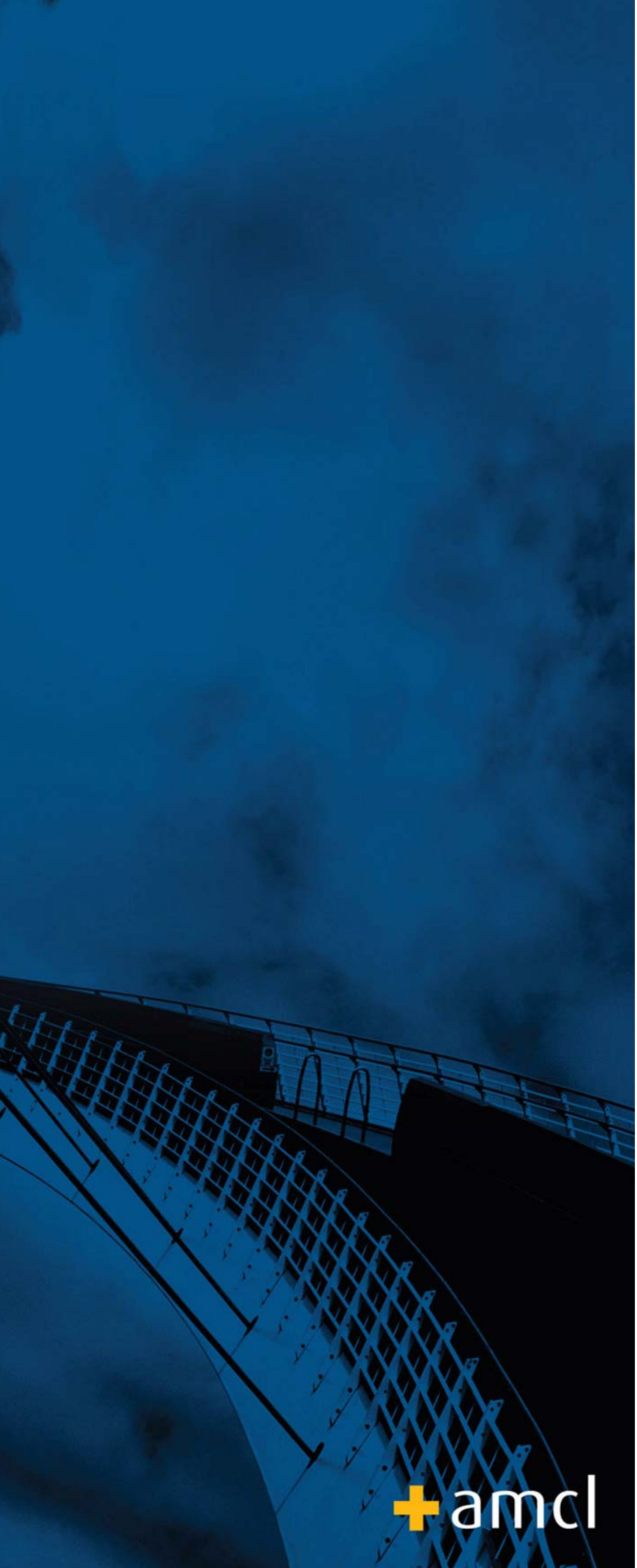

A Report for
Network Rail, the ORR and Southern
from
Asset Management Consulting Limited (AMCL)

Version 1.0
12th December 2011

Asset Management on Sussex Route to Achieve Sustainable Performance
Phase 1 Report

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AMENDMENT HISTORY		
Version	Sections	Amendment Details
Draft A	All	Initial draft document for client review
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Executive Summary

Southern Railway Limited wrote to the Office of Rail Regulation in December 2010 raising its concerns about deteriorating performance on Network Rail's Sussex Route. The Office of Rail Regulation and Network Rail subsequently commissioned Asset Management Consulting Limited (AMCL), the Independent Reporter for Asset Management, to undertake a first phase review of Asset Management on the Sussex Route at both a whole system and at a tactical level. The first phase of this review was focused on electrification assets, both as a specific asset group and as a proxy for a review of generic Asset Management practices within Sussex Route., Whilst some generic Asset Management practices have been reviewed, it should be noted that the scope of work limited the breadth of the review to such practices as those associated with Electrification. This report documents the findings of the first phase of the review.

Current Asset Management practices were reviewed against the simplified Asset Management process shown in Diagram 1 below which is separated into three key areas.

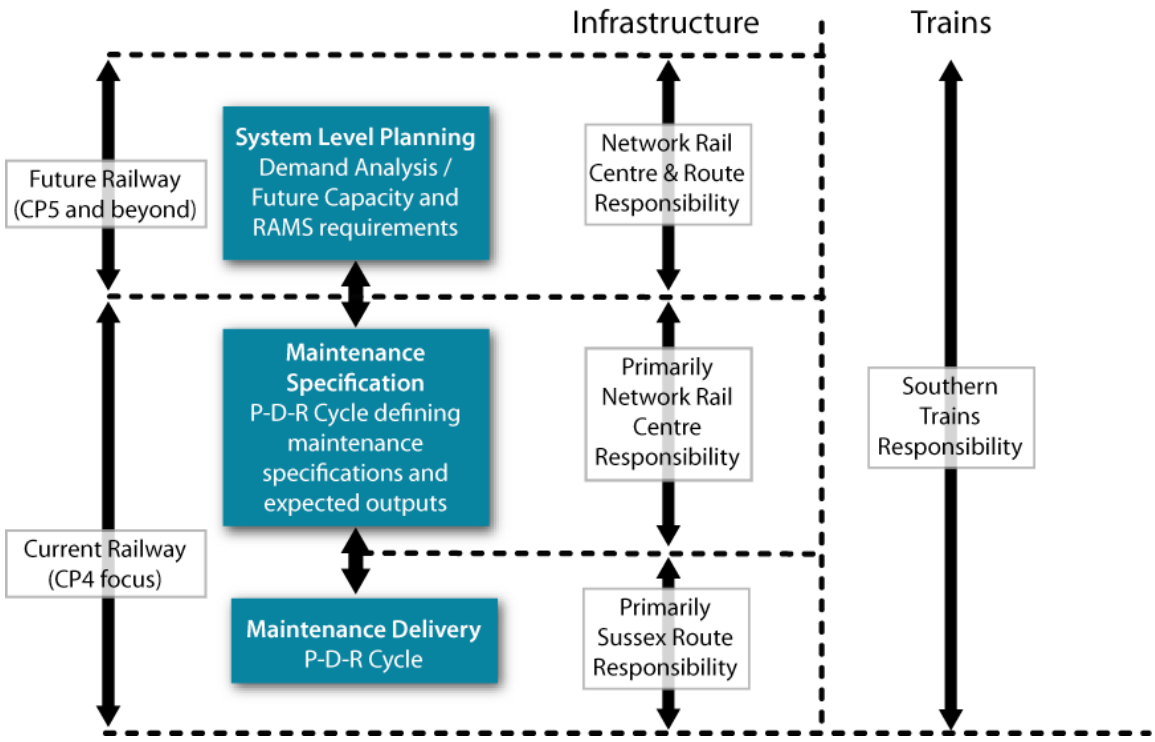

Diagram 1 Simplified Asset Management Process

1) **System Level Planning** - the management of demand and the translation of this demand into a statement of required capacity and a specification of Reliability, Maintainability and Availability (RAM) targets.
2) **Maintenance Specification** - the specification of maintenance requirements and standards to meet these capacity and RAM requirements as part of an engineering change process.
3) **Maintenance Delivery** - the delivery of the maintenance requirements defined in the standards as part of a plan-do-review delivery process.

The findings and recommendations are structured around these three areas, including the consideration of the asset information that informs all three. Although the review has focused on electrification assets, where these findings and recommendations are felt to be generic this has been highlighted.

The key conclusions of this report are:

System Level Planning

Demand analysis and understanding future capacity requirements is a long-term planning activity that needs to consider the needs of Control Period 5 and beyond. Historically, this system level planning has not been undertaken to a sufficient level of detail, or from a whole system perspective – therefore there are a number of findings related to the implications of this.

1) A number of recent electrification system failures on the Sussex Route were a result of the load demands identifying 'weak' points in the system, be they condition, manufacturing, materials or equipment rating issues.
2) Network Rail is currently unable to quantifiably determine the electrification system route capacity (supply) of the infrastructure or the continuous real-time load (demand) requirements of the train services that operate on it. Whilst both these measures are notably complex and dynamic, Network Rail does hold a certain level of knowledge, as well as undertaking modelling of capacity and testing of loads for specific purposes. However, without a full understanding of these measures, it is impossible for Network Rail to predict the performance of the electrification system.
3) Continuous real-time load data can only be provided by the installation of relevant load measurement transducers connected to a new SCADA (Supervisory Control and Data Acquisition) system. A new SCADA system is currently scheduled for commissioning in Control Period 5 along with fitment of transducers to new circuit breakers and retrofitting of transducers at existing 'node sites' where certain criteria are met.

4) In the absence of this strategic understanding of demand and the associated capacity and RAM requirements, Network Rail must be provided with longer notification periods in order to appropriately assess the potential impact of changes to train services or rolling stock on the electrification system.
5) The review has identified a key issue in managing performance is Network Rail's strategic approach to aligning electrification system capacity on the Sussex Route with future demand.
6) The available electrification system route capacity has been gradually eroded by increases in train services and the resulting increase in traction loads over the last few years, and no major enhancements to electrification system route capacity have been justified or funded beyond those identified as necessary for specific timetable changes.
7) Without the provision of electrification system route headroom, further incremental changes to train services or rolling stock may have a significant performance impact.

Maintenance Specification

Network Rail Centre is responsible for the development of Maintenance Standards so the following findings are likely to apply to all routes with similar electrification infrastructure to the Sussex Route.

8) Some analysis of maintenance fitness for purpose is undertaken, but this is not part of a formally documented engineering plan-do-review process.
9) The maintenance specification plan-do-review loop is limited by Electrification engineering resource constraints and prioritisation, based on criticality across Network Rail's electrification system asset base and there has been no quantified justification or optimisation of the Maintenance Standards for DC electrification system assets identified.
10) There is no current capacity or RAM specifications attributed across the DC electrification system hierarchy against which Maintenance Standards are meant to be delivering or measured.
11) Conductor rail equipment failures are considered by AMCL to have been impacted by degrading condition, outdated Maintenance Standards and a lack of specific Work Instructions.
12) A revised process for assessing and collating quantified condition data for some electrification system assets was introduced in 2011 but knowledge of degradation rates is currently variable across the DC electrification asset base.

13) In contrast, this review has found that Southern Railway Limited has a well documented engineering review and change management process to assure the completeness and adequacy of maintenance specifications.

Maintenance Delivery

14) The maintenance delivery plan-do-review loop utilised in Sussex Route is understood to be the generic approach used throughout Network Rail and generally forms a closed loop process. However, a potential risk in relation to the satisfactory completion of the plan-do-review loop was identified during the review due to an inconsistency between electrification Maintenance Standards and the 'grace' period for closing out maintenance tasks within the Ellipse system.

15) Sussex Route has established a number of maintenance and intervention initiatives to mitigate electrification system performance issues in the short-term, including the introduction of inspection processes for conductor rail equipment, such as the use of infra-red equipment.

16) Maintenance Work Orders generated by Ellipse do not adequately detail the relevant Maintenance Standard or Work Instruction.

17) The lack of data captured in the Fault Management System is considered by AMCL to form a systemic constraint on failure mode based root-cause analysis, particularly for non-service affecting failures, across the asset base. This appears to be a generic issue that is not limited to electrification assets.

18) Quantified knowledge of electrification system condition and degradation profiling is limited, particularly with respect to conductor rail equipment.

19) Until detailed capacity and load information is available for the electrification system, Southern Railway Limited and Sussex Route will need to continue to work together to further mitigate performance issues.

The recommendations from this review to improve performance on the Sussex Route are listed below. They are grouped into one general recommendation and recommendations on the three areas discussed above of System Level Planning, Maintenance Specification and Maintenance Delivery.

General

1) Although the focus of this phase of the review was on the Asset Management of electrification assets, this was found not to be the largest driver of performance issues.

Electrification assets were ranked 12th by annual delay minutes and 4th by total number of faults on the Sussex Route. Asset Management practices may also vary by asset discipline so consideration should be given to reviewing the Asset Management of other key asset types in a further review phase.

System Level Planning

These recommendations are strategic in nature and will need to be led by Network Rail Centre:

2) By April 2012, Sussex Route (with the support of Southern Railway Limited) should formalise appropriate notification periods for train service changes, recognising that the period of notification will be longer the more significant the change.
3) By April 2012, Sussex Route (with the support of Southern Railway Limited) should agree and establish an appropriate and continuously rolling long-term planning horizon for the Joint Performance Improvement Plan.
4) Prior to the submission of the Strategic Business Plan for Control Period 5, Network Rail should ensure proposals for the retrospective fitment of load measurement transducers to existing DC electrification equipment provide appropriate granularity of continuous real-time load measurement data to a central point to facilitate system performance prediction and aligns with the commissioning of the proposed new SCADA system.
5) Prior to the submission of the Strategic Business Plan for Control Period 5, Network Rail should further develop the 'Sussex Route Traction Power Strategy' in line with Policy Number EP-127 'Power Strategy' of the draft Control Period 5 Electrical Power Asset Strategy, including outline designs for increasing the electrification system route headroom to agreed levels.
6) By the end of Control Period 4, Network Rail should determine a methodology to determine electrification system route capacity and electrification system route headroom.
7) Within the first year of Control Period 5, Network Rail should ensure that all appropriate projects provide electrification system reinforcement not just to meet the requirements of the projects and but also to provide or maintain an agreed level of electrification system route headroom. This will require justification and may require the provision of appropriate funding.
8) Within the first year of Control Period 5, Network Rail should develop the proposed more 'nimble' approach to Electrification System Modelling to inform strategic thinking and the early stages of projects as an alternative to the existing complex systems.

Maintenance Specification

These recommendations are strategic in nature and will need to be led by Network Rail Centre:

9) By April 2012 Network Rail should ensure that Ellipse Work Orders include specific reference to, or appropriate details of, the current Maintenance Standards or Work Instructions.

10) By April 2013, Network Rail should develop an appropriate suite of conductor rail equipment Work Instructions and identify and fill any further gaps in DC electrification system maintenance documentation.

11) By the end of Control Period 4, Network Rail should establish a Southern DC Electrification System Network Management team to determine the procedures, processes and systems required to manage and develop the Southern DC electrification system and propose an organisation, taking into account the practices of Distribution Network Operators and equivalent organisations.

12) Within the first year of Control Period 5, Network Rail should adopt a Reliability. Availability and Maintainability specification based approach to the maintenance of DC electrification system assets, with appropriate apportionment of targets across the system.

13) Within the first year of Control Period 5, Network Rail should systematically review and quantifiably optimise, on a cost-risk basis, all DC electrification maintenance regimes, in accordance with the established Reliability, Availability and Maintainability requirements.

14) By April 2012, Network Rail should establish appropriate Maintenance Standards, Work Instructions and competency arrangements for the use of infra-red equipment on DC electrification equipment.

Maintenance Delivery

These recommendations are tactical in nature and will need to be addressed by Sussex Route:

15) By April 2012, Sussex Route should establish a process to ensure that the engineering root-cause of electrification infrastructure faults is fully captured within FMS and used to justify all relevant performance improvement initiatives.

16) By April 2012, Sussex Route should formalise the process to liaise with Southern Railway Limited, undertake on site-investigation as appropriate and rapidly determine the root causes and agreed resolutions for conductor rail and train shoegear incidents.

AMCL would like to take this opportunity to thank the stakeholders and interviewees involved in the review.

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1 Introduction

1.1 Background

The Department for Transport (DfT) re-awarded Southern Railway Ltd. (Southern) the South Central train operating franchise in June 2009. The franchise runs from September 2009 until July 2015, with the possibility of extension until 2017. The franchise operates extensively on the infrastructure managed by the Sussex Route of Network Rail.

Southern wrote to the Office of Rail Regulation (ORR) on 23rd December 2010, raising its concerns about Network Rail's performance on the Sussex Route. The letter identified that Network Rail Sussex Route was falling short of its 2010/11 Joint Performance Improvement Plan (JPIP) targets. It also raised concerns that this was part of a longer-term trend of performance deterioration on the Route and that it may point to systemic issues. To address the longer-term issues, Southern proposed in its letter:

"A wide and detailed independent analysis of the systemic root causes of Network Rail Sussex's long term poor performance for Southern."

Although a number of issues were mentioned in the letter, the mandate defining the subsequent review requirements was based on a phased approach. Phase one of this approach, specified in the mandate, was to review the whole life management of the electrification system on the Sussex Route.

To undertake the identified review, Network Rail and the ORR engaged AMCL as the current Independent Reporter (Part B: Asset Management) to both organisations.

This report documents AMCL's findings from the Phase one review.

1.2 Purpose

The overall stated purpose of the quadripartite (ORR, Network Rail, Southern and AMCL) agreed mandate is to undertake a review of the Asset Management of the Sussex Route both at a whole system (strategic route) and at a tactical level.

It was agreed that the study was to consider actions that both Network Rail and Southern can take in order to improve the Sussex Route's long-term performance.

Key objectives were to identify actions to improve:

- Knowledge of the condition and criticality of the asset base;
- The relationship between interventions and reliability and availability of the infrastructure; and
- The analysis and justification for establishing and predicting long-term performance of the asset base.

The outcome was anticipated to bring more certainty around long-term performance forecasts on the Route.

1.3 Scope

The overall scope of Phase one was to assess the identification, planning and application of Reliability, Availability and Maintainability (RAM) techniques used for the management of the Sussex Route infrastructure and Southern rolling stock, with a specific focus on electrification infrastructure. The review was to recommend actions that Network Rail and Southern can use to improve:

- Planning of interventions (maintenance / renewals / JPIP schemes) based on asset information;
- Defect and fault management processes and interventions;
- Understanding of the relationship between asset interventions, system capability to deliver timetable requirements, and performance; and
- Long term performance forecasts within set tolerances (in particularly to inform industry strategic planning).

The review was required to check whole industry system level and tactical asset management practices against a closed loop (for example in a simple plan – do – review cycle) which considers whole-system performance. The key elements of the mandated scope were:

1) Context Analysis - The review should provide a clear context for activity by summarising current position and trends in the performance, condition and use of the infrastructure.
2) System Level Planning (Plan) - At a system level, the review should consider the asset information regarding the power supply capacity of the system and the models that are used to forecast Reliability, Availability and Maintainability of the whole-system and sub-systems.

3) Maintenance Practices (Do) - The review should consider the current maintenance definition/justification, planning and delivery practices for electrification assets on the Sussex Route.
4) Asset Information (Review) - The review should consider how asset information requirements are specified and the information is collected, analysed and understood to manage whole system performance.

1.4 Methodology

The mandated methodology consisted of four key elements:

- A desktop based study of relevant documentation;
- Data collection (including maintenance records) and analysis;
- On-site interviews; and
- Reviews of all asset intervention definition/justification, planning and delivery processes.

1.5 Definitions

The following definitions are provided to ensure a consistent understanding of critical elements of the review findings:

- 'electrification system route capacity'
  - The electric train services that an electrification system on a Route or part of a Route can support.
- 'electrification system route headroom'
  - The estimated percentage difference between electrification system route capacity and the demand of the existing electric train services on a Route or part of a Route.
- N-1 Security
  - A level of security of supply such that the planned timetable can be supported when one feeder circuit or major item of plant is out of service.

1.6 Abbreviations

Abbreviation	Description
BUGLE	Performance Management System used by TOCs
ADIP	Asset Data Improvement Plan
ATOC	Association of Train Operating Companies
AWS	Automatic Warning System
CAR	Corrective Action Request
CRE	Conductor Rail Equipment
DfT	Department for Transport
DINIS	Distribution Network Information System
DNO	Distribution Network Operator
DQuIP	Data Quality Improvement Programme
EP	Electrification Power
E&P	Electrification and Plant
E&PME	Electrification & Plant Maintenance Engineer
EP	Electrical Power
ETE	Electric Track Equipment
FMS	Failure Management System
FSC	Firm Service Capacity
HQ	Headquarters (Network Rail central offices)
IIP	Initial Industry Plan
IMDM	Infrastructure Maintenance Delivery Manager
IME	Infrastructure Maintenance Engineer
JPIP	Joint Performance Improvement Plan
MAA	Moving Annual Average
MDU	Maintenance Delivery Unit
MOLA	Master Operating Lease Agreement
MPV	Multi-Purpose Vehicle
MTIN	Miles per Technical Incident
MVA	Mega-Volt Amperes
NCAP	National Core Audit Programme
NCR	Non Conformance Repot
NG	National Grid
NIRG	National Infrastructure Reliability Group
NST	Traction Power Design National Specialist Team
OHL	Overhead Line

Abbreviation	Description
ORR	Office of Rail Regulation
OSLO	Overhead System Loading
PDR	Plan-Do-Review
PPM	Public Performance Measure
Railsys	Proprietary train movement modelling application
RAM	Reliability Availability Maintainability
RAM*	Route Asset Manager
RIMD	Route Infrastructure Maintenance Director
RIRG	Route Infrastructure Reliability Group
RSSB	Rail Safety and Standards Board
RUS	Route Utilisation Strategy
SCADA	Supervisory Control and Data Acquisition
Southern	Southern Railway Ltd.
Southern PSE	Southern Power Supply Enhancement
SR PSU	Southern Region Power Supply Upgrade
SRA	Strategic Rail Authority
SSM	System Support Manager
STK	Singe Track Kilometre
TDAC	Train Delay Attribution Clerk
TIN	TRUST Incident Number
TOC	Train Operating Company
TPWS	Train Protection and Warning System
TRUST	Train Running System TOPS
VISION	Visualisation and Interactive Simulation of Train Operations
VMI	Vehicle Maintenance Instruction
VOI	Vehicle Overhaul Instruction

Table 1 Abbreviations

1.7 Structure of Document

Due to the scale of the review, this report has been kept deliberately strategic and focused on the key issues impacting the performance of the electrification system on the Sussex Route. The structure of the report is:

- Section 2 - an overview of the preceding Context Analysis report;
- Section 3 - a summary of AMCL's key findings from the overall review;

- Section 4 - an overview of Southern's Asset Management practices;
- Section 5 - an overview of Network Rail's (Sussex Route) Asset Management practices; and
- Section 6 - AMCL's key conclusions and recommendations.

2 Context Analysis Report

A specific initial element of phase one of the review was to undertake a 'Context Analysis' exercise. This was to provide a high-level, independent, summary of the current position and trends in the performance, condition and use of the systems and to highlight any key data gaps or weaknesses that may constrain good Asset Management and sustainable performance. The detailed findings of the Context Analysis are available in a separate report[1]. They are therefore not repeated here.

The key findings of the initial Context Analysis report, which are subject to further review in the body of this report, were:

- From the failure and incident information provided for the last 5 years, approximately 77% of the delay attributable to Network Rail was incurred by Southern Trains.
- Southern Trains appeared to have a relatively robust method of recording failures, their causes and root causes. However, although the immediate cause of failure was always recorded, there were a relatively high number of failures in the performance management system with blank root causes.
- Network Rail's method of recording incident and failure information prior to Period 4 2009/10 was considered by AMCL to be well below the standard that would be expected for an organisation managing the portfolio of assets that Network Rail is responsible for. Since that time, there had been a step-change in the completion of two specific fields within in the Failure Management System (FMS), but the extent to which this data represents the root cause of failure requires further analysis of the use of 'no cause found'. (This is considered to be a generic Network Rail issue and is being reviewed by the ORR under a separate workstream.)
- There was also found to be no direct link between FMS and TRUST, the train delay incident monitoring system, making it difficult to assess the delays associated with failures in FMS. This was considered to make it difficult to undertake the type of analysis that should be common place in an effective Asset Management organisation, for example:
  - Pareto analysis cannot be undertaken to determine the worst performing asset types as TRUST and FMS are not linked and TRUST is an unreliable source in relation to recording the asset type that caused the failure.

[1] Sussex Performance Review - Context Analysis Report - Draft B; AMCL, July 2011.

  - Root cause analysis is constrained because the root causes of failures were not systematically recorded within FMS prior to 2009/10 and since then, the quality of root cause of failure being captured within FMS is variable and Network Rail's post-incident approach to data based analysis of root causes is only applied to certain sub-sets of incidents.
  - Network Rail's ability to develop improvement plans that tackle the priority problem areas is constrained as it requires the above analysis to support this.

- It was found that on the Sussex Route 27% of incidents (representing 7% of total delay minutes) were attributed to TRUST Category 601 (All Z codes – Unexplained), which increased uncertainty around any subsequent analysis of the data.
- From the analysis undertaken, Electrification did not appear to be the worst performing infrastructure asset type; ranked 12th in the TRUST delay categories (by annual delay minutes) and 4th in FMS (by total number of faults). In fact, Points and Track Circuits were found to be the highest cause of minutes delay (for infrastructure categories).

