



## Strategy for regulation of health and safety risks - chapter 6b: 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.

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.

We will:

- 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 these asset regimes.
- 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 to predict or report failure. It may 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 third parties) and the opportunities for improvement.

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## 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 (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. 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. See the later

discussion of London Underground's (LUL) approach to analysing the impact its assets have on a range of risks. Other duty holders could learn from this example.

5. Further, these assets are vulnerable to the influence of the actions of outside parties – and those actions are not always easily detectable, such as a third party diverting drainage some distance away from the railway which results in unanticipated increased outfall onto the rail infrastructure. In February 2013, for example, massive track deformation was caused to Network Rail infrastructure when a colliery tip failed at Hatfield colliery near Stainforth resulting in damage that kept lines closed for five months. In March 2013 a drill from piling operations unrelated to the railway penetrated and obstructed a tunnel between Old Street and Essex Road stations. In neither case was there any obvious warning to the railway duty-holder of what was about to transpire.

6. The Rail Accident Investigation Branch (RAIB) carried out a class investigation in 2014 into a number of landslides, including Hatfield Colliery. RAIB also investigated the Old Street tunnel breach. In both resulting reports its recommendations to prevent recurrence included measures 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. London Underground has been more successful than others, partly because of the relatively compact nature of its network. It is leading the way in proactively seeking out activities that could impact its operations. ORR recognises the significance of third 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, and a significant number on light and heritage railways. Network Rail also manages culverts greater than 450mm 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 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, by contrast, '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. Since 2014 ORR has devoted more of its work effort to the 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.

## 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 failure.

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.

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:

- Age of assets – the majority of Civils assets on the mainline and LUL networks were constructed before 1900;
- Many are at or near the limits of their design life – and could be susceptible to rapid deterioration;
- Legacy of pioneering efforts – we have inherited a large asset population built without benefit of current understanding - so not as resilient as modern designs

- Construction details have sometimes been lost so there is uncertainty about composition, drainage and materials;
- Both mainline and LUL networks have experienced very significant increases in traffic levels and, thus, loadings to which assets are subjected;
- These are assets that are perceived to have very long life cycles, so have historically been 'sweated' – not always subjected to appropriate inspection and maintenance regimes;
- Initiating failures may be hard to detect visually – in hidden parts of structures and earthworks;
- Earthworks, in particular, are vulnerable to high rainfall during extreme weather events, and river bridges 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, 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 good safety record was achieved despite Storm Desmond and other extreme events in December 2015 – the wettest calendar month on record for the UK. We will ensure that Network Rail continues to refine and improve its contingency arrangements for extreme weather events.

19. 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 up 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. Since this incident, ORR has become aware of a number of other failures of ancillary structures.

## The Law

20. 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)

21. These place duties on duty-holders to reduce risks to their employees, other workers 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).

## Network Rail overview

22. 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 and maintenance (including preventative maintenance) regime that is based on adequate knowledge of the type of structure and its behaviour, condition and capability.

23. 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 in paragraph 20. 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 Routes to achieve requirements, but ensuring effective implementation is the responsibility of individual Routes.

24. ORR inspections have found varied, inconsistent degrees of compliance 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. Despite the challenges of

frequent changes to renewals plans and funding available we have found strong, innovative leadership at the centre of Network Rail - whose vision deserves to be realised.

## **Network Rail Asset Management**

25. 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. Routes with incomplete registers have plans to improve them, but there is a risk that this may delay the process of inspecting, maintaining and renewing those assets which are already known about. Until recently a small number of locations across the network had not been surveyed for the presence of earthworks.

26. 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 routes, most of the examinations are carried out by contractors, the exception being London North West (LNW) route, which has brought this work in-house. Completing examinations, assessments and evaluations on schedule is a challenge for Network Rail, which has incurred significant examination and assessment backlogs, primarily affecting structures but also including earthworks and buildings in some routes. However, the situation is improved from that which existed prior to ORR enforcement action requiring Network Rail to reduce the backlog.

27. 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. Network Rail has acknowledged the shortcomings in its evaluation processes, and has a programme to address them.

28. Network Rail's renewals plans have at times been affected by financial constraints on the routes. 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. This process has been approached differently across the Routes and ORR continues to verify that appropriate decisions have been made and risk control measures are in place as necessary.

29. Network Rail's ambitions for renewals of its Civils assets during Control Period 5 (CP5) and CP6 have been significantly curtailed. It must now 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.

## **Adverse weather arrangements on Network Rail infrastructure**

30. 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. However, progress has been slow. Management of critical drainage systems, also key in minimising the risk of failure, has been the subject of ORR enforcement action.

