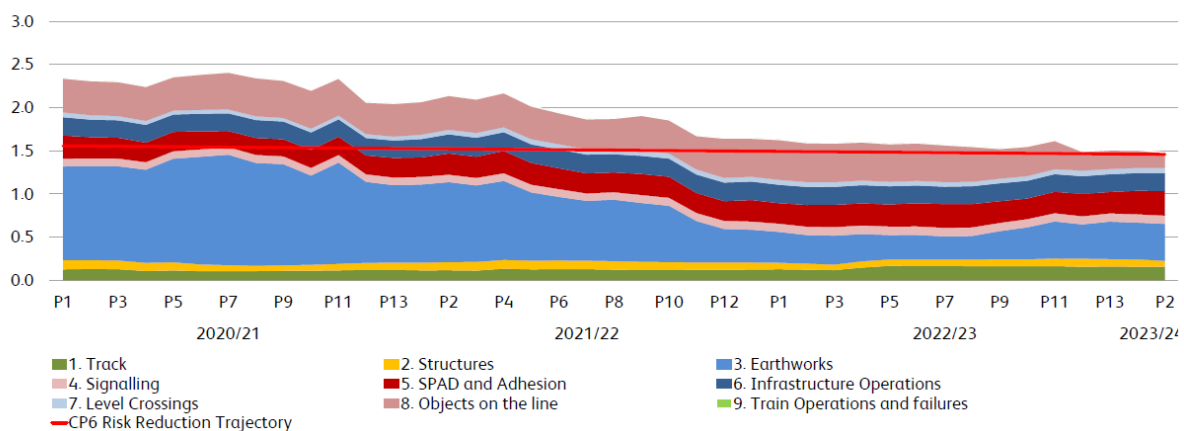
- (c) ensure that the whole sector improves its understanding of the challenges of climate change and develops plans to address increasingly frequent and severe weather events;
- (d) ensure that improved industry intelligence about likelihood and consequence of failure informs prioritised programmes of renewal to modern resilient designs – and underpins interim contingency arrangements to mitigate the effects of failure. The need for this is most acute on Network Rail controlled infrastructure where plans to renew Civils assets have been vulnerable to curtailment;
- (e) promote industry adoption of appropriate asset management regimes, weighing renewal, refurbishment, maintenance and inspection activities against each other, to maximise safe management of Civils assets;
- (f) encourage the industry to improve engineering innovation so that there is a reduction in the reliance on human systems. This might include greater use of remote monitoring of asset condition and use of technology to predict or report failure. Some parts of the industry have been slow to adopt remote monitoring technologies for earthworks and structures. Coherent strategies for the development and roll out of appropriate and robust remote monitoring are needed. This is particularly true of Network Rail, which needs to monitor and mitigate the effects of deferring renewals of its Civils portfolio;
- (g) work with the industry to improve consequence management in the event of adverse weather – especially on the mainline network. Risks associated with scour of structures and to coastal, estuarine and river defences (CERDS) are also closely linked to extreme weather and ORR will seek to ensure that they are minimised. Innovation may also include increased adoption of more specific information to train crews during adverse weather;
- (h) engage with Network Rail and other parts of industry to secure a suitable systems engineering approach to the management of Civils assets – recognising the interfaces and dependencies with other asset disciplines (and third parties) and the opportunities for improvement. At any location on the various networks regulated by ORR, the safety of the infrastructures is dependent on the interaction between several asset types – earthworks, drainage, structures (for example, culverts), and track. If these assets are managed in isolation, with little in the way of holistic oversight of the performance of the ‘railway’ asset as a whole, this can lead to ineffective management of the asset.

Appendix One – Mainline Safety Risk Data

1. The most recent passenger risk data from RSSB's Precursor Indicator Model (see chart at Figure 1 below) shows the change in passenger related fatalities and weighted injuries (FWI) risk from infrastructure failure incidents between April 2020 and May 2023.