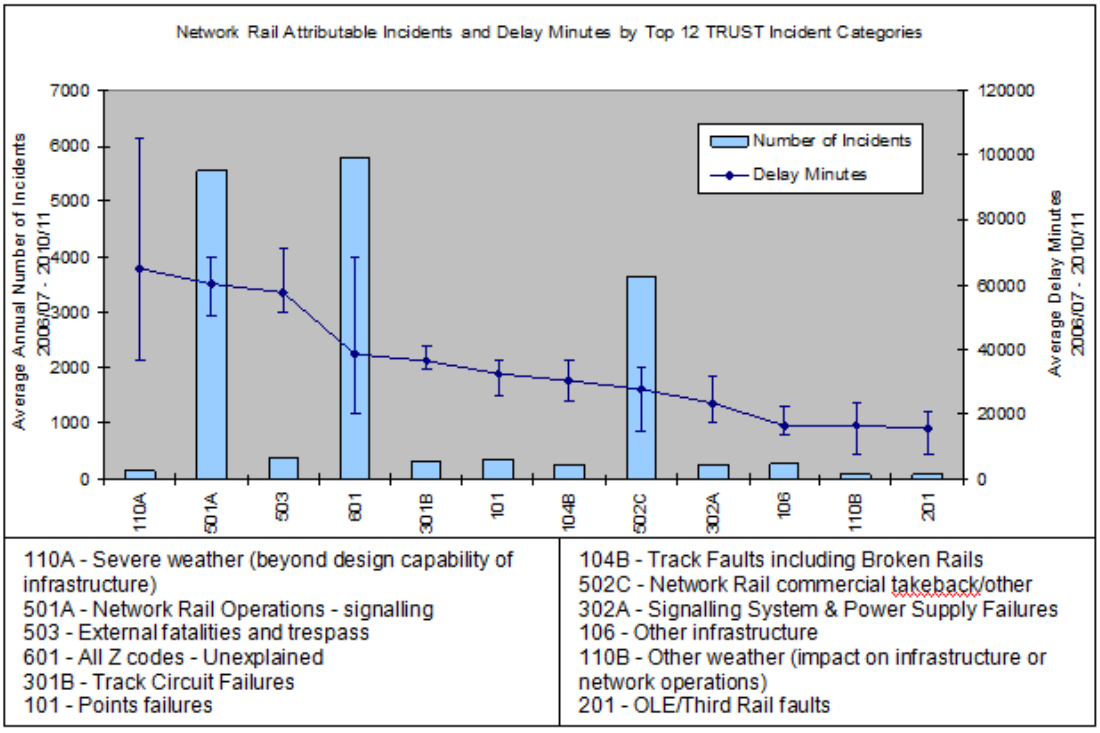


Diagram 2 Top-12 TRUST Incident Categories 2006/07 - 2010/11

- Analysis of the age, condition and utilisation information on Electrification assets appears to be reasonably well managed in both Network Rail and Southern.

Following the Context Analysis, the following recommendations were made:

1) Network Rail, the ORR and Southern Trains should immediately review whether the scope of this mandate should be widened to include Points and Track Circuits as well as Electrification, given the findings of this context analysis.

   It should be noted that this recommendation was considered in the quadripartite review process, following publication of Draft A of the Context Analysis report, where it was agreed to continue with the focus on electrification during phase one of this review.

2) Both parties should immediately identify - or commence - and contribute to a strategic performance working group, tasked with the ongoing, and fully transparent, continuous improvement of long-term performance on the Sussex Route.

It should be noted that a number of issues raised relating to FMS data were considered to be generic and outside the scope of this review by the quadripartite review group but are being further considered by the ORR.

3 Key Findings

The following sections summarise the key findings of the extended review, above and beyond those of the Context Analysis report. Further detail behind each of the key findings is provided in Sections 4 and 5.

Although a review of the Asset Management activities of both Southern and Network Rail has been undertaken, it is in no way intended to form a comparison between the organisations. They are considered very different entities, with very different business objectives, drivers and logistical constraints. Nor is it meant to infer a lack of effort or knowledge of any individuals within either organisation who have all been extremely supportive throughout this review.

Southern's business objectives focus very much on the operation and maintenance elements of Asset Management. Network Rail as a whole has a wider Asset Management remit and significantly different issues of scale and logistics.

As the driver for this review was Southern's concerns with Network Rail's performance, the majority of the key findings are focused on Network Rail's Asset Management practices. In general, Southern was found to manage its generally narrower Asset Management remit of the operation and maintenance in line with industry good practice. Where it is considered that Southern can contribute to performance improvements across the Route, within the constraints of its franchise arrangements, this has been identified.

3.1 System Level Planning

3.1.1 Background

The following should be noted as important background information relating to this review:

- Historically, the availability of traction energy from the third rail has not been a major issue as a result of significant electrification system route headroom in the system.
- Over the decades the available electrification system route headroom has been slowly eroded as train service and thereby rolling stock loads have increased.
- Availability of traction energy became a significant issue on the Sussex Route in the early 2000s, when the older 'slam-door' rolling stock was replaced with more modern rolling stock with increased performance and higher auxiliary loads including air conditioning equipment.
- A number of recent electrification performance issues are considered to be a direct result of the Sussex Route electrification system effectively working at, or in some cases, beyond its

capacity and the load demands identifying 'weak' points in the system, be they condition, manufacturing, materials or equipment rating issues.

3.1.2 System Capacity

The key findings relating to system capacity are as follows:

- Major enhancements of the electrification system on the Sussex Route since the early 2000s, including the Southern Region PSU, have not increased electrification system route capacity beyond the requirements of specific timetables. This is largely due to funding constraints.
- Erosion of electrification system route headroom has also occurred due to relatively minor changes to train service loads, sometimes referred to as ‘load creep’. As a result, in some cases, this has required repeated further reinforcement of the electrification system on the Sussex Route, the loss of N-1 security of supply levels or the establishment of operating constraints on electrification equipment outages or on trains.
- This approach is understood to be significantly different to that of comparable infrastructure operators, such as DNOs, where headroom and security of supply levels are managed to defined system wide requirements.
- Due to the fact that any spare electrification system route headroom has effectively been consumed on parts of the Sussex Route, particularly on the Southern end of the Brighton line, any change, no matter how minor in relative terms, may result in traction power supply issues and possibly the need for electrification system modelling to determine if any further electrification system reinforcement is required. As a result, appropriate notification periods for any required train service changes during Control Periods are required.
- The timescales to bring about electrification system changes can be significant as long lead times exist for most items of electrification system equipment procurement.

3.1.3 System Modelling

The key findings relating to system modelling are as follows:

- Network Rail's currently complex modelling processes to establish requirements and constrained modelling resources can impact timescales.
- Network Rail is seeking to take a more 'nimble' approach, particularly in relation to the electrification system modelling requirements associated with proposed train service changes to enable reduced modelling timescales at a strategic level and during early GRIP stages.

3.1.4 Anticipated Growth

The key findings relating to anticipated growth are as follows:

- The Sussex RUS predicts an increase in passenger demand across the Route of 20% between 2008 and 2020.
- Other passenger growth factors which may result in further performance issues related to electrification capacity include:
  - The potential expansion of Gatwick Airport in 2019;
  - Increases in Thameslink services during Control Periods 4 and 5; and
  - Planned service changes for the 2012 Olympics.
- Whilst identifying likely service changes and 'Key Gaps', the Network Rail RUS for Sussex does not currently consider the management of general electrification capacity issues as a 'Key Gap'.

3.1.5 Funding

The key findings relating to funding are as follows:

- To date, a business case has not been developed by Network Rail for a significant increase of electrification system route headroom to mitigate the associated performance issues and continued growth expectations on the Sussex Route.
- The Control Period 5 submission for funding process is currently at the IIP stage, including a draft Asset Policy for Electrical Power.
- The draft Control Period 5 Electrical Power Asset Policy (Policy No EP-127) requires that a ‘route based traction power strategy shall exist for each electrified route’ and proposes that each should include ‘outline designs for increasing the available headroom for the system of 10%, 20% and 30%’.
- Network Rail has not yet developed a methodology for the specification of electrification system route capacity or the determination of electrification system route headroom.
- The draft Control Period 5 Electrical Power Asset Policy (Policy No EP-129) states ‘new assets should economically provide additional capacity and facilitate a minimum of 0.25% increase per year for design life’. For assets with a 60 year life this represents an allowance for growth of 15% which on average addresses just under a further 10 years of growth following installation, at the general linear increase in demand of 1.6% per year for AC and DC electrification systems over the last 20 years.

- Network Rail has stated the draft Control Period 5 Electrical Power Asset Policy is focused on a whole-life cost approach but has also acknowledged that there are issues around the availability of adequate asset information to fully support this approach.

3.1.6 Performance Management & Forecasting

The key findings relating to performance management and forecasting are as follows:

- Network Rail is currently developing first generation degradation relationships for a number of electrification assets but quantified condition data for DC electrification system assets was found to be immature in terms of evidencing and justifying these relationships to support longer-term forecasting, in conjunction with growth and capacity requirements.
- The Sussex Route's electrification load growth requirements, capacity constraints and associated performance issues will only be able to be fully addressed once the issue can be quantified with some clarity by the comparison of continuous real-time load measurement data against agreed electrification system route capacity data.
- It is the issue of lack of knowledge around the 'supply and demand' of the Sussex Route electrification system which is key and which until resolved will continue to hinder the quantified management of the electrification system. It is also the key barrier to the development of sustainable and long-term performance forecasting within set tolerances for the electrification system.
- Network Rail has stated it is in the process of developing a new national SCADA system for commissioning within Control Period 5.
- The fitment of load measuring transducers to electrification equipment connected to the new SCADA system is essential to enable continuous real-time monitoring of electrification system loads but there are currently no formal plans to fit load measuring transducers to existing electrification equipment, except at ‘node’ sites.
- The Sussex Route JPIP, managed jointly by Network Rail and Southern, currently only considers a six-month time horizon. It is understood that a JPIP for 2012/13 and 2013/14 is to be prepared next year and that work on longer-term planning for CP5 is underway.

3.1.7 Electrification System Management

The key findings relating to the electrification system management are as follows:

- Declared electrification system route capacity needs to be established.
- Currently, there is no dedicated Management Team in place to oversee the management and development of the Southern DC electrification system networks. Such a team will be

essential when the proposed new SCADA system, if coupled with load monitoring transducers, starts to provide continuous real-time load data for each part of the Sussex Route which will need to be compared against the declared electrification system route capacity and the estimated electrification system route headroom for each part of the Route and actions determined and promulgated throughout Network Rail.

- Notably, an August 2011 RSSB Research Brief has been published which concludes that 'the industry should prioritise the work needed to support the decision as to whether to include DC to AC conversion in the industry's investment agenda for future control periods'.

3.1.8 Capacity and RAM Specification

The key findings relating to capacity and RAM specification are as follows:

- Network Rail has not established Reliability, Availability or Maintainability specifications for the DC electrification system based on the appropriate apportionment of business objectives derived RAM targets across the system hierarchy. Subsequently, there is no robust measurement process against these targets currently in place.
- Network Rail has not established electrification system route capacity for the Sussex Route.

3.2 Maintenance Specification

The diagram below provides a generic overview of a simplified Maintenance Specification plan-do-review loop. The interface to System Level Planning is the future capacity and RAM requirements, shown at the top of the diagram. The interface to the subsequent Maintenance Delivery plan-do-review loop are the maintenance schedules (periodicities and tasks/work instructions), shown at the bottom of the diagram.

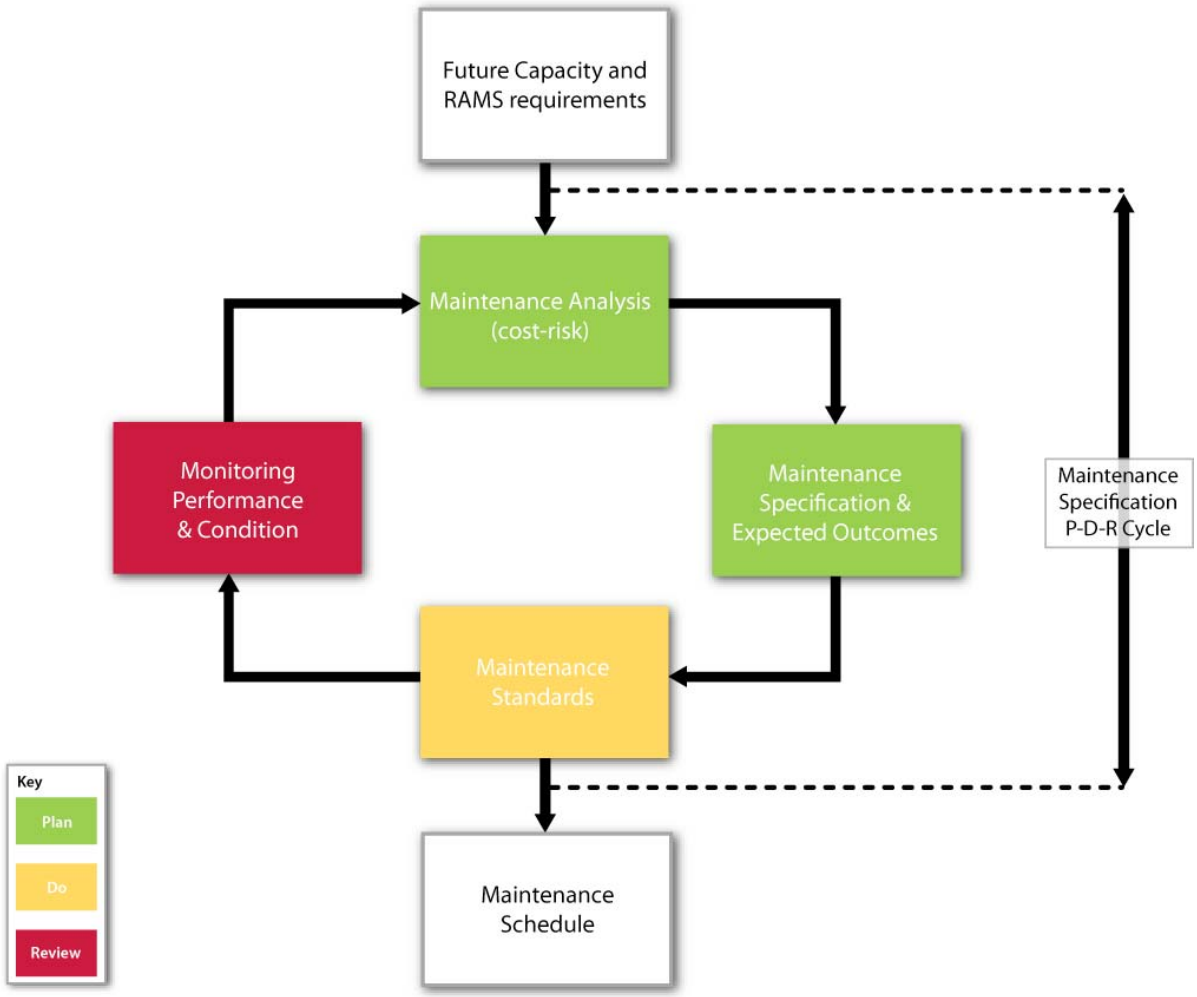


Diagram 3 Simplified Maintenance Specification Plan-Do-Review Loop

3.2.1 Maintenance Specification PDR Loop

The key findings relating to Network Rail's EP maintenance specification plan-do-review loop are:

- The lack of capacity and RAM specifications, as identified in Section 3.1.8, means the assessment of adequacy of existing EP Maintenance Standards against target business deliverables is constrained.
- Network Rail has a generic and standardised control process for the review, amendment, authorisation and briefing of changes to Maintenance Standards which is applied to EP assets.
- Although Network Rail's EP maintenance processes and standards are subject to regular review and briefing, there was little evidence of this process being applied to the tasks and frequencies associated with the DC electrification system.
- No quantified justifications have been established for the DC electrification system tasks and periodicities and they have not been subject to optimisation processes, such as Risk Based Maintenance.
- Following interviews during the review it was established that optimisation of the Maintenance Standards for the DC electrification system assets was considered by Network Rail stakeholders to be constrained by the availability of relevant resources and priorities, based on overall system costs, when compared to OHL, for example.
- Along with the constraints imposed on review and monitoring of the adequacy of existing EP Maintenance Standards by the lack of capacity and RAM specifications, there was also no formal process for the monitoring of performance and condition identified during the review. Monitoring is undertaken via the available condition data, performance information provided by Network Rail's generic Infrastructure Maintenance Reliability Group and the National Infrastructure Reliability Group (NIRG), supported by the Route Infrastructure Reliability Group (RIRG), i.e. Sussex (RIRG), but the lack of formal process definition remains a concern in the overall plan-do-review loop.

3.2.2 Other Maintenance Specification Findings

The key findings relating to maintenance definition for EP assets are as follows:

- Although coverage across Distribution and Plant assets appears good, Network Rail currently has no formal Work Instructions for the maintenance of conductor rails. These are understood to currently be in development.
- Based on a simple review of the adequacy of the Maintenance Standard for conductor rails, two non-compliances were noted; one concerning the periodicity of examinations required and one relating to the requirements for examination of the electrical and mechanical properties of conductor rail fish-plated joints.

- Sussex Route is mitigating this non-compliance by the use of infra-red camera based inspections. It was noted however that there are currently no formal Network Rail Standards or Work Instructions for infra-red monitoring of DC electrification equipment.

3.3 Maintenance Delivery

The diagram below provides a generic overview of a simplified Maintenance Delivery plan-do-review loop. The interface to the Maintenance Specification plan-do-review loop are the Maintenance Standards and associated schedules (periodicities and tasks/work instructions), shown at the top of the diagram.

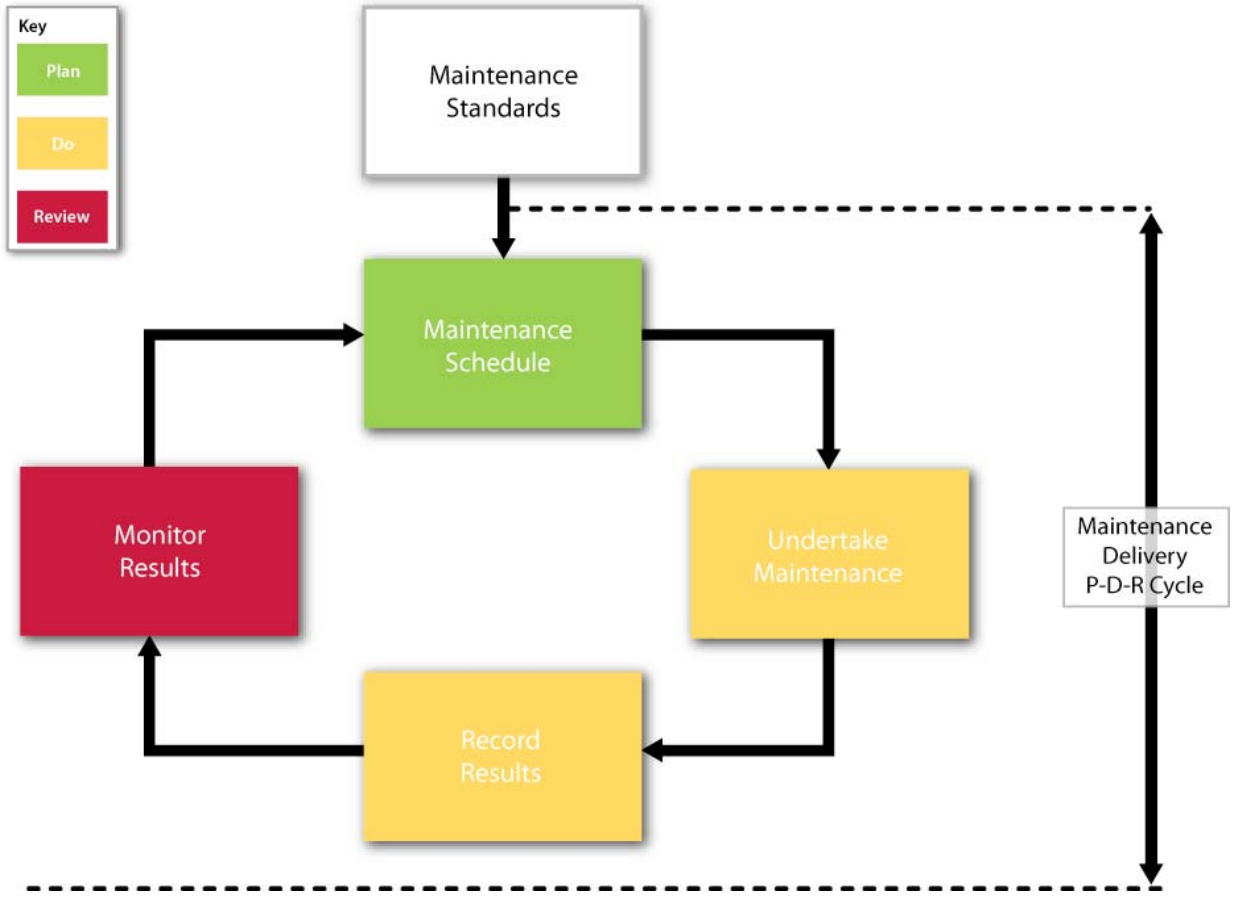


Diagram 4 Simplified Maintenance Delivery Plan-Do-Review Loop

3.3.1 Maintenance Delivery PDR Loop

The key findings relating to Network Rail's EP maintenance specification plan-do-review loop are:

- Maintenance delivery within Sussex Route utilises Network Rail's generic processes and practices.
- The scheduling/planning, including the production of Work Orders, and recording of work done is managed in Network Rail's Ellipse work management system. The processes for identifying, disseminating, monitoring and assuring the work requirements in Ellipse were found to be well documented.
- A potential risk was identified during the review due to an inconsistency between electrification Maintenance Standards and the 'grace' period for closing out maintenance tasks within the Ellipse system.
- The monitoring of results, at the Route level, was found to be consistently and thoroughly documented through Ellipse based process documentation and associated reporting mechanisms.
- As per Section 3.2.1, no formal process was provided by Network Rail during the review with respect to the monitoring of the adequacy of the relevant Maintenance Standards via the RIRG, NIRG and Infrastructure Maintenance Reliability Groups.

3.3.2 Sussex Route Maintenance Practices

The key findings relating to the maintenance practices for EP assets are as follows:

- Sussex Route has instigated maintenance practices aimed at improving performance, including the use of Infra-red cameras to search for ‘hot spots’ associated with conductor rail connections.
- Sussex Route has also identified and sourced funding for a range of electrification performance improvement initiatives, centred on the replacement of low-level electrification system components as a result of train service changes highlighting performance issues, be they condition, manufacturing, materials or equipment rating issues.
- Substation maintenance night-time working is currently utilised for some busy areas and more is likely to be required in the future in order to enable compliance with the policy of an N-1 level of security.
- There are opportunities for Southern and Sussex Route to formalise a joint working process to investigate train/electrification infrastructure interface faults to rapidly establish the root cause of each failure - rolling stock or infrastructure - and set-up mitigation actions where justified.

3.3.3 Seasonal Management

The key findings relating to the seasonal management of EP assets are as follows:

- Seasonal performance on the Sussex Route in 2010/11 was impacted by heavy snowfall, the role of Seasons Delivery Specialist being vacant and poor management of the MPVs used to mitigate seasonal factors.
- Management of maintenance for autumn and winter periods has been radically overhauled for 2011/12, partly as a result of the 'Curley Report'. Resources, preparation and management appear to have been significantly improved and developed in conjunction with relevant stakeholders.

3.4 Asset Information

3.4.1 TRUST Attribution

The key findings relating to TRUST attribution for EP assets are as follows:

- Performance is captured in TRUST and theoretically supported at the root-cause level by FMS.
- TRUST code data provided for the Sussex Route indicates that for Electrical Power ‘third rail faults’ equate to 3% of the total minutes delay and ‘signalling system and power supply failures’ 5%, compared to ‘severe weather’ related incidents of 19%. The majority of ‘signalling system and power supply failures’ are due to signalling relay failures not to loss of signalling power supplies.
- 'Management TIN's' are used to capture numerous individual delay incidents when incidents occur too rapidly for the clerks to attribute each individual delay incident and are onerous to retrospectively analyse.
- 'Management TINs' can result in incorrect allocation of delay incidents and skew overall performance analysis.
- Sussex Route is actively implementing a plan to mitigate the occurrence and impact of 'Management TINs'.

3.4.2 FMS

- FMS issues were identified in the Context Analysis report and were further acknowledged by Network Rail at the recent EP Asset Policy reviews.
- Changes were made to the FMS fault recording process in August 2009 which resulted in improvements in the consistency of data captured. However, since August 2009

approximately 28% of electrification failures in FMS had no meaningful root-cause attribution.

3.4.3 Other Asset Information

The other asset information findings are:

- There is reasonable availability and accuracy of 'what', 'where' and 'age' data.
- Condition data has been collected on electrification equipment in the Sussex Route for a number of years. Network Rail Centre identified recently that this wasn't fully sufficient to meet its requirements and instigated a large-scale exercise in 2011 to accelerate condition assessment and data collection using a revised process. The revised assessment process is acknowledged by Network Rail as still too subjective and requiring further development.
- As a result of the limited historical asset condition data, quantified asset deterioration knowledge is also constrained, although initial deterioration modelling has been initiated, it cannot be verified against historical data for a number of DC electrification system asset types.
- As stated previously, in terms of capacity and real-time load data, Network Rail is currently very limited.

4 Southern Asset Management Review

4.1 Background

In 2009, Govia was awarded the South Central franchise to run from September 2009 until July 2015, with the possibility of extension until 2017. The operator - Southern - is a trading name of Southern Railway Ltd., a wholly owned subsidiary of Govia. Southern also held the previous franchise on the South Central area.

The previous South Central franchise end date was brought forward to September 2009, following inclusion of the Gatwick Express service. This date was selected as it would allow the new operator to be in place during significant changes to the timetable in and around South London in December 2009.

It is understood that the bidding process for the new franchise began in May 2008, when expressions of interest were sought and the process formally began on 20 August 2008 when the DfT announced that Govia were one of the four shortlisted bidders, along with the National Express Group, the Stagecoach Group and NedRailways Limited. The Department for Transport announced on 9 June 2009 that Govia had retained the franchise.

Notably, Network Rail's current regulatory Control Period 4 runs from April 2009 to March 2014. Planning and funding submissions for Control Period 4 were developed and submitted over an approximately 2-year period prior to the start of the actual Control Period. Therefore, the franchise was awarded and the significant timetable changes occurred within the first year of a 5-year, fixed price, infrastructure management period. It was also not until the franchise was finally awarded that Network Rail was able to definitively know which of the bidders' technical submissions and subsequently electrification demands would be required. It is understood that the Sussex Route Asset Manager (Electrification) had approximately 3-4 months to review all four of the shortlisted bids and assess potential implications.