31. Improvements to Network Rail's arrangements for management of scour are being made, in the wake of an incident at Lamington viaduct on 31 December 2015. A train reported a dip in the track when passing over the viaduct (Scotland route), and subsequent investigation revealed serious damage to the structure due to scour. It was later found that the structure, and others on the route, was not being monitored during adverse weather or flood conditions, the route's extreme weather management plan having apparently fallen into abeyance. Concerns were also raised about deferral of scour prevention works at the structure.

32. The incident at Lamington led to a wider review of the arrangements for management of scour and monitoring during extreme weather in England and Wales. This found that not all routes had monitoring plans in place for vulnerable structures in extreme weather. An assurance action plan was produced by Network Rail, which includes actions to critically review the extreme weather management plans and mitigation regimes for these structures; and to review the relevant policy and standards in place. Similar action is required to manage the risk at Coastal, Estuarine and River Defences (CERDs) during adverse weather.

33. 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; monitor ground saturation; measure flow rates in water courses; 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.

### **Ancillary structures on Network Rail infrastructure**

34. Prior to the failure at Newbury (paragraph 17); 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.

35. 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)**

36. Safety management arrangements for Network Rail's Operational Property (Buildings) estate lags behind that being achieved in other disciplines. Many assets do not have an up to date assessment in place; and hidden critical element (HCE) examinations have not been carried out at many structures. Programmes are in place to rectify these problems, but they have relatively long timescales. Plans for examining ancillary structures on operational property (such as station lighting columns) also lag behind those on other parts of Network Rail's estate.

## London Underground

37. 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 from Civils assets). 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.

38. 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.

39. London Underground demonstrates good practice in respect of several elements of its Civils asset management strategy. It 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.

40. 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. 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.

41. Overall, LUL displays a mature approach to the management of its civils assets. This is despite the challenges of ageing assets and intensive use. Optimal asset management brings considerable performance benefits, as well as controlling safety risk, and this has been a strong incentive for LUL to seek solutions to the challenges posed by its Civil Engineering population. For this reason ORR has not devoted the same level of resource to inspection of London Underground as it has to the mainline network.

## Tramways and Light Rail

42. Our primary focus has been on the initial integrity of new operating systems within tramways and light rail and how they are maintained. Thus, 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.

43. 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.

44. 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.

45. 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.

46. 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.

47. Where there is similar infrastructure to mainline and metro railways – primarily non-street running parts of tram networks, often inherited from heavy rail – the risks are significantly different due to the ability of trams to stop more quickly should an obstruction or other derailment risk be encountered.

## Heritage railways

48. 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 us 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.

49. 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 acute. 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. Incidentally, investigations during repairs revealed that there were some 108 drainage culverts; prior to the storms SVR had records of just 28.

50. 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.

51. In particular 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.

52. 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. As this sector-specific guidance grows in maturity and becomes embedded so ORR activity will become more reactive in nature.

## **ORR Activity**

53. 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 is being placed on improving Network Rail's management of Civils assets. This is 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 devote more resource to influencing Network Rail in respect of Civils than all other duty holders combined. In doing so, ORR has regard to the devolved nature of Network Rail's organisation and carries out work with both the centre and the Routes.

54. 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.

55. 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. For example, there remain gaps in Network Rail's basic asset information; particularly in the field of drainage. 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. 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 ambitious plans to renew Civils assets have been significantly curtailed, but where a rebalancing of activities – with an emphasis on refurbishment – is proposed;
- c. promote industry adoption of appropriate asset management regimes, weighing renewal, refurbishment, maintenance and inspection activities to maximise safe management of Civils assets. An emphasis will be placed on assets such as ancillary structures which have in the past been subject to a relatively 'light touch' asset management approach and which are at or may be reaching the end of their serviceable life;
- d. 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, who needs to monitor and mitigate the effects of deferring renewals of its Civils portfolio;
- e. 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;
- f. 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. LUL has shown the benefits of adopting a systems engineering approach.

