The Twenty Point Plan

Fleet Management Good Practice Guide

Issue 16.1

Rail Delivery Group

National Rail

AMENDMENT RECORD

Issue	Dated	Notes
16.1	July 2025	'Light touch' update to historical references and hyperlinks within all 20 Point Plan sections. Note: No major content changes have been made to sections as part of this update.
16	October 2024	Update to subsections within Section 2: Fleet Reliability, reflecting Mp701D as the prime measure of fleet reliability.

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Foreword

Running trains on time has been our customers' top priority, whether they are commuter or leisure travellers or businesses that send freight by rail. Meeting this need is of utmost importance for all of us in the rail industry, as running trains on time has a direct impact on customer satisfaction. It is important, for the industry - as well as its stakeholders – to strive for a punctual, reliable and safe service.

Since the COVID-19 pandemic, it has been more challenging to meet customers' needs, due to the increase in the number of passenger and freight trains running on the network. As a consequence there is an increased impact on punctuality and reliability when trains are delayed or cancelled due to issues with rolling stock. The challenge is intensified by the high volume of changes, including fleet overhauls, new fleet introductions and cascade programmes, combined with unforeseeable issues affecting the global supply chain.

A cross-industry programme to enable the improvement of rail network performance is being driven by the Network Performance Board (NPB) which includes TOCs, Network Rail, the DfT and the ORR. This has been brought into sharp focus in the light of the recent NPB refresh and the new Network Performance Restoration Framework which aims to arrest the long-term decline in performance and lay the foundations for a reliable railway – where the Fleet community is ready to work collaboratively across departments both within their businesses and external stakeholders to address fleet performance issues. Fleet Challenge Steering Group (FCSG) and Fleet Reliability Focus Group (ReFocus) provide members with the platform to engage and discuss fleet performance challenges and share knowledge.

The 20 Point Plan is the practitioner-created guide to help businesses deliver improvements in their rolling stock performance through willingly sharing hard-earned knowledge and good practices. The continued evolution of the plan is a visible demonstration of the will that different businesses have in collaborating to meet the challenge of providing reliable, punctual journeys for passengers. Its value comes from the fact that what is shared are things that practitioners and experts have found to work in practice.

The 20 Point Plan captures good practices that will improve the experience for our passengers. Amongst these good practices are improving the reliability of new trains entering service and of trains returning from overhaul, reducing technical events that cause delay, promoting collaboration and the use of modern diagnostic tools to recover from failure faster.

Our industry is changing and evolving and keeping the 20 Point Plan up to date, relevant and useful is essential to enabling our success.

Daniel Mann

Director, RDG Industry Operations

Meeting the Challenge

The Fleet Reliability Focus Forum (ReFocus) was introduced by the Engineering Council in November 2010 and tasked with identifying best practice and sharing knowledge amongst rail industry partners such as TOCs, OEMs, ROSCOs, Network Rail and others. This forum has made a very valuable contribution to fleet delivery over this time and continues to provide an evolutional good practice guide to support the industry.

ReFocus captures knowledge through peer groups who are experts and this knowledge is then incorporated in the Fleet Management Good Practice Guide.

ReFocus has developed new sections of the Guide and revised existing sections. Sharing knowledge and best practice ultimately allows TOCs and their partners to deliver a reliable and punctual service.

However, the railway still faces many challenges. With the increase in demand and society's expectations constantly evolving, it is attracting more and more customers and businesses. This creates significant challenges, with historic methods of delivering continuous improvement only able to provide marginal benefits. A more holistic view, covering not only the technical aspects but also the people and the culture, will need to be explored and set out in the Guide. This includes integrating new technology, data, people and processes to allow for more trains to run on an increasingly busy network.

ReFocus has made real progress in tackling some of these problems by working with industry partners and not just on a fleet-centric basis. This allows us to comprehensively examine generic railway issues by working with operational colleagues and Network Rail, as well as other industry partners such as the OEMs and the ROSCOs. This collaborative approach has enabled us to update the Fleet Management Good Practice Guide to reflect today's thinking.

ReFocus also takes a holistic view of society and cultural challenges in order to drive change. It looks at technology and innovations that allow new processes and practices to be developed and addresses the gaps where clear value can be added. This knowledge is used to inform other industry strategy groups, such as Fleet Challenge Steering Group, of gaps and shortfalls which may need addressing now or in the near future.

Other industries face similar challenges to the railway with ever-increasing demand from users and the constant need to move forward and deliver a reliable and safe service. Benchmarking with other industries gives members opportunities to transfer knowledge and incorporate it within their own business.

Mark Johnson (Engineering, Technology and Contracts Director, Southeastern Railway)

Chair, Fleet Reliability Focus Group (ReFocus)

Contents

What is the purpose of this document?

The Twenty Point Plan (20PP) is the current industry view of how to maximise the reliability of the UK national rolling stock fleet. Where helpful, it includes examples of best practice.

Who is it for?

Train Operating Company (TOC) engineering teams, new engineering directors and fleet managers and other rail partners to help them:

- decide which issues to concentrate on in their own organisation and who to visit to see best practice so that they can develop their own ways of managing their fleets to increase reliability, and
- develop relationships and partnerships

Who owns it?

The Fleet Reliability Focus Forum (ReFocus).

What / who is The Fleet Reliability Focus Forum?

ReFocus is a voluntary group of railway engineers who have accountability for rolling stock. Attendees include The Network Performance Board (NPB), TOCs, Rolling Stock Leasing Companies (ROSCOs), Original Equipment Manufacturers (OEMs), Network Rail and the Department for Transport (DfT).

What does The Fleet Reliability Focus Forum do?

ReFocus seeks to improve train performance through a better understanding and sharing of knowledge. A number of activities are undertaken, such as:

- collating and sharing national data – consistently produced to independently audited and agreed criteria.
- fleet comparisons and benchmarking – understanding reliability differences and challenging delivery where appropriate.
- spreading best practice – 20PP implementation follow-up, site visits.

Simplifications

The UK rail industry involves different parties with different divisions of labour. The typical model of a TOC with a soggy lease from a ROSCO is generally used to simplify interpretation of the 20PP. Similarly, references to DfT include the Welsh Assembly Government and the Scottish Government as appropriate. The principles apply irrespective of which party is actually undertaking each activity.

1. Summary

This document has been developed by fleet engineers for fleet engineers to help improve rolling stock performance.

This issue contains:

- Fleet Reliability (Section 2) – Fleet Technical Incidents (701D), Miles per 701D Incident (Mp701D) and Fleet Non-Technical Incidents (701A).
- Management for Improvement (Section 3) – principles, methods and examples to motivate sustained improvement, including Day-to-Day; Monitoring and Feedback; Change Management; Risk Evaluation.
- Seasonal Management (Section 4) – maximising the level and consistency of fleet performance during seasonal variances by operations and engineering working together to produce robust and effective management plans. This section is intended to promote a structured approach to seasonal planning and operations.
- Train Preparation (Section 5) – this section places emphasis on the plan, do, review process to ensure fleet safety, reliability and presentation.
- Delivering the Service (Section 6) – engineering, operations and planning understanding each other and pulling together: depot planning and train planning (e.g. Rules of the Depot); faults and failures (e.g. 2-way communications); measures of fleet performance. Working together on seasonal preparedness is vital.
- The Depot (Section 7) - the key frontline resources of fleet maintainers: depots (design, capacity and capability), their management and staffing, including motivation, training, skills development and competence assessment; the High Performing Depot Specification.
- On-Depot Fault Finding (Section 8) – this section explores good practice for on-depot fault finding, especially around No Fault Found; also, the best procedure for establishing robust fault finding.
- The Vehicles (Section 9) – the core activities of fleet maintainers: collecting and using data (Failure Mode Analysis, condition monitoring, analysing trends); managing repeat defects, deferred work and configuration control; developing the maintenance regime; understanding availability.
- Managing Ageing Rolling Stock (Section 10) - The purpose of this section is to increase awareness and knowledge of the factors to consider when identifying and managing ageing rolling stock and how to mitigate the impacts to avoid significant reliability and performance reduction.
- Electrical and Electronic Overhaul (Section 11) - This section covers the key areas to consider regarding electrical & electronic overhaul: Planning, Sharing information and Technical investigation
- The Infrastructure (Section 12) – how to manage engineering interfaces between vehicles and infrastructure (relationships, preventing problems).
- Managing Fleet Incidents (Section 13) - incidents on the railway will impact the whole system, usually measured in train delay minutes. This section includes guidance on how fleet incident management is best implemented.
- Supply Chain (Section 14) – having the right parts when and where required (spares holding, floats, measures, link to risk, change control, obsolescence, forecasting) and improving the quality of the parts through effective closed-loop relationships.
- New Train Procurement (Section 15) – how to buy a new train fleet for best 'out-of-the-box' service performance, risks associated with whole fleet behaviour following introduction.
- No Fault Found (16) - focuses on rolling stock component warranty claims where the supplier cannot find a fault with the returned component.

- ROSCOs (Section 17) – how ROSCOs can facilitate reliability improvement throughout vehicle lives, including fleet management plans; user groups and common issues; optimising for duty cycles.
- Overhaul Management (Section 18) – there is a recognised risk that a vehicle re-entering service post-overhaul suffers from a reduction in reliability; this section aims to address the issues which cause a fleet's reliability to decline.
- Outsourced Maintenance (Section 19) – best practice in TOCs managing outsourced maintenance, connection to training and development of 'in-house' skills and competences (principles are also relevant to TOCs which do most of their work in-house).
- Business Continuity Management (Section 20) – how any business can prepare and implement the strategic and tactical capability of the organisation to plan for and respond to incidents and business disruptions in order to continue business operations at an acceptable pre-defined level.

2. Fleet Reliability

This section specifies the common fleet reliability and performance measures used by the fleet community. It clearly defines the principle measures which are reported to ReFocus, describing what should be and should not be included in the data.

2. Common Reliability Data

The key measure agreed by Fleet Challenge Steering Group and reported by ReFocus is Miles Per 701D (**Mp701D**), a measure of the reliability of fleet. The underlying data for this measure is provided to ReFocus at an individual fleet level and reported back each industry period.

Note: Mp701D is the prime measure of fleet reliability reported by ReFocus.

In addition to Mp701D, data is also collated from fleet engineers to record:

I. Number of AWS/TPWS 701D Incidents
II. Total Number of Non-Technical (701A) Incidents
III. Total Number of Out-Of-Use toilets, in service on all fleets, across the period

Each of these measures are reported to ReFocus at TOC level only.

2.1 Miles per 701D Incident

2.1.1 DEFINITION

Incidents that occur as a result of the technical failure of on-train equipment are coded to 701D. Mp701D is a measure of the engineering reliability of trains expressed as the average mileage between 701D codified incidents that are associated with a 3 minute (or more) primary delay on one journey and/or result in any cancellation (or part cancellation). Mp701D is reported for individual fleets. The measure is produced by RDG from data provided by TOCs with operational control as shown in *Table 3*. The operating TOC is accountable for fleet reporting to RDG but for subleased fleets, the lessor and lessee should agree between them who is responsible.

2.1.2 SOURCE OF UNDERLYING DATA

The mileage is derived from actual fleet unit/trainset mileage as recorded in GEMINI or equivalent. Note that an HST trainset counts as 1 unit, not 2 power cars and x trailer cars separately, so the unit miles equate to the train miles. Two 2-car 150/2 sets working in one train count as two units and therefore its unit miles are twice the train miles.

Information relating to 3 Minute Delays is derived from TRUST, COMPASS, Control Logs and/or BUGLE. All sources need to be scrutinised for the relevant fleet codes as appropriate for each TOC.

2.1.3 DETERMINING THE NUMBER OF 701D INCIDENTS

In all cases, a 3 Minute Delay is defined as a train incident which results in a delay of 3 or more primary minutes to that train where the root cause is a technical or maintenance-related defect on the train. Any such incident which results in a cancellation or part cancellation is also included.

2.2 Fleet Technical TRUST Incidents - 701D

In order to make good business decisions, good data and information is a fundamental requirement. TOCs therefore need excellent Delay Attribution processes in place that result in accurate data stored in TRUST (Train Running Under System TOPS). This assists the wider industry to accurately establish the national picture in terms of fleet reliability performance.

In terms of 'Fleet' there are two 'KPI categories', namely: 701D: FLEET (TECHNICAL) and 701A: FLEET (NON-TECHNICAL).

Table 1 lists all the TRUST incident cause codes for a 701D incident.

Note: This table is fully aligned with the content of the latest version of the Delay Attribution Principles and Rules (DAPR) document available from Network Rail.