Figure 1: RSSB Precursor Indicator Model, to Period 2 2023/24

Train Accident Precursor Indicator Model (PIM) - One Period in Arrears

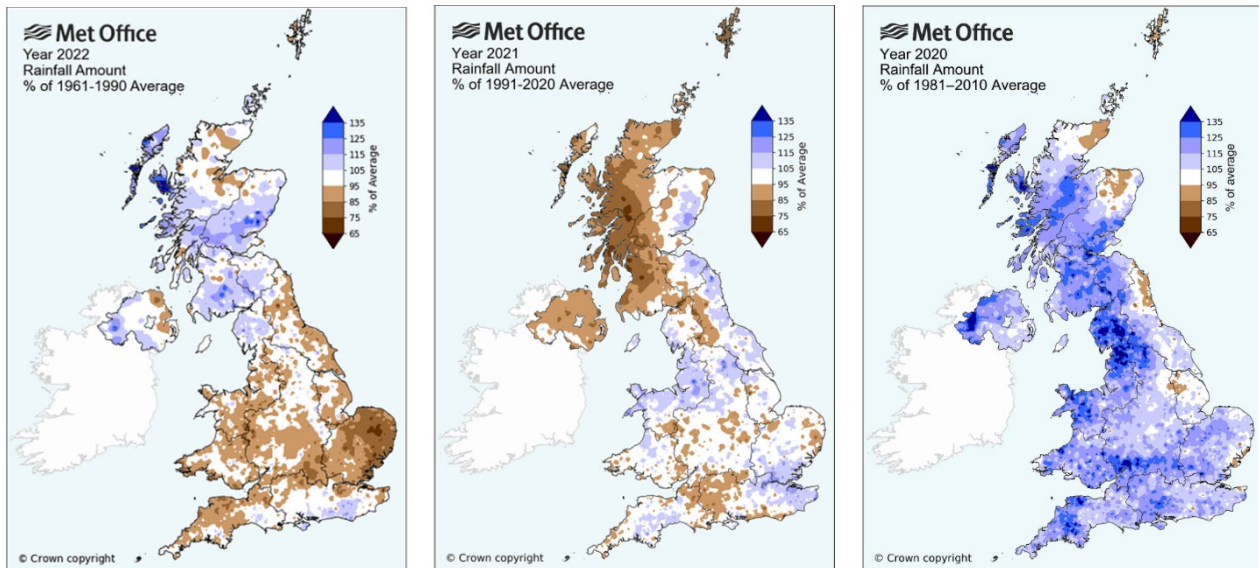


Source: RSSB

2. The Met Office reports in its most recent 'State of the UK Climate' report (2022, published 26th July 2023) that 2022 rainfall was 94% of the 1991–2020 average. 2022 included the UK's eighth wettest February on record but January, March, April, July and August were all notably dry, particularly across England and Wales. The report also notes that five of the 10 wettest years for the UK in a series from 1836 have occurred in the 21st century.
3. Since 2009, the UK has had its wettest February, April, June, November and December on record in monthly series from 1836, as well as its two wettest winters. For the most recent decade (2013–2022) UK winters have been 10% wetter than 1991–2020 and 25% wetter than 1961–1990. There has also been a slight increase in heavy rainfall across the UK in recent decades. Storm Eunice on 18 February 2022 was the most severe storm to affect England and Wales since 2014.
4. Although 2022 was a relatively benign year in terms of rainfall it should be noted that 2020 was the UK's fifth wettest year in a series from 1862, with 116% of the 1981–

2010 average and 122% of the 1961–1990 average rainfall. February 2020 was the UK's wettest February and fourth wettest calendar month on record in a series from 1862. 2020 also included the fifth wettest winter, the fifth driest spring and, for England, the driest May on record in a series from 1862.