4.2 System Level Planning

The franchise arrangements in general play a significant role in the approach to system level planning and strategic Asset Management within Southern. As a result of the relatively short timescales, in Asset Management terms, defined by the franchise agreements and the leasing of the rolling stock assets for the period, a number of good practice Asset Management processes are not developed. Examples include whole-life cost modelling, planning and

justification of strategic renew or repair options and cyclical condition assessments and deterioration profiling. The franchise arrangements set out by the DfT are also performance (PPM) focused. Southern are therefore commercially driven to concentrate on maximising performance against predefined targets within the timescales of the franchise. This also makes Network Rail a critical supplier and drives the need for a good working relationship/partnership between the organisations from the Southern perspective. From the failure and incident information analysed for the last 5 years, approximately 77% of the delay incurred by Southern was attributable to Network Rail and 23% was attributable to Southern.

In terms of system level planning, the arrangements described above focus Southern on optimising the reliability, availability and to some degree the maintainability of its various fleets to maximise performance. These are the activities that can be primarily managed and optimised by Southern. As a result, Southern focuses on the Operate and Maintain elements of Lifecycle Delivery within the overall scope of Asset Management, highlighted in Diagram 5 below.

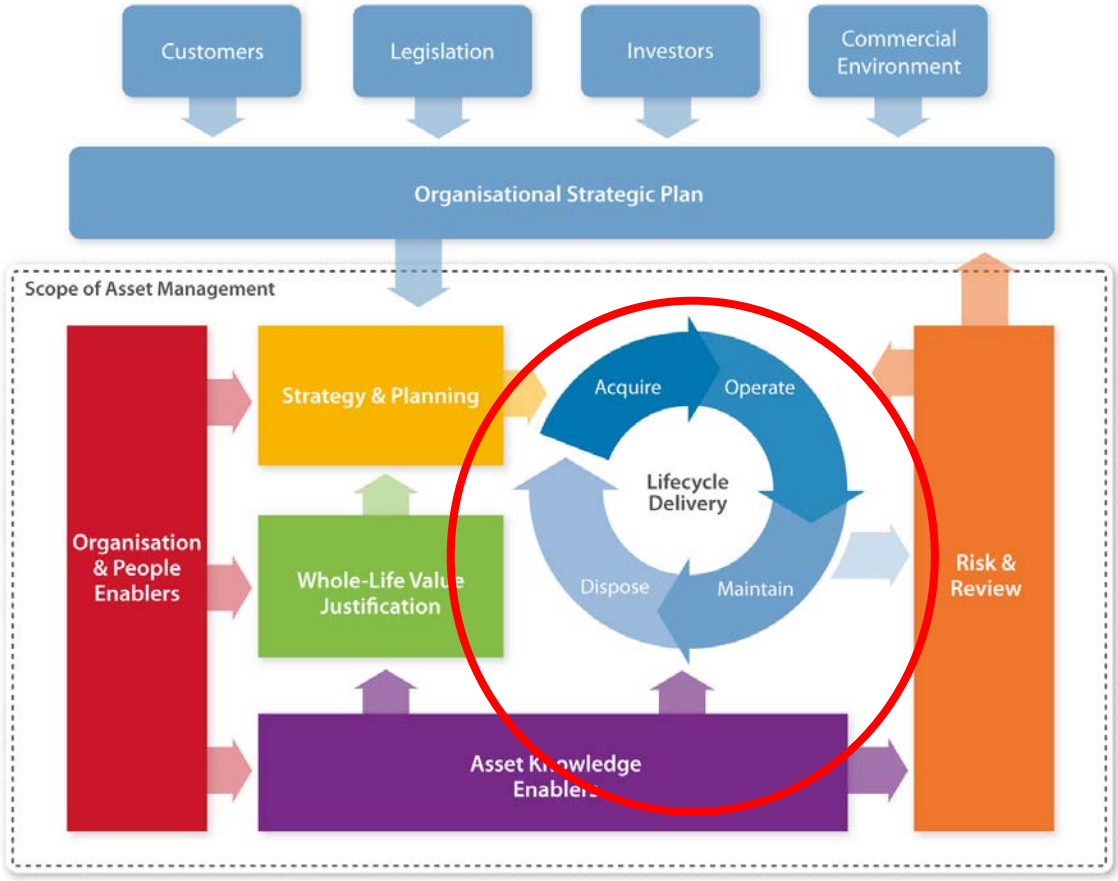


Diagram 5 Southern's Key Role Within the Scope of Asset Management

To achieve this effectively, Southern has to consider and manage all of the other activities identified in Diagram 5 to some degree. Examples include the sourcing and hand-back of the Rolling Stock, the use of asset information to optimise maintenance and operation, risk and review processes and organisational structure and supply chain management. However, the focus is on the optimised operation and maintenance of the fleet within the constraints of the franchise and the infrastructure on which it runs.

The Southern fleet consists of the units - and respective owners - shown in Table 2.

Class	Number of Units	Owner
73	1	Southern
171	16	Porterbrook
313	19	Eversholt
377	182	Porterbrook
442	24	Angel
455	46	Eversholt
456	24	Porterbrook
460	2	Porterbrook

Table 2 Summary of Southern Fleet

Southern leases the units from the owners under a 'dry' lease arrangement, whereby Southern is responsible for all maintenance activities. This is a relatively unusual arrangement, in that the majority of TOCs in the UK have an arrangement where the TOC is not responsible for some of the heavy maintenance responsibilities. Although potentially more commercially risky, this arrangement gives Southern greater control over the reliability and availability of the units than a typical MOLA type arrangement. It allows Southern to plan, manage and optimise maintenance and overhaul requirements across the board, in a manner which best fits achievement of its performance requirements.

The lease agreements contain hand back arrangements which oblige Southern to keep the units in good condition, with a range of obligations and requirements. Examples were provided by Southern as evidence for the review.

To achieve the requirements of the lease agreements and optimise performance throughout the franchise, Southern has developed Asset Management Plans for each class of unit. A number of examples were provided and appear to provide a powerful tool and a good focus on how the asset needs to be managed to meet the objectives of the business. The purpose of the Asset Management Plans is to detail all the planned activities on the fleet and consolidate the

Reliability and Availability plans, Performance Improvement Plans, Safety Performance Monitoring and Overhaul Plans. Notable elements of the plans include details of the assets, defined availability targets and performance history against target, as shown below.

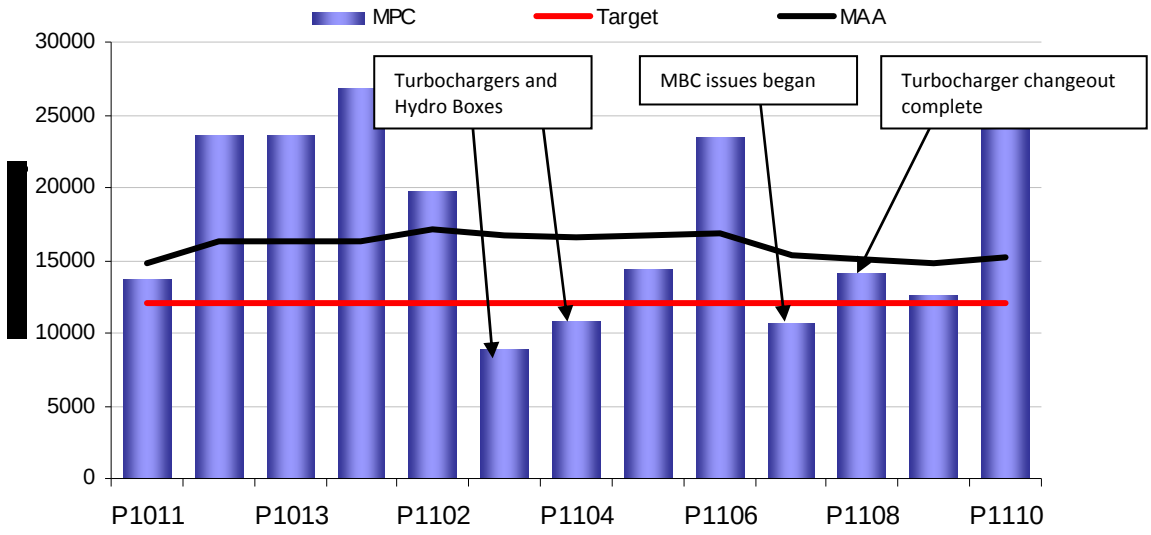
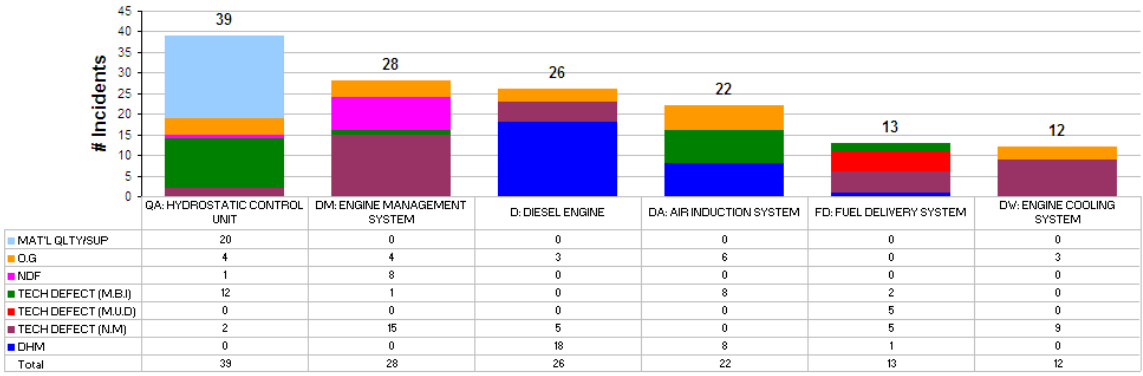


Diagram 6 Example Southern Asset Management Plan Performance Monitoring (171 Fleet)

The Asset Management Plans also consider the root-cause of failures (as shown in Diagram 7) and outline the key risks and safety factors identified for each fleet.



	QA: HYDROSTATIC CONTROL UNIT	DM: ENGINE MANAGEMENT SYSTEM	D: DIESEL ENGINE	DA: AIR INDUCTION SYSTEM	FD: FUEL DELIVERY SYSTEM	DW: ENGINE COOLING SYSTEM
MAT'L QLTY/SUP	20	0	0	0	0	0
O.G	4	4	3	6	0	3
NDF	1	8	0	0	0	0
TECH DEFECT (M.B.I)	12	1	0	8	2	0
TECH DEFECT (M.U.D)	0	0	0	0	5	0
TECH DEFECT (N.M)	2	15	5	0	5	9
DHM	0	0	18	8	1	0
Total	39	28	26	22	13	12

Diagram 7 Example Southern Asset Management Plan 13-Period Root Cause (171 Fleet)

The Asset Management Plans also identify key performance improvements, based on the root-cause analysis, safety enhancements, seasonal plans, materials managements, franchise commitments, overhaul plans and maintenance plans. Critically, the plans also prioritise and schedule the identified work and forecast the likely performance improvements, with confidence assessments, over a two-year period. An example of the output is shown in Diagram 8.

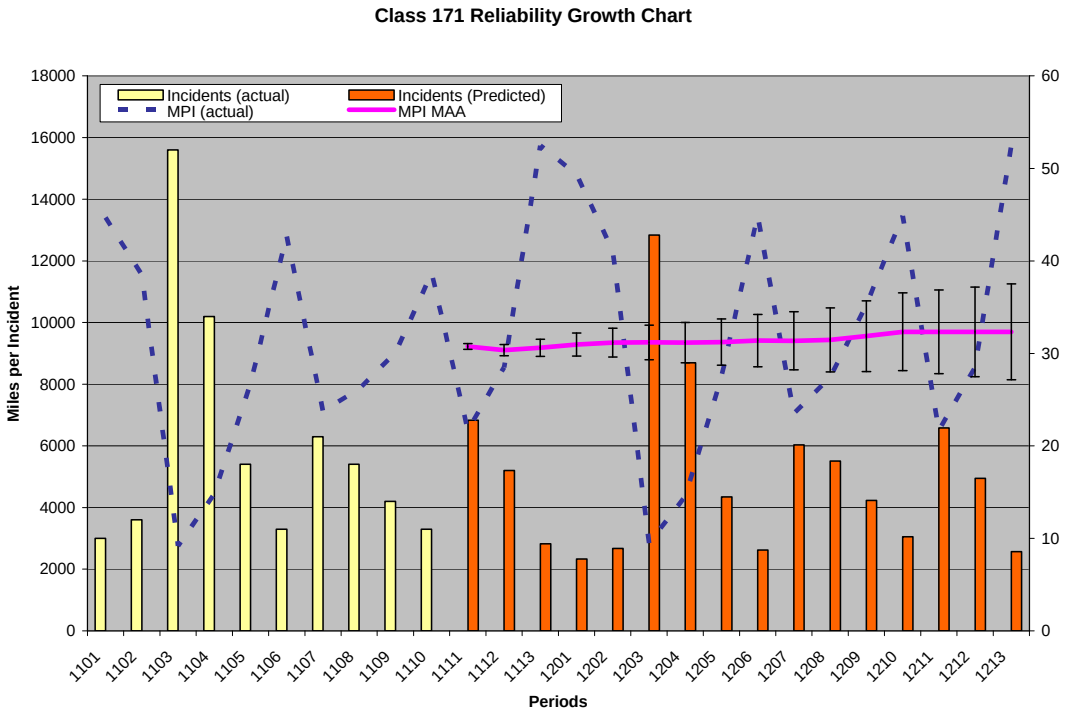


Diagram 8 Example Southern Asset Management Plan Performance Forecast (171 Fleet)

The knowledge of the condition and criticality of the asset base in terms of performance is captured, updated and managed using these individual Asset Management Plans for each class of unit. These plans are considered by AMCL to represent industry good practice. The physical condition of the assets is managed by a well defined preventive maintenance and overhaul regime (see Section 4.3) and performance improvement initiatives identified and prioritised against performance and root-cause analysis.

The reliability and availability requirements and targets for improvements for all classes of unit are set in the Asset Management Plans and performance against these targets is captured and reviewed on a periodical basis. This includes comprehensive collation and analysis of performance and root-cause data. An example of the periodical review 'summary' for one of the fleets is shown in Diagram 9 below. The analysed data and information sitting behind the summary sheets was found to be extensive and the analysis process generally thorough. Root-cause analysis was undertaken down to the maintainable or replaceable item on the rolling stock. As identified in the Context Analysis report, some issues remain around the extent of the root-cause codes. Southern admitted that it went too far in the devolution of asset coded areas in the process development. It was also stated that the organisation is currently working towards

resolving this issue. The interim solution of working to the maintainable/replaceable item on the train has provided an apparently sound back-stop.

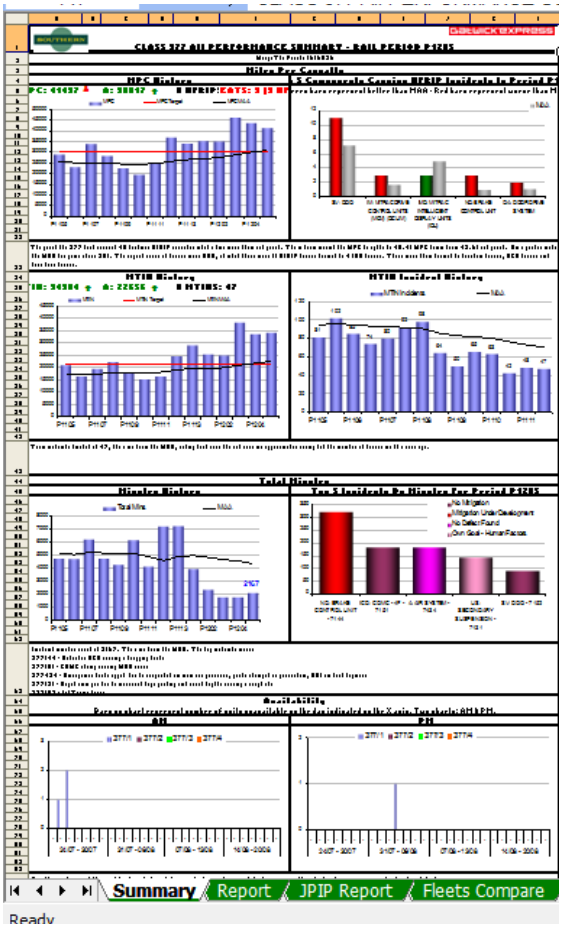


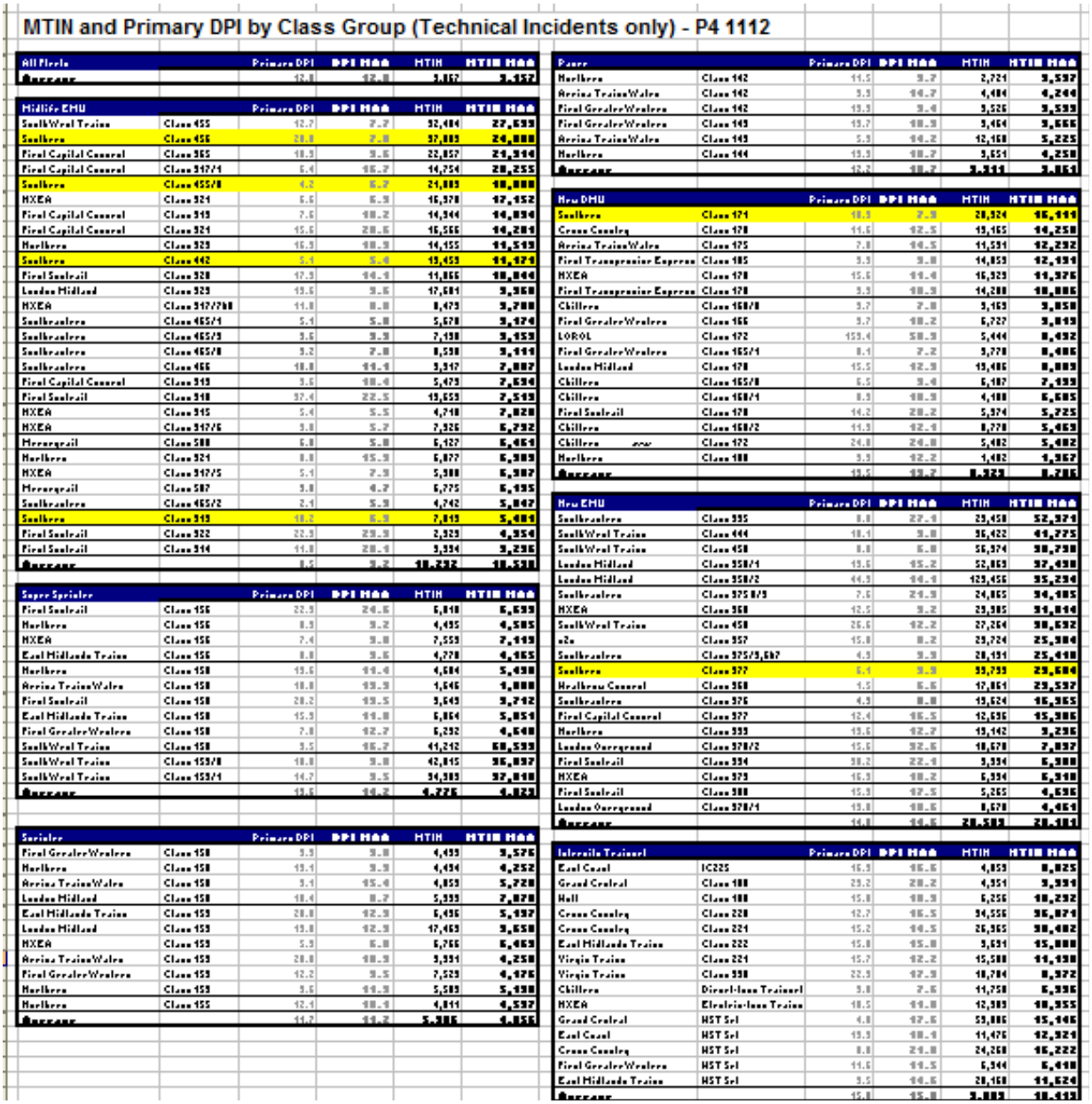
Diagram 9 Example Southern Periodical Performance Analysis Summary Sheet (Class 377)

Any changes to the maintenance regimes or enhancements to meet the targets are managed by dedicated teams of engineers, assigned to each fleet.

Failure details are gathered from a number of sources, the primary source being operational incidents. Fleet capture all failure incidents regardless of whether the ATOC MTIN three minute delay threshold has been reached. The performance reports produced each period for each class of unit are considered to be relatively standard practice for UK passenger TOCs. However, repeat faults are also monitored for up to a year on each unit to assure resolution. This is considered to be good industry practice based on AMCL's knowledge of other comparable organisations.

In addition to the internal reports and management processes, input is provided to the ATOC national performance measure. The MTIN MAA gives an indication of performance. As can be

seen Southern (highlighted in yellow) generally compare well with other TOCs operating the same, or similar, units when ranked according to MTIN. Although it is recognised that operational issues may affect relative performance between TOCs and fleets.



MTIN and Primary DPI by Class Group (Technical Incidents only) - P4 1112

All Fleets		Primary DPI	DPI MAA	MTIN	MTIN MAA
Average		12.8	12.8	3,857	3,857

Midlife EMU		Primary DPI	DPI MAA	MTIN	MTIN MAA
SouthWest Trains	Class 455	12.7	7.7	32,484	27,533
Southern	Class 456	28.8	7.8	37,883	24,888
First Capital Connect	Class 365	18.3	9.6	22,857	29,344
First Capital Connect	Class 317/1	5.4	16.2	14,754	28,255
Southern	Class 455/8	4.2	5.7	24,883	18,888
HXEA	Class 321	5.5	5.9	16,378	17,152
First Capital Connect	Class 319	7.5	18.2	14,544	14,834
First Capital Connect	Class 321	15.5	28.6	16,566	14,281
Northern	Class 323	16.3	18.3	14,155	14,543
Southern	Class 442	5.1	5.4	15,453	14,474
First Southrail	Class 320	17.3	14.1	11,855	18,844
London Midland	Class 323	13.5	9.5	17,581	9,358
HXEA	Class 317/7&8	11.8	8.8	8,473	9,788
Southeastern	Class 465/1	5.1	5.8	5,678	9,474
Southeastern	Class 465/9	9.5	9.9	7,198	9,153
Southeastern	Class 465/0	9.2	7.8	8,538	9,111
Southeastern	Class 466	18.8	14.1	3,347	7,887
First Capital Connect	Class 319	9.5	18.4	5,473	7,634
First Southrail	Class 318	37.4	22.5	13,653	7,549
HXEA	Class 315	5.4	5.5	4,718	7,828
HXEA	Class 317/6	5.8	5.7	7,326	6,792
Merseyrail	Class 508	5.8	5.8	5,127	5,451
Northern	Class 321	8.8	15.9	5,877	5,383
HXEA	Class 317/5	5.1	7.9	5,388	5,387
Merseyrail	Class 507	5.8	6.7	5,775	5,195
Southeastern	Class 465/2	2.1	5.3	4,742	5,047
Southern	Class 313	10.2	6.3	7,813	5,481
First Southrail	Class 322	22.5	29.9	2,329	4,354
First Southrail	Class 314	11.8	20.4	3,334	3,236
Average		8.5	9.2	10,232	10,538

Super Sprinter		Primary DPI	DPI MAA	MTIN	MTIN MAA
First Southrail	Class 158	22.9	24.6	5,818	5,533
Northern	Class 156	8.9	9.2	4,455	4,585
HXEA	Class 158	7.4	9.8	7,559	7,443
East Midlands Trains	Class 156	8.8	9.6	4,778	4,965
Northern	Class 158	13.6	14.4	4,684	5,438
Arriva TrainsWales	Class 158	10.8	13.9	1,646	1,888
First Southrail	Class 158	28.2	13.5	5,643	5,742
East Midlands Trains	Class 158	15.9	14.8	5,854	5,851
First Greater Western	Class 158	7.8	12.2	5,292	4,648
SouthWest Trains	Class 158	9.5	16.2	41,242	58,533
SouthWest Trains	Class 158/8	10.8	9.8	42,845	36,897
SouthWest Trains	Class 158/4	14.7	9.5	34,383	37,848
Average		13.6	14.2	4,775	4,823

Sprinter		Primary DPI	DPI MAA	MTIN	MTIN MAA
First Greater Western	Class 158	9.5	9.8	4,455	5,525
Northern	Class 158	13.1	9.9	4,454	4,252
Arriva TrainsWales	Class 158	9.1	15.4	4,853	5,728
London Midland	Class 158	18.4	8.7	5,333	7,878
East Midlands Trains	Class 153	28.8	12.9	5,436	5,497
London Midland	Class 153	13.8	12.9	17,463	5,658
HXEA	Class 153	5.9	6.8	5,755	5,463
Arriva TrainsWales	Class 153	28.8	18.9	3,331	4,258
First Greater Western	Class 153	12.2	9.5	7,523	4,126
Northern	Class 153	9.5	14.9	5,583	5,438
Northern	Class 155	12.1	18.4	4,811	4,592
Average		11.7	11.7	5,385	4,856

Pacer		Primary DPI	DPI MAA	MTIN	MTIN MAA
Northern	Class 142	11.5	9.7	2,721	3,592
Arriva TrainsWales	Class 142	9.5	14.7	4,484	4,244
First Greater Western	Class 142	13.9	9.4	3,526	3,533
First Greater Western	Class 143	13.7	18.9	3,454	3,666
Arriva TrainsWales	Class 143	5.5	14.2	12,168	5,225
Northern	Class 144	13.3	18.2	3,651	4,258
Average		12.2	12.7	3,311	3,851