Table 1 – 701D Applicable Cause Codes

Code	Description	Abbreviation	Use Cases / Delays and Cancellations associated with technical faults to:

M0	Delays associated with faults relating to train-borne safety systems within the cab	CAB SAFETY	• Driver Safety Device (DSD)
			• Driver Vigilance Device (DVD)
			• Global System for Mobile Telecommunications – Railway (GSM-R) hardware confirmed fault, including:
			  ○ Cab radio will not switch on or boot up
			  ○ Cab radio locks up or freezes and cannot be used – normally accompanied by a fault message and code such as 'Radio Failure 0x' – where x is a number between 1 and 7; or 'Cab Radio Fault' and 'Control Panel Failure'
			  ○ Calls cannot be made due to a defective train aerial.
			• Warning Horn
			• On Train Data Recorder (OTDR)
			• Radio Electronic Token Block (RETB) Equipment
			• Speedometer
			• Headlight or Tail Lights

M1	Delays associated with faults with the Pantograph, ADD, train borne power switch over systems and PANCHEX activations	PANTO/AC	Delays associated with faults in the train borne power change over equipment. Confirmed Pantograph Automatic Dropping Device (ADD), associated system faults, positive PANCHEX activations and train borne power switch over systems (AC) such as: • Pantograph • PANCHEX Activation • Automatic Dropping Device (ADD) **Note: PGD17 Incident Investigation Template – Appendix 3 outlines how such incidents should be investigated** • Automatic Power Control (APC) • Automatic Power Change Over (APCO) train borne equipment **Note 1: Refer to Code 'NA' for balise controlled system failures** **Note 2: This code is used for balises that are defective or fail if the affected infrastructure mounted balise is the**

			responsibility of the Train Operator and not Network Rail. • Where two or more consecutive trains, that utilise the same Balise, fail to recognise that Balise (where Balise is the responsibility of the Train Operator and not Network Rail).
M2	Delays associated with faults affecting the train-borne train control / signalling systems	ETCS / CBTC	Delay associated with the trainborne ETCS/ERTMS/ATO/CBTC system • Automatic Train Operation (ATO) system • Communications Based Train Control System • European Train Control System (ETCS) • European Railway Traffic Management System (ERTMS)
M7	Delays associated with faults with train doors and associated systems	DOORS	• Crew Doors • Passenger Doors • Gangway Doors • Toilet Doors • Cab Conversion Doors • Door open incidents • Delays associated with faults in the train borne Platform Identification Beacon System (PIBS) equipment e.g. Not-balise controlled Selective Door Operation (SDO) system **Note 1: Refer to Code 'NA' for balise controlled SDO failures** **Note 2: This code is used for balise failures if the affected infrastructure mounted balise is the responsibility of the Train Operator and not Network Rail.** • Where two or more consecutive trains, that utilise the same Balise, fail to recognise that Balise if the affected infrastructure mounted balise is the responsibility of the Train Operator and not Network Rail
M8	Delays associated with other technical faults above the Solebar	ABOVE SBAR	• Cab Heating, Ventilation and Air Conditioning (HVAC) • Saloon HVAC • Internal Lighting • Vacuum Circuit Breaker (VCB) • Line Breaker / High Speed Circuit Breaker (HSCB) • Toilets • Window faults – excluding windows broken by vandalism or external causes • Faulty passenger facilities e.g. seating • Fire (not caused by vandalism) **Note: PGD17 Incident Investigation Template – Appendix 1 outlines how such incidents should be investigated**
M9	Delays associated with train-borne systems where NO FAULT is found with the train-based equipment or the track	FLEET NFF	The Train Operator staff are unable to find the reported train-related safety problem or can prove the report to be false. • A single train fails to interact with infrastructure mounted system (balise) correctly on one or more occasion. Such systems include: o Automatic Power Control (APC) o Automatic Train Protection (ATP) o Automatic Warning system (AWS)

			○ European Train Control System (ETCS ○ Automatic Power Change Over (APCO) ○ Platform Identification Beacon System (PIBS) ○ Selective Door Operation System (SDO) ○ Radio Electronic Token Block (RETB) ○ Train Protection and Warning System (TPWS) • Global System for Mobile Telecommunications – Railway (GSMR-R) fault is reported on a train, but no fault can be found. • Where one train fails to recognise a Balise but subsequent trains, utilising the same Balise, recognise it and no fault is found with the affected train.
MB	Delays associated with Electric locomotives	ELEC LOCO	• Electric locomotive systems • Fire (not caused by vandalism)
MC	Delays associated with Diesel locomotives	DIESL LOCO	• Diesel locomotive systems • Fire (not caused by vandalism)
MD	Delays associated with other technical faults below the Solebar	BELOW SBAR	• Air System • Propulsion system: ○ Transmission ○ Drive Train ○ Engine ○ Gearbox ○ Final Drive ○ Traction Motor • Train Electrical System • Batteries • Fire (not caused by vandalism) **Note this includes delays associated with known defective trains operating in service, including:** ○ Trains with part-defective traction systems ○ Tilting trains with defective tilt systems.
ME	Delays associated with Steam Locomotives	STEAM LOCO	• Steam locomotive systems • Fire (not caused by vandalism) • Lineside fire caused by steam locomotive
MG	Engineering technical failures/defects associated with T+RS that has just come off depot	OFF DEPOT	Technical failure off depot • Equipment left isolated from depot e.g. Door locked out of use, TPWS isolated, etc. • Equipment fails off depot e.g. repeat failure of windscreen wiper or Loss of power
ML	Delays associated coaching stock (or wagons for freight trains)	WAGN / COACH	• Coaches • Parcels vehicles • Wagons
MN	Delays associated with brake and brake system faults –	BRAKE/WHLS	• Brake system ○ Air/pneumatic ○ Electrical/dynamic • Wheel Slide Protection

	including Wheel Flats		• Wheel Impact Load Detection (WILD), WHEELCHEX or GOTCHA Activation • Poor brakes • Wheel Flats

MQ	Delays associated with faults with 3rd rail, shoe beam and train borne power switch over systems (DC)	SHOE/DC	Delays associated with faults in the train borne power change over equipment. Confirmed shoe beam or associated system faults Incl. train borne power switch over systems (DC)
			• 3rd Rail Collector Equipment:
			  ○ Shoe beam
			  ○ Slipper
			  ○ Shoe shunt
			  ○ Pedestal
			• Blown shoe fuse
			• Train borne power switch over systems (DC)
			Note 1: Refer to Code 'NA' for balise controlled system failures
			Note 2: This code is used for balises that are defective or fail if the affected infrastructure mounted balise is the responsibility of the Train Operator and not Network Rail.
			• Where two or more consecutive trains, that utilise the same Balise, fail to recognise that Balise (where Balise is the responsibility of the Train Operator and not Network Rail).

MR	Delays associated with train-borne sander or scrubber faults	SANDER	• Sanding system • Wheel scrubber
MT	Delays associated with train-borne Safety System Faults (Not Cab Based)	SYST FAULT	• Automatic Train Protection (ATP) • Automatic Warning System (AWS) • Hot Axle Box detection (HABD) e.g. confirmed hot axle box. • Wheel Impact Load Detector (WILD) • Track Circuit Actuator (TCA) • Train Protection Warning System (TPWS)
MW	Delays associated with the effect of non-severe weather on the train	WEATHR FLT	Non severe weather causing problems to individual passenger Fleet equipment types. **Note: 'VW' exception if there is severe weather affecting most modes of transport.** • Water Leaks (associated with precipitation) • Windscreen wipers • Frozen equipment – where prior mitigation has not been carried out, e.g. couplers; doors; air systems; etc. • TOC Directive preventing trains from passing through standing water at a level where the rule book allows movement of trains. • Running Brake Tests due to weather • Running at reduced speed due to frozen brakes • Fleet imposed restrictions due to weather e.g. reduced speed operation through flood water
MY	Delays associated with Coupler, Coupling system and	COUPLER	• Coupler mechanism • Coupler buttons • Coupler control system • Intercar Jumpers/connective cables

	jumper cable faults – excluding track or driver based issues		
NA	Delays associated with balise activated train-borne systems	TASS/TILT	• On-board Tilt Authorisation and Supervision System (TASS) • On-board Selective Door Operation (SDO) • On-board Correct Side Door Enable (CSDE) **Note: Incidents should be coded 'IM' if the infrastructure mounted equipment is defective.**

Note: The cause code 'MP' for rail-wheel interface adhesion problems (including ice on the running rail) falls under KPI category 750 "Low Adhesion inc. Autumn (Train Operator)".

2.2.1 Clarification on what should be included as a 701D incident:

- Incidents caused by the technical failure of a train component or system. This is regardless of whether that component or system is under any warranty.
- Incidents on empty stock moves caused by the technical failure of a train component or system, regardless of whether or not a passenger service has been affected.
- Incidents caused by the failure of a component or system caused by poor maintenance instructions or regime or by a maintainer incorrectly following the correct procedures.
- Incidents where delay has been exacerbated by operational error or inaction but where the root cause was technical or maintenance-related.
- Incidents caused by technical failure even in the event of adverse weather or other conditions.
- Incidents as a result of known defective trains being in traffic.
- Incidents where subsequent investigation cannot identify a technical fault e.g. No Fault Found / No Defect Found.
- 701D should include repeat failures of trains for the same technical defect. Note: Such incidents should be dealt with in accordance with the agreed procedures (described in sections E4.5-E4.7 inclusive) of the Delay Attribution Principles and Rules.
- Failure to stop incidents resulting in part or full cancellation or delay should be included if the root cause is the technical failure of a train component or system.

2.2.2 Clarification on what can be excluded (as a 701D incident) following successful reattribution:

- Train incidents caused by human vandalism.
- Train incidents caused by proven infrastructure defects.
- Train incidents caused by any external cause as per the Delay Attribution Principles and Rules, i.e. unrelated to a technical or maintenance-related train fault (for example, brake defect due to equipment damaged by suicide), or extreme contamination.
- Operational problems associated with stock availability, (i.e. provision of the wrong stock type or short-formed services), unless the operational problem has been caused by rolling stock that has become defective after having been declared fit for service to Operations (i.e. train has been prepped and a diagram allocated) or due to restricted train formations (i.e. multi-only operations).

2.2.3 Clarification on merging incidents:

Delay Attribution should be undertaken at Level 1, but where this has not been possible - for a train where multiple incidents have been created for a single train journey in TRUST, they can be combined. For example, if a long-distance train has a traction fault and as a consequence generates multiple TRUST incidents on its London-bound journey - then these incidents can be merged in accordance with agreed industry Delay Attribution processes.

However, if the TRUST incidents have been created on the same day for the same piece of rolling stock whilst working different trains/journeys, these incidents should NOT be merged and each incident must be treated separately for Mp701D reporting purposes.

2.2.4 No Fault Found:

Where a reported defect is No Fault Found, the 3 Minute Delay will remain, even if the problem has not been definitively understood or resolved, until it has been possible to prove beyond reasonable doubt that the defect did not occur and the associated delay has been reattributed to the party responsible (see 2.2.5 - Disputing incidents). Evidence from OTDR, TMS or similar analysis carried out using traditional fault-finding is acceptable.

2.2.5 Disputing incidents:

This applies when Fleet department believe an incident should be disputed and there is no initial evidence to indicate the incident was due to a technical failure, but there is evidence that this incident should be referred to another area of the business. It is worth bearing in mind two factors here:

- The purpose of delay attribution is primarily to collect data on asset failures - would your dataset be better or worse without the incident?
- Is any other party better placed to deal with (and prevent recurrence of) the incident than Fleet?

A flow chart was developed by a subgroup of Fleet Reliability Focus Forum members in the review of Issue 10 of the 20PP and is provided in Appendix A to aid decision-making.

2.3 Fleet Non-Technical TRUST Incidents - 701A

A non-technical incident is allocated to code 701A in TRUST when such an incident causes a total delay of 3 or more minutes, or a cancellation (or part cancellation) at any point for a single root cause where the root cause is related to 'fleet' management activities. Where applicable, this can be considered as an approximate measure of respective TOC depot performance.

Non-technical should not be used for incidents attributed to staff incompetence. *See Section 2.2.1.*

The number of incidents is aggregated over all fleets and depots that were impacted, along with the delay minutes.

Table 2 lists all the TRUST incident cause codes for a 701A incident.

Note: This table is fully aligned with the content of the latest version of the Delay Attribution Principles and Rules (DAPR) document available from Network Rail.