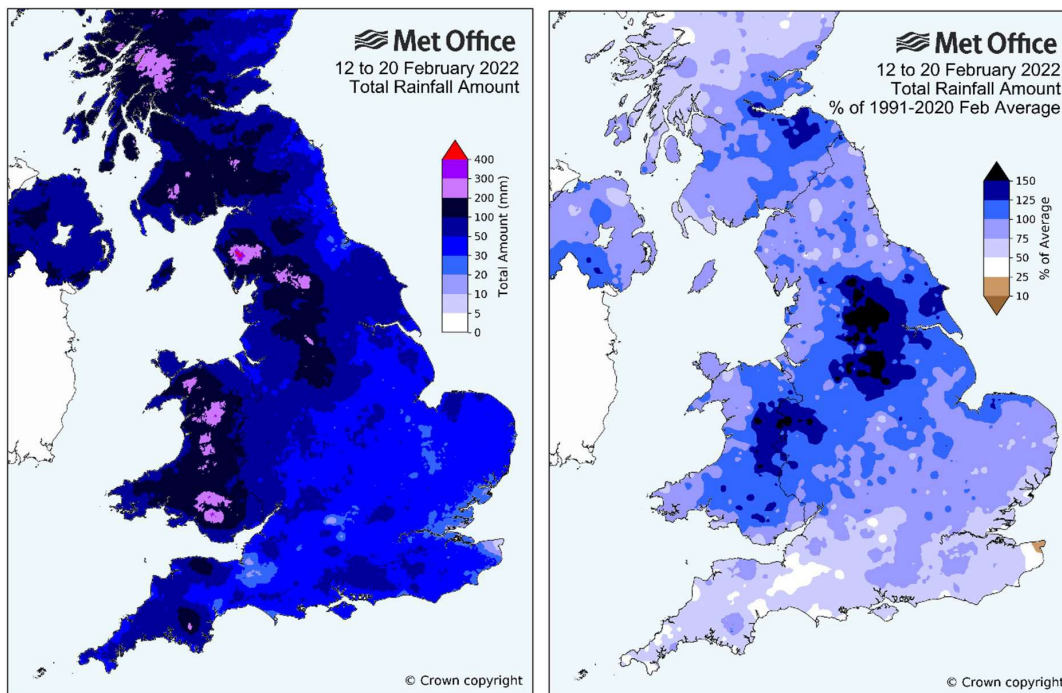
Figure 2: Rainfall in 2022-2020 compared with long term averages (Met Office)



Source: Met Office

5. In February 2022, storms Dudley, Eunice and Franklin brought major weather impacts. Although the most serious impact of these storms was related to high winds, significant rainfall was also experienced (see figure 4 below.) The railway industry responded with widespread line closures and speed restrictions. Although this resulted in significant disruption and performance impacts, there were no major safety incidents reported.

Figure 3: Rainfall accumulations during February 2022 storms



Source: Met Office

6. It should be noted that, until the incident at Hunton Bridge tunnel near Watford on 16 September 2016, and despite the poor weather and increase in failures, there had been no derailments since 2012/13, suggesting an improved standard of consequence management following ORR enforcement in August 2012. Other key factors, such as the management of critical drainage systems, have been the subject of ORR enforcement action aimed at reducing the risk of cutting failures. Unfortunately, the accident at Carmont in August 2020 demonstrated that more work is needed to manage the risks associated with adverse weather.

Appendix Two – Glossary of terms

Acronym	Definition
CDM	The Construction (Design and Management) Regulations 2015
CERDS	Coastal, Estuarine and River Defences
CP5	Control Period 5 (2014 - 2019)
CP6	Control Period 6 (2019 - 2024)
CP7	Control Period 7 (2024 - 2029)
FWI	Fatalities and Weighted Injuries
HCE	Hidden Critical Element
HS1	High Speed 1
OLE	Overhead Line Equipment
ORR	Office of Rail and Road
RM3	Risk Management Maturity Model
ROGS	The Railways and Other Guided Transport. Systems (Safety) Regulations 2006



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