New DMU		Primary DPI	DPI MAA	MTIN	MTIN MAA
Southern	Class 171	18.3	7.9	28,324	15,111
Cross Country	Class 170	11.6	12.5	13,165	14,258
Arriva TrainsWales	Class 175	7.8	14.5	11,531	12,292
First Transpennine Express	Class 185	9.9	9.8	14,853	12,191
HXEA	Class 170	15.6	11.4	15,323	11,376
First Transpennine Express	Class 170	9.9	18.9	14,288	12,885
Chiltern	Class 168/0	9.7	7.8	9,163	9,858
First Greater Western	Class 166	9.7	18.2	6,727	9,849
LOROL	Class 172	153.4	58.9	5,444	8,492
First Greater Western	Class 165/1	8.1	7.2	9,778	8,486
London Midland	Class 170	15.5	12.9	13,486	8,883
Chiltern	Class 165/0	6.5	9.4	6,187	7,193
Chiltern	Class 168/1	8.9	18.9	4,188	6,685
First Southrail	Class 170	14.2	28.2	5,324	5,225
Chiltern	Class 168/2	11.9	12.9	8,778	5,463
Chiltern [new]	Class 172	24.8	24.8	5,482	5,482
Northern	Class 158	9.9	12.2	1,482	1,967
Average		13.5	13.7	8,323	8,286

New EMU		Primary DPI	DPI MAA	MTIN	MTIN MAA
Southeastern	Class 395	8.8	22.4	23,458	52,324
SouthWest Trains	Class 444	18.1	9.8	35,422	41,275
SouthWest Trains	Class 458	8.8	6.8	56,374	38,758
London Midland	Class 350/1	13.6	15.2	52,863	37,438
London Midland	Class 350/2	44.5	14.4	123,456	35,234
Southeastern	Class 375 8/9	7.6	24.9	24,865	34,185
HXEA	Class 360	12.5	9.2	23,385	31,844
SouthWest Trains	Class 450	26.6	12.2	27,264	38,692
e2e	Class 357	15.8	8.2	23,724	25,384
Southeastern	Class 375/3,6&7	4.3	9.3	28,191	25,448
Southern	Class 377	6.1	9.3	33,733	23,684
Heathrow Connect	Class 360	4.5	5.6	17,861	23,532
Southeastern	Class 376	4.3	8.8	15,624	16,365
First Capital Connect	Class 377	12.4	16.5	12,636	15,385
Northern	Class 333	13.6	12.2	15,142	9,236
London Overground	Class 378/2	15.6	12.6	18,678	7,837
First Southrail	Class 334	38.2	22.4	5,334	5,388
HXEA	Class 379	16.3	18.2	5,334	5,348
First Southrail	Class 388	15.3	12.5	5,265	4,636
London Overground	Class 378/1	13.8	18.6	8,678	4,464
Average		14.8	14.6	28,583	28,181

Intercity Trainset		Primary DPI	DPI MAA	MTIN	MTIN MAA
East Coast	IC225	16.3	16.6	4,853	8,825
Grand Central	Class 180	29.2	28.2	4,351	5,331
Hull	Class 180	15.8	18.3	5,256	18,292
Cross Country	Class 220	12.7	16.5	34,556	36,874
Cross Country	Class 221	15.2	14.5	26,365	38,482
East Midlands Trains	Class 222	15.8	15.8	5,631	15,888
Virgin Trains	Class 221	15.7	12.2	15,588	11,138
Virgin Trains	Class 390	22.3	17.3	18,784	8,372
Chiltern	Diesel-loco Trainset	5.8	7.6	11,758	6,336
HXEA	Electric-loco Trains	18.5	14.8	12,383	18,355
Grand Central	HST Set	4.8	17.6	53,886	15,146
East Coast	HST Set	15.3	18.1	11,476	12,321
Cross Country	HST Set	8.8	24.8	24,268	16,222
First Greater Western	HST Set	11.6	14.5	5,344	5,448
East Midlands Trains	HST Set	3.5	14.6	28,168	11,624
Average		15.8	15.8	5,883	10,413

Diagram 10 ATOC MTIN Rankings P4 1112 (Southern highlighted in yellow)

4.3 Maintenance Practices

Southern undertake all maintenance and overhaul activities in-house which provides a number of advantages from an engineering perspective in that control and knowledge of all activities is retained.

Southern have a detailed Quality Manual which documents all activities affecting quality and performance.

The organisation of the Southern Fleet team, as outlined in Quality Manual SCFS/1/1002 was presented by Southern. Due to the range of activities undertaken the team consists of some twenty-five to thirty personnel who undertake both technical and managerial roles. The Fleet organisation is also responsible for Train Presentation and Control which is considered good practice. The team members who have been met as part of the overall review have been knowledgeable and motivated.

The documentation used to maintain the units are the industry standard Vehicle Maintenance Instructions (VMI) and Vehicle Overhaul Instructions (VOI). These documents contain all the maintenance tasks to be undertaken along with their schedule and periodicity. The documents are based on either documents produced by British Rail or manufacturer's instructions. The documents are formally reviewed at least annually by the Engineering Standards Review Group (ESRG) (this group also review the audit plan). Any changes required are subject to the Engineering Change process which encompasses a robust risk assessment procedure. Should issues be raised with the maintenance instructions whilst undertaking the activity Non Conformances can be raised by shop floor staff via the Company Intranet.

When reviewing and managing the overall maintenance system the following areas are considered, in accordance with the Quality Manual:

- Safety;
- Reliability;
- Availability/Productivity;
- Modifications to assets;
- Modifications to other areas affecting T&RS performance;
- Reviews/Audits;
- Cost;
- Legislation/Standards;
- Change of use; and
- Change of maintenance facility or provider.

Should changes be required to the system the changes would be managed by Southern's Engineering Change process, the key stages of which are shown below.

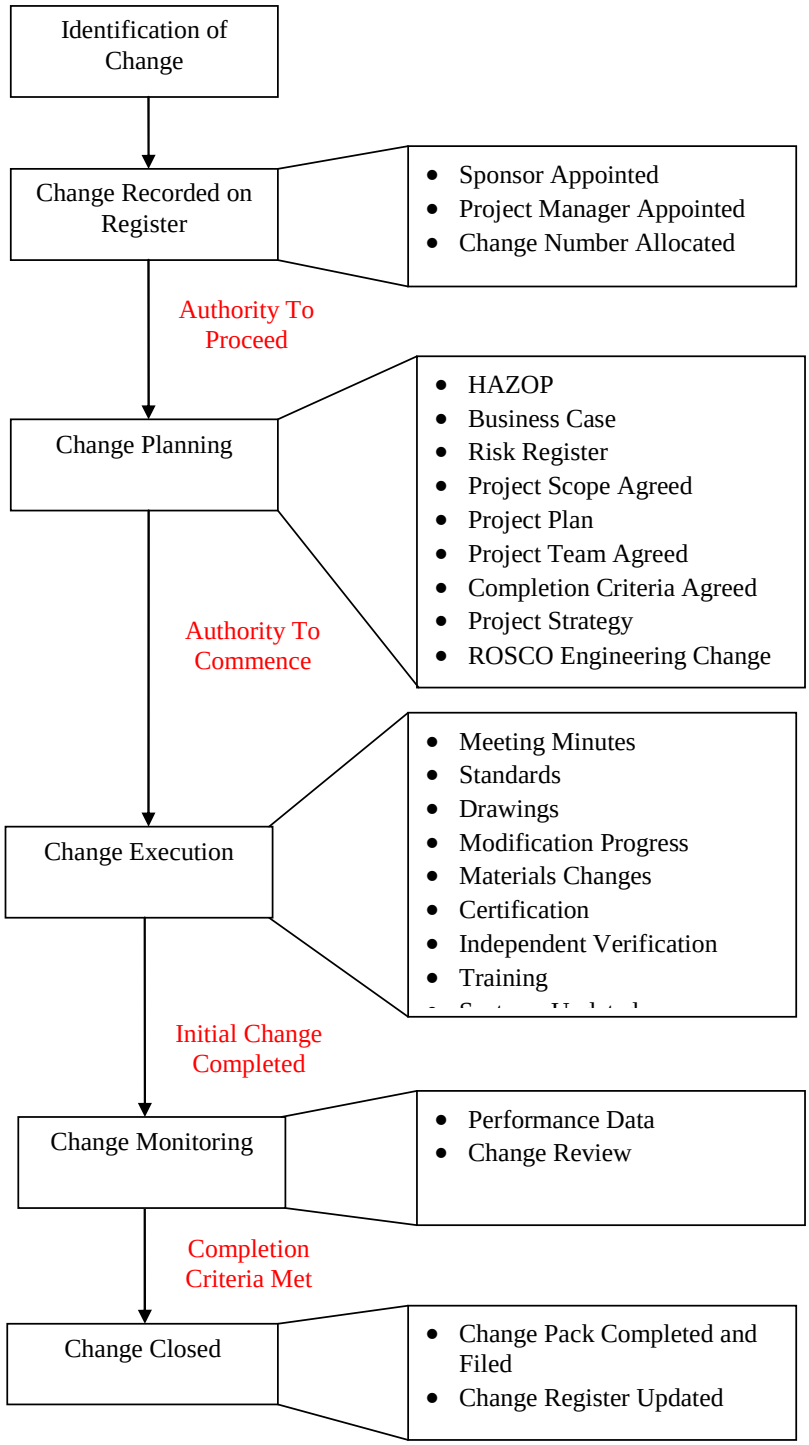


Diagram 11 Southern's Engineering Change Management Process

The maintenance and overhaul instructions cover special tools and materials definition, equipment calibration and staff competence. Supplier management practices and engineering change controls are covered by separate instructions.

The VMIs and VOIs are stored and controlled using the Control Of Documentation And Correspondence (CODAC) system. Access to the system is available to all maintenance staff on terminals at the place of work.

Controlled schematics, drawings and software configuration are also available to all maintenance staff on terminals at the place of work, via the company Intranet.

The XV system is used for maintenance planning and control of deferred work. MVQuery is used to interface with XV to capture details of all work undertaken to give a complete vehicle history. Although these systems are powerful tools, the hard copy vehicle work sheets remain the master copy from a legislative point of view. Examples of maintenance task sign off sheets were provided by Southern as evidence.

A site audit of the Selhurst maintenance facility showed the facility to be clean and well organised. The units in the facility all appeared well maintained and in good condition, particularly the Class 455 units which are now almost thirty years old. It was also noted that current performance figures were displayed within the depot.

Diagram 12 Selhurst Depot

As well as the periodical performance review meetings, performance improvement meetings between Southern, the Owner and the Manufacturer (for New Trains) are also held on a regular basis. When a problem area is identified as requiring action the liaison between the technical support and the shop floor is managed by the Fleet Improvement Engineer and the Fleet Performance Manager. Also, as well evidenced by Southern, the maintenance team is given an extensive monthly brief covering performance, modification, investigations and changes to maintenance arrangements.

A further initiative is the use of Minimum Investigation Requirements. These are a supplement to the maintenance instructions in areas suffering problems and ensure faults are consistently and comprehensively approached. The intention of this is to ensure that a minimum level of work is carried out when investigating defects of this nature, where necessary. The documents have to be signed off by the Production Manager/Leader which ensures that, even if the issue appears to be obvious from initial check, the technicians are required to undertake all further checks identified in the Minimum Investigation Requirements. The Minimum Investigation

Requirements may be supplemented by Standards for complex issues, again this is effectively a maintenance supplement for problem areas. Examples were provided of the detailed standards and corresponding Minimum Action Requirements for specific equipment. The approach is considered to be thorough, effective and represent good industry practice.

In addition to monitoring performance and undertaking initiatives to improve technical performance, the Fleet team considers how to reduce the impact of an incident in traffic. A very impressive initiative is the use of a system to allow Control to talk drivers through failure rectification, known as Manage Train Failures (MTF). The MTF system allows Controllers to decide when to implement specific policies and rules and then to guide the Controller through a step by step list of areas to address with Drivers to resolve the issue in the most expeditious manner. A comprehensive technical training programme has also been undertaken for Controllers to gain a greater appreciation of the design and operation of the units.

Diagram 13 Example Screenshots of Southern's MTF System

Southern also benefits from a large proportion of their fleet being fitted with remote monitoring systems which allows any systems starting to move away from their required standard to be identified and preventive rather than corrective action be taken.

Southern's fleet organisation is subject to both external and internal audits. An example of an external audit undertaken for the unit's owner (Porterbrook) was provided, which identified a number of significant issues. Also provided was the Corrective Action Report, which identified that significant issues were found. Although prompt resolutions were identified and managed, it does provide evidence of the need for continual improvement of the maintenance processes. It would seem prudent to review the relevance of the issues identified by the audit across all other fleets.

Internal audits have recently been undertaken on shoegear maintenance and Sander maintenance and reports from these audits were provided for evidence. Both reports contain

recommendations that will lead to continued performance improvement. Southern maintains a rolling 12-month forward programme of internal audits and audits that they plan to undertake on Suppliers. The audits undertaken on shoegear and Sander maintenance and on AWS/TPWS maintenance show that areas of interface with the infrastructure are being considered. In addition to the formal audit programme, four times a year the maintenance of each class of unit is audited by the Assistant Fleet Engineer and the Fleet Improvement Engineer. These are undertaken by stopping a unit after exam and checking the condition of the unit. Detailed reports are generated against each task in the maintenance regime being audited. Issues raised are documented and resolutions and future requirements then agreed with the relevant Depot staff .

Train preparation is part of the Fleet function and an internal monitoring process (EquIP) is used to assess customer experience.

Southern and Network Rail hold regular meetings to progress interface issues, notably the Third Rail Users Group run by Network Rail with TOCs and Birmingham University, Cab Secure Radio (CSR) Working Group, Third Rail Interface Meeting and Wheelchex Meeting.

A Class 377 Third Rail Monitoring Train has also been introduced as an initiative between Network Rail, RSSB and Southern to look at ramp ends using non-contact lasers. Southern are also currently developing a business case to support the implementation of the axle bearing acoustic monitoring system RailBam.

4.4 Asset Information

Southern was found to have extensive asset information in the areas critical to its business. Technical data on the fleet asset base is well documented, controlled and widely available to the stakeholders within the organisation, including technicians working within the depot at the point of work.

Asset age is thoroughly documented, along with all relevant interventions, such as refurbishments and system configuration changes. Southern have engineers dedicated to each class of unit who are responsible for performance and failure mode information. Maintenance records are held both in hard copy and electronically for all maintenance interventions. Asset usage is also well monitored using standard practices in the UK TOC sector, both by Southern for its own fleet and as part of the wider industry monitoring schemes.

High-level condition assessment and deterioration profiling does not appear to be undertaken within the constraints of the franchise arrangements. However, clear requirements for hand-back of the leased assets are documented and full transparency of all interventions to the asset is a key part of the arrangements.

Defects and faults are identified from TRUST, BUGLE, defects found on maintenance and information from remote monitoring systems fitted to the units. This data is extensively analysed by the Fleet team and improvement programmes implemented. Seven Service Codes, giving a cost per area of £5 per minute to £124 per minute are used to develop business cases for performance improvements. The Manage Train Failures system is also used to reduce the impact of failures in traffic.

Although Southern has developed potentially overly complex failure and root-cause attribution codes, the working practice of collection and analysis of information at the maintainable/replaceable item level appears sound and is considered by AMCL to provide an appropriate level of detail to support the predefined RAM targets for the fleet.

In general, the systems used appear effective, are well recognised on an industry basis and are trusted by the stakeholders within the organisation. The data and information afforded by the systems also appears to be well trusted and is generally appropriate to Southern's business requirements.

5 Network Rail (Sussex Route) Asset Management Review

5.1 Background

Network Rail's Sussex Route covers the area to the South of London, including the Brighton Main Line and main line train services from London Victoria (Central), London Bridge, and London Blackfriars via the Redhill line, Brighton Main line and Arun Valley line to areas including:

- Redhill, Reigate and Tonbridge;
- Gatwick Airport;
- Horsham;
- Brighton;
- Eastbourne and the East Coastway;
- Worthing and the West Coastway; and
- Chichester and South Hampshire.

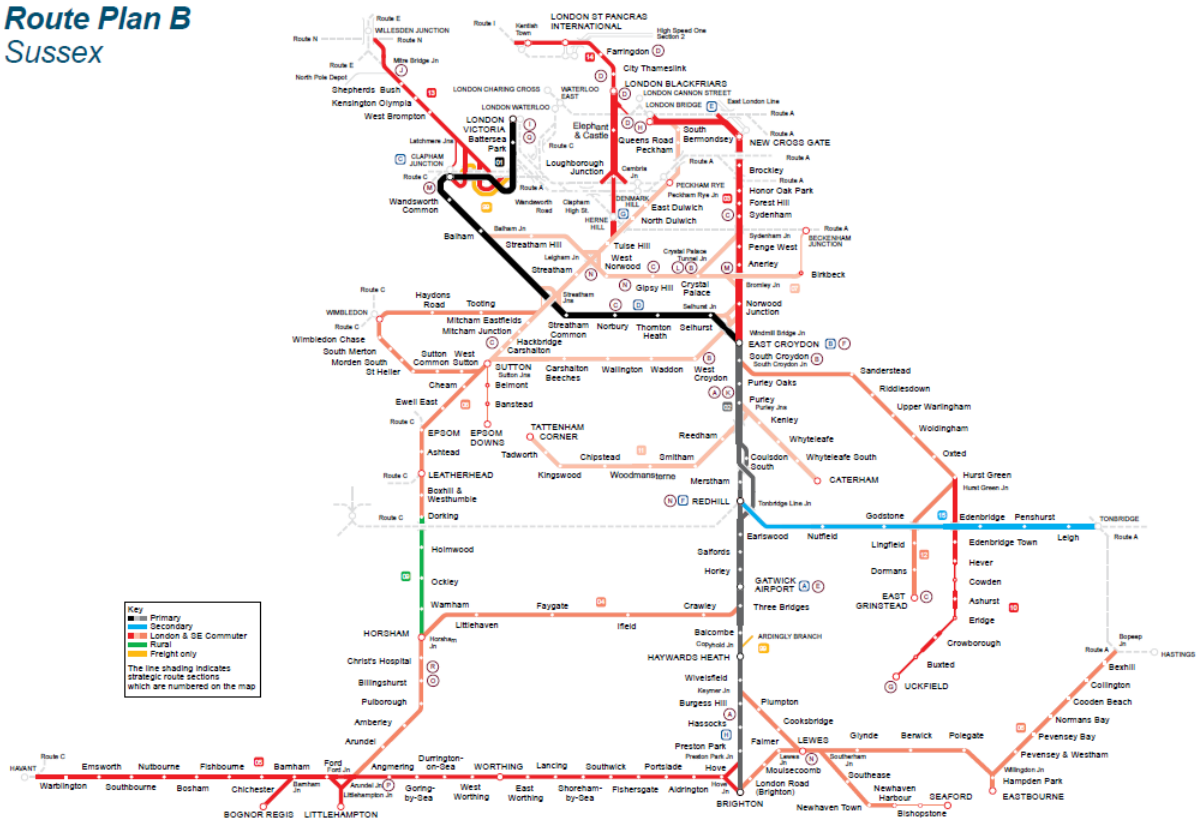


Diagram 14 Geographic Scope of Sussex Route (Network Rail: Route Plan 2010, Route Plan B Sussex)

The area was converted to a top-contact third-rail DC electrification in the 1920s for suburban routes and the 1930s for more outlying areas, including the main line to Brighton.

In general, DC traction systems (especially third rail systems) are limited to relatively low voltages and the capacity of such systems can limit the speed of trains, size of trains and powered facilities, such as the amount of air-conditioning that the trains can provide.

It is understood that the speed of trains on third-rail systems is limited to approximately 100 mph (160 km/h). This is due to the need to maintain reliable contact between the shoe and the rail. This issue is particularly onerous with respect to the dynamic loads experienced by the train shoes as they contact the third-rail ramp.

Third rail systems can be designed to use top contact, side contact or bottom contact. Top contact is considered less safe, as the live rail is exposed. Uncovered top-contact third rails, such as are found in the Sussex Route, are also vulnerable to disruption caused by ice on the conductor rail top surface.

The DC electrification system on the Sussex Route has contributed 8% of total delay minutes attributed to infrastructure (as assigned in TRUST) to date this year.

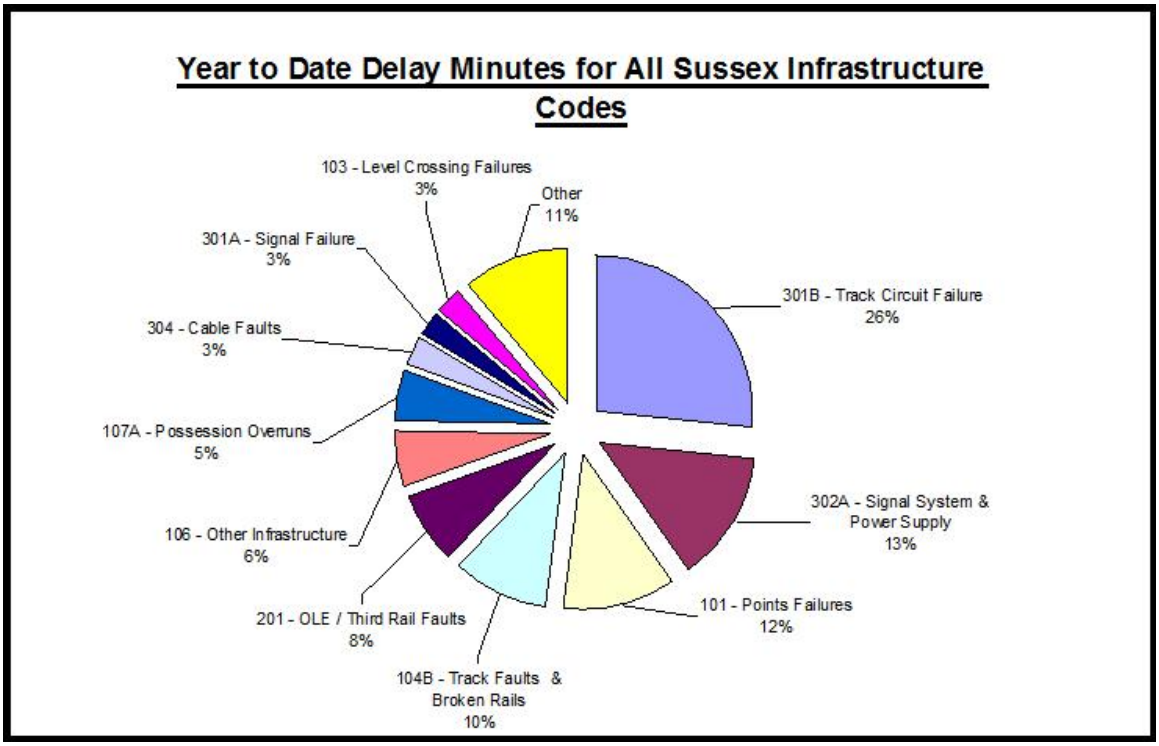


Diagram 15 Year to Date Delay Minutes for all Sussex Infrastructure Codes

5.2 System Level Planning

Unlike Southern, Network Rail as a whole, including the Sussex Route and the central services provided by Network Rail Centre is responsible for the full range of Asset Management activities shown in Diagram 16 below.

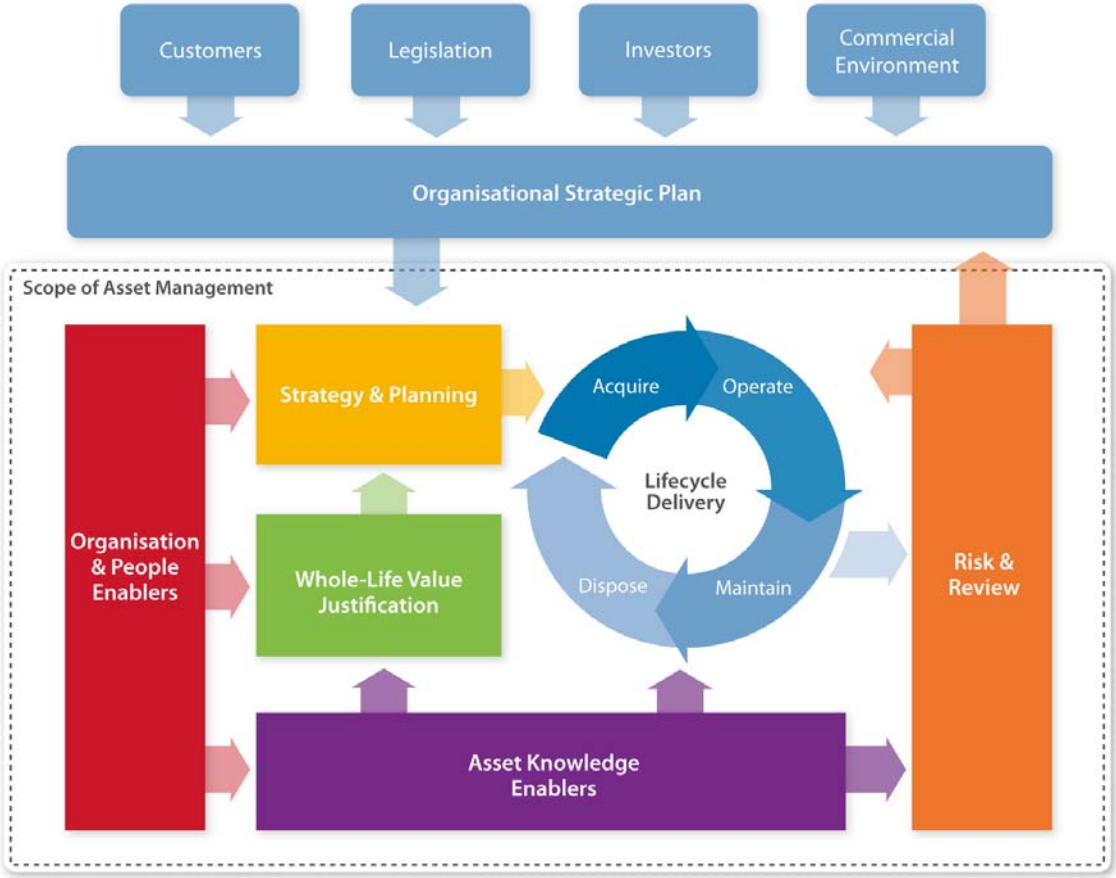


Diagram 16 Network Rail - Scope of Asset Management

The two organisations are therefore very different entities in terms of the scope of their overall Asset Management responsibilities. Southern are one of Network Rail's key clients overall and the operator of the vast majority of journeys on the Sussex Route. The Sussex Route itself is one of the major contributors of PPM on the network.