Table 2 – 701A Applicable Cause Codes

Code	Description	Abbreviation	Use Cases / Delays and Cancellations associated with the following:
MF	Off depot non-technical fleet delay	NON TECH	• Doors left isolated by cleaners • Coolant checks by fitters • Fuel checks by fitters • Fitter completing other non-technical inspections • Global System for Mobile Telecommunications – Railway (GSM-R) Railway Emergency Call (REC) initiated in error from a train cab that is on the Network Rail Network by a member of train maintenance staff or a train cleaner.
MS	Planned Underpowered or Short Formed Service and/or Vehicle – including Exam Set Swaps	ALOC STOCK	• Shortage of serviceable rolling stock i.e. Availability shortage. • Operating stock with a lower maximum speed to maintain the Sectional Running Times e.g. 75mph stock operating a 100mph service. • Stock Change / Set swap as a result of a 'Fleet' request • Operating a 'short-formed' service e.g. 4-car vice 8-car; 9-car vice 11-car • Operating a 'long-formed' service e.g. 5-car vice 4-car; 11-car vice 9-car • Operating 'non-tilting rolling stock' over a route that needs 'tilt' in order to meet the Sectional Running Times. **Note: PGD16 Stock Swaps Scenarios and Delay Allocation provides further detail**
MU	Depot Operating Problem	DEPOT OPS	• Operating problem or mishap at an off-Network Rail network location affecting trains entering or leaving that location, including: ○ Staffing problems ○ Congestion ○ Planning issues ○ Shunting problems ○ Problems with another Operator's train ○ Operator of train waiting outside the location does not provide information on an incident

			- Parts of the depot unavailable to use e.g. defective track, defective pointwork, local power supply outage etc. • Units late off maintenance • A REC is initiated off Network Rail Network, in error from a train cab, preventing trains from accessing the network and/or the off-Network Rail network location, including where it has not been possible to identify the person initiating the REC. • Objects that are thrown or fired at trains or Network Rail Infrastructure from depots. • Non-severe weather causing passenger depot operating problems **Note: 'VW' exception if there is severe weather affecting most modes of transport.** • Fire in depot (not caused by vandalism)

2.4 Splitting incidents

Where an incident delay or cancellation has been attributed in a way such that it has been split between different Responsible Managers, the following applies:

If, following an agreed Responsible Manager 50:50 split of any incident – should the threshold of 3 minutes primary delay remain attributable to fleet for that incident (and by default any part cancellations) then that incident should be counted as a full 701D (or 701A) incident - as appropriate.

2.5 Data submission

RDG contacts fleet operators at the beginning of week 2 to request the data required to complete *Table 3* by the end of week 2 (Friday). Each TOC submits data for <u>every vehicle</u> they operate.

2.6 Data resubmission

No formal process is in place to refresh data post-TOC submission. However, amendments can be made at RDG's discretion. All amendments must be submitted to the RDG data analyst for approval. Resubmissions must be of significance to avoid continuous changing of TOC reports.

Table 3 – example of TOC report containing the new measures

FLEET RELIABILITY DATA ENTRY

Industry Period : 1 Year : 2024/25

TOC : TOC A

Enter fleet data in yellow cells.

FLEET	Number of Units/ Trainsets	Total Number of Vehicles	Vehicles per Unit	Unit Mileage	No. of 701Ds (as per 20PP)
Class XXX	15	75	5.00	184,609	18
Class YYY	56	574	10.25	1,172,436	99
Class ZZZ	8	40	5.00	34,298	3

Number of TPWS/AWS 701Ds : 0

Number of 701As: 177

Toilet KPIs

	UAT	Non-UAT
Total Number of Toilets[1]	4622	7536
Number Out of Use [2 3]		
Tanking	5	4
Others	52	19

[1]Total number of toilets daily, put into service on all fleets, summed across the period

[3]Total number of "Out-of-use" toilets, daily, in service on all fleets, summed across the period

[2]Definition of "Out of use"

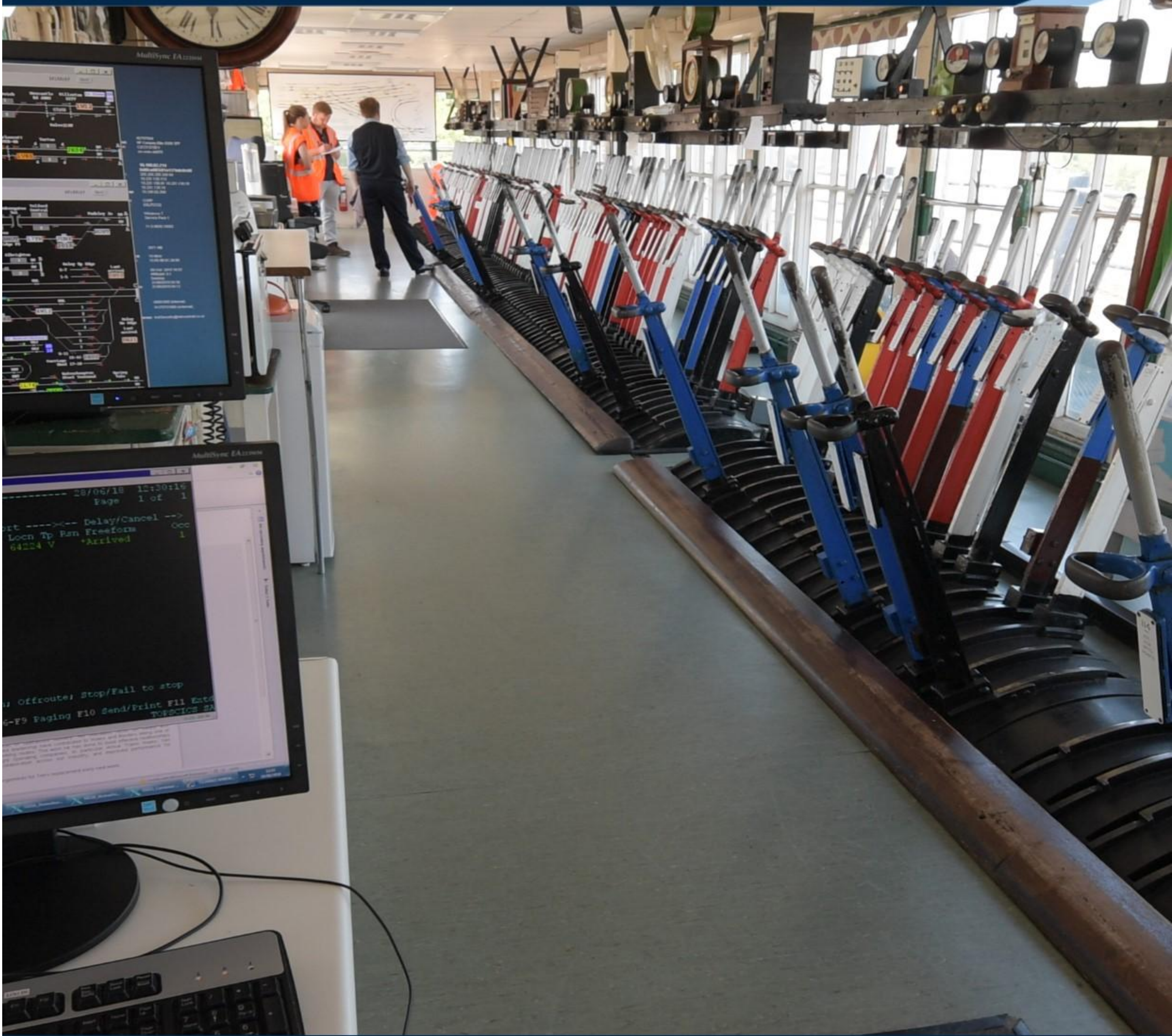
Tanking

Tanking unavailability (Refill water) or Emptying (CET)

Others

Door does not opens, closes or locks
Toilet unit does not flushes or empties
Tap does not dispense water
Sink does not drains

3. Management for Improvement



This section provides guidance for designing effective risk-based management approach. As well as how to achieve day-to-day management objectives through monitoring and feedback techniques.

3 Management for Improvement

3.1 Principles

Sustained reliability improvement is closely associated with structured management processes. Ideally, these processes form a framework within which individual activities are shaped to achieve maximum benefit. To assure success, Operator contracts/concessions and business objectives should be used as the primary focus for developing initiatives. Best practice views management for improvement in three phases:

a) Design – to establish long-term sustained progress
b) Change – to implement design changes through projects
c) Sustain – to focus on monitoring, analysis and feedback to motivate further improvements

A) Management process design should:

i. Evaluate depot/facility capacity and capability to ensure engineering objectives can be fulfilled
ii. Evaluate short- and long-term staff and resource requirements to match commitments and plans
iii. Specify skills and competences required by staff to support current and future obligations
iv. Develop a data structure capable of measuring both process and vehicle performance
v. Specify maintenance plan controls
vi. Establish appropriate relationships internally and externally with suppliers of spares and components, ROSCOs and any other maintenance services
vii. Identify the management routines through which each element of the design will be implemented or employed to achieve maximum benefit

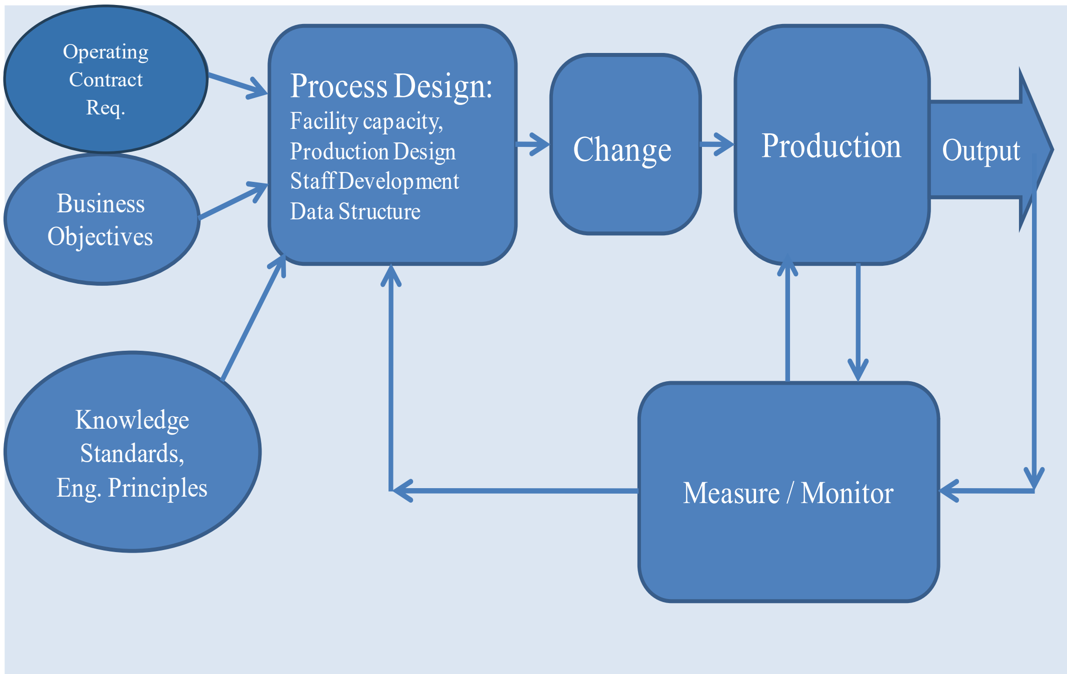
B) Change projects should:

i. Ensure all staff are fully aware of changes and participate in them and are competent to perform new roles where required
ii. Ensure all risks and cross-functional links are identified and appropriately managed
iii. Be coordinated to ensure that the extent and pace of each one does not put overall performance (or that of other change projects) at risk

C) Sustaining processes should:

i. Establish, integrate and analyse all data sources, including measuring the effectiveness of change projects
ii. Identify where and how to change and improve process design

In summary, a structured management process framework for reliability improvement can look like this:



3.2 Risk Evaluation

It is often difficult to apply a management process framework. It should be led by business priorities, with an underpinning engineering risk assessment to inform decision-making and achieve timely and effective improvements. Train operators need to understand the relationship between operational performance and the work undertaken on vehicles.

An example methodology is set out in 3.2.1. below. Whatever method is used, the outcome should:

- Identify the most important maintenance tasks (including intrusive tasks, e.g. component exchange and overhauls, which are major risk sources)
- Review and restructure internal training and competence development techniques to minimise risks
- Inform decisions on the procurement of any maintenance and/or design services
- Motivate relationships with suppliers of services, especially overhauls and any contracted-out maintenance work
- Inform the analysis of engineering design changes

Note: The Railway Undertaking is accountable for controlling the same risks, whoever performs the work on the vehicle. This document does not discuss procurement decisions (as we reiterate in *Section 17*), but the management of underlying engineering risks is crucial to performance and an essential element in any robust decision-making process.

3.2.1 **Risk Evaluation Examples**

In this approach, a model of the vehicle/train is the foundation for all subsequent work. Firstly, all recognisable components are identified uniquely and grouped into systems, such as air, brakes and doors. However, each system encapsulates all the components required for it to perform its specified functions, regardless of the components' specific characterisation. As a result, the system may contain a complex combination of mechanical, electrical, electronic, pneumatic and other types of component. Clear system boundaries and unambiguous function definitions are required.