## 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 May 2011 and April 2016.

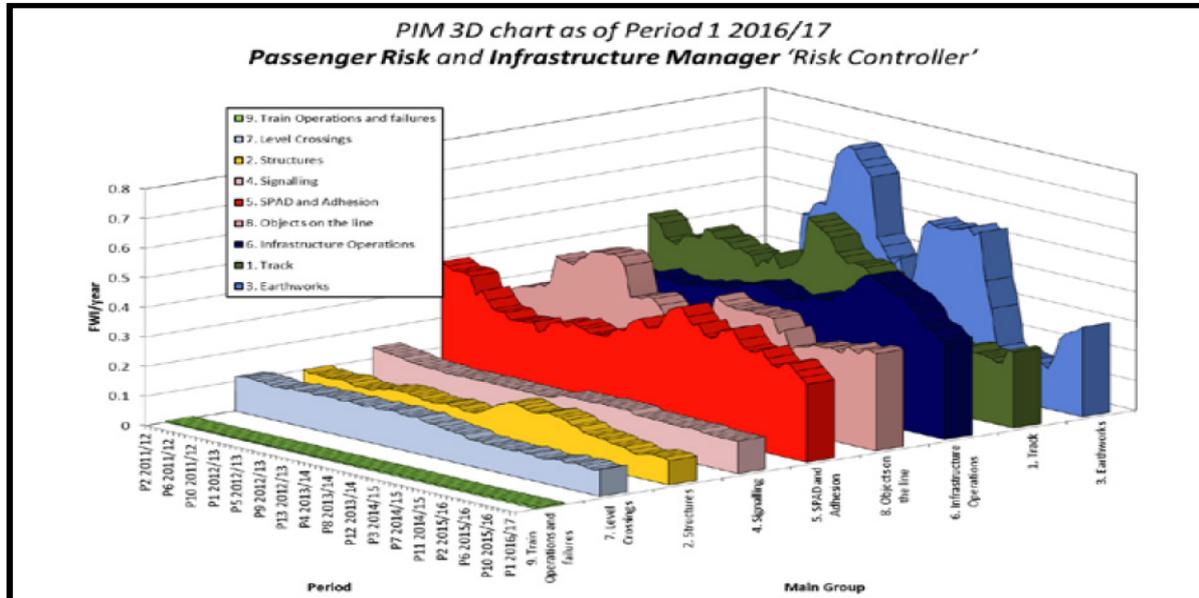


Figure 1: RSSB Precursor Indicator Model

2. Structures failures represent a significant contribution to the overall serious train accident risk. The Structures FWI has remained relatively constant during the time period, with an increase to a peak value of 0.22 which occurred during 2014. Structural failure can result in significant risk of an incident, which can result in significant consequences. Figure 2 (below) shows the relative contribution of different types of incident to the overall risk arising from structures on Network Rail infrastructure.

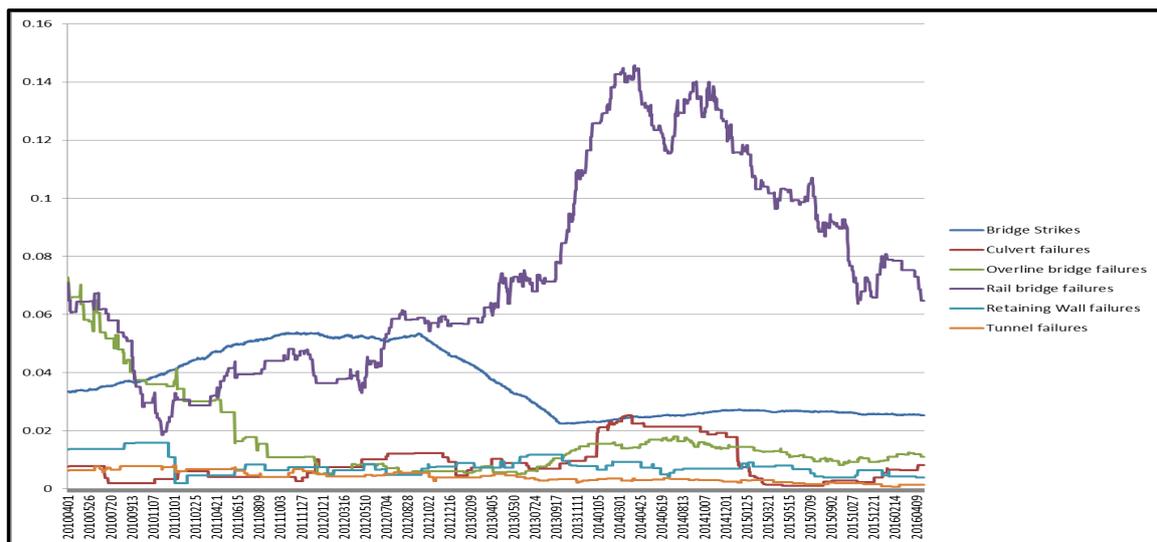
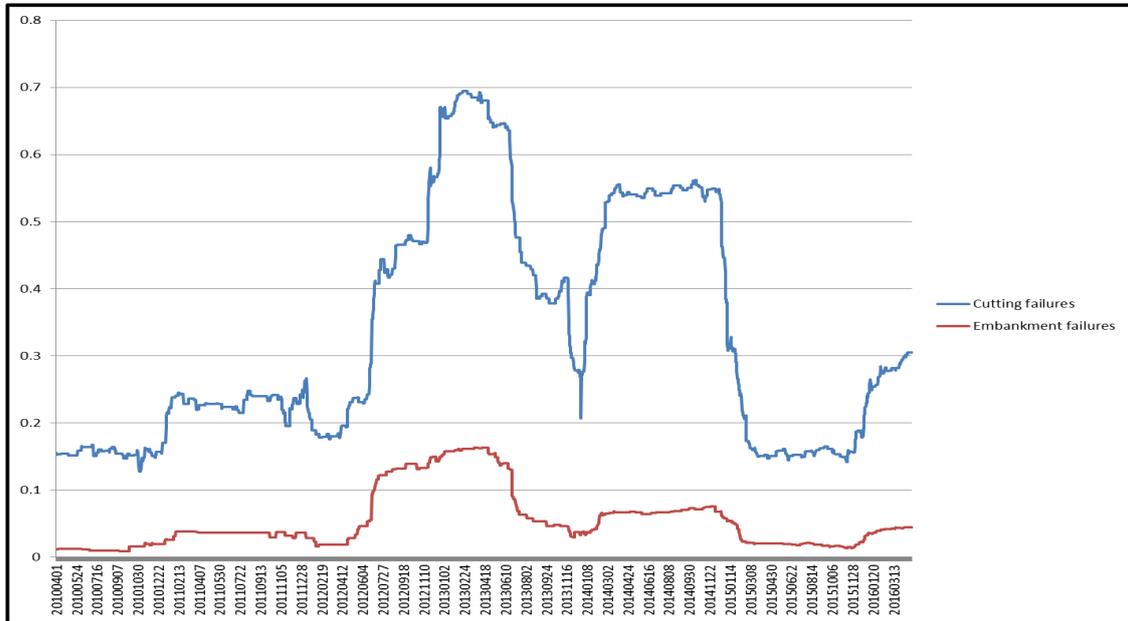