5.2.1 Supply and Demand

Parts of the Sussex Route electrification system are effectively working at, or in some cases, beyond their capacity. The available electrification system route headroom has been gradually eroded over time both through major changes to services and rolling stock, including cascading of stock, and incremental creep as a result of train lengthening and extra peak services.. This is

a key issue leading to a number of the performance issues recently encountered on the Route (see Section 5.2.4). It has also caused a number of service restrictions to be applied due to the constraints of the electrification system. By way of example, this has included the application of a limit on maximum current demands for different rolling stock configurations where appropriate.

Growth in traction power supply demand across the network has been significant in recent years. Network Rail's own draft EP Asset Policy (Electrical Power Asset Policy_v1_draft 05-07-11.doc) shows the change in total demand for AC and DC traction power supplies over the last two decades. The analysis identifies a general linear increase in demand of some 1.6% per annum. The dip in demand in 1993/1994 is stated as due to industrial action whilst the increase in demand in 2005/2006 is identified to be the result of a hot summer. The profile is believed to have flattened over the last few years as a result of the impact of regenerative braking on trains, which is in use on the Sussex Route.

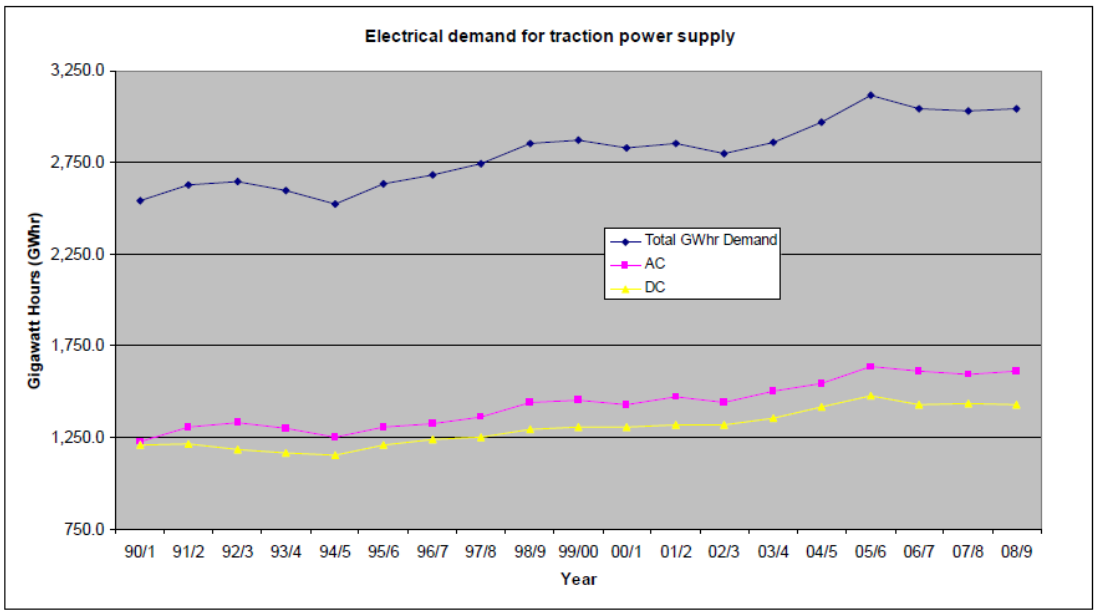


Diagram 17 Power Supply Demand (Network Rail - Electrical Power Asset Policy_v1_draft 05-07-11.doc)

The Sussex RUS alone, which is one of a number which impact the Sussex Route, identifies increasing growth in passenger demand, which it forecasts to grow by 22% between 2008 and 2020. Although not directly correlated to power supply demand, this does provide evidence that this issue is likely to continue to grow in significance. Whilst the increased use of regenerative braking may mitigate net overall power demand growth in the future, on an EP basis this may still cause system and specific equipment issues due to higher return flows.

Although considered to some degree in the body of the document, it is surprising the Sussex RUS does not currently identify the electrification system route capacity as a 'Key Gap', except for a specific reference for freight under Gap H. It is stated that RUSs consider 'Gaps' where the current or future railway system does not or will not meet the requirements that will be placed upon it, unless intervening action is taken.

5.2.2 Intervention Planning

Although no formal process definition was identified, the overall planning activity for major EP interventions was summarised in PowerPoint format to AMCL, as shown in the diagram below.

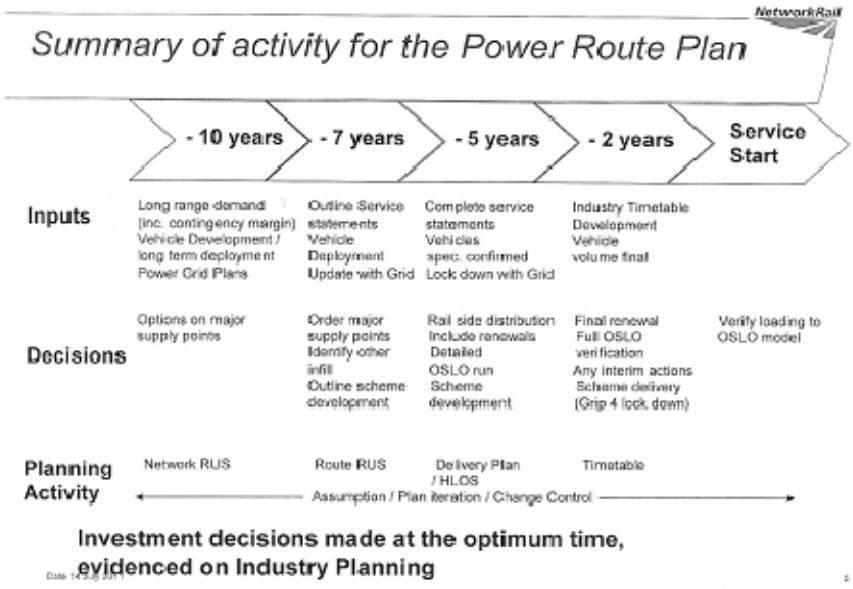


Diagram 18 Network Rail Demand Analysis to Service Start Summary Slide

Despite the apparent lack of formal process, the approach to long-term planning of EP system reinforcements in response to significant train service changes was stated by Network Rail as being functional and effective, in terms of the necessary inputs being provided by the various industry stakeholders. Necessary intervention projects and plans are identified to achieve those service changes a suitable time period out from service start point and the project plans included and delivered within the relevant Control Period submissions.

However, these relatively major planned EP intervention projects are developed to achieve and are justified against, a significant change in train service which is planned well in advance. The resulting interventions are therefore budgeted and implemented to achieve a specific timetable only. They also consider any necessary electrification system reinforcements due to capacity constraints, established by modelling, or condition improvements on a case by case basis to

achieve the targeted timetable only. It is understood that no recent projects have actively increased electrification system route headroom. Even where this has been initially included within project plans, budgets have eventually been reduced to deliver the necessary reinforcements for a specific timetable only. The impact of this is that Sussex Route has effectively been managing and maintaining a 'just sufficient' railway in electrification system route capacity terms since the early 2000s. With electrification system route capacity at, or potentially beyond - for certain periods in certain areas - its maximum, any minor changes to train services, fault situations, unplanned rolling stock movements, etc. could cause significant issues such as the burn-out of ETE components. This is believed to have been a critical factor leading to recent 'on the ground' EP performance issues and a key element of the concerns raised by Southern's letter to the ORR.

A key example of the 'just sufficient' planning approach is the Southern Region PSU project. Sponsored by the then SRA, the PSU initially represented a significant EP upgrade to facilitate the introduction of modern rolling stock with greater traction and auxiliary power demands. The PSU was initially scoped as an approximately £1bn upgrade project, which would have provided substantial electrification system reinforcement across key areas of the Route. Due to budget constraints it was subsequently downgraded to a £650M project to support the proposed 2001 timetable changes only.

As a result continued train service capacity increases and further rolling stock changes since the PSU have, in many cases, required further reinforcement of the electrification system on the Sussex Route.

A more recent example is the current Southern Power Supply Enhancement (Southern PSE) project. This has been recently de-scoped for the East Grinstead route to match the proposed service introduction of reduced peak current Thameslink trains without the provision of any electrification system route headroom.

As well as the long-term planned service increases and rolling stock changes, continued erosion of available electrification system route headroom has been taking place by relatively minor changes to train service loads, sometimes referred to as ‘load creep’. These often occur within Control Periods and are not considered or funded to the same degree within the overall network planning process. Again, because Sussex Route is operating a 'just sufficient' electrification system, the impact of service changes and load creep often manifests itself in performance issues, often as a result of electrification system component ratings being exceeded. To AMCL's knowledge, no business case has been developed by Network Rail for a significant increase of

electrification system route headroom on any part of the Sussex Route. This is understood to be partly due to the lack of capacity and load data (see Section 5.2.4) on which to quantifiably justify such a business case.

The continuation of the policy whereby projects currently only propose electrification system reinforcement adequate to meet their specific requirements is likely to result in further equipment failures and performance issues if further 'load creep' occurs. This is particularly the case on the Sussex Route, where the electrification DC system is operating close to capacity.

A more appropriate arrangement would be to enhance the electrification DC system equipment on all or selected parts of the Sussex Route as a separate project to provide sufficient system headroom, with each subsequent project then providing reinforcement to meet its requirements and to ensure that the previously provided electrification system route headroom is maintained.

RSSB Research has completed a research project T950 entitled ‘Investigating the economics of the third rail DC system compared to other electrification systems’ as requested by the Future Electrification Group, and its parent body, the Vehicle/Train Energy System Interface Committee. The August 2011 report recommended that ‘industry should prioritise the work needed to support the decision as to whether to include DC to AC conversion in the industry's investment agenda for future control periods’.

A paper has recently been submitted to the Network Rail Investment Panel requesting authority ‘for a GRIP 1 feasibility study into the conversion of the third Rail DC traction system in the South East to AC overhead line’.

If such a major strategic decision were made to progressively convert the existing DC electrification system in the South East to an AC electrification system, such a project would take many years to complete.

5.2.3 Notification of Train Service Changes

In order for Network Rail to meet the changing requirements of TOCs, it important that notification of any train service changes is provided to Network Rail at the earliest opportunity. Early notification of changes is absolutely essential when an electrification system such as the Sussex Route electrification DC system is operating near capacity with little or no system headroom.

The introduction of the Class 442 fleet on to the Brighton Line in December 2008 is an example of where insufficient time was provided to Network Rail to undertake the necessary detailed assessment. This was also noted as a wider industry issue, with the proposals for rolling stock cascade from other Routes not clarified with appropriate notification periods by the DfT.

Network Rail first received notification of the proposed transfer of just 17 units in September 2007 but it is understood that at that time no timetable was available to enable any electrification system modelling work to be undertaken. In due course, modelling work was undertaken and some overloading issues were identified and resolved, although in very tight timescales given the current arrangements within Network Rail (see Section 5.2.5).

Following introduction of Class 442s, conductor rail arcing issues arose at Gatwick due to the different collector shoe spacing of the units. Inadvertent tripping of Brighton Line rectifier protection equipment is still an on-going performance issue.

The significance of the introduction of the Class 442 fleet with respect to the large number of hook switch and positive cable lug failures that have occurred is not definitive. The only evidence of direct load failures was at specific substations. However, it is considered that their introduction may have been a contributing factor to a DC electrification system which has parts that are already operating close to or exceeding the capacity available. At a minimum, the increased load demands identified 'weak' points in the system, such as the lugs and hook switches, be they condition, manufacturing, materials or equipment rating issues.

The past practice of assuming that the DC electrification system has adequate capacity to cope with train service changes is no longer acceptable. It would seem appropriate that train service changes should only have to be accepted by Network Rail following an appropriate notification period proportional to the scale of the proposed change. Notifications outside of these periods should not be permitted.

Without an agreed set of notification periods it is difficult for Network Rail to deliver a DC electrification system with sufficient system capacity to meet the requirements of the proposed train service.

5.2.4 DC Electrification System Management and Development

As stated, on many parts of the Sussex Route the DC electrification system would appear to be operating at or near the limit of its capability. Since the replacement of slam door stock by more modern rolling stock with higher power demands in the early 2000s any significant train service

change now requires detailed consideration of the ability of the existing DC electrification system to meet the additional load requirements.

The electrical constraints detailed in the Network Rail Acceptance Panel certificates for Class 377s and for Class 442s indicate some of the areas where capacity is exceeded under normal and single outage conditions and where action has been required.

Rectifier transformer failures have occurred on the Brighton Line due to overloading of transformer windings and tap changer equipment. More recently, a number of failures of Mk 7 hook switches and positive cable lugs, particularly south of Redhill and to some extent along the East/West Coastway, indicate that some ETE is now also being operated in excess of equipment ratings, or highlighting manufacturing or materials issues with the equipment, and manifesting itself in service performance issues. The diagram below provides a visual overview of the extent of lug and hook switch equipment failures on Sussex Route

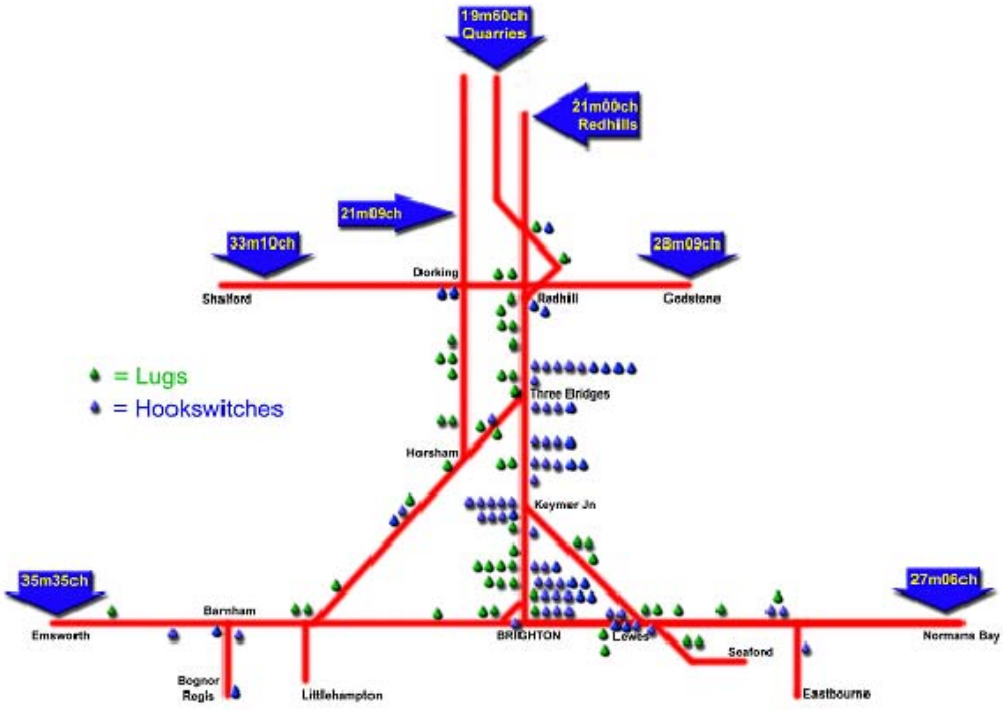


Diagram 19 Sussex Route EP Equipment Failure by Type/Location

Electrification equipment is in most cases provided with short-time ratings in addition to continuous ratings and it is the management of these short time ratings that often presents the greatest difficulty in the assessment of whether further reinforcement is required to meet the additional load requirements resulting from train service changes.

Network Rail does have an improving electrification asset information and condition database (see Section 5.5) with knowledge of the ratings of individual items of electrification equipment. However, at a system level, Network Rail does not have knowledge of the capacity of the various parts of the Sussex Route, nor does it have knowledge of the continuous real-time loadings.

This lack of capacity and load data, even at the static rather than dynamic level, significantly hinders Network Rail in the management of the electrification system. It is AMCL's opinion that no business can be effective and efficient on a sustainable basis without a thorough understanding of key supply and demand information. The lack of this information is also a key factor in Network Rail's inability to reliably forecast future system performance.

To understand the electrification system impact of proposed service changes in the Sussex Route, significant reliance currently appears to be placed on the knowledge, experience and expertise of the relevant engineering and maintenance teams in Sussex Route, supported by the NST Modelling Team and Test Section, where possible. Again, this is not considered by AMCL to be a sustainable approach in the long-term and there appears to be limited business continuity plans in place should any key resources be lost.

The NST Test Section has just completed, or is near to completion of, a series of requested spot load measurements on the Sussex Route. These load measurements will enable a more thorough understanding of the DC electrification equipment that is close to or exceeding the specified equipment ratings. Although this applies to the local test areas only.

Spot load measurements could be taken on the Sussex Route as and when required by the Test Section. However, the Test Section has national responsibilities for AC and DC electrification system load measurement, AC and DC electrification system testing and the commissioning of new electrification. As a result, the relevant resources may not always be available when required. The necessary resources and availability of the NST Modelling Team and Test Section appear to be significantly stretched by the demands of the national network

The continued management of a ‘just sufficient’ asset on the Sussex Route is likely to continue to impact on performance in the longer term due to further electrification equipment failures occurring as result of overloading of system components, possibly on the most unexpected parts of the DC electrification system, such as occurred with the recent series of hook switch and positive track cable lug failures.

The Network Rail draft EP Asset Policy includes the following 'Power Strategy' policy statement EP-127:

'A Route based traction power strategy shall exist for each electrified Route. This should include outline designs for increasing the available headroom of the system of 10%, 20% and 30% (aligned with the Rail technical Strategy). Option selection should consider the costs/benefits of all scenarios. The replacement of assets should be optimised to facilitate renewal of the energy network and the alignment of the traction power strategies'.

The above should not be confused with EP-129 policy statement which relates to the provision of a 0.25% increase in additional capacity per year of design life for new assets and applies at an equipment level not at a system level.

Issue 1 of the EP Route Asset Strategy for Sussex was issued on the 17th December 2010 but has yet to be enhanced to include signalling power supplies and rail heating. This strategy addresses electrification requirements to meet Control Period 5 specific requirements but does not as yet address any outline designs for providing additional system headroom. The Route Asset Strategy does not include any consideration of a whole life cost approach to the provision of new or replacement of existing electrification equipment.

Prior to making a start on the determination of any outline designs for additional system headroom, a methodology must first be developed at a national level for AC and DC electrification systems for the determination of electrification system route capacity and electrification system route headroom for which initial definitions are proposed for consideration (see Section 1.5).

The development of an agreed methodology represents a challenge for the industry, particularly for DC electrification systems, due to the complexity of the overall network comprising electricity supplies from the DNOs, the Network Rail high voltage distribution network, DC substations and the third rail DC system. To effectively manage an electrical system such as the southern DC electrification system a clear understanding of system capacity and system headroom available is essential.

Regenerative braking is in use on the southern DC electrification system and provides benefits in the reduction of the electrical energy required by Network Rail from the DNOs and thereby a reduction in energy cost. However, the transmission of regenerated energy from one train to another may result in additional equipment loadings further compromising the available system

capacity and adding further complexity to the determination of electrification system route capacity and available electrification system route headroom. It could also potentially lead to further 'real world' performance issues.

Equally essential to the effective management of an electrical system is a clear understanding of the capacity of the DC electrification system and real-time load measurement data. Diagram 20 shows Network Rail's current view on the Sussex Route capacity based on DC substation rectifier capacity data. This is not considered to be a clear indication of the 'electrification system route capacity' as it only reflects capacity of one item of electrification equipment rather than the quantified network capacity taking into consideration all other electrification equipment comprising the DC electrification system.

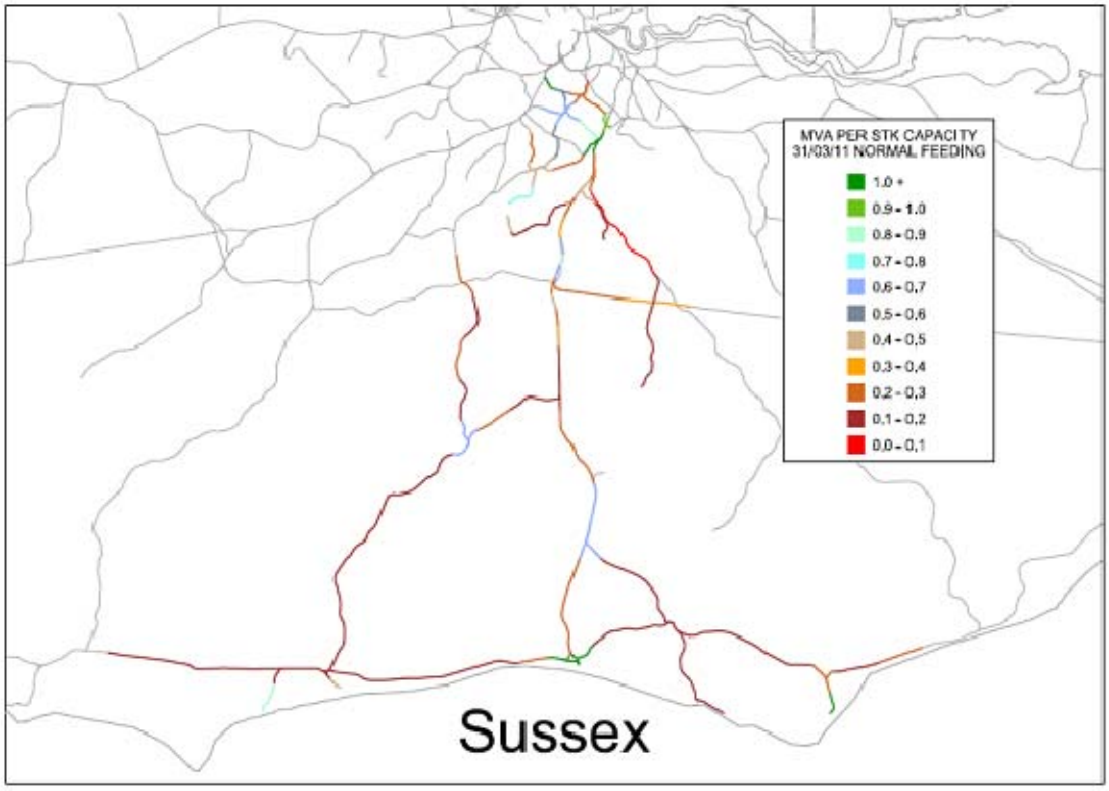


Diagram 20 Capacity of the Electrification Systems in MVA per STK (Network Rail)

Network Rail is proposing to install a new SCADA system in Control Period 5 which will provide the capability to transmit real-time load data from electrification substations to a central point. However, this will also require load measuring transducers to be fitted to equipment at the appropriate locations on the DC electrification system and supported by relevant storage and analysis systems. Without this instrumentation, data communication and analysis systems,

Network Rail will be unable to effectively source the necessary dynamic data to effectively manage the electrification systems.

The Network Rail draft EP Asset Policy also includes the following 'Load Monitoring' Policy Statement EP-11 :

'*All new circuit breakers suites shall be fitted with transducers to capture current flows for each circuit breaker and associated busbar voltage. Existing 'node' sites shall be retrofitted with load monitoring equipment where it is economical to do so and the asset is intended to remain in service for at least 5 years. Load measurement data shall utilise the existing SCADA infrastructure for data transfer.*'

As most circuit breakers can have asset lives of up to (or exceeding) 50 years, it could take a substantial time implementing the proposed policy before sufficient real-time load management data is available to effectively manage the DC electrification system.

A programme of fitment of load measurement transducers to existing circuit breakers to tie in with the introduction of the new SCADA equipment would enable effective management of the DC electrification system to be achieved within the Control Period 5 timeframe.

Prior to the availability of real-time load measurement data for comparison against known electrification system route capacity data, a Southern DC Electrification System Management Team should be set up. The objective of which should be to develop appropriate methodology, processes, procedures and systems to enable the effective management of the southern DC electrification system for Wessex, Sussex and Kent at the earliest opportunity in Control Period 5.

The staffing arrangements, processes, procedures and systems that organisations such as the National Grid and the DNOs employ to effectively manage their electrical networks should be considered in the determination of what is the most appropriate organisation for Network Rail.

5.2.5 DC Electrification System Modelling

DC electrification system modelling has for many years been undertaken using a software modelling package called OSLO, linked with a train movement software modelling package called VISION. These modelling arrangements have been used, enhanced and validated over a period of more than 30 years, initially for AC electrification systems and then later for DC

electrification systems. VISION has now been replaced by RAILSYS for train movement modelling by the Network Rail NST.

DC electrification system modelling is undertaken for normal feeding with all electrification equipment in service and as required for a range of different DC electrification equipment outage scenarios and any likely train service perturbations.

The high voltage network supporting the DC electrification system is modelled by the NST using a software modelling package called DINIS, which is used widely in the electricity supply industry.