Operational events are then associated with the degradation of systems and their constitutive components, identifying those that pose the greatest potential risk to operational safety and reliability. One immediate consequence is that a single outcome may arise from many potential root causes.

Components may be ranked according to their propensity (when degraded) to lead to specific operational hazards and events. For example, in terms of safety-related risks, a single point component failure leading to a catastrophic consequence would naturally rank more highly than a minor hazard involving the simultaneous and serial degradation of a combination of components.

To complete the analysis, the maintenance plan should be reviewed

- to identify possible omissions;
- to rank all tasks in relation to their potential to affect the vehicle risk profile; and
- to identify the impact of internal and supply chain activities.

See below for some (worked) examples.

Defect Condition	Failure Effect	Hazardous Consequence	Principal performance improvement factors to be considered
Wheel pan casting defect, notch or other similar condition affecting mechanical integrity	Crack propagation leads to fragmentation of wheel	Vehicle derails Collision with infrastructure Collision with another rail vehicle Flying debris impacts adjacent infrastructure and/or staff and customers	Single point failure with potentially catastrophic consequences All tasks associated with the manufacture and maintenance of wheelsets are critical Internal training and staff competence are critical Supply chain relationships and competences critical Training and competences internally and in supply chain must include importance of adherence to standards and consequences of poor compliance At level 4, instructions required specifically to assist identification of degraded conditions
Brake actuator slack adjustor mechanism failure	Actuator fails to apply brake on one wheel	Marginal effect on braking performance	A single point failure with little potential to cause significant risk
Multiple brake actuator slack adjustor mechanism failures	Many actuators fail to apply brake causing significant loss of brake force	Station overruns SPAD Collision with infrastructure or other rolling stock	The simultaneous failure of many components is required to produce a significant consequence This could be associated with accumulating unnoticed degradation of equipment over time requiring a review of level 4 maintenance tasks, training and competence arrangements This could alternatively be associated with overhaul standards requiring review of supply chain relationships, application of maintenance tasks and use of appropriate competences
Combined power brake controller internal component loose, degraded, worn	Power demand cannot be removed without recourse to emergency override device Brake cannot be applied without use of emergency override device	Station overruns SPAD Collision with infrastructure or other rolling stock	Single point catastrophic failure affecting whole train brake, mitigated by emergency override device but dependent upon driver response Status of component therefore critical Design standards and materials used for controller components are critical Manufacturing process control critical to operational reliability of component Maintenance and overhaul standards and supply chain relationships are critical

Threaded fixings of incorrect grade or surface finish used to assemble bogie	A single component failure likely to lead to cumulative failures of others Performance of affected major components compromised Potential for major component to come adrift Structural integrity of bogie at risk	Loss of brake system functionality Derailment Detached component strikes adjacent infrastructure or staff and passengers Vehicle strikes infrastructure or other rolling stock Loss of traction system performance	A single point failure possessing the potential unless detected to degrade performance and safety All maintenance tasks requiring use of threaded fixings are critical. Work control for this type of task is critical Material management activities, kitting and access/ availability of material are critical Both logistics and maintenance services supply chain are critical Training and competence must include guidance on the identification of degraded components and failure mechanism to mitigate risk of compromised performance and structural integrity

3.3 Day-to-day processes

Reliability is improved through sustained and rigorous attention to detail and compliance with published standards, with ownership of all issues.

Robust management

- ensures that routine maintenance tasks are always performed in accordance with standards;
- ensures that defective equipment conditions and remedial actions are always recorded;
- asks repeatedly, “why?” to get to the root cause of an issue. Once the real root cause is understood, it can be addressed and fixed.

It is common knowledge that typically half of Train operator’s fleet root causes are not about modifying the train, but due to other issues, such as:

- maintenance quality (which may relate to staff morale, training, facilities);
- defect management (to get to the root cause, e.g. including train drivers in closed loop processes);
- management of contingency and redundancy (including robust plans and feedback on performance).

Maintenance quality and **defect management** should be measured and trended, e.g. % maintenance ‘own goals’ (errors, failure to remedy all issues so repeat defect arises).

Example: Northern undertakes routine ’in-process’ audits of equipment condition and evaluates the findings using a rigorous condition-based quantitative assessment. The results are linked to compliance with maintenance standards. Trends over time are used to tackle poorly performing systems and components. The data is used to assess staff competence too. Feedback is used to review maintenance standards, material and component quality and staff training programmes.

Example: A Train Operator asked “why?” through their defect management process and classified every incident into 10 different cause codes. These go beyond naming the failed parts to assigning management responsibility. Each cause code (including No Defect Found) has an ’owner’ in fleet management, whose objective is to reduce the number of incidents. In the example below from a best practice TOC, maintenance own goals are 11%.

Fleet Incidents by Cause Code		TOTAL
9	Material Quality / Supply	1%
8	External / Passenger	0%
7	External / Network Rail	0%
6	Traincrew Error	2%
5	Climatic / Railhead	2%
4	Maintenance (Non) Compliance	11%
3	No Defect Found	24%
2	No Fleet Awareness	1%
1	Confirmed Technical Fault	42%
0	Asset / Heavy Maintenance	18%

Significant improvement can often be made without making changes to the train itself.

Example: Class 333 reliability doubled without any modifications thanks to a joint effort between Northern, Angel Trains and Siemens involving high-level buy-in (steering group attended by 3 directors), plus a project manager from each company, working groups and team ethos.

The same maintenance quality and defect management principles apply equally to specific systems and whole fleets.

Example: recommendations from the sliding door comparison made across several fleets

- Cultivate good incident reporting
- Do not attempt to rectify door faults in service – lock them and label them out of use until they can be properly rectified
- Remember the importance of staff training and the benefits of having only competent staff maintaining and repairing doors
- Ensure sufficient time is allowed for door maintenance to encourage attention to detail and to find and rectify faults
- Consider the benefits of increasing the content and frequency of door mechanical jobs and door pocket cleaning
- Avoid extended time between door overhauls
- Implement Remote Condition Monitoring Systems to identify ‘outliers’

Example: TPE were seeing 10-12 flat battery incidents on Class 185 per period. Battery discharge was compared with design capability and changes made to maintenance, cleaning and traincrew practices (e.g. using shore supply) to better suit battery capability. The revised train disposal arrangements are checked through periodic TMS downloads which identify potential problems. The incidence of flat batteries is now so low that a technical modification is not considered necessary.

Contingency management includes robust planning processes where the benefits (e.g. of having sufficient trains and enough time to maintain them properly) are weighed against the costs (e.g. of leasing additional stock). Significant, cost-effective improvements can be made through timetabling and clever use of the timetable.

Example: Chiltern have some short diagrams that return to Aylesbury depot on which units with hard-to-identify faults can be deployed. This reduces the risk of service disruption and enables in-service monitoring that facilitates progressive fault investigation and rectification.

Redundancy management includes feedback to understand whether levels are correctly set.

Example: Alstom along with the train operator used OTDR/TMS to count how many more yellow signals trains see in practice. With the high number of yellow signals on certain routes, trains cannot run to timetable if one traction pack is out. As a result, they revised their redundancy plan accordingly and are working with Network Rail to resolve the root cause.

Collective sharing includes learning from the successes (and failures) of others, pooling data and combining efforts, e.g. user groups, ReFocus meetings and visits, best practice sharing.

3.4 Periodic review and feedback

Diligent day-to-day activities support the routine periodic review of operational performance and process KPIs. Periodic reviews should use quantitative evidence to verify that the design analysis of depot capacity, resource levels and production planning arrangements continues to be adequate. Results should be used to revisit underlying assumptions, assess the effectiveness of change projects and as a basis for further improvement projects.

Routine activities are performed within a designed environment (*see 3.1 above*) and even the most competent frontline manager will be overwhelmed by over-optimistic availability targets, insufficient resources or inadequate depot capacity. *Section 7* looks at the depot in more detail.

3.5 Change management

Key elements of change management include: cross-functional, senior level commitment; involvement from all staff; working towards a common project structure; planned and staged implementation of individual projects; sufficient resources and feedback.

Robust day-to-day management can be undermined by inadequate change processes.

Overall, industry best practice includes:

- Strategic analysis of objectives to identify and prioritise processes/activities which need improvement
- Early engagement of all relevant stakeholders at a sufficiently senior level
- Publishing a structured plan showing the staging and implementation of all projects (to prevent detrimental impact on day-to-day routines)
- A risk-based approach covering both technical and soft issues, as well as cross-functional links
- A clear and common template for all projects
- Recognising the link between technical and process change, simplifying management controls and training requirements
- Configuration controls for vehicles, maintenance plan and supply chain

and for every project:

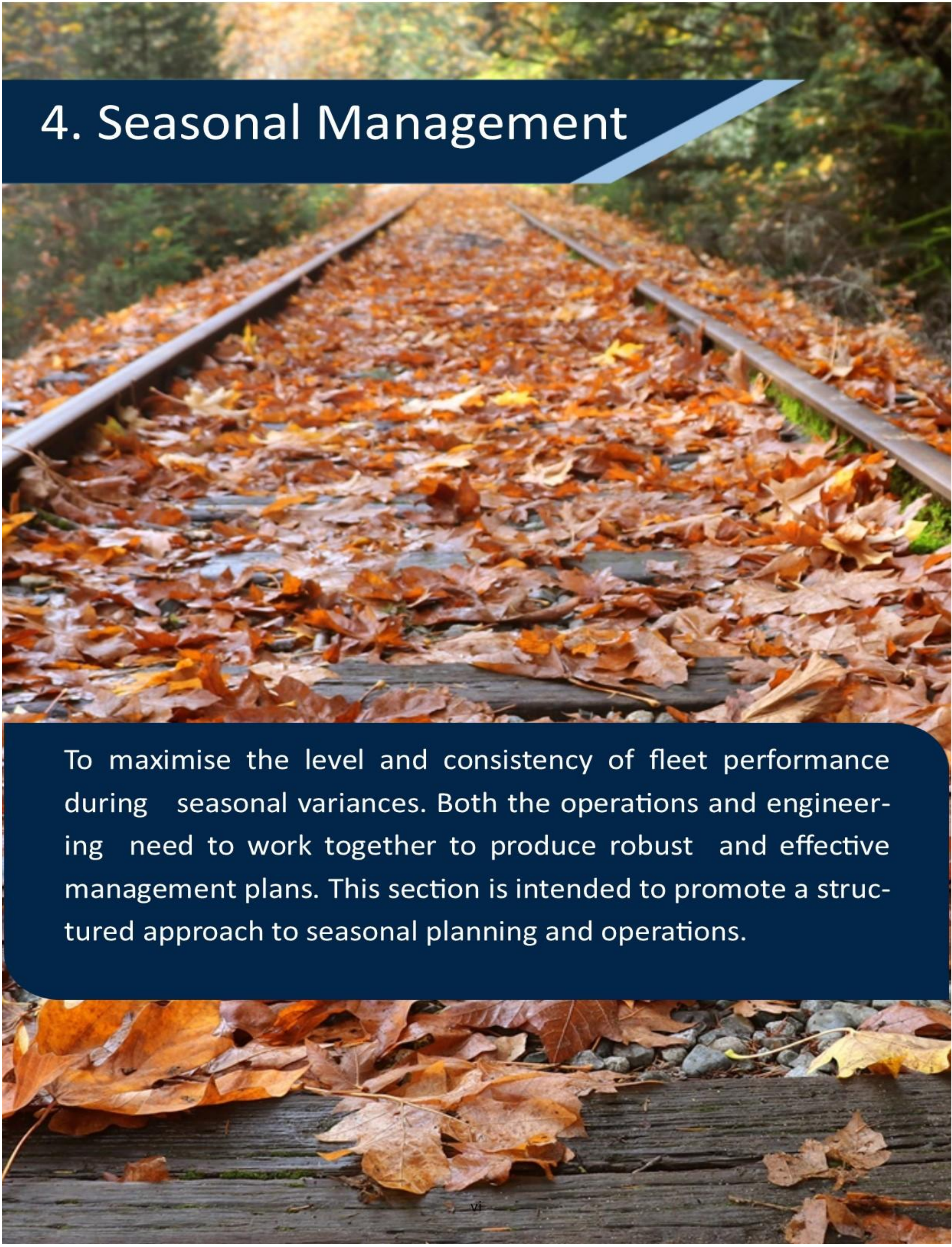
- A clear and achievable remit and timescales
- An appropriately skilled project manager supported by a suitable team
- Sufficient resources
- Strong involvement of staff whether directly associated with the project or not

Example: Northern has developed a comprehensive set of business objectives and identified the management processes to improve in order to achieve them. This means focusing on input to achieve fundamental and sustained output improvements. Using this structure, a standard change implementation plan has been developed to ensure that each project is fully resourced and can be completed on time without posing significant risk to day-to-day service delivery. All projects follow an identical template for easy monitoring by managers and staff.