Figure 2: Contributions of structural failures to train accident risk

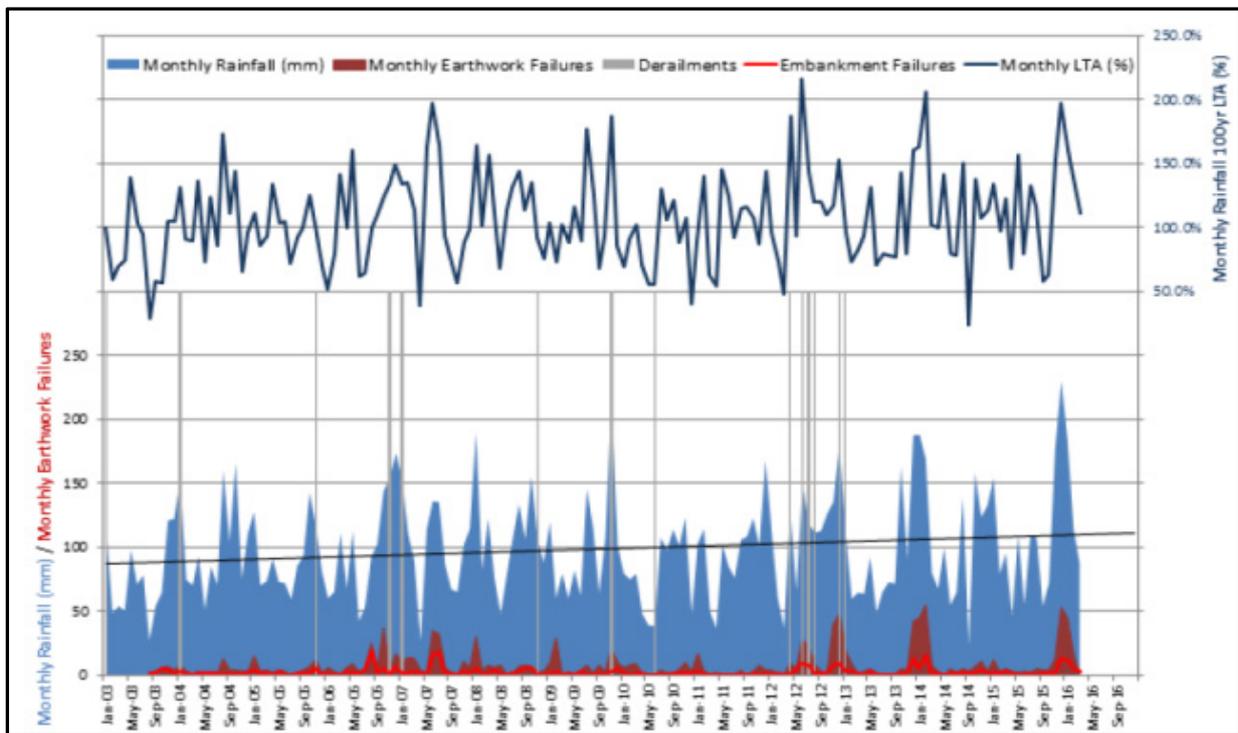
3. Whilst the Structures FWI has remained relatively constant during the time period the earthworks FWI value, in contrast, fluctuates significantly. Earthworks failures are highly