Modelling using OSLO and DINIS requires not only the extensive details of the electrification DC system to be modelled but also details of the rolling stock and the train timetable. The time required to set up OSLO and DINIS and to evaluate the results can be significant.

At early GRIP stages, timetables and rolling stock are often not known and even though assumptions can be made, the time taken to determine and enter data, run the models, evaluate the results and prepare a report can, from a project perspective, be much too long.

Network Rail recognise that OSLO and DINIS are not the best modelling tools to use at a strategic level and at early GRIP stages and have proposed that a more ‘nimble’ and faster modelling tool be developed to guide decision making at a strategic level and at the early stages of the GRIP process.

5.2.6 Capacity and RAMS Specification

The output of the overall System Level Planning process is nominally electrification system route capacity and RAM specifications, which, in turn, inform and guide the specification of maintenance and the development of maintenance standards. However, during the review it was clarified by Network Rail that whilst there are high-level performance based reliability targets, it has not established reliability, availability or maintainability specifications for the DC electrification system, as an apportionment of business objectives derived RAM targets across the system hierarchy.

Neither has Network Rail currently defined the electrification system route capacity for the Sussex Route..

5.3 Maintenance Specification

The maintenance of electrification assets on the Sussex Route is undertaken by the Route Infrastructure Maintenance Delivery function in accordance with national standards defined by EP Engineering at Network Rail Centre. In terms of translating EP Asset Policy and Engineering Standards into 'on the ground' work the cascade is via the Sussex Route Electrification RAM* to the E&PMEs, via standard briefing processes, for which evidenced was provided. The E&PMEs are part of the Maintenance function within the Route, which is responsible for assurance and delivery. The delivery of maintenance is therefore undertaken by a different branch of the organisation to that specifying the maintenance.

Whilst Network Rail has a generic and standardised control process (Standards Management Process Requirements) for the review, amendment, authorisation and briefing of changes to Maintenance Standards which is applied to EP assets, the lack of capacity and RAM specifications means the assessment of adequacy of existing EP Maintenance Standards against target business deliverables is considered by AMCL to be constrained.

There was also no formal process for the monitoring of the adequacy of EP Maintenance Standards achieving the necessary asset/system performance and condition, identified during the review. Monitoring is undertaken via the available condition data, performance information provided by Network Rail's generic Infrastructure Maintenance Reliability Group and the NIRG, supported by the Sussex RIRG. Agendas and minutes of these relevant meetings were provided as evidence and the outline of the general approach, shown in Diagram 21, was provided during the review as guidance. However, a formally defined process for the review of

adequacy of Maintenance Standards against overall objectives is considered by AMCL as an omission against good practice and a potential risk to the overall Maintenance Specification PDR loop.

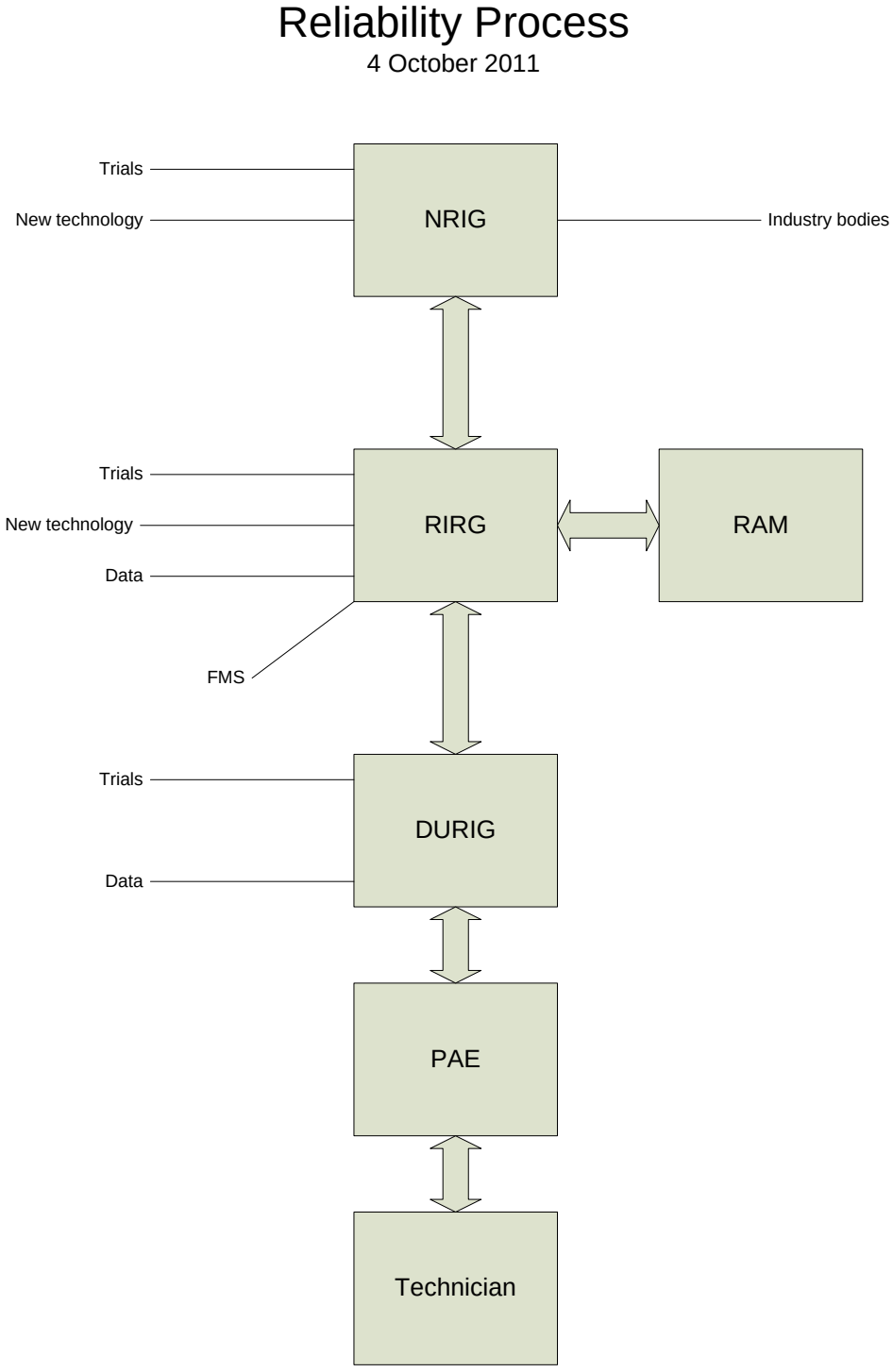


Diagram 21 Network Rail's Reliability Process

For EP maintenance there is a suite of standards and detailed work instructions for both electrical distribution and plant but no detailed work instructions were identified for conductor rail equipment during the review. However, following the release of the Draft A version of this report, Network Rail stated that relevant documentation has been under development and is currently in draft format.

Although Network Rail's EP maintenance processes and standards are subject to regular review and briefing, based on the above standard, there was little evidence of this process being applied to the tasks and frequencies associated with the DC electrification system. Analysis has shown that the Plant work instructions were updated this year and the Distribution work instructions updated between 3 and 7 years ago, most about 5 years ago. However, it has not been possible to establish what the update process consisted of across the suite.

It is understood that justification of the maintenance tasks and periodicities for the standards and work instructions relevant to electrification assets on the Sussex Route has never been formally established and documented by Network Rail. OHL maintenance regimes have been subjected to some degree of review and optimised justification, via the Department of Trade and Industry MACRO project, during the Railtrack era. However, third rail electrification systems have never been subjected to risk-based maintenance optimisation, such as that shown in Diagram 22.

Network Rail stated this is due to resource constraints and the relative criticality of the third rail asset base, with the overall cost considered small when compared to other major asset types, such as OLE. However, quantified justification of the tasks and periodicities against risk, including performance risk, for electrification assets in the Sussex Route would seem prudent.

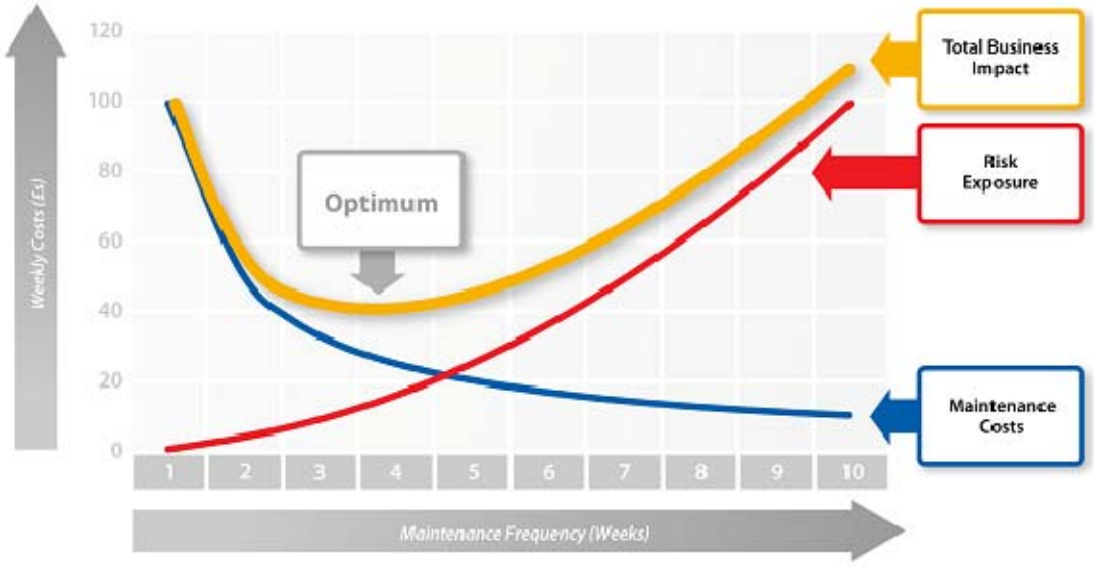


Diagram 22 Basic Cost-Risk Optimisation Principle

The November 2010 NCAP E&P Technical Audit of the Croydon DU lists 8 minor non-conformance reports. NCR No 4 refers to the lack of a work instruction to undertake impedance relay calibration tests. Under section 7 'Good Practices', the final paragraph includes the statement '… owing to the lack of formal instructions covering the CRE maintenance activities, the CRE section manager has created an instruction pack as an easy reference for his staff'. A review of the completeness and ready availableness of relevant maintenance standards should be undertaken as part of the overall justification review identified above. It is noted that evidence was provided that Network Rail is actively monitoring issues with existing Maintenance Standards and associated documents but the need for an exhaustive review and development plan, including timescales, is considered necessary.

One key area of direct performance impact for TOCs is the electrification interface between the conductor rail and the rolling stock shoe gear. This is considered in the Network Rail Business Process Document NR/GN/ELP/27010 (Guidance for compatibility between electric trains and electrification systems).

It is understood that consideration is currently being given to transferring the relevant conductor rail/shoegear parameters, currently contained as guidance in NR/GN/ELP/27010 back to the RGS GE/RT8023 'Compatibility between electric trains and electrifications systems'. This opportunity should be utilised to ensure that the relevant detailed requirements for the shoegear to conductor rail interface are captured and standardised, such that the interface can be

managed appropriately and effectively. In order to fully understand and mitigate the root-causes of performance impacting lost shoe gear incidents in the interim, it is proposed that Sussex Route should formalise the process to liaise with Southern Railway Ltd., and undertake on site-investigation, as appropriate, of conductor rail and train shoegear incidents.. The team should work jointly with Southern's Fleet Engineers to rapidly establish the root cause of each failure - rolling stock or infrastructure - and set-up mitigation actions where justified.

It is noted that the two organisations are already working together, with academic partners, to facilitate the collection of further data relating to the shoegear/conductor rail interface.

This review has not considered the adequacy or the sufficiency of the relevant maintenance standards or work instructions. To undertake this assessment would be difficult without relevant targets to assess against. However, during the review consideration was given to Network Rail Company Standard NR/SP/ELP/27048 ‘Maintenance of positive conductor rail’ in view of the recent high number of fish-plated conductor rail joint failures that had occurred. It was noted that a non-compliance was in place in respect of the periodicity of examinations required under section 6.1, this is understood to be due to an error in the standard. It was also noted that the requirements in respect of the examination of the electrical and mechanical properties of conductor rail fish-plated joints were not complied with, as this work is not now permitted to be undertaken live and to have an isolation to undertake such work would be inefficient and disruptive to operations. Sussex Route is mitigating this non-compliance by the use of infra-red camera based inspections. It was noted however that there are currently no standards or work instructions for infra-red monitoring of electrification equipment. Although a User Guide has been developed by Sussex Route, it is not clear without relevant standards how the use of Infra-red camera use is being specified and controlled, how the investment has been quantified in terms of cost-benefit or how appropriate user competencies have been established.

It is understood that there are currently no Reliability, Availability or Maintainability (RAM) targets analysed, defined and attributed across Network Rail's DC electrification system and sub-systems. Without a RAM based approach to the engineering management of EP assets the current and predicted performance of the system and sub-systems cannot be established.

5.4 Maintenance Delivery

5.4.1 Scheduled Maintenance

Maintenance of EP assets on the Sussex Route is managed via the Ellipse work management system. The Maintenance Scheduled Tasks, i.e. work description and periodicity, for each item are entered into Ellipse in accordance with relevant equipment standards. It is understood the requirements are entered by the SSM and approved by the relevant functional engineer, although formal documentation of this process was not identified during the review process. The maintenance delivery cycle is then delivered as summarised in the 'Ellipse Maintenance Cycle' Diagram in Appendix A. The detail of how the Ellipse system is used is summarised in the 'Ellipse Equipment Register Design' diagram in Appendix B. It should be noted that the diagrams contained in the appendices are summaries only and that they are supported by comprehensive and detailed documentation in the form of the Ellipse Handbook and other relevant documentation. Although stakeholders did identify issues with the user interface, in general the process and use of the Ellipse system appears well defined and understood within the organisation. The ‘Ellipse Equipment Register Design' includes a sample print of a Work Order which under 'Work Order Description' states 'S&C Slide chair oiling' and under ‘Equipment Details’ gives an equipment reference number. The sample electrification Work Orders provided by Sussex Route had equipment details under 'Work Description' but no details of the work to be undertaken was evident on the Work Order. Another sample electrification Work Order referenced now superseded Railtrack standards.

The ‘Ellipse Maintenance Cycle’ requires the 'Work Order Number, Description and Tasks, Equipment & Location' to be included on the Work Order but does not appear to require reference to the relevant Maintenance Standard or Work Instruction for the work to be undertaken. It would seem appropriate that in addition to the description of the maintenance work to be undertaken that the relevant Maintenance Standard or Work Instruction reference should also be included on the Work Order to clarify tasks, testing processes, tooling requirements, etc. This issue is now understood to have been escalated by Sussex Route to Network Rail Centre as a potential generic issue.

The list below shows the meetings framework that is used to manage work in all its aspects in Infrastructure Maintenance. Evidence in the form of agendas and minutes for Sussex Route was provided to support this process, which is augmented by the array of Standard Reports defined in the Ellipse Work Management Handbook. The list is presented in short-term to long-term order and includes the review of all Ellipse work activities, including current work and work that

has not been completed (NR/L3/MTC/PL0175/07 “Weekly Section Manager’s Plan-Do-Review (PDR) Meeting”).

- Daily Supervisor’s Roll Call Meeting;
- Weekly Section Manager’s PDR;
- Maintenance Delivery Unit Weekly Planning Meeting;
- Route Business Review (RBR);
- Monthly Business Review (MBR);
- T-33 Maintenance Delivery Unit Quarterly Plan Development Meeting;
- Annual Maintenance Access Briefing (start of the business planning cycle); and
- Delivery Unit Annual Integrated Work Plan input meeting.

It is understood that all maintenance requirements assigned to each maintenance delivery team are scheduled in weekly batches, which include all work that is scheduled for completion by the Friday of that week. These are generally produced on the Wednesday prior to the week in which the maintenance is scheduled. The Sussex Route Maintenance Delivery Managers interviewed all confirmed that they believed resources were adequate in the Route for the workload.

For MSTs, compliance is a measure of the interval between a cycle of maintenance, and it is directly related to the Network Rail standard frequency and any allowable tolerance for a task against the asset. Diagram 23 below is used to explain how the report is compiled.

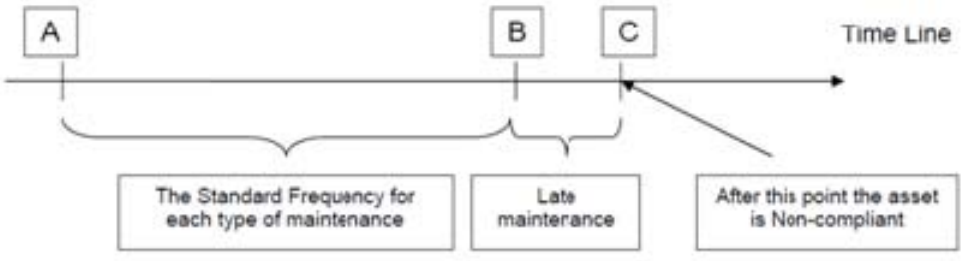


Diagram 23 MST Compliance (Ellipse Handbook)

A – The Last Performed Date. It indicates when the last inspection occurred.

B – The Next Performed Date. This is calculated as Last Performed Date + Standard Frequency. At this point, if the maintenance has not been completed it is considered as late. It has passed its standard frequency but it is within the standard tolerance.

C – The Next Performance Date + Tolerance. If the maintenance has not been completed at this stage, the asset will be flagged as non-compliant (missed) and would require urgent attention from the IMDM and the Engineer.

5.4.2 Work Arising

For work arising, non-compliance is measured by monitoring the Required Finish Date. This date is calculated by using the priority assigned to the work and if this work is not completed by this date, a non compliance to standards occurs.

For Work Arising, compliance is measured using the Required Finish Date. Diagram 24 below is used to explain how the report is compiled.

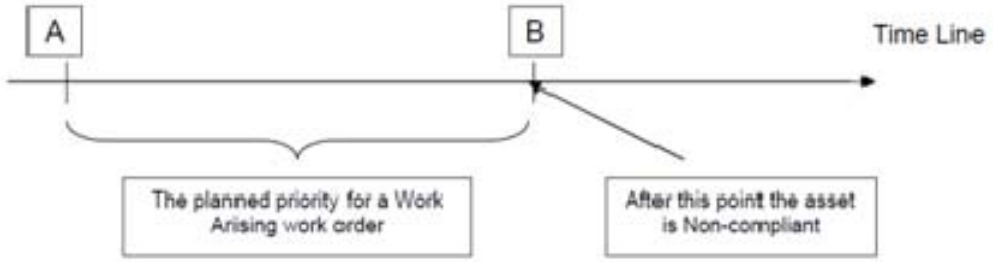


Diagram 24 Work Arising Compliance (Ellipse Handbook)

A - Found Date, it is the date provided on the Work Arising Instruction Form (WAIF), indicating when the job was found. This is captured under the Raised Date in Ellipse.

B – Required Finish Date, This is determined by the standard and it is in accordance with the Planners Priority.

A work arising Work Order is deemed as non-compliant if the Required Finish Date is passed and the Work Order is still open in Ellipse. Prior to reaching this stage the work should be completed and closed in Ellipse. Alternatively, it can be inspected by the supervisor and if permitted by the standard, the Work Order can be reprioritised. It is understood that a Work Arising Work Order can be reprioritised up to six times, depending on its criticality and that of other work requirements. The process for management and assurance of this is again well documented in the Ellipse Work Management Handbook

It was also noted that a WAIF and associated Work Order may be raised and completed retrospectively in the Ellipse system to capture work undertaken on site as and when the issue was found, if appropriate.

5.4.3 Late Maintenance & Non-Compliance

Late Maintenance (sometimes referred to as Backlog) is understood to be where a Work Order raised in Ellipse has not yet been closed out in the system after its scheduled Next Performed Date (or Required Finish Date for Work Arising, see Section 5.4.2). This may be because the maintenance has not yet been completed or because the 'paperwork' has not yet been completed and/or the system updated by the Section Planner, for example if the work was completed on a Friday before Bank Holiday weekend. It was stated by Ellipse system experts in Sussex Route that the Late Maintenance 'grace period' (standard tolerance) for close-out of Ellipse Work Orders after the scheduled date of the MST or Work Arising is currently 13 days. As per Diagram 23 and Diagram 24 above, scheduled work which exceeds this 13 day period is subsequently considered non-compliant (missed).

Not withstanding the Ellipse 'grace period' for entering maintenance completion information, it is understood that for EP assets there is currently no allowable tolerance for MSTs against the assets within the Maintenance Standards. If the maintenance has not been completed by Point B in Diagram 23 then the maintenance is technically con-compliant with the Maintenance Standard defined periodicity but if this is still within the generic Ellipse 13-day 'grace period', this would not be flagged as non-complaint.

Evidence was provided of EP backlog monitoring on a weekly basis. Overall trend data for EP assets by MDU was also provided and is shown in Appendix D. However, Sussex Route did not routinely store the data so that trend analysis could be undertaken at the 'Distribution & Plant' and 'Conductor Rail Equipment' by MDU level. The following charts of trend data were provided following specific analysis of weekly reports by the Sussex Route team. Because of variances in the data available it was not possible to provide the data consistently.

The following chart shows the % of the workbank for Croydon MDU which is within the 13 day 'grace period'.

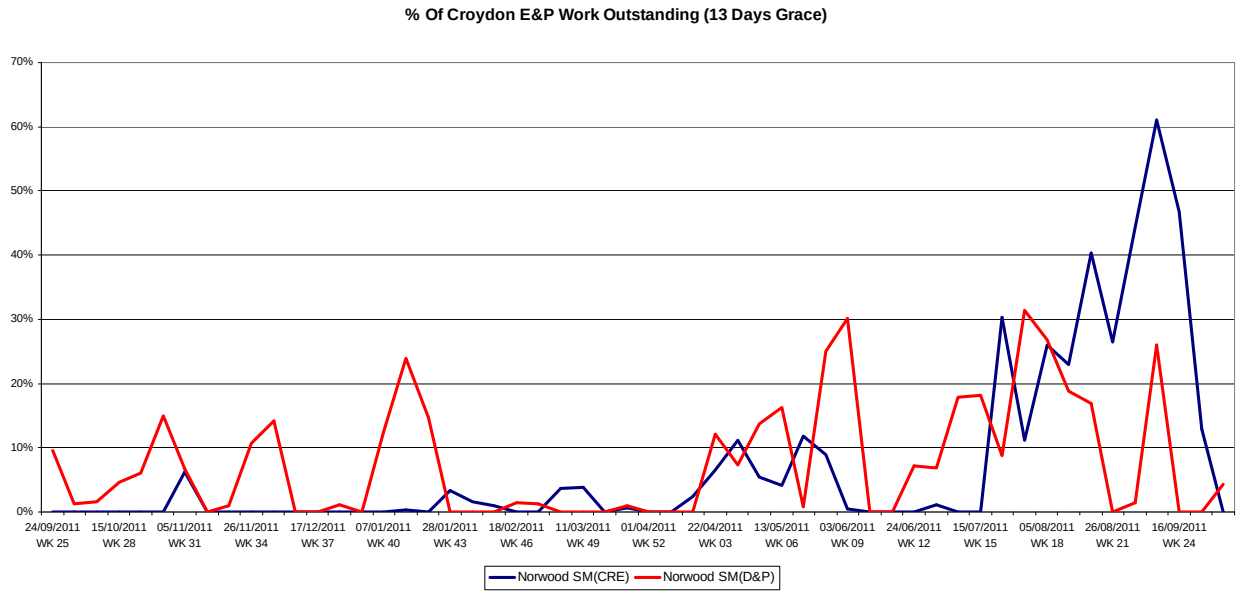


Diagram 25 % Of Croydon E&P Work Outstanding (13 Days Grace)

The target tolerance set by Network Rail is 2% and it can be seen that this is exceeded on a number of occasions. It was stated by Sussex Route that the increase in the above chart commencing in week 2 11/12 was caused by the boundary changes during the Phase 2b/c reorganisation process necessitating re-planning of the work for the revised organisations. The CRE rise since week 15 11/12 was stated as being due to points heating testing, annuals and condition monitoring all coming out together as a one off, due to poor scheduling. These were stated by Sussex Route as not 'true' backlog as they were not required to be completed until October.

The following chart shows the count of Work Orders outstanding (as opposed to %) by week for Brighton MDU which are within the 13 day 'grace period'. The data for the overall workbank size by week was not available for Brighton MDU. Where there is no count shown it was confirmed that backlog in those weeks was zero.