Example: Class 350 new train introduction. Siemens Northampton's major project involved training maintenance staff and drivers in Germany many months before the start of service.

Example: Northern staff participate fully in change projects and understand what is happening when they are briefed on progress and impact.

4. Seasonal Management



To maximise the level and consistency of fleet performance during seasonal variances. Both the operations and engineering need to work together to produce robust and effective management plans. This section is intended to promote a structured approach to seasonal planning and operations.

4 Seasonal Management

4.1 Introduction

Seasonal ambient temperature variations and weather can adversely affect the performance of traction, rolling stock and rail head conditions if they are not recognised and planned for. Different types of rolling stock may be affected in different ways, so a thorough understanding of seasonal effects on a particular rolling stock and processes in place to minimise them are essential.

Plans need to take into account the time of year, so a weather calendar or seasonal preparation plan should be visible at all levels. Progress against targets should be monitored and KPIs developed to allow for future analysis. Any plans and processes in place to manage seasonal changes must be controlled through a constant review cycle and the plans for seasons management should recognise that seasons start at different times of the year and plans must be flexible enough to accommodate this.

The guidelines below are intended to promote a structured approach to seasonal planning and operations. Individual TOCs and maintainers should review them with key stakeholders in the context of their own operations and take measures they feel appropriate to meet their business needs.

To maximise the level and consistency of fleet performance during seasonal variances, operations and engineering need to work together to produce robust and effective management plans.

Seasons management should be viewed as an integral part of processes, change management, maintenance cycle and normal performance improvement and treated as the norm, not as an additional function/process.

4.2 Common seasons processes

4.2.1 Analysis of previous data

Review changes from previous years	Design specification changes
Think about design changes	Slips, trips and falls
Modifications	Process changes
People competencies	Maintenance actions/cycles
Trains	Depot infrastructure
Performance	Station overruns
Mp701D (Miles per 701D Incident)	PPM (Public Performance Measure)
DPI (Delays Per Incident)	Delay minutes
Cancellations	Material usage
Seasonal variances in stock levels	Supplier performance
Killfrost (did it perform at the desired temperatures?)	Product development with suppliers
New replacement products available	Safety review
SPADS and location	Poor braking and location
NIRs	Passenger and traincrew
Environment condition	Air conditioning/heating when a train is in a failed state
Lighting conditions	Frozen footsteps

4.3 Planning for winter

The following section addresses planning issues for winter and has been extended to consider prolonged periods of extreme weather conditions.

To ensure good service reliability and availability going into the winter period, efforts should be made to ensure that fleet condition and service continuity can be sustained given the inevitable degradation of fleet condition and deferral of maintenance arising from extreme winter weather. Efforts should be made to reduce demand/outstanding work prior to winter operation.

The industry guidance on preparation for and operation during winter (GEGN8628) was developed to capture all lessons learned and good practices.

This section comprises six sub-sections:

4.3.1 Standard winter preparedness

Initial winter preparedness is largely around enhancing vehicle maintenance plans to ensure that an acceptable level of winter operation can be maintained. This should only be used as an initiator for winter planning. Vehicle maintenance plans may not cover all areas critical to maintaining service during winter. This section should be used to enhance fleet winter operations.

Key risk areas must be considered to ensure the effectiveness of any plans. The list is not exhaustive and should be adapted to meet your specific needs:

- Vehicle maintenance should undertake an annual review and look-ahead process to consider how effective standard winterisation tasks have been and what needs to be incorporated into exams going forward, e.g. pipe equipment, lagging, horn trace heating, air system pre-treatment, pre-filtration of electrical machines, etc.
- It is helpful to differentiate between what should be classified as winterisation and what should be included in standard maintenance tasks. Winterisation should be aimed at specific winter preparedness and not used as an opportunity to catch up on previously deferred work, for example to get heating systems working again post summer operations.
- Development of specific winter exams (that are not lost within general exams).

<u>Stock holdings</u>

- A key material stock holding review should be conducted well in advance of the winter period. Deployment of critical spares to strategic locations should be planned and implemented to support the operational requirements of the fleet.

<u>Safety risks and performance risks</u>

- Winter 'survival kits', i.e. appropriate clothing, tools, local support networks to be defined and allocated within the winter plan.

<u>Depot & infrastructure</u>

- Winterisation checks on key plant and equipment such as wash plants, fuel, CET, etc.
- Gritting rosters.
- Supply chain in place to support the availability, potentially at short notice, of critical plant, i.e. space heaters, etc.
- Thorough materials planning paying particular attention to critical stock holdings of killfrost and thaw granules, etc.

- Contingency plans: alternative suppliers should be identified to support existing supply base
- Review depot-based risk assessments to ensure the adequacy of mitigation arrangements
- Ensure availability and preparedness of road vehicles, etc. (snow chains, availability of 4x4s)
- Ensure availability of equipment for local deployment, i.e. shovels, rock salt, etc.

Operations planning

- Review of business continuity management plans
- Consider depot and infrastructure facilities: clear access to the depot
- Operational restrictions and trigger events: clarify the triggers to move to the next level of winter management and how these instructions will be communicated
- Consider a cut-and-run policy review to ensure disruption is minimised
- Consider staff deployment at local stations and other key locations to allow the service to be maintained
- Winter competence development: define clear roles and responsibilities, develop a training plan to reflect the requirements of the organisation

Weather forecasting management

- Ensure that 28-day, 7 day and 24 hour planning horizons are being considered
- Extreme Weather Advisory Team (EWAT)
- Define key decision-makers; contact list circulated to relevant parties

www.nrws.co.uk – Network Rail weather forecasting facility

Delay attribution

Consider negotiating temporary measures with the infrastructure manager to allow for recovery of delay re-attribution (time to investigate thorough attribution of delays whilst 7-day rule is in place).

4.3.2 Extreme winter preparedness

Tasks contained within this section look at periods of sustained extreme conditions, trigger levels and co-ordination of response. Extreme winter measures may be short-term and require increased flexibility from all stakeholders to allow positive reaction to changing plans and emerging trends.

Trigger events should be clearly defined to produce a detailed plan when extreme prolonged weather conditions are forecast. Different fleets and route diagrams will be subject to different trigger levels, so it is critical to understand the different levels of activity for trains and their environments. Plans should allow trigger events to ramp up or down based on restrictions which will affect the level of service being offered. Co-ordinated fleet/operations management plans will be needed to manage trigger events.

Trigger events take many forms but are based on changing conditions for operation, such as:

- Changing weather conditions (snow, snow and wind, etc.)
- Moving to different diagrams/operations
- Decision criteria for operational restrictions (reducing line running speeds, etc.)
- Stepping up vehicle maintenance/fleet management activities
- Identification of critical operating parameters; go/no-go criteria for trains
- Passenger information systems, heating, lighting
- Consideration of revised maintenance plans: deferral of non-key elements to create capacity for additional key system checks (ballast damage, broken seals, de-icing, etc.)
- Development of catch up plans for deferred/outstanding work

- Contingency roster cover (more staff on nights, less work on days)
- Developing a key competency matrix for specific extreme weather tasks supported by risk assessment

Pre-service start up conference call

- Joint review between engineering, operations and control to determine the level of stock availability which can realistically be achieved to deliver a reliable service; this will determine the flexibility of the timetable
- Levels of degradation of rolling stock, i.e. reduced traction power in extreme circumstances in multiple-units only operation, to be agreed by all parties after giving due consideration to the associated risk to service
- Lessons learned and feedback from previous service and plans adapted where appropriate

Cleaning and servicing strategy

- Consideration of winter response teams to disperse to units in service to address key systems (couplers and doors, etc.)
- Deployment of winter kits: key supplies for keeping trains running (de-icers, etc.) for use by nominated winter response team

Failure review and forward planning meetings

- Held at regular intervals to ensure clear instructions to manage the fleet and personnel
- At least every 24 hours: what issues are emerging? what containment plans are required (short- and medium-term mitigations)?
- Data downloads to be collated and reviewed from relevant data sources (OTDR, defect analysis tool and other sources of relevant data)
- Capture of issues for future continuous improvement

Depot and infrastructure maintenance

- Contingency plans in place to guarantee critical routes are clear for access to and around depots and key service points (access for fuel trucks, staff, emergency vehicles or temporary conversion of depot facilities [mess rooms or offices])
- Review staff welfare provisions in the event that they are stranded at work or away from home (block reservations at local hotels, taxi etc.)
- Maintenance planning for extreme weather: continuity of utilities, etc.
- Depot yard maintenance (points, conductor rail, walkways, car parks, etc.)
- Ensure that extreme weather risk assessments for depot management are up-to-date, staff briefings to promote awareness of the arrangements to be employed
- 3rd rail icing/de-icing is a common issue during winter operations; co-ordinated planning with Network Rail to mitigate and minimise disruption should the situation warrant it
- Staff occupational and operational health and safety

Operations planning

- Train preparation contingency planning
- Support for drivers at dispersed locations, earlier start for drivers
- Train disposal and mobilisation techniques: in severe weather, leave train live/powered up/engines running

Communications strategy

- Key to managing extreme conditions as well as ensuring a certain service level and clear channels of communication
- Definition of key roles and decision-makers
- Delegated authorities
- Media management
- Passenger information (CIS) and Internet
- Standard operations review agenda (identification of key staff numbers, etc.)
- Definition of review and governance structure
- What reviews take place & how often?

4.3.3 Response

Whilst plans have been put in place to allow for extreme winter operation, implementation of plans and contingency measures must be monitored to ensure an effective response to potentially dynamic conditions.

Extreme winter operation

It is critical to ensure a service can be maintained and plans are in place to allow flexible reactions to changing conditions during fleet operation. Clear lines of communication must be established to allow feedback from frontline staff. This will facilitate the analysis of emerging trends, which in turn will assist effective planning.

Timetable flexibility

- Allow for proactive response to extreme weather
- Co-ordinated response from engineering and operations
- TRUST updated to reflect timetable changes
- Public awareness of timetable changes
- Posters at stations to show timetable changes
- Website updated at regular intervals
- Pre-printed schedule cards for operational staff
- Pre-printed messages for on-board traincrew
- PIS updates

Service running

- High-level monitoring and review team to co-ordinate feedback from critical sources (traincrew, fleet managers, station managers, control staff, etc.) for stock availability/reliability, traincrew availability, local weather conditions, passenger levels, etc.

At-risk passengers

- Consideration should be given to passengers who are vulnerable to the elements during extreme winter weather
- Blankets
- Refreshments
- Priority passenger alighting

Preserving the service during operation

De-icing and removal of snow from critical systems/components at pre-determined locations supplied with sufficient resources to carry out critical tasks. Some examples are listed below, but this is not a definitive list:

- Tail light visibility
- Horn functionality
- Door operation and removal of grit from door tracks
- De-icing door tracks and door gear
- Greasing of door gear and rubber seals (silicone grease)
- Coupler de-icing and bagging
- Wiper check (frozen to the screen)
- Information from driver (meet and greet)
- De-ice both passenger and driver tread plates
- Consider utilising non-frontline staff for preservation tasks
- Recovering/preparing the service for operation during extreme weather (overnight)
- To maintain availability of stock for service, extensive recovery plans should allow for overnight maintenance of key systems, which may require the deferral of non-safety-critical maintenance tasks
- Where possible, keeping the stock in a warm condition or keeping units powered up continuously
- For diesel units and to preserve resources (fuel, etc.), implementation of a 1 in 4 rules (run for one hour in every four)
- Consider battery management on diesel stock where infrastructure allows for charging

4.3.4 Extreme winter recovery

Fleets can suffer from extensive damage during extreme weather. This guidance should be used to plan for winter operation recovery. Flexible recovery plans should allow for continued operation of service while fleet repairs and recovery are carried out.