weather-dependent, with most occurring during periods of very wet weather or short, very intense storms. The peak value of 0.88 occurred during the winter of 2012/13. As shown in the graph at figure 3 below, cutting failures (blue line) are responsible for a significantly larger proportion of the FWI when compared to embankment failures (red line) (Network Rail infrastructure).



**Figure 3: Contributions of earthworks failures to train accident risk**

4. Earthworks failures are closely associated with extremes of weather. These events appear to be becoming more frequent. The Met Office reports ('State of the UK Climate 2015') that seven of the ten wettest years for the UK have occurred since 1998. December 2015 was the single wettest month on record and included the highest 24 hour and two day rainfall records – both during Storm Desmond. Lancashire and Cumbria experienced the most severe weather events, consequently suffering a large increase in earthworks failures accounting for one third of the national total during the winter 2015/16 period. Embankment failures also rose over the same period, having remained at a relatively low level during the early part of 2015-16. The graph at figure 4 below shows the close relationship between rainfall and earthworks failures on Network Rail infrastructure, and indicates where these have led to derailments.



**Figure 4: Relationship between rainfall and earthworks failures**

5. The Met Office reports that in recent decades there has been an increase in annual average rainfall over the UK, particularly Scotland. Further, it is reported that eight of the ten warmest years for the UK have occurred since 2002, and all ten warmest years have occurred since 1990. December 2015 (storm Desmond and other named storms) was the warmest December on record. Mild winters are associated with behaviour of the jet stream that leads to more frequent high rainfall events. The decade 2006-15 was on average 0.3 degrees warmer than the 1981-2010 average and 0.9 degrees warmer than the average for 1961-1990. In addition, nine of the ten warmest years for coastal sea temperatures occurred after 1989. Mean sea level around the UK is estimated to have risen by 1.4mm/year in the 20<sup>th</sup> Century.

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 recent ORR enforcement action (February 2015) aimed at reducing the risk of cutting failures. The Hunton Bridge derailment and subsequent train collision demonstrates the potential for very serious consequences associated with earthworks failures, particularly in cuttings.