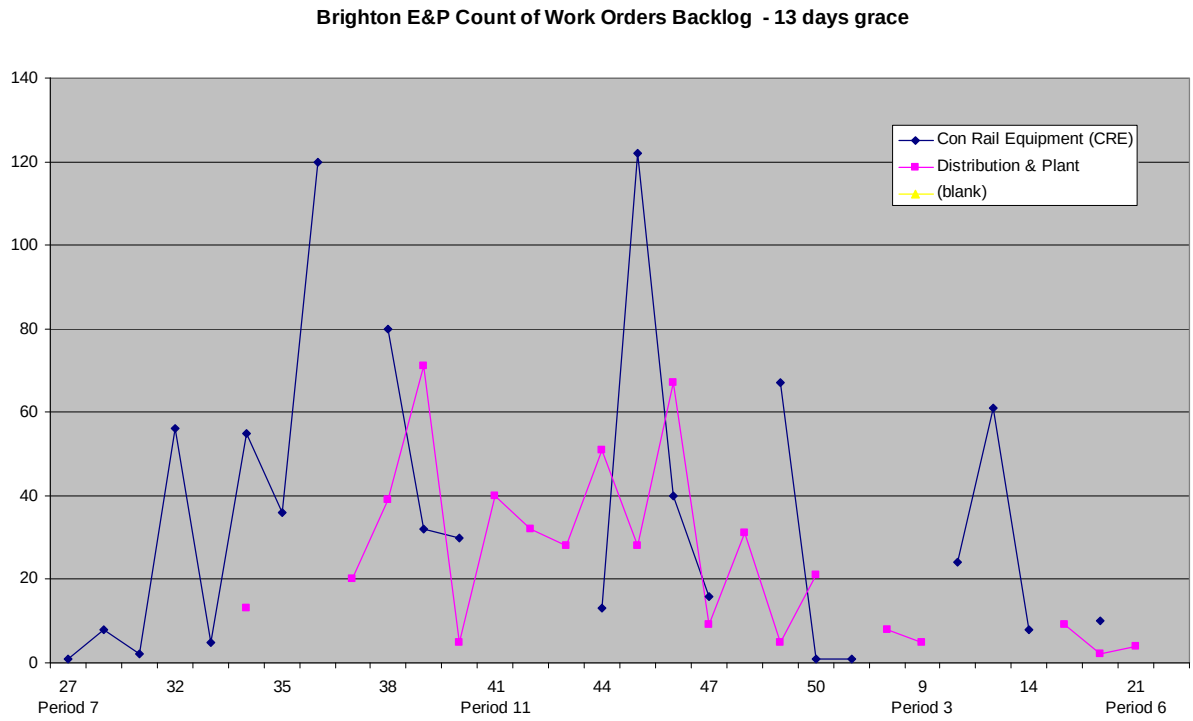


Diagram 26 Brighton E&P Count of Work Orders Backlog - 13 days grace

The charts show highly variable backlog rates, some of which were explained by poor planning. However, the analysis, both above and in Appendix D identified Croydon as significantly worse than Brighton. It should be noted that 'Backlog' does not necessarily constitute non-compliance with standards, simply that the planned maintenance date has been passed - and is within a 13-day 'grace' period. However, mitigation of backlog is likely to support better overall performance in the long-run and mitigate the risk of non-compliance.

Overall Sussex Route EP 'Non-compliance' data was provided as shown in the following chart. this shows EP assets which have exceeded the scheduled date and the 13-day 'grace period'.

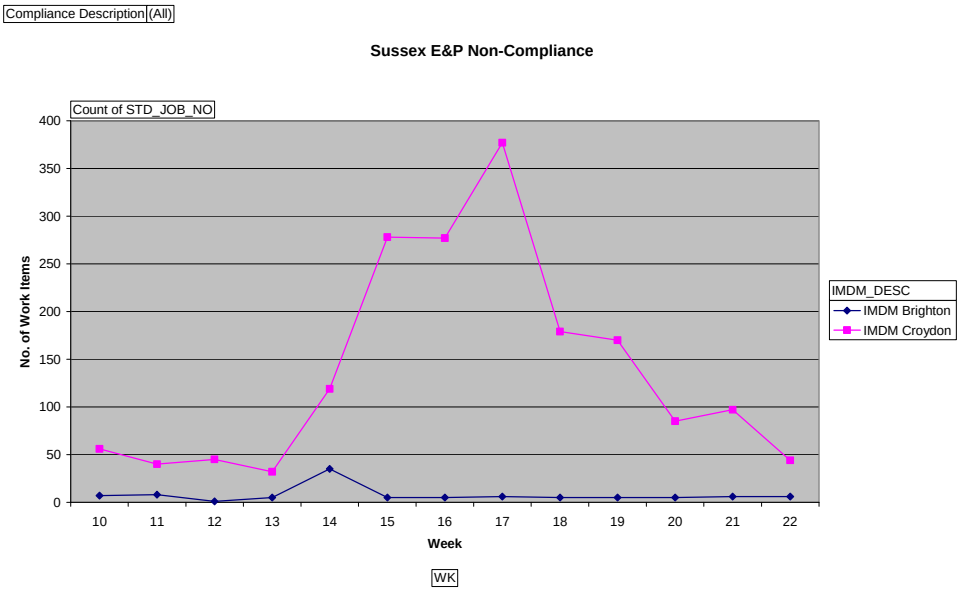


Diagram 27 Sussex Route EP Non-Compliance

5.4.4 General

With respect to electrification specific maintenance on Sussex Route, a number of further key points were noted as a result of the review:

- As many parts of the Sussex Route DC electrification system appear to be operating at or near the limit of its capability, the achievement of N-1 level of security during maintenance is no longer possible during normal service hours in some areas. Some night work is currently being undertaken in order that some electrification equipment in high loading areas, particular DC track circuit breakers, can be taken out of service while still meeting system N-1 level of security of supply requirements. This is as required in the draft EP Asset Policy, Policy No EP-132 'Redundancy'. Example areas where this occurred were noted as Wandsworth and Selhurst but there was no specific list available.
- Maintenance staff are rostered and called out in response to equipment failures. The 'target' response time for faults is less than 60 minutes. However, this is a Sussex Route 'guide' only and was stated by Network Rail as not being documented or evidenced.
- Monitoring of skills and competences for maintenance technicians is in place using competence matrices and computer based reviews every 15 months, which was well evidenced. The overall matrix and assessment process was developed as part of the Phase 2B/C re-organisation, which went live on 1st April 2011. Prior to this, a process termed Assessment In The Line (AITL), which was introduced in 2006, assured that competence was specified centrally and managed locally via job descriptions and competency

handbooks, in compliance with relevant standards. Competency assessment prior to 2006 was undertaken using IMC procedures adopted by NR. Under this arrangement records were held in many different locations.

- Calibration of relevant tools and equipment is managed by a national Network Rail process. The system is based on the Network Rail intranet portal and provides a calibration database, 28-day notice of calibration and weekly reports to the relevant functional engineers. Again this was well evidenced.

5.4.5 Seasonal Management

TRUST code data provided for the Sussex Route indicates that for Electrical Power 'third rail faults' equate to 3% of the total minutes delay, compared to 'severe weather' related incidents of 19%. As identified in the Context Analysis report, 2010/11 was also a particularly bad year for leaf fall and snow issues impacting performance.

A number of issues were identified with Network Rail's management of the seasonal issues during 2010/11. These included the Seasons Delivery Specialist role for Sussex Route being vacant throughout 2010/11 and the MPVs utilised for seasonal management undergoing maintenance at the key times of the year they were required. There was also limited resources available as 4 MPVs and 12 drivers had to be shared between Kent and Sussex Routes.

However, following last year's issues and a recent seasonal management review undertaken by John Curley, Sussex Route has made significant changes to its approach to seasonal management. Resources have been increased to 5 MPVs and 25 drivers, exclusively for use in the Sussex Route and processes and plans have been developed with Southern and other stakeholders to optimise responses and actions to weather forecasts and actual weather incidents. The revised approach appears well planned and agreed with relevant stakeholders.

5.4.6 Performance Improvement Initiatives

Sussex Route has worked to develop a targeted performance improvement initiatives campaign. This has included 'Project Radical', which commenced in May 2010 and was developed to achieve performance improvement targets defined in the JPIP. The prioritisation of initiatives was understood to be based on a combination of good practice statistical process control data analysis and engineering judgement. The identified performance improvement initiatives for electrification from this analysis were:

- MK7 TO MK8 hookswitches at sub stations;

- Fitment of Bi metallic Lugs at power risk locations;
- Fitment of Phylidas Nuts on lugs;
- Replace known faulty Micom bolts with longer ones;
- 1000 Welds on third rail; and
- Upgrade palm lugs to extended palm lug.

In general, these are upgrades to relatively minor components of the overall electrification system. This reflects the issues identified earlier of a system working at or near capacity highlighting performance issues via overloaded, or sub-standard, low-level electrification system components.

Whilst the approach appears sensible in terms of short-term reinforcement to prevent known performance issues, the above represents a number of major logistical tasks and risks the performance issues being pushed to other elements of the overall system. Without a system-wide approach to reinforcement, performance cannot easily be assured or predicted.

5.5 Asset Information

5.5.1 Delay Attribution

The attribution of performance delay is defined in Network Rail's Delay Attribution Guide, which is stated as being developed with and supported by the wider industry. The overall high-level process is shown in Diagram 28, below.

On a day-to-day basis, delay attribution is initially managed via TDACs based in control centres. It is understood that when a delay occurs the TDACs liaise with the relevant signaller to establish an initial 'best cause' of the delay which is then entered into TRUST by the TDAC as a Level 1 attribution. Some of the delays will be assigned to a TOC who may dispute the attribution and escalate the issue for resolution at Level 2, in accordance with defined processes.

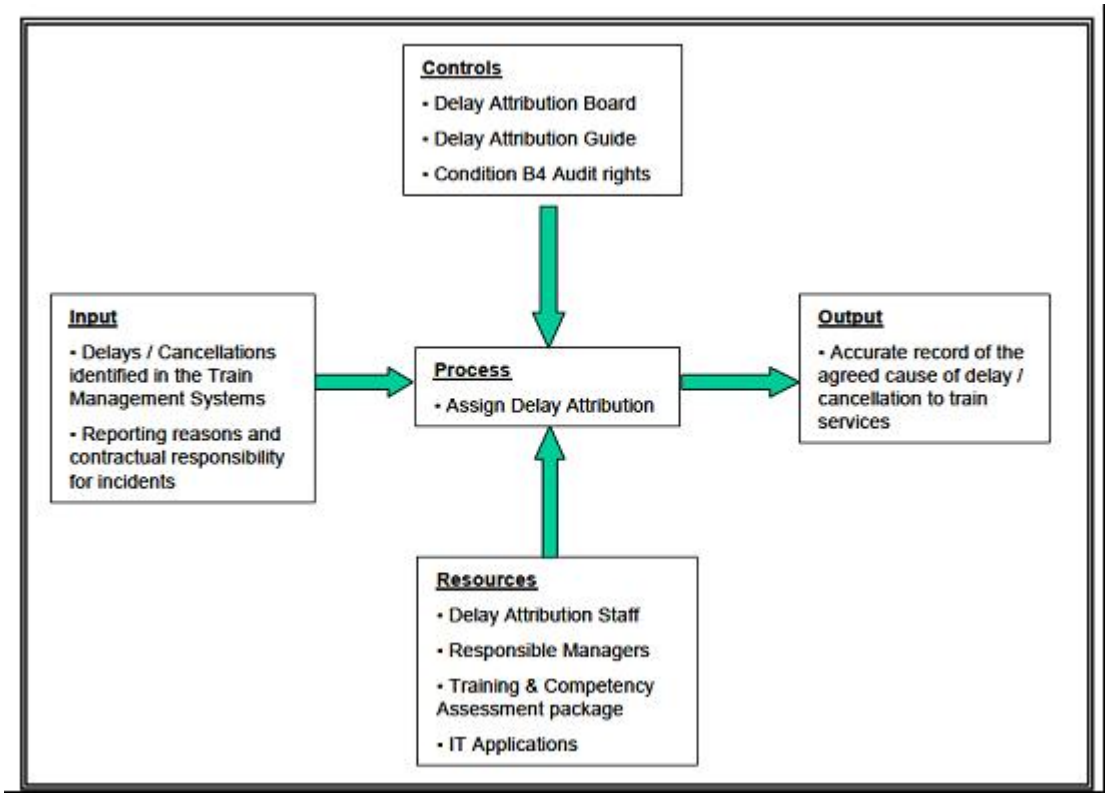


Diagram 28 Delay Attribution Process (Network Rail: Delay Attribution Guide)

The details of the operational delay attribution process have not been considered in detail by this review. However, it has been considered from the perspective of understanding root-cause of performance issues and managing the infrastructure appropriately.

It was noted that in Sussex Route, the number of TDACs was reduced from 18 to 10 approximately 18 to 24-months ago. Based at Victoria and Three Bridges control centres, the cut in numbers resulted in an average of 2 TDACs per control centre per day but only 1 TDAC, based at Three Bridges to cover the whole Route, at nights. A single TDAC for the whole Route during nights was recognised By Network Rail as an issue, particularly if there was an operational problem during the evening peak, which they had to single-handedly sort out through the night. The severe weather occurrences in late 2010 were also the first winter period through which the reduced number of Sussex Route TDACs had operated and further highlighted the resource constraints.

When the number of train delay incidents becomes extreme, for example in adverse weather conditions, the TDAC(s) may not be able to actively enter all the relevant delay incidents into the TRUST system. In this situation multiple delays are captured under a single TRUST Incident Number (TIN), commonly referred to as a 'Management TIN'. 'Management TINs' are invariably

attributed to Network Rail and often under causes such as adverse weather. However, many hundreds of individual delay incidents may be contained within a single 'Management TIN'. This can result in incorrect classification of performance issues, potentially on a large scale. This in turn can skew performance data analysis towards key incidents, such as adverse weather, when they're may actually be a range of underlying causes or attributions. The multiple layers of analysis required to decode 'Management TINs' right down to actual root-cause on rolling stock or infrastructure is onerous and time consuming.

Sussex Route does work to analyse 'Management TINs' but focuses particularly on areas of repeated unexplained delays as the resource demands are too great. It was also noted that while there is 'guidance' from Network Rail Centre on the analysis of 'Management TINs' there is no formal process defined. As a result correct attribution and explicit definition of root-cause may never happen in a number of cases.

Sussex Route did state its belief that in extreme cases, such as the heavy snowfall last winter, it would be virtually impossible for any number of TDACs to pro-actively manage all delay incidents without resorting to amalgamating multiple incidents into 'Management TINs'. However, the organisation is cognisant of the issues encountered and is implementing a management plan to mitigate the size and number of the 'Management TINs'. This includes:

- Moving back to 12 TDACs - although this is still understood to be the smallest number of TDACs for a Route and on one of the busiest Routes;
- Recruiting two more TDACs to retrospectively analyse delay attribution; and
- Training office based staff to support Level 1 attribution processes in times of significant delay incidents.

It is considered the measurements taken will help to mitigate the issues associated with 'Management TINs'.

The management of performance information is also one area where Sussex Route and Southern work closely together. The respective performance teams are co-located and plans for further integration and more effective processes are currently being developed.

The basis of the joint performance improvement work between the two organisations is the JPIP. However, this plan currently only looks forward six-months. Both parties recognise the need to expand this horizon and it is understood that a JPIP for 2012/13 and 2013/14 is to be prepared next year and that work on longer-term planning for CP5 is underway. AMCL would

support this approach for the JPIP to consider more strategic timeframes. This also aligns with Recommendation 2 of the Context Analysis report (see Section 2).

5.5.2 Root-Cause Analysis

The Context Analysis report also identified a number of concerns about the use of FMS within Sussex Route and generically within Network Rail. It was noted that a national Network Rail initiative had changed the process for the entry of data in FMS in approximately August 2009. Prior to this date, the root-cause of failures was not being captured in an analysable format in Sussex Route. The accuracy and effectiveness of the data captured post August 2009 were also questioned but this matter is now subject to a separate review being led by the ORR.

Although Sussex Route have evidenced the use FMS to help define its performance improvement initiatives, this analysis is considered by AMCL to be constrained by the underlying quality of the FMS data. An analysis of electrification fault root-causes, post April 2009 when changes to the FMS process were instigated, shows a relatively high percentage of failures which have no meaningful root-cause attribution within the FMS system.

Analysis & Diagram reference	Including Null % no meaningful attribution	Excluding Null % no meaningful attribution
Not included in Sussex report - Sussex Top 10 Component Level 1 Categories Since Period 4 2009 (All Assets)	21	21
Not included in Sussex report - Sussex Top 10 Component Level 2 Categories Since Period 4 2009 (All Assets)	12	12
Diagram 21 - Sussex Top 10 Component Level 1 Categories Since Period 4 2009 (Electrification Assets)	28	28
Diagram 22 - Sussex Top 10 Component Level 2 Categories Since Period 4 2009 (Electrification Assets)	27	28

Table 3 Electrification Root Cause Analysis (Post August 2009)

Network Rail has since clarified that root-cause analysis is undertaken by the application of post-incident root-cause analysis by its Infrastructure Maintenance Reliability Group, utilising the data captured in FMS. However, analysis of this nature can only be applied to sub-sets of failures and is often guided or prioritised by those failures which have the biggest impact on train delay. Whilst this is a sensible way to prioritise such post-incident root-cause analysis, it risks missing the definition of root-causes for the large range of failures which do not cause train delay incidents and facilitating a pro-active approach to root-cause mitigation prior to future

impact on train services. Capturing root-cause details within FMS for all failures, where possible, and establishing appropriate corrective actions for increasing non-service impacting failure trends, as well as train delay incident causes, would assure a less reactive approach to performance issues.

5.5.3 Condition Data

The maturity of condition monitoring, assessment and degradation data was found to vary across the DC electrification system assets in Sussex Route and generally stored in separate spreadsheets, although the Network Rail Centre EP team is starting to make use of the Ellipse condition module.

Within Sussex Route, high voltage cables are understood to be a mix of fluid filled, paper insulated and XPL types. Although there was no formal condition assessment process identified, good knowledge of age profiles, as a proxy for condition, was evidenced for the majority of the individual assets across all types. Fluid filled cables are also subject to well evidenced monitoring of oil loss and pressure as a further condition proxy and rolling analysis of the 'worst offenders' undertaken. XPL cables have been installed in the last 20 years and have a 40-50 year design life. They are subject to annual inspection for defects and major degradation or replaced on failure. Paper insulated cables are understood to be replaced on failure or as part of the replacement of associated equipment, such as transformers. It was noted that there are only small numbers of paper insulated cables still utilised in Sussex Route.

Condition assessment data for all key DC electrification system assets between and including the AC circuit breakers and the DC circuit breakers in the Sussex Route has been collected for a number of years and was well evidenced. However, this is understood to have been based partly on requirements laid out by the ORR and partly to support Network Rail's own processes. As part of the Control Period 5 IIP process Network Rail established that this did not meet all of its own asset information requirements, particularly with respect to supporting the development of the new Tier 2 WLCC models.

As a result, as part of the ADIP initiative to identify and develop asset information gaps in support of the 2011 IIP, EP asset condition data was identified as a key workstream. Between March 2011 and June 2011 formalised asset condition data was evidenced to have been collated for key electrification assets across the Sussex Route. The data collated included condition assessments of all equipment between and including the AC circuit breakers and the

DC circuit breakers. This process utilised a new national Work Instruction and constituted a significant achievement in AMCL's opinion.

However, it provides only a first baseline data set in the new format for these key assets. While development of a whole-life cost model for EP is understood to have been developed, incorporating deterioration curves, validation of those deterioration rates will not be possible until more mature condition data is available. It could be argued that comparisons with other industries are possible for some asset types, such as transformers. However, equivalent assets used by DNOs, for example, are rarely in comparably hostile environments as those experienced in the railway. Network Rail has also acknowledged that the process used for this initial round of national electrification condition data collation requires further refinement and enhancement.

Conductor rail and associated trackside equipment are understood to not have a formal condition assessment process in place but are subject to 12 monthly inspections, although these are largely visual. This has recently been augmented in Sussex Route by the use of Infra-red equipment. These inspections drive subsequent WAIFs to rectify noted issues, although a number of these rectifications can no longer be undertaken live, limiting the opportunity to implement them.

Conductor rail itself is also subject to monitoring via the use of a laser equipped measurement train, although it was acknowledged that at the time of the review there were issues around the management and analysis of the large amounts of data generated by the train. Conductor rail renewals are understood to be based on the relevant wear data and associated components, such as DC cables, will be replaced at the same time as the conductor rail.

The experienced team in Sussex Route are considered by AMCL to have excellent tacit knowledge in the area of asset condition. This combined with the existing asset condition data is considered to facilitate budget prioritisation. Nevertheless, without verified deterioration profiles and a quantified understanding of the current and likely future condition of assets it is difficult to justify interventions to proactively mitigate performance issues. Mature, quantified condition data and deterioration profiles for electrification assets is considered an asset information gap which could impact performance.

5.5.4 Asset Information Gaps

Considering the key elements of asset information, as defined in Network Rail's own 'Asset Information Strategy Vision & Approach'[2], a summary of the key gaps which actively impact on performance of the Sussex Route is shown in Table 4 below.

ID	Asset Information Element	Sussex Route Status
0	What & Where	The what and where of asset data is deemed suitable following the relatively recent DQuIP and ADIP initiatives to improve asset data nationally. Both Brighton and Croydon MDUs show 99% plus Ellipse data completeness in the latest national league tables and are compare well in relative terms with the other MDUs. Extensive knowledge of the asset base was also demonstrated by the individuals interviewed through the review process. Although this information element could clearly impact performance, there is not considered to be a significant gap.
1	Capability (considered as capacity information for the purposes of this electrification focused review)	As discussed throughout the document, detailed quantified knowledge of the capacity of the electrification system is considered a significant gap in Network Rail's - not just Sussex Route's - knowledge. The experienced team in Sussex Route appear to have excellent tacit knowledge in this area but it is not currently extensively backed up with data. In conjunction with limited quantified knowledge of loading data, the direct impact on performance is evidenced by the component burn-out failures experienced, performance constraints, etc.
2	Work Bank	The strategic work bank and Control Period 4 Delivery Plan are considered to have been developed in accordance with relevant timetables and information. Sussex Route also appears to have generally sound maintenance intervention scheduling data in the Ellipse system - although some concerns regarding backlog and the information provided on Work Orders were identified (see Section 5.4.1). Sussex Route has also developed a number of performance improvement initiatives which it is implementing. Overall, there is not considered to be a significant gap in the asset information which directly and negatively impacts performance.
3	Condition	As per Section 5.5.3.

[2] Network Rail: Asset Information Strategy Vision & Approach, V1.3, March 2011

ID	Asset Information Element	Sussex Route Status
4	Utilisation (considered as load information for the purposes of this electrification focused review)	As discussed throughout the document, detailed knowledge of the load data for the electrification system is considered a significant gap in Network Rail's - not just Sussex Route's - knowledge. The experienced team in Sussex Route appear to have excellent tacit knowledge in this area but it is not currently extensively backed up with data. In conjunction with limited knowledge of capacity data, the direct impact on performance is evidenced by the component burn-out failures experienced, performance constraints, etc.
5	Performance	Performance data, as collected in TRUST, is not considered to be an asset information gap as such. However, the consideration of root-cause below the relevant TRUST categories and the potential skewing impact of 'Management TINs' are considered to be issues which do not support the optimised management of performance. This is further compounded by the issues identified with the root-cause data within FMS.
6	Cost Modelling	As noted above, whole-life cost modelling for electrification assets is understood to be under development as part of a Network Rail Centre process for the 2011 IIP. It is not currently considered as an asset information element with direct performance impacts on the Sussex Route.
7	Analysis & Decision Making	This element refers to the justification and evidencing of Asset Policies. Again, this is considered a Network Rail Centre process and not to have a direct impact on performance within the Sussex Route.

Table 4 Summary of Asset Information Gaps

6 Conclusions & Recommendations

6.1 Conclusions

The key conclusions of this report are:

System Level Planning

Demand analysis and understanding future capacity requirements is a long-term planning activity that needs to consider the needs of Control Period 5 and beyond. Historically, this system level planning has not been undertaken to a sufficient level of detail, or from a whole system perspective – therefore there are a number of findings related to the implications of this.

1) A number of recent electrification system failures on the Sussex Route were a result of the load demands identifying 'weak' points in the system, be they condition, manufacturing, materials or equipment rating issues.
2) Network Rail is currently unable to quantifiably determine the electrification system route capacity (supply) of the infrastructure or the continuous real-time load (demand) requirements of the train services that operate on it. Whilst both these measures are notably complex and dynamic, Network Rail does hold a certain level of knowledge, as well as undertaking modelling of capacity and testing of loads for specific purposes. However, without a full understanding of these measures, it is impossible for Network Rail to predict the performance of the electrification system.
3) Continuous real-time load data can only be provided by the installation of relevant load measurement transducers connected to a new SCADA (Supervisory Control and Data Acquisition) system. A new SCADA system is currently scheduled for commissioning in Control Period 5 along with fitment of transducers to new circuit breakers and retrofitting of transducers at existing 'node sites' where certain criteria are met.
4) In the absence of this strategic understanding of demand and the associated capacity and RAM requirements, Network Rail must be provided with longer notification periods in order to appropriately assess the potential impact of changes to train services or rolling stock on the electrification system.
5) The review has identified a key issue in managing performance is Network Rail's strategic approach to aligning electrification system capacity on the Sussex Route with future demand.

6) The available electrification system route capacity has been gradually eroded by increases in train services and the resulting increase in traction loads over the last few years, and no major enhancements to electrification system route capacity have been justified or funded beyond those identified as necessary for specific timetable changes.
7) Without the provision of electrification system route headroom, further incremental changes to train services or rolling stock may have a significant performance impact.

Maintenance Specification

Network Rail Centre is responsible for the development of Maintenance Standards so the following findings are likely to apply to all routes with similar electrification infrastructure to the Sussex Route.

8) Some analysis of maintenance fitness for purpose is undertaken, but this is not part of a formally documented engineering plan-do-review process.
9) The maintenance specification plan-do-review loop is limited by Electrification engineering resource constraints and prioritisation, based on criticality across Network Rail's electrification system asset base and there has been no quantified justification or optimisation of the Maintenance Standards for DC electrification system assets identified.
10) There is no current capacity or RAM specifications attributed across the DC electrification system hierarchy against which Maintenance Standards are meant to be delivering or measured.
11) Conductor rail equipment failures are considered by AMCL to have been impacted by degrading condition, outdated Maintenance Standards and a lack of specific Work Instructions.
12) A revised process for assessing and collating quantified condition data for some electrification system assets was introduced in 2011 but knowledge of degradation rates is currently variable across the DC electrification asset base.
13) In contrast, this review has found that Southern Railway Limited has a well documented engineering review and change management process to assure the completeness and adequacy of maintenance specifications.