Recovery planning

- Review of fleet position and dispersal vs. maintenance plans and diagrams
- Maintenance recovery plans should allow the fleet to re-enter its cycle of maintenance at the earliest opportunity
- Deferred work recovery plans should manage the most critical deferred maintenance and defects first
- Post extreme winter checks should be considered for all vehicle systems potentially affected by extreme weather, i.e. door set up, electrical connectors, tilt systems, axle damaged from impact of ice balls containing ballast, etc.
- Repair recovery plans may be longer term as material and spares may be subject to reduced availability, e.g. traction motors, wheel sets, etc. This may then lead to maintenance containment plans to increase inspection of key known degraded components, extending operational life until sufficient spares become available

Business needs

- Delivery of a service requires a full understanding of the business needs and the planning of fleet availability to enable realistic and achievable priorities to be set

Historical Example: AGA chose to minimise the impact in service of the Class 317 fleet (now ceased) by prioritising traction motor changes so that at least 50 of the available 60 units were operating on full tractive power. At this point, the units on degraded power did not influence or degrade the operation of the service

- The recovery time of the fleet could be reduced by temporarily increasing the resources available or sub-contracting recovery to approved suppliers

An example of this is GTR who utilised Alstom (formally Bombardier) technical staff to remove and temporarily repair defective ACM modules which previously allowed snow ingress due to poor sealing arrangements. This allowed the fleet to resume service until a permanent solution could be developed

4.3.5 Post winter review

- The winter review process should allow for a period of formal reflection on and documentation of successes and failures. This is an opportunity to learn lessons and implement changes to plans for future extreme weather events. Some areas for consideration are shown below, but this is not an exhaustive list
- Consideration of vehicle sustainability in changing climate
- Maintenance strategy review (post winter checks [drying out water ingress, etc., winterisation exam improvement])
- Modification strategy (horn relocation, horn heating, horn baffle plates)
- Revised materials and logistics plans with key suppliers (incl. ROSCOs)
- Imaginative approach to emerging climate trends when developing cost-benefit argument for winter modifications
- Challenge established norms
- Not ‘accepting’ known winter failure modes as this is not sustainable for future operational performance
- Traction motors can draw in moisture from snow and cause earth faults and flash over. Long-term solutions should be developed where possible, such as ducting systems
- Review potential for quick repairs as opposed to full overhaul when returned for snow damage
- Review ROSCO and/or maintainer stock holdings
- Planning of extreme winter operations and maintenance should be an overarching principle of fleet operation and management; risk assessments should be carried out for all anticipated non-routine activities

<u>Delay attribution</u>

- Segregation of winter failure modes (e.g. within BUGLE) to enable post winter review and planning for subsequent years

4.3.6 Other considerations

Although outside the day-to-day running of fleet, consideration should be given to areas which may be of concern in the future.

Train procurement specification

- Lessons learned from extreme winter operation should be captured and considered for inclusion in a future version of the Key Train Requirements (KTRs) to improve new train performance and reliability. This is particularly critical due to the levels of climate change and the extremes of conditions in which rolling stock is required to operate.

4.4 Planning for summer

High temperatures can also affect the comfort of passengers and traincrew as well as the functionality and performance of the rolling stock.

Cab and saloon air conditioning and any driver cooling fans fitted, must be fully serviced and functional prior to the onset of high temperatures. It should be remembered that the temperature variance within the summer months can be quite dramatic and this can affect the functionality of many systems within the rolling stock.

- Air flow electronic racks, traction motors
- Filters cleaned/serviced
- Air flow paths for cooling are clear of debris

Radiators

- Clear of debris to ensure air flow is smooth
- Ensure radiators are fully topped up with coolant

Windscreen washing

- Ensure windscreens are cleaned regularly and washer bottles topped up

Door system

- Check bearings and rubber joints for degradation leading to poor open and closing
- Summer adjustments to avoid binding of the door system

Toilets

- CET tanks to be emptied on a regular basis to minimise odours and the spread of germs

Infrastructure

- Tracks can also become a major issue during times of extreme heat with instances of rail buckling. Work closely with Network Rail to identify Critical Rail Temperature (CRTs) sites and manage speed restrictions and the potential impact of the train plan
- Depot infrastructure also needs to be considered during extreme temperatures, including identifying any potential risks to the depot's ability to deliver the service

Management of the environment to ensure depot safety

- Infestations
- Insects
- Vermin
- Birds (nests, etc.)
- Waste management

4.5 **Autumn**

The leaf fall in autumn often causes poor rail head conditions and can affect performance in a number of ways.

Low adhesion extends running times by decreasing acceleration (due to possible wheelspin) and deceleration (defensive driving to prevent wheelslide). Many TOCs have developed autumn timetables, which allow extra time on those routes most likely to be affected during this period each year.

Low adhesion significantly increases the likelihood of wheel flats, despite defensive driving. Knowing that all wheelslide prevention equipment (WSP) is in good working order prior to the commencement of the leaf fall season is important.

Low adhesion also significantly increases the likelihood that wheels will slip when taking traction resulting in units failing to run to time. It is therefore essential that maintainers are on top of traction system performance. Prior to and during autumn, a particular risk surrounds DC motors where there are supply chain issues.

Low adhesion sites should be reviewed with NR, historic sites in the sectional appendix can change, the reasons for declaring them exceptional should be clear (freight, traction adhesion, stopping for a platform, etc.).

Wheel flats require attention in the form of wheel lathe slots. To reduce the effect on unit availability, it is desirable to keep within the planned number of units for tyre turning. Getting ahead of schedule with pre-planned tyre turning based on mileage or tread condition prior to the leaf fall season can free up space.

With some fleets, tyre turning may not be possible on all vehicles if the tread thickness is already below a certain size, so wheelsets will have to be renewed. This will require pre-planning; pre-ordering wheelsets so they are available on site prior to the leaf fall season. It may also mean getting ahead of schedule with other routine lifting work to free up space on the lifting facilities and create fleet availability headroom during this period.

Particularly bad leaf fall conditions can affect a large proportion of the fleet at the same time, despite careful planning. A contingency plan should be pre-agreed with all concerned within the TOC to cope with reduced fleet availability.

<u>Rolling stock</u>

- Communication to traincrew
- Driver briefings on defensive driving
- Reporting of poor traction hot spots

<u>Autumn surgeries</u>

- Opportunity for feedback between drivers, management and Network Rail
- Whiteboards within traincrew depots to leave feedback on performance-related issues

<u>Operations</u>

- Network Rail
- Analysis of rogue units
- Lathe records
- WSP health checks

- Dump valves firing in the correct sequence
- Blocked valves can vent
- Spares availability
- Sanders and sand storage
- Blocked delivery units
- Use correct grade of sand
- Increased use of sand during leaf fall
- Sander top ups may be more frequent

<u>Scrubber blocks</u>

- Which trains can be fitted with scrubber blocks
- What percentage of the wheelsets should be fitted with scrubber blocks
- Leaf mulch build up under units
- Ensure filters are clear of leaves to maintain proper air flow

<u>Door pockets</u>

- Ensure guides and runners are clear of leaves to guarantee smooth operation of door system

<u>Depot</u>

- Ensure availability plan is in place
- Maintenance of wheel lathe is carried out prior to leaf fall
- Wheelset availability
- Fleet wheelset condition check prior to autumn

<u>At-risk units</u>

- Units with low wheel life expectancy to be deployed within local geographic location of wheel lathe
- Minimises the risk of units running with restriction to wheel lathe

<u>Infrastructure</u>

In the period leading up to and during leaf fall, infrastructure management is critical to ensuring the delivery of a reliable service. This should be in partnership with Network Rail to ensure the effective use of all tools available. Examples are given below but this list is not exhaustive.

- Effective vegetation management
- Programme of vegetation clearance
- Station cleaning
- Do not sweep leaves onto the line (sweep and bag)
- Identification of vegetation hot spots (high-risk sites)

Rail head treatment

- Traction gel applications
- Location-specific
- Joint management and deployment of rail head treatment train
- Contingency for start and finish dates for the rail head treatment train

Northern have employed the policy of riding with drivers to identify areas within its geographic network of extreme areas at risk of poor performance or safety due to leaf fall. This is in conjunction with Network Rail to keep such areas to a minimum. This work stream also includes the identification of areas of high priority for remedial work, which in turn reduces the number of station overruns, wheel flats and wrong side track circuit failures.

5. Train Preparation

Train Preparation (TP) activities are primarily undertaken for three reasons: Safety, Reliability and Cleanliness. This chapter places emphasis on the Plan, Do, Review approach for train readiness for services.

5. Train Preparation

In many cases, Train Preparation (TP) is more appropriately performed by drivers. In essence, the message is that each train type and each location dictate who is best placed to carry out TP.

There is a lot of evidence that TP activities are frequently duplicated by maintenance staff and the train preparer. Two examples are featured below. It is good practice to identify duplication and eliminate it as far as possible.

Example: In relation to Thameslink units, GTR undertake a berth check where checks are undertaken to pre-empt any start time failures. Activities are undertaken for reliability reasons as opposed to meeting a safety requirement.

Example: Two extremes of TP duplication were reported by a Train Operator

On one fleet, fuel point exams were enhanced to protect the depot from conductors finding faults. On this fleet, 3 checks are undertaken:

- Check 1: Maintenance staff undertake a daily exam.
- Check 2: Shunters undertake the conductor prep.
- Check 3: Depot driver undertakes driver prep.

It was reported that these checks were additionally implemented on Class 323 units, with the introduction of Check 1 improving the reported reliability performance of this fleet by 25%.

Conversely, on another fleet, the manufacturer's maintenance staff undertake train preparation and hand over a piece of paper to the driver to confirm that the train is in a fully fit state. The train driver then simply takes the train into service.

N.B.: Items marked **[KTR]** have been considered for inclusion in future versions of the Key Train Requirements (KTR) to improve the train preparation process (both in terms of time and ease). The latest edition of the KTR can be accessed on the RSSB website.

5.1 Plan

Planning for train preparation is equally critical to the preparation itself. The following points focus on good practice when considering train preparation, arrangements and examples of current industry practice.

Consideration should be given to the reasoning behind train preparation post-maintenance. It should not be used as a catch-all to identify maintenance or cleaning process deficiencies.

The frequency of train preparation should be kept to a minimum. Good practice would be for it to be valid for at least 24 hours. In some instances, units are stabled for extended periods of time, during which two preparations are undertaken. Consideration should be given to whether the TP periodicity could be extended to make better use of staff resources.

Historical Example: At the time, East Midlands Trains' (EMT) Meridian fleets were prepared by Bombardier as per their Train Supply Agreement. This preparation did not expire, therefore once prepared, a train could be left as long as necessary and taken into service without a second preparation.

Conversely, EMT's 15x units (maintained in-house but on the same depot) needed to be prepared every 2 hours. This was justified as protecting the depot from start time failures as a result of drivers arriving late to report defective cab heat, as the unit has cooled down since the original TP was undertaken.

Example: Avanti West Coast's (AWC) Class 390 fleet has a TP validity of 24 hours.

Example: When meeting to discuss this good practice, members noted that some fleets require physical attention every 24 hours otherwise they shut down. The example cited was a LIM reset on Electrostar Units. This functionality was not considered appropriate **[KTR]**.

On the other hand, some TOCs have instigated depot TP activities to address an epidemic of start time failures reported by traincrew. This reduced failures to two in 18 months.

The introduction of new rolling stock has been an initiator of change for TOCs in relation to TP and is a good opportunity for TOCs to review their TP processes from first principles.

Where trains are frequently prepared on depot, consideration should be given to access to the depot becoming restricted/impossible. Where this occurs, contingency plans should ensure early identification of faults and minimise any potential reduction in reliability.

Historical Example: In normal operation, the Virgin Trains West Coast Class 390 fleet returned to a depot every day. In 2015, the West Coast Main Line was severed by a damaged viaduct. This resulted in a noticeable number of outstanding defects arising across the fleet; a symptom of difficulty accessing the fleet.

Preparation can be further complicated at outstations such as Nottingham station where it is not possible to walk around the exterior of the train. A different TP regime is implemented that does not involve the need to inspect the underframe of the unit. Consideration should be given to where units are prepared to ensure that they are not consistently prepared at locations with no access below the solebar.

Example: Alstom report that it is not possible to walk around the Class 378 units whilst in their stabling points, therefore below-solebar TP activity is not undertaken at these locations.

5.2 Do

Good practice is considered to be preparation of the train by maintenance staff (since they are best able to effect a repair) and therefore provide a unit that is fit for service to the driver who, upon receipt of formal documentation, takes the train into service. It is accepted that this arrangement is not possible at all locations.

Historical Example: Gatwick Express (GX) Stewarts Lane depot generated paper TP certificates that were left in the cabs. GX fitters were also depot drivers in order to provide an efficient staff resource.

At GTR's Hornsey depot, their depot staff (including the shunters) undertake TP. At their outstations, the traincrew undertake TP.

The train management system of modern stock could avoid the need for a piece of paper to demonstrate TP validity, thus reducing the need for the physical transport of documentation to the vehicles and any potential loss/damage. **[KTR]**.

Similarly, where possible, the TMS should be used to monitor the status of systems on the train which require preparation, particularly at locations such as outstations.

Example: As the GTR Electrostars are more frequently prepared at outstations, the Train Management System Intelligent Display Unit is used by fitting staff during TP.