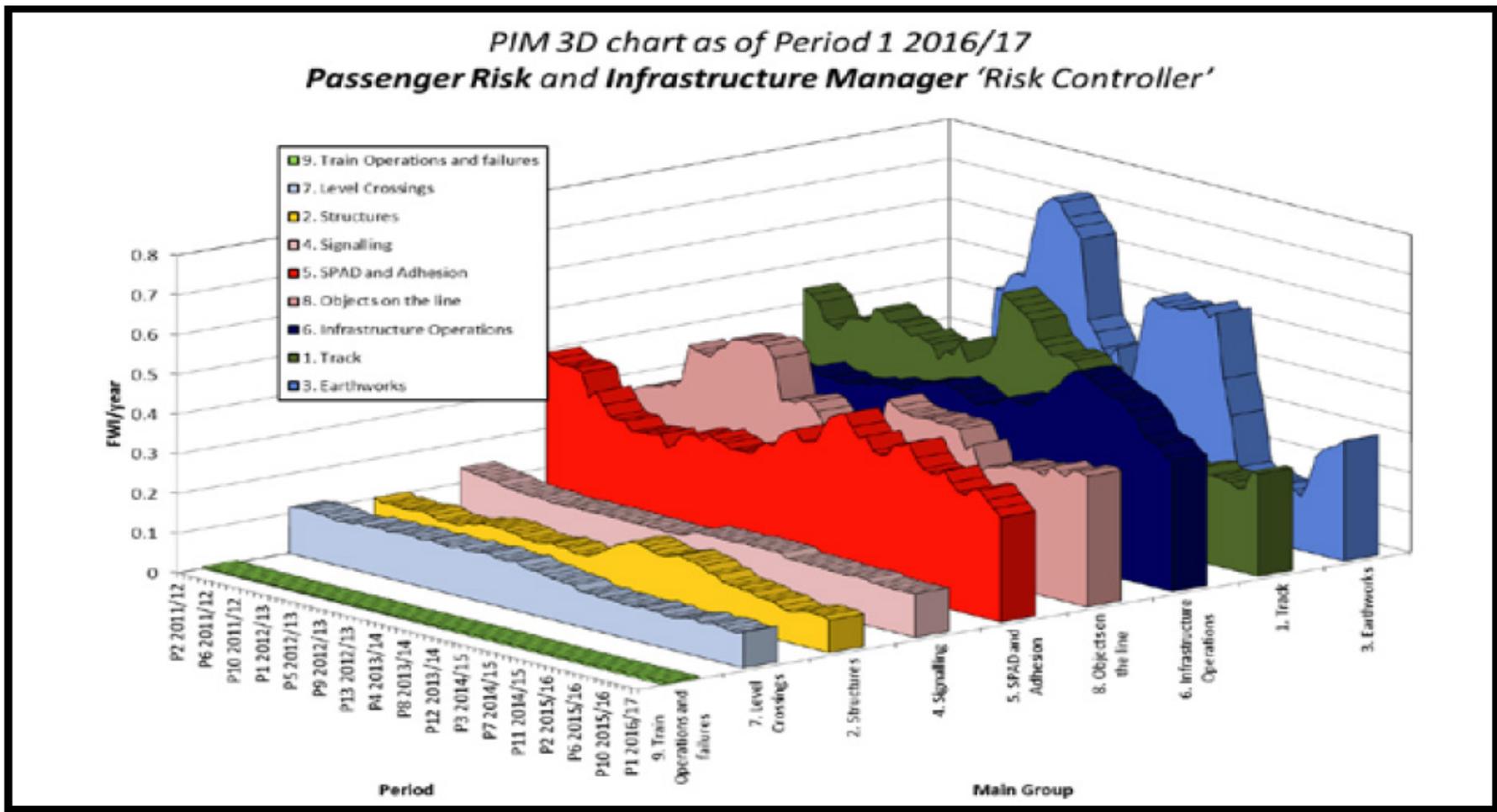
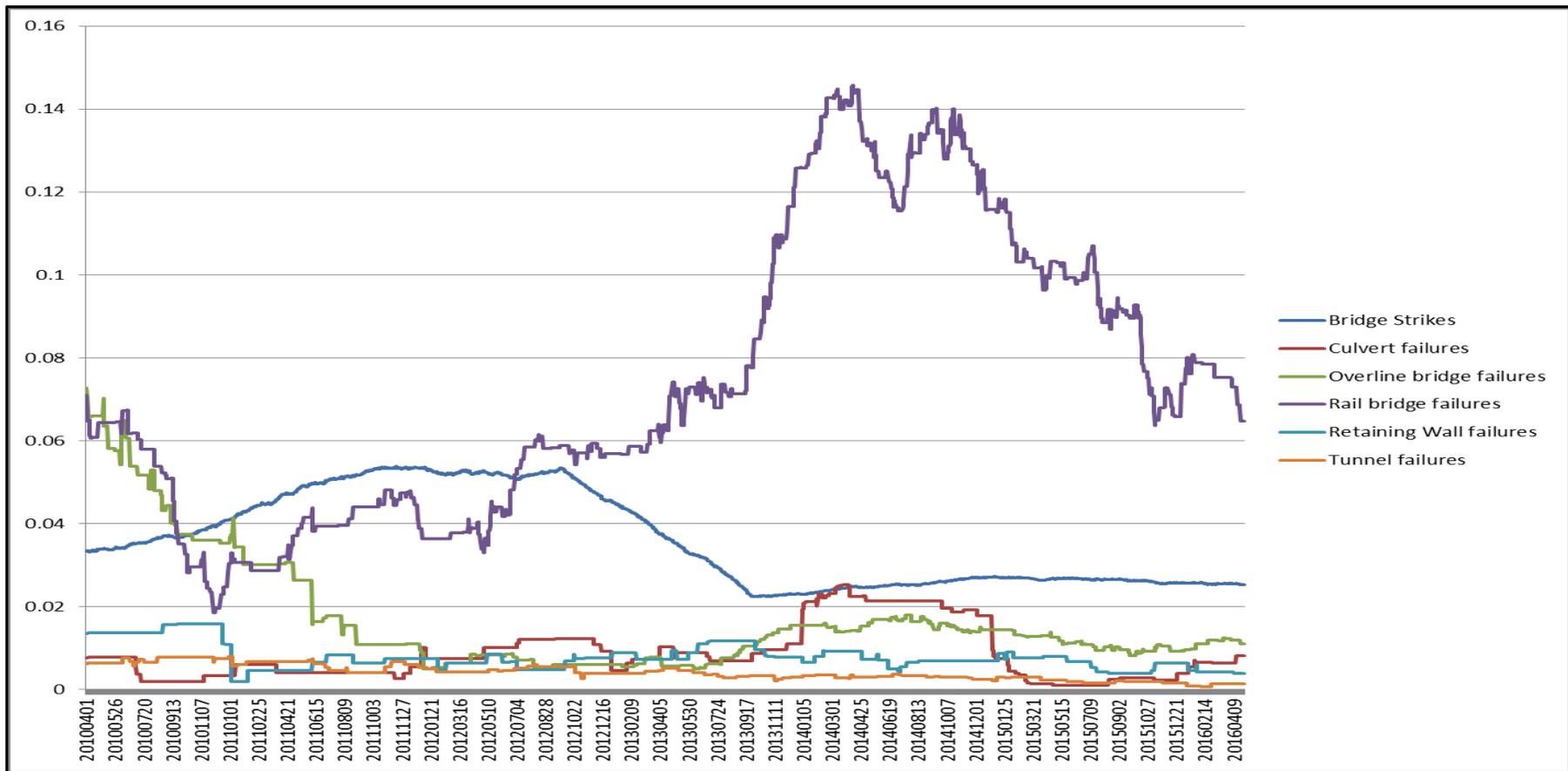