Maintenance Delivery

14) The maintenance delivery plan-do-review loop utilised in Sussex Route is understood to be the generic approach used throughout Network Rail and generally forms a closed loop

process. However, a potential risk in relation to the satisfactory completion of the plan-do-review loop was identified during the review due to an inconsistency between electrification Maintenance Standards and the 'grace' period for closing out maintenance tasks within the Ellipse system.

15) Sussex Route has established a number of maintenance and intervention initiatives to mitigate electrification system performance issues in the short-term, including the introduction of inspection processes for conductor rail equipment, such as the use of infra-red equipment.

16) Maintenance Work Orders generated by Ellipse do not adequately detail the relevant Maintenance Standard or Work Instruction.

17) The lack of data captured in the Fault Management System is considered by AMCL to form a systemic constraint on failure mode based root-cause analysis, particularly for non-service affecting failures, across the asset base. This appears to be a generic issue that is not limited to electrification assets.

18) Quantified knowledge of electrification system condition and degradation profiling is limited, particularly with respect to conductor rail equipment.

19) Until detailed capacity and load information is available for the electrification system, Southern Railway Limited and Sussex Route will need to continue to work together to further mitigate performance issues..

6.2 Recommendations

The recommendations from this review to improve performance on the Sussex Route are listed below. They are grouped into one general recommendation and recommendations on the three areas discussed above of System Level Planning, Maintenance Specification and Maintenance Delivery.

General

1) Although the focus of this phase of the review was on the Asset Management of electrification assets, this was found not to be the largest driver of performance issues. Electrification assets were ranked 12th by annual delay minutes and 4th by total number of faults on the Sussex Route. Asset Management practices may also vary by asset discipline so consideration should be given to reviewing the Asset Management of other key asset types in a further review phase.

System Level Planning

These recommendations are strategic in nature and will need to be led by Network Rail Centre:

2) By April 2012, Sussex Route (with the support of Southern Railway Limited) should formalise appropriate notification periods for train service changes, recognising that the period of notification will be longer the more significant the change.
3) By April 2012, Sussex Route (with the support of Southern Railway Limited) should agree and establish an appropriate and continuously rolling long-term planning horizon for the Joint Performance Improvement Plan.
4) Prior to the submission of the Strategic Business Plan for Control Period 5, Network Rail should ensure proposals for the retrospective fitment of load measurement transducers to existing DC electrification equipment provide appropriate granularity of continuous real-time load measurement data to a central point to facilitate system performance prediction and aligns with the commissioning of the proposed new SCADA system.
5) Prior to the submission of the Strategic Business Plan for Control Period 5, Network Rail should further develop the 'Sussex Route Traction Power Strategy' in line with Policy Number EP-127 'Power Strategy' of the draft Control Period 5 Electrical Power Asset Strategy, including outline designs for increasing the electrification system route headroom to agreed levels.
6) By the end of Control Period 4, Network Rail should determine a methodology to determine electrification system route capacity and electrification system route headroom.
7) Within the first year of Control Period 5, Network Rail should ensure that all appropriate projects provide electrification system reinforcement not just to meet the requirements of the projects and but also to provide or maintain an agreed level of electrification system route headroom. This will require justification and may require the provision of appropriate funding.
8) Within the first year of Control Period 5, Network Rail should develop the proposed more 'nimble' approach to Electrification System Modelling to inform strategic thinking and the early stages of projects as an alternative to the existing complex systems.

Maintenance Specification

These recommendations are strategic in nature and will need to be led by Network Rail Centre:

9) By April 2012 Network Rail should ensure that Ellipse Work Orders include specific reference to, or appropriate details of, the current Maintenance Standards or Work Instructions.
10) By April 2013, Network Rail should develop an appropriate suite of conductor rail equipment Work Instructions and identify and fill any further gaps in DC electrification system maintenance documentation.
11) By the end of Control Period 4, Network Rail should establish a Southern DC Electrification System Network Management team to determine the procedures, processes and systems required to manage and develop the Southern DC electrification system and propose an organisation, taking into account the practices of Distribution Network Operators and equivalent organisations.
12) Within the first year of Control Period 5, Network Rail should adopt a Reliability. Availability and Maintainability specification based approach to the maintenance of DC electrification system assets, with appropriate apportionment of targets across the system.
13) Within the first year of Control Period 5, Network Rail should systematically review and quantifiably optimise, on a cost-risk basis, all DC electrification maintenance regimes, in accordance with the established Reliability, Availability and Maintainability requirements.
14) By April 2012, Network Rail should establish appropriate Maintenance Standards, Work Instructions and competency arrangements for the use of infra-red equipment on DC electrification equipment.

Maintenance Delivery

These recommendations are tactical in nature and will need to be addressed by Sussex Route:

15) By April 2012, Sussex Route should establish a process to ensure that the engineering root-cause of electrification infrastructure faults is fully captured within FMS and used to justify all relevant performance improvement initiatives.
16) By April 2012, Sussex Route should formalise the process to liaise with Southern Railway Limited, undertake on site-investigation as appropriate and rapidly determine the root causes and agreed resolutions for conductor rail and train shoegear incidents..

Appendix A Ellipse Maintenance Cycle

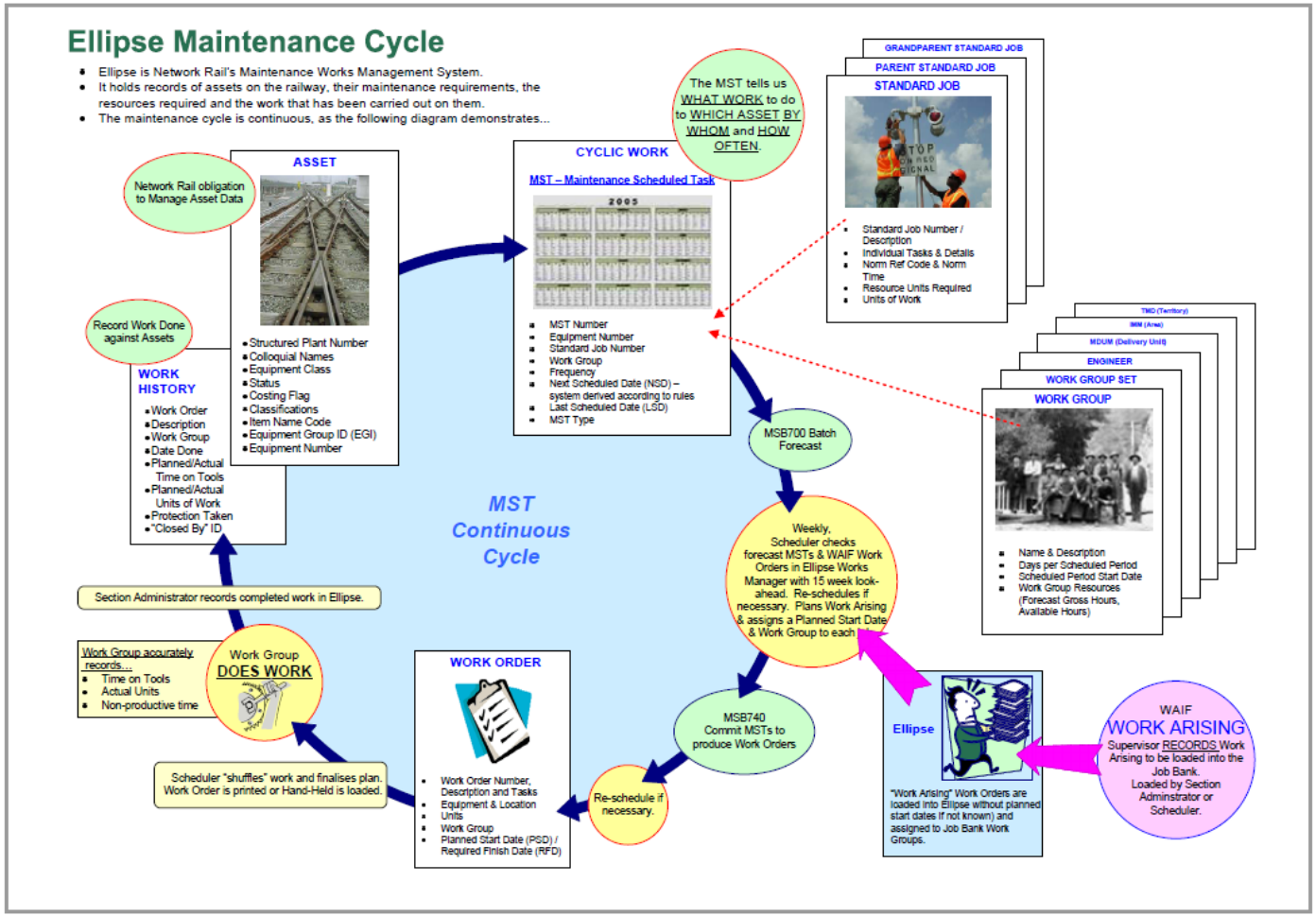
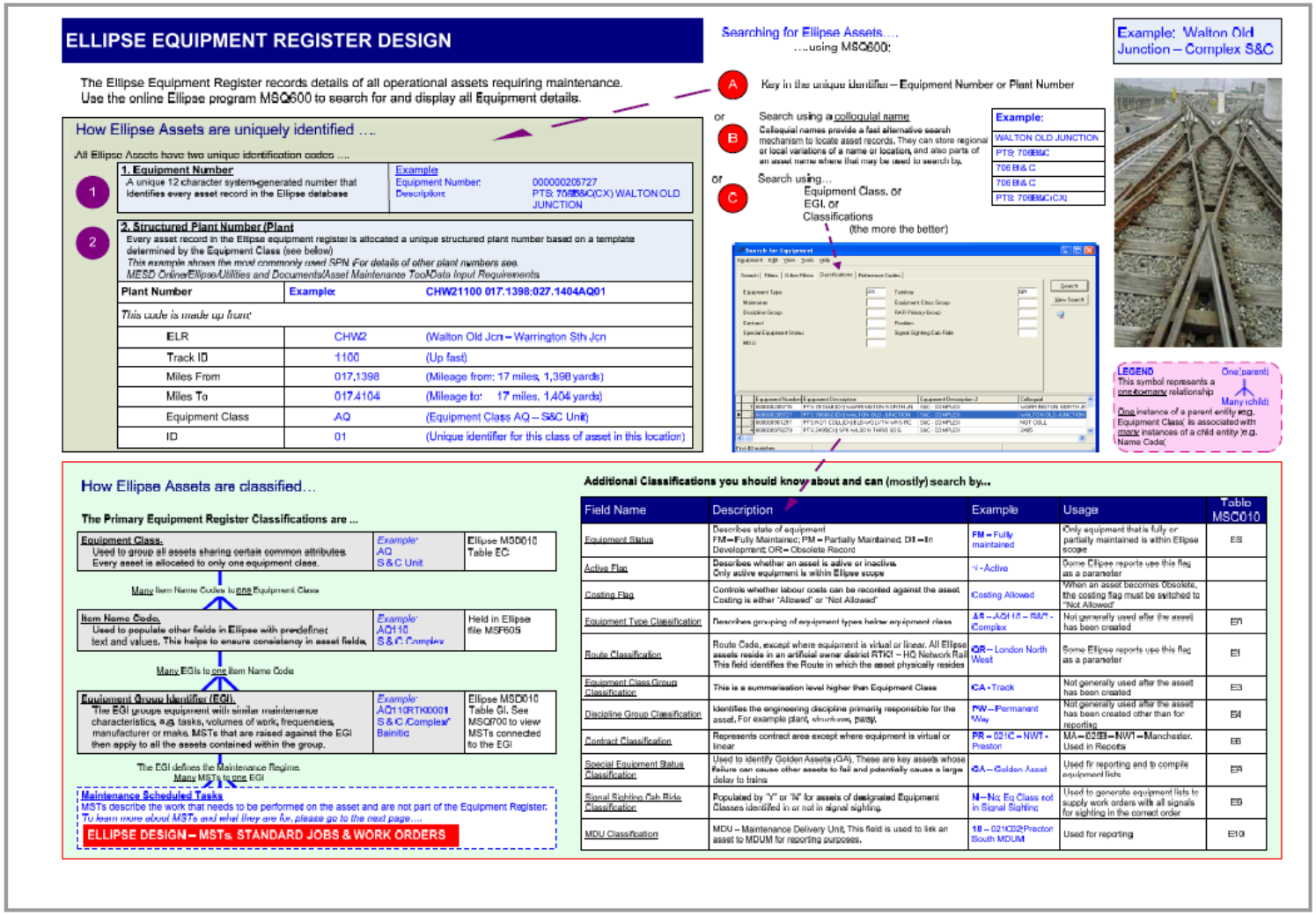


Diagram 29 Network Rail's Ellipse Maintenance Cycle

Appendix B Ellipse Equipment Register Design



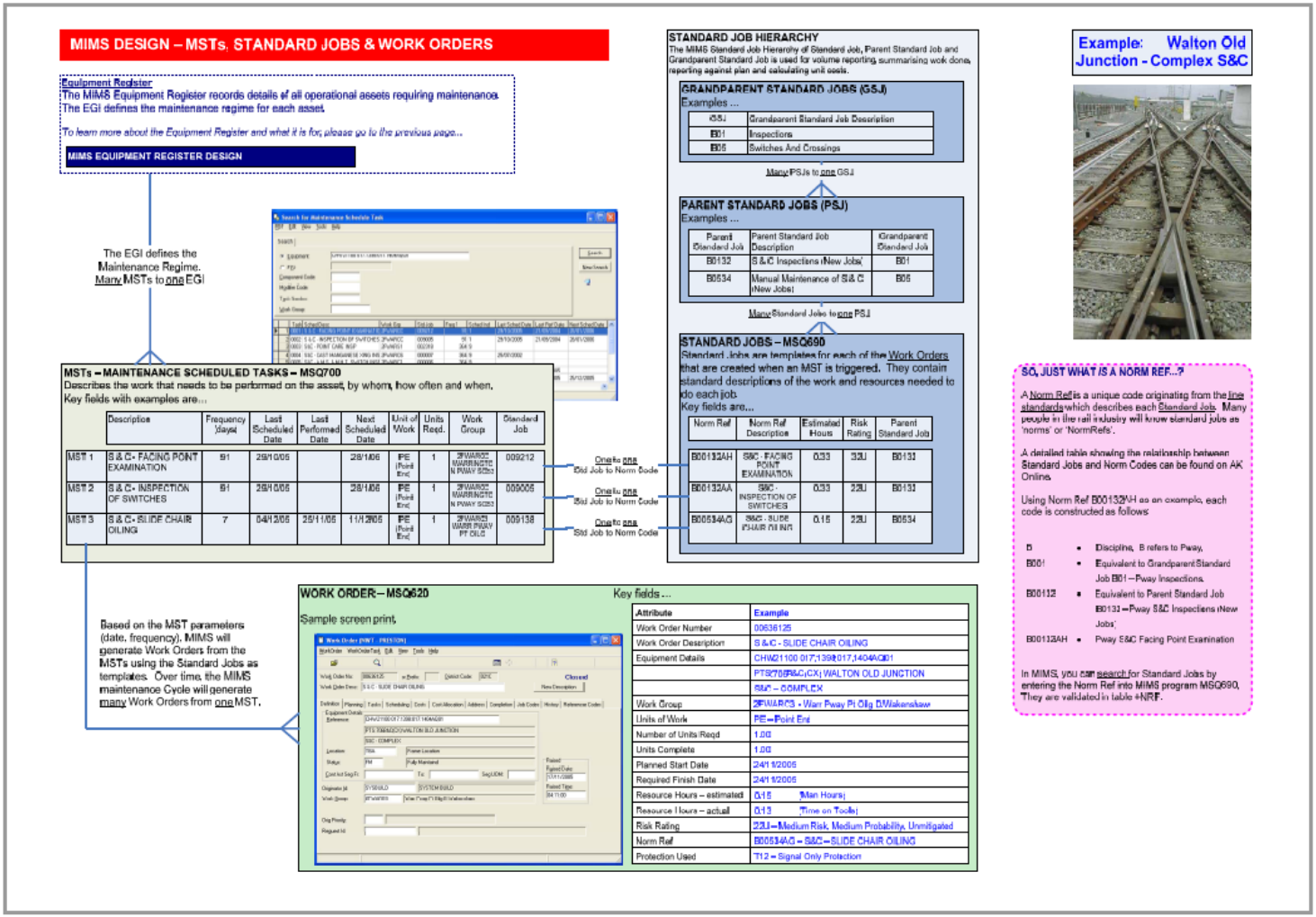


Diagram 30 Ellipse Equipment Register Design

Appendix C List of Interviewees

Name	Organisation	Role
Mac Andrade*	Network Rail	Route Infrastructure Maintenance Director
Cliff Elsey*	Network Rail	Route Asset Manager (Electrification)
Gavin Hobbs*	Network Rail	E&P Maintenance Engineer
Bob Cookson*	Network Rail	E&P Maintenance Engineer
Richard Langham*	Network Rail	Route Support Manager
Jamie Green*	Network Rail	Infrastructure Maintenance Performance Manager
Gerry McFadden*	Southern	Engineering Director
Dave Hickson*	Southern	Fleet Engineer - New Trains
Matt Edmonds	Network Rail	Assistant E&P Maintenance Engineer
Dave Poole*	Southern	Fleet Performance Manager
Spencer Thompson*	Network Rail	Head of Asset Management (Electrification)
Chris Rowley	Network Rail	Senior Network Planner
Phillipe Belvier	Network Rail	Acting Head of Traction Power Design Team
Ollie Glover	Network Rail	Route Performance Manager
Alan Thorpe	Network Rail	Systems Support Manager
Simon Green*	Southern	Head of Fleet Engineering
Ruth Clifton	Network Rail	Senior Sponsor
Joel Mitchell	Southern	Head of Performance
Richard Stainton	Network Rail	Professional Head Electrical Power
Liam Sumpter	Network Rail	Infrastructure Maintenance Delivery Manager
John Bartlett	Network Rail	Infrastructure Maintenance Engineer
Chris Vessey	Network Rail	System Support Manager
Paul Harwood	Network Rail	Principle Network Planner
Tony Francis	Southern	Standards Engineer
Dan Ward	Southern	Systems Engineer

* Indicates multiple interviews

Appendix D Backlog Trends

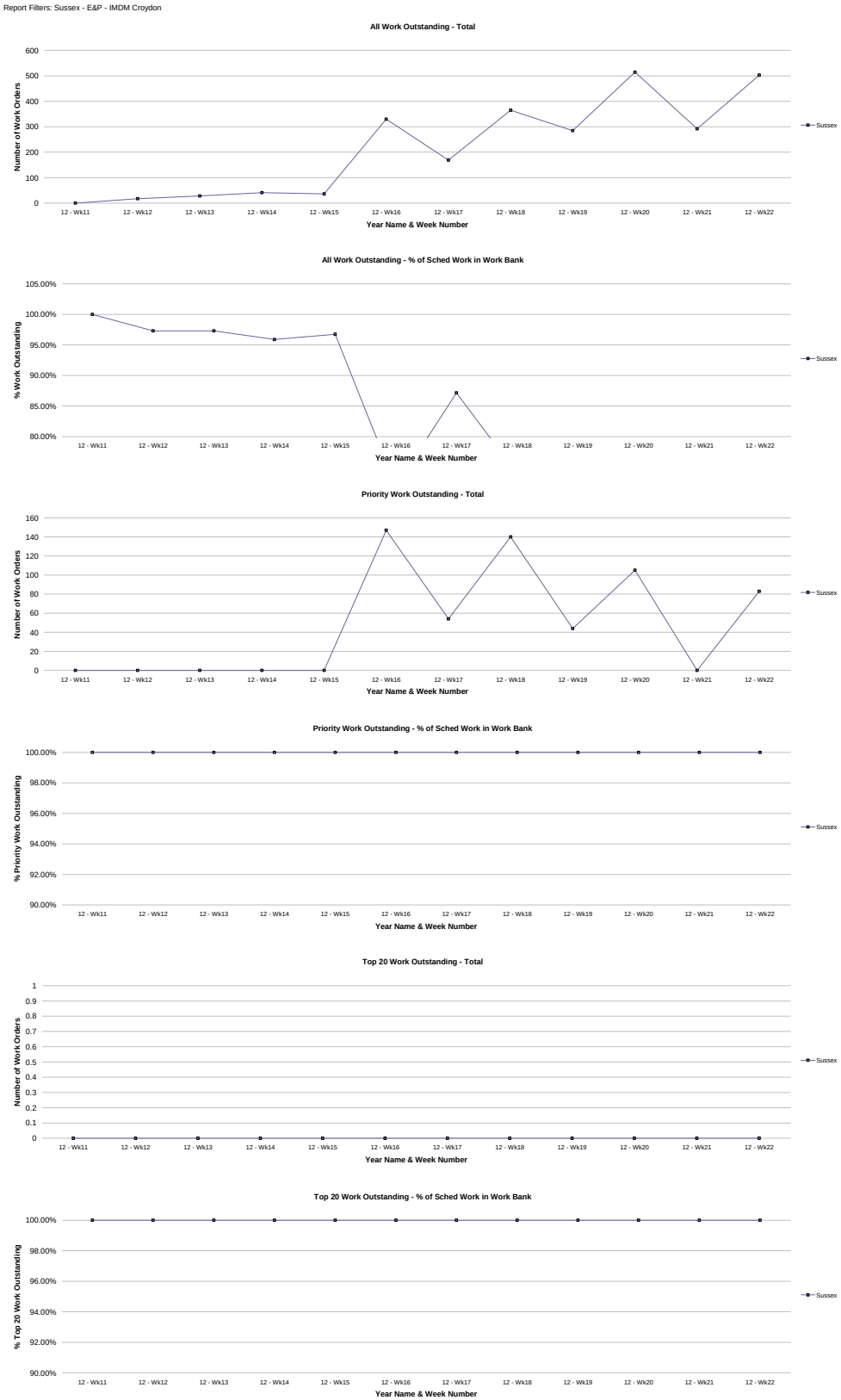


Diagram 31 Backlog Trends - Croydon MDU

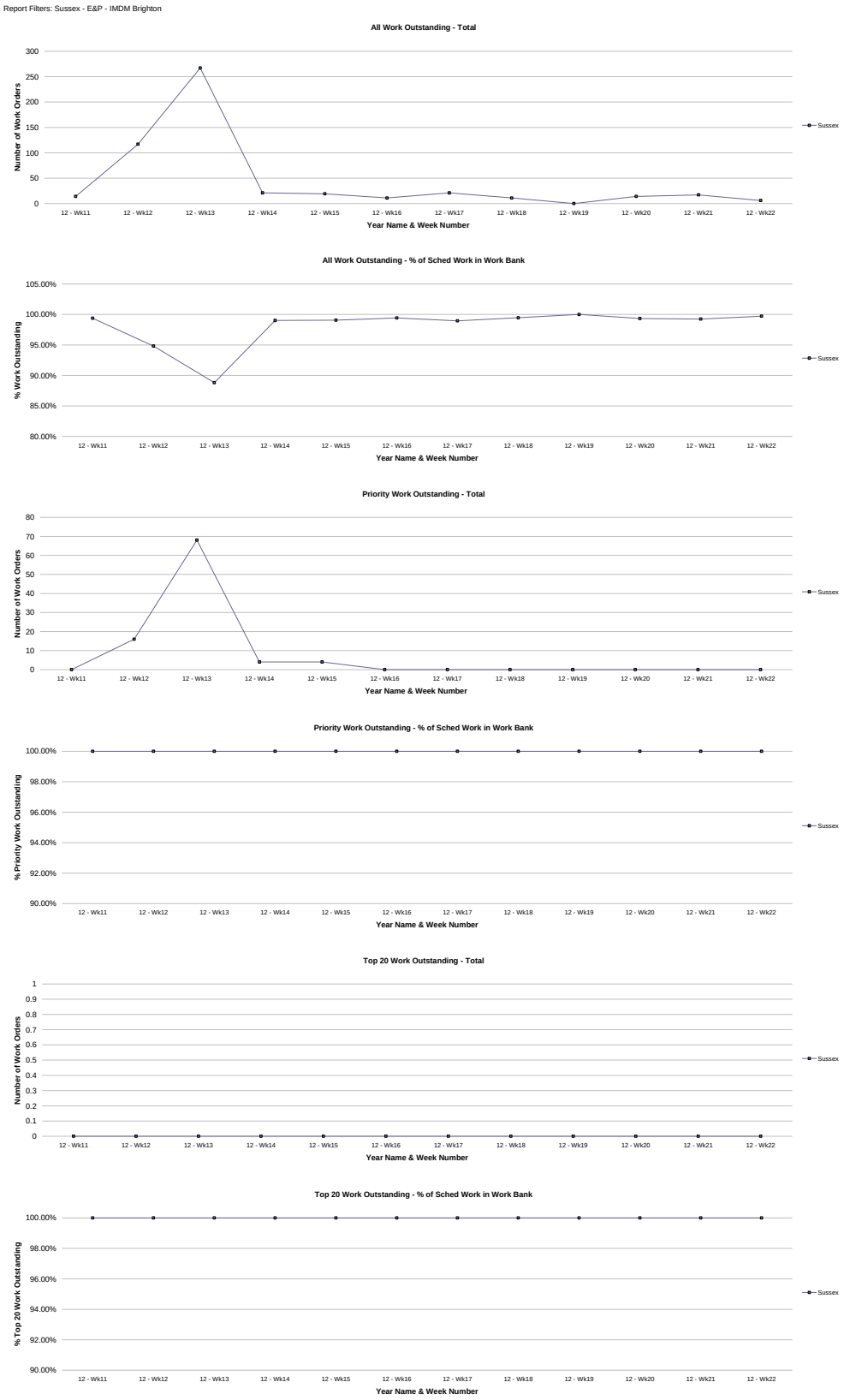


Diagram 32 Backlog Trends - Brighton MDU