Example: SWR's Siemens Northam Depot is not large enough to accommodate their entire fleet so they use remote diagnostics to identify faults, details of which are then used to direct the activities of a "man in a van" repairer.

Where units frequently run through Automatic Vehicle Inspection Systems (AVIS), the case could be made for a reduction in TP activities. These systems are able to report on the state of various external systems (i.e. brake disc and pad presence and thickness, fire bottle level, whether side skirts are left open, etc.) and can minimise TP if the unit is run through this system on a regular basis. It is important to note when the inspection is done, i.e. preferably on the way into the depot.

Where possible, train preparation should be uniform across depots. At the time of writing, different depots undertake different TP activities. There is a disparity not just between TOCs but also between depots within TOCs. A significant barrier to this is Industrial Relations (IR), whereby a major change to TP would be difficult to achieve without the support of staff. This issue primarily occurs between staff grades within TOCs.

When considering future trains, it is worth investing time and effort thinking about how the system will work and streamlining the TP process, i.e. Could the TMS report system status (healthy/faulty)? Could physical checks be removed from the TP inspection? **[KTR]**

Self-tests should be as reliable as possible, to prevent spurious fault messages upon start-up, which can result in a conflict with diagnostics.

On Siemens Desiro units, the TMS features different pages of information that are presented to the user on the TMS display. It is crucial to ensure that the level of information presented to the driver in relation to faults is sufficient for them to provide a value-added action to rectify the fault. However, there is balance to be struck, since there is such a thing as too much information.

Faults can be classified as major or minor. Major faults are those that the driver is aware of and can undertake a timely response to once the fault has been reported, e.g. a fault in relation to the safety of train. Minor faults are those that do not require the immediate attention of the driver and can be addressed at a later stage.

There is a danger that additions to TP activities over the years have been to ensure that drivers cannot fail trains - in order to protect fleet reliability performance reporting.

There is little or no requirement for depots or TP to test horns, head, tail and marker lights. This functionality is tested by drivers routinely when vehicles are in service. There is little chance that these components will fail between service and re-preparation.

Point of interest: When comparing the railway to the automotive industry, upon completion of a car service, it is not typical for the customer to walk around the car undertaking an inspection. It should be noted, however, that aircraft pilots still perform a walk around of their aircraft prior to flight.

Where systems display an analogue dial featuring any potential dubiety, it should be obvious whether the reading is a clear pass or fail.

Example: Class 15x fire systems feature a dial reading “red, green, red”, i.e. low pressure, medium pressure, high pressure. What it does not tell, however, is that high pressure is not considered a problem when compared to low pressure. Train preparers may, upon seeing a needle in the red zone, fail the train without knowing this. **[KTR]**

Good practice when preparing coupled multiple units is keeping units in their consist rather than needing to separate to prepare them individually. Splitting units introduces risk and therefore should not be necessary.

Example: Some TOCs reported that units running in multiple are split upon train preparation to check the functionality of the couplers. This is the only reason for splitting the units and was deemed to be unnecessary and introducing undue risk.

Whilst it may be considered by some to be a belt-and-braces approach to TP every cab in a train consist, it does represent good practice since it can be argued this prevents defects subsequently being identified by traincrew.

5.3 Review

The causes of TP failures should be analysed. This will help to understand the systemic issues and, via a pareto-based approach, begin to tackle the most frequently recurring failures. This analysis can be broken down further to look at the failures which occur on depot compared to those which occur at outstations.

Any incidents which have occurred as a result of improper train preparation should be reviewed but caution nonetheless exercised as if new checks are initiated as a result of every incident, TP becomes ungainly and unwieldy.

TP activities should be routinely reviewed (ideally on an annual basis) to ensure that they remain relevant and of benefit to the process.

6. Delivering the Service

To optimise the reliability of any railway the people involved need to adopt the most appropriate approach in each set of circumstances. Establishing clear communication paths and better attitude around hard issues are essential steps to delivering better reliability.

6. Delivering the Service

How engineering, operational, planning and retail functions work together to deliver the service is vital to day-to-day reliability and on-going reliability improvement. Sometimes these relationships span actual contractual boundaries, but whatever the organisational structure, the functions must still all pull together to deliver the service.

Three areas where there are often the greatest challenges and the greatest scope for reliability improvements in terms of numbers of incidents and operational impact (e.g. minutes lost) of each incident are:

1. Co-ordination of depot and train planning
2. Communications processes around faults and failures
3. Measures of fleet performance and how they are used to improve performance

For each area, we have shared experience and thoughts about:

- hard issues, like should there be contracts or internal contract-type relationships (e.g. interface rules set out in requirements documents such as Service Level Agreements); and
- soft issues, like culture (i.e. creating a culture of engineers and operators working together to optimise combined overall delivery)

We need to recognise everyone's expertise and enhance understanding of the bigger picture for the sake of overall decision-making. As with every other area in ReFocus, we need to make the most of on-going experience, using effective feedback loops based on sound analysis of individual incidents and trends to develop and disseminate our overall learning.

If a train develops a fault at a remote location in a low traffic density on a regional railway, it is probably best for the driver to telephone a nominated depot maintenance person for advice, allowing the train to proceed, possibly in a controlled degraded mode. If, however, the same train develops the same fault on the approach to a busy station at a peak time, it is probably best to declare the train an operational failure and clear the line.

In summary, to optimise the reliability of any railway, the people involved need to select the most appropriate approach in each set of circumstances. Setting out some clear plans around hard issues is an essential step to consistently delivering reliability, as is having a culture of people who work together for optimum overall service delivery (e.g. departing from these plans in a controlled, mutually agreed way when this is the best thing to do).

6.1 Co-ordination of depot and train planning (timetable and resources)

TOCs should have a resilient, joined-up plan for reliable service delivery. A narrow approach to train planning may not take full account of either operational resourcing constraints (e.g. where on-train staff book on and off) or diagramming for maintenance requirements (e.g. where facilities, fitters and cleaners are, and the time they need to do their work). Some train operators resolve this by co-locating depot and train planning teams; others have an engineering planner who sits on the train planning group.

Train planners need to understand depot capacity (*see 7.2*) and the consistently deliverable availability of all fleets. This is a good example of hard and soft issue management: We need some hard plans which are owned by each area of expertise (e.g. the depot plan, the train plan, the drivers' rostering plan). However, everyone needs to remember that we all exist to deliver a service, so these plans must be flexible, which invokes the soft side of talking to each other and not making assumptions.

Train and depot planners should meet to discuss every timetable change and ideally more regularly, to review experience, discuss the frequent diagram changes necessary to accommodate track engineering possessions and maintain relationships.

Example: GWR has documented Rules of the Depot which set out minimum requirements, e.g. for how long and how many trains are required in the depot in order to maintain them effectively. The programme of delivery of units to the depot at Bristol to feed the relatively short, single-road fuelling shed has been carefully worked out. Delivery against this plan is closely monitored with feedback on a daily basis. Shortage of one driver, for instance, leading to coupling together too many units for an empty move to the depot, can cause havoc to the operation and impinge heavily on time available for maintenance.

Example: GWR ran a series of diagramming workshops involving engineers, diagrammers, operators and driver managers to enable all to understand the fuelling, cleaning and maintenance requirements of the different fleets of DMUs, along with operating constraints and the length of time units could be made available at depots for maintenance. The joint aim to optimise maintenance downtimes and on-depot slots resulted in a good working train plan.

Example: A Transport for Wales Rail production manager emails a daily report direct to the Operations Director and Head of Drivers, as well as control and the engineers. This uses traffic lights to document the previous day compared to plan: No: of units to depot before 1800, 2200 and 0001; No: of A and B exams; No: of drivers provided; depot staffing levels. Any shortfalls highlighted in red are discussed and reviewed by the directors, daily if necessary.

Best practice TOCs evaluate the costs and risks associated with changes to service requirements (e.g. changing the timetable or the vehicle diagrams), as well as the benefits. Engineers should be clear about what is optimal in their area, and also about setting out any costs and risks associated with a proposed change.

For example, TOCs should conduct a risk assessment on any proposed timetable change in terms of their ability to ***reliably deliver the service*** (e.g. Is the proposed rolling stock utilisation plan robust? Are turnaround times sufficient? Does the TOC really want to suffer the likely increase in unreliability from having another terminal station stabling point?). Risk assessments should also include issues like the ability to ***deliver service quality*** (e.g. turnaround times required for adequate cleaning, diagramming to enable adequate toilet maintenance).

Example: Historically a Train Operator minimised the coupling and uncoupling of units. This means that they run more 8-car than 4-car sets, which increases fleet mileage and hence the mileage-dependent maintenance requirement. However, the benefit is a reduced risk of failures with huge operational impact.

Example: c2c's costs and benefits mean that they cannot eliminate coupling from their service pattern and must take a different approach. They effectively justify an insurance position of having a station fitter at Shoeburyness who can reduce the risk of service impact, e.g. by supporting operational staff undertaking coupling and uncoupling and dealing with technical issues as they arise.

The plan is not just about setting the timetable and letting it run, **feedback loops** are crucial here, too. A good way to develop a more robust train plan is to monitor how the service degrades during the operational day. Traditional measures of availability of trains for traffic tend to centre upon a certain time of day (e.g. Was the 6am stop position met?), but more frequent measures may be useful to identify risks to service performance, as well as actual service degradation. Then effort (and resources) can be directed where they will have most effect (e.g. where to put a stand-by set or a terminal station fitter).

6.2 Communications processes around faults and failures

Best practice for delivering the service is to go beyond the safety baseline required in a standard contingency plan. TOCs need a cut-and-run policy: How long (and indeed whether) to support the driver in fault finding and resolution will vary under different operational circumstances. What is important is that the driver knows what approach to take on each occasion; it is usually best for the driver to contact control as soon as possible to confirm the approach to be taken.

Example: Historically First Capital Connect, had prior agreement between depot/control/operators on how to react to various common faults, e.g. leave in service, swap out before bottleneck (central tunnel section). A specific problem on Meridian doors was managed through an instruction of “if in doubt, lock it out”, much reducing service delays.

Even if train reliability is poor, in the life of any driver, train faults will actually be quite rare. Hence the driver may need support to work through something which maintenance staff might regard as a common fault that is easily mitigated.

Drivers may also be in a state of anxiety and require moral support to deal with incidents where they are on their own in the cab and under pressure.

Example: SWR has “Phone a Friend” (a dedicated helpline for defect reporting and support) which covers mandatory reporting (e.g. RT3185s) and quality issues (e.g. graffiti or blocked toilets). Southeastern specifically train drivers in fault reporting at driver training school, using simulators for drivers to practice fault rectification.

Example: A small handbook has been jointly developed for drivers by engineering and operations staff working together at c2c. It is carried by drivers as part of their essential kit with the threat of disciplinary action if they do not. The booklet is sub-divided by colour-coded pages into traction faults, door faults, brake faults, etc. for easy identification. It is updated to reflect experience; one recent change is to amend ‘report as soon as possible’ to ‘report at terminal station’, to save having to stop to report a fault.

Example: In some TOCs, the driver phones the maintenance control centre where the controller uses a computer-based ‘Decision Support Tool’ fault chart. This ensures a consistent approach to on-train fault-finding and means that depot maintenance staff know what was done.

Timely and useful feedback from operational staff to the maintainer (e.g. what happened, what they tried to do to fix it) is notoriously difficult to obtain. This means that subsequent root cause identification is less efficient than it might be and there is a greater risk of repeat failures. Feedback can be enhanced by closing the loop. Some TOCs write to drivers thanking them for their report, explaining what was found and maybe suggesting a useful mitigation for them if it should occur again, or letting them know that a permanent technical fix will be developed. This positive feedback encourages better reporting.

Example: Service feedback can also be obtained automatically without having to wait for drivers' reports. Electronic condition monitoring systems (e.g. MITRAC on Alstom's former Bombardier fleets) enable simultaneous fault information to be transmitted to depots so they can plan in advance the priorities and resources (e.g. expertise and materials) for maintenance that night.

Example: Use of condition monitoring systems and communications links between trains and depots to report the condition of the equipment. This data can be invaluable when it comes to interpreting drivers' reports. It is possible to dial up the train in real time to investigate and respond to specific reports.

It is vital that the different functions understand each other's expertise and issues. The fitter needs to know what it feels like to be at the front of a broken train full of hundreds of people wanting to get home; the driver needs to understand that it's very hard to find (let alone fix) a fault when the person who saw it hasn't taken the effort to describe what happened adequately. Some ways of enhancing understanding and empathy have been described above for dealing with specific failures, remembering that communication needs to be two-way to be effective: drivers fill in fault reports and get feedback on what was found.