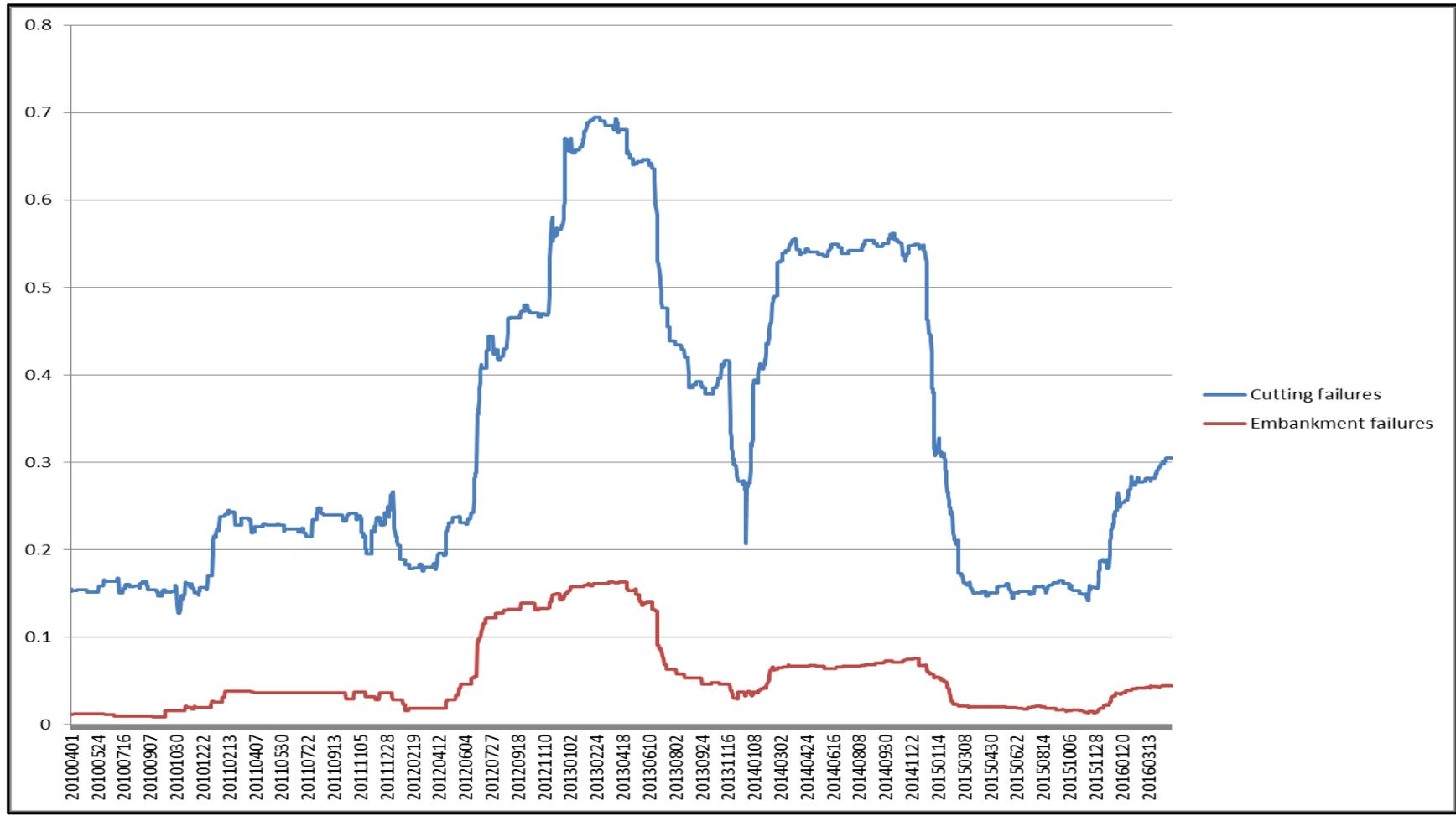