Other good practices are:

- a newsletter for drivers to promote understanding, focusing on topics that are known to be of interest to drivers, e.g. defect reports, driver managers or after attending driver briefings
- an engineering slot in the drivers' safety update briefing enabling face-to-face, two-way discussion of current issues and future developments

Example: EMR highlighted an Operations Manager who, as an ex-driver, acts as the interface between drivers and engineering staff. He attends reliability meetings and inserts relevant extracts in the magazine produced for operations staff. This includes information on significant incidents, what was found and what action was taken. There are other items that keep drivers in the loop, such as 'watch out for such and such a unit, it has a new design of cab window – please look and tell us what you think'. The role facilitates regular driver surgeries with drivers and fleet staff, and E-mails engineering directly with any driver issues that arise, greatly speeding up the process of resolution and feedback.

Historical Example: An EMT coupling video has been made using EMT-liveried trains (and staff with local accents!) to remind all of the standard procedure to be used during coupling and uncoupling sets – 'The Happy Coupler'. It was also identified how important it is to ensure that every regular couple and uncouple is shown in the driver's diagram to avoid last-minute problems.

6.3 **Measures of fleet performance** (and how they are used to improve performance)

Different functions within an operator or across a contractual boundary undertaking independent data analyses sometimes produce different results and discussing these differences takes up a lot of time and energy.

Consequently, a joint dataset should be agreed to focus on reducing both the likelihood of failures occurring as well as the impact of each failure. Sound analysis will direct efforts to the areas which will potentially deliver the greatest service reliability improvement per pound spent.

> Example: VTEC (now known as LNER) reported projects reducing the likelihood of failures occurring (including increasing battery life if the static converter fails; visual indication of transformer gas detection rather than a power shutdown and improved sander nozzles to prevent spurious dragging brakes reports). They also work to reduce the impact of delays e.g. by upping the speed limit of the Class 67 thunderbird light engine running to a failed train from 75 to 100mph.

The ability to produce an agreed dataset is very much to do with the soft issues of building trust, relationships and understanding between different areas of expertise.

> Examples: c2c produce common data which is summarised on a one-page document called Service Affecting Incidents. This is discussed at performance meetings where actions to improve reliability are agreed and reviewed. Key to the success of this process is that the actions taken by different parties are transparent: Operations know that Fleet is developing a long-term fix for fault z, so they are keen to help mitigate its effect by working round it using procedure y.

Once the dataset and root causes are agreed, different players can feel more comfortable about working together to minimise the impact of any fault. There are often short-term operational mitigations which can be very effective in improving reliability whilst a long-term engineering fix is developed and implemented.

> Example: A new fleet had interlock problems with the exterior bodyside doors for cab access when changing ends. Whilst an engineering solution was being developed and implemented, the drivers agreed to use the saloon doors to access the cab to reduce the risk of cab exterior door interlock failure. This more holistic approach delivered a more reliable service even before the technical improvement could be rolled out.

It is also important to capture faults that do not yet affect the service but reduce operational flexibility.

> Example: c2c measure degraded mode operations where one cab has to be buried inside a train (e.g. because of failed windscreen wipers or inoperative TPWS). They want to understand the nature and level of their operational inflexibility for splitting and turning trains round as it affects the overall resilience of their service delivery. c2c measure trends in these areas even where no delay is experienced in service, because it is a measure of a reduction in their capacity to mitigate any other event which occurs.

More is better: There are other examples of expanding the definition of faults in order to capture more issues to be resolved before they impact service delivery. Many operators treat a problem which causes a step up internally as seriously as if it had caused a cancellation. In other words, they acknowledge they are making use of the resilience they have built in to their diagramming and make the most of the learning experience. This attitude is also important in prioritising customer issues other than simply getting there on time, e.g. cleanliness, functional toilets, Heating, Ventilation and Air Conditioning (HVAC) etc. Soft issues are critical here in creating a culture where people accept that different functions contribute to the whole.

Fewer is better too: At the other end of the scale, some TOCs have mechanisms which focus on the worst incidents in each period, e.g. those which cause the most delay minutes, or all incidents above a certain threshold of delay minutes. A full cross-functional review of the failure is carried out to identify real root cause(s) and more effective long-term mitigations. It often elicits other opportunities for improvement as actions are typically fed into cross-functional groups and progress is monitored by the performance manager.

Train service performance has been improved by:

- Focussing people on what is most important to themselves and their internal customers
- Creating indices by which progress can be monitored
- Providing more structure and formality around previously casual arrangements
- Improving cross-functional understanding and organisational learning
- Providing useful quantitative data to assist business cases to address root causes, improve resilience and make mitigations more effective

In summary, TOCs should take a holistic, structured approach to assessing the measures needed for improvement. This then requires robust analysis, checking for statistical significance of variations and identifying common cause issues - where concentrating on the root cause can eliminate multiple failures.

7. The Depot

This section covers the frontline resources needed to maintain reliable trains including motivation training, skills development and competence assessment.

7 The Depot

This section covers the frontline resources needed to maintain reliable trains:

7.1 Human resources – staff motivation and skills, staffing level
7.2 Depot capacity – sufficient for outputs required, optimal use
7.3 Depot facilities – for vehicles and people

Much of this Section emphasises that the above are part of managerial design. The design process must reflect reality and it must enable frontline managers to perform their day-to-day duties effectively.

Note: In addition to what is outlined in this section, RDG have drafted *RDG-ENG-009: 'Depot Performance Handbook'* which describes and outlines good practice that organisations should consider when trying to assess the performance of their Depots, Yards, or Sidings; whilst developing Timetables and whilst considering related performance improvement initiatives.

7.1 Human resources

7.1.1 Motivation

As stated in *Section 3.1*, reliability depends on the quality of maintenance and thoroughness of fault-finding to address the root cause (in addition to various management activities). Work on vehicles depends on having sufficient people with the right skills and other resources (see below), but also on the effort of individuals. Rail vehicle maintenance is often carried out in difficult conditions, e.g. shifts are designed to suit vehicle downtime, not family life; much work is done at night; even with good depot facilities, access to certain parts of vehicles 'in-situ' is often awkward, compared with working on a bench.

Well-established management best practice is evidenced by human-factor assessments of UK rail vehicle maintenance: people work better if their input is appreciated and acted on. For example, local ownership of maintenance instructions enables prompt incorporation of feedback from maintainers, e.g. to correct errors and develop improvements.

Where possible, ownership should be extended to the depot (or maintenance team) responsible for these units. This can include e.g. following up what other depots/outstations do/do not do to these units; focus on long-term repeat intermittent defect resolution; undertaking deferred work.

Historical Example: Soho Depot benchmarked maintenance team performance against KPIs which included the reliability of the trains they worked on. This was possible with a self-contained fleet of Class 323 units, most of which returned home each night.

Techniques such as **Lean maintenance**, **Kaizen** and **6 Sigma** are frequently adopted, both for the outputs they deliver and for the impact that engaging people in improving their work has on their morale. These techniques can help identify and remove frustrating parts of the job, such as walking to stores or waiting for parts. (Note that a culture of wanting to better use staff and not cut jobs is required for such programmes to be effective, i.e. incremental continuous improvement rather than big-step changes.)

Example: ScotRail used lean techniques at Haymarket to free up a person on each B exam to devote to repairs/deferred work/mods.

Example: At Longsight, a full time Kaizen Promotion Manager was backed up by a (almost) full time Kaizen Technician. A high-quality facility was permanently set aside for Kaizen on site at the depot. A 5-year plan of strategic objectives was backed up by a plan of projects for the next 12 months drawn up by the Directors. Each project was supported by a 5-day Kaizen Event, releasing staff from the maintenance teams and involving 2 or 3 people who were familiar with the tasks involved, supported by other groups, such as stores, or even a Director. Experience showed that the more varied the makeup of the team, the better the result. The aim was to hold a Kaizen Event around every 6 weeks. A project plan charted progress. Actions arising from the events were carried out within 30 days by other people. There was a 30-day action list which showed who was dealing with what by when. Events at Longsight identified at least a 30% saving in time, with additional safety improvements. The whole Kaizen process had a very beneficial effect on staff morale, as they appreciated being listened to and developing their own ideas. Any saving in staff time was re-invested in quicker processing of outstanding repairs, never in staff reductions.

Maintenance work (especially defect management) should be a closed-loop process: enabling learning, 2-way communication and encouraging collective focus on shared goals. Best practice is to use communications rooms (also called information rooms, reliability rooms, war rooms) sited somewhere that people actually use 24/7, e.g. mess rooms, clocking-on points.

These rooms should display up-to-date data and action plans AND be actively used in start-of-shift staff briefings and management progress meetings.

Typical questions for staff briefing meetings might be:

- How is the fleet performing? (what happened in traffic yesterday? how did maintenance go last night?)
- What are the trends? (is reliability improving? why are trains unavailable?)
- What issues are we keeping an eye on? (rogue units, repeat defects)
- Staff issues – training plan, progress with issues raised

A corporate team spirit should also be encouraged. This can be hard work during an Operator contract change, but can also be seen as an opportunity for a positive step change.

Historical Example: At EMT (now EMR), the scope of a refurbishment programme for the Class 153 and 156 units was discussed extensively with the staff. The resultant spec was fed back to them through the drivers' reps and in an ops newsletter, which featured articles about the proposed scope of the refresh and inviting people to send in further suggestions.

Some TOCs have staff suggestion schemes - with all engineering suggestions going to the Engineering Director. Best practice is to respond within one week, with a close out in 3 weeks. Small cash awards are then presented every 3-6 months in front of colleagues for the best suggestions.

7.1.2 Skills

Depot staff have traditionally been provided with skills that are directly related to work on vehicles. It is however now recognised that these skills, although vital, are not sufficient. For example, effective change projects depend on the contribution and insight of staff throughout the organisation. Hence best practice includes soft skills, e.g. quality systems, improvement techniques (such as Kaizen), lean maintenance and the use and presentation of data.

> Example: Northern trained all depot staff in quality improvement techniques. These skills were used daily to improve their production processes and data rooms were used to monitor and validate their changes.

Another change from more traditional approaches is to understand and define all the skills and competency needs of all staff. Best practice uses the results of a vehicle/train risk assessment model and enables staff to understand:

- The connection between sub-standard equipment condition and operational performance/risks
- Specific material and component degradation processes and how to identify them on train equipment, particularly on exams
- Vehicle/train system behaviour under normal and degraded equipment conditions

> Example: Southern trains its staff specifically in different fixing methods and the degraded mechanism associated with each type to ensure structural integrity and performance throughout service life.

Another best practice is to actively train technicians in root cause investigation through structured programmes, rather than hoping talented individuals will develop themselves.

> Example: c2c developed a competence assessment module for staff going out to attend to trains, based not only on their familiarity with repairing the vehicles, but on understanding what can be done in the minimum time in a failure situation, the effect on the train service, how to communicate effectively with the drivers, etc.

Modern vehicles are increasingly complex, and this is being recognised in specialisation of skills rather than asking people to be ‘jacks of all trades’. Specialisms tend to be focused on systems, e.g. traction, doors.

There is also increasing specialisation in the sort of work undertaken and where. For example, some depot staff work only on routine exams, whilst others need advanced fault-finding skills to deal with defects arising in service and to find root causes.

> Examples: SWR simply said “Don’t dabble with doors at outstations. If there’s an issue, lock the door out of use and report it so it can be planned for later (skilled) attention.” Southern used a core group of people to find faults, team technicians who support each maintenance team.

7.1.3 Training

Training content

Best practice is to create the syllabus necessary for a modern depot workforce based on a thorough analysis of the skills needed and using both core traditional technical materials and new sources. Training materials should be aligned with maintenance plan instructions and quality system techniques by trainers working closely with accountable professionals in these areas.

> Example: Southern treats all its engineering training material as engineering standards, ensuring they are aligned to maintenance plan instructions and subject to the same controls, updating mechanisms and professional oversight.

Training delivery

Best practice is to roster training days for all staff. This is essential to deliver a defined development plan within a specified timescale and sustain continuous progress. Production managers must facilitate training programmes to support team leaders with a balanced range of skills to reliably deliver production and quality targets.

Many organisations have found that new entrants benefit from mentoring by an experienced member of staff. Best practice suggests that a trainer is ideal for this role, providing an unbiased guide where peer pressure may not always be constructive.

> Example: Northern appointed a personal mentor to each new entrant who guided the individual's progress and ultimately decided when the individual is fully capable of performing her/his responsibilities.

> Example: West Midlands Railway trained the technical team as trainers for training delivery to staff.

> Example: GWR at Exeter Depot use on-the-job coaching by technicians.

7.1.4 Competence assessment

Competence assessment is the industry's principal mechanism for assuring work on vehicles. Most schemes use on-the-job observations focused on inspection tasks as the main source of evidence. However, best practice is to base competence assessment on fundamental risk assessment (*see Section 3*): this means concentrating on tasks that