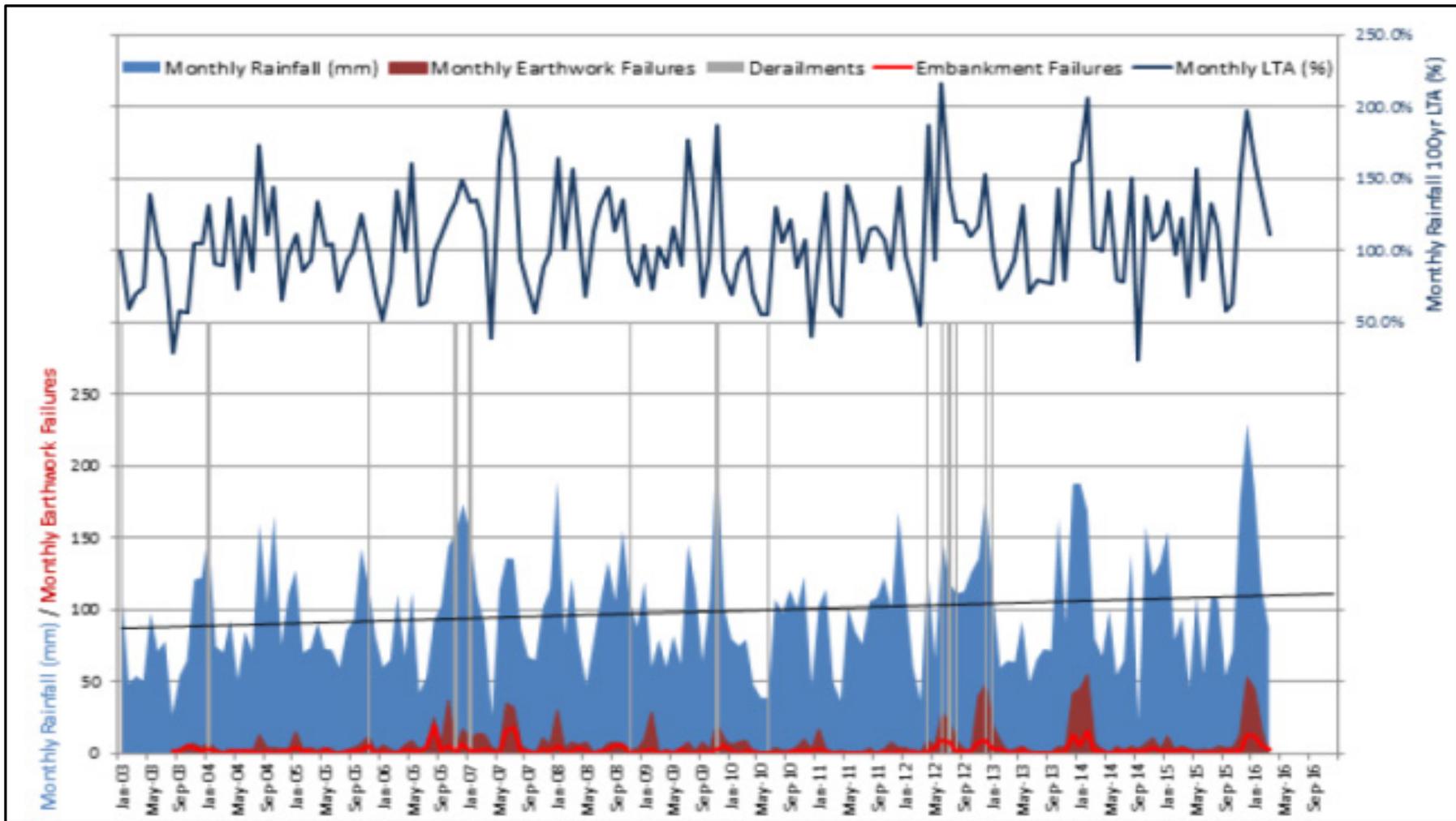
Figure 1: RSSB Precursor Indicator Model



**Figure 2: Contributions of structural failures to train accident risk**



**Figure 3: Contributions of earthworks failures to train accident risk**



**Figure 4: Relationship between rainfall and earthworks failures**

## Appendix Two – Glossary of terms

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)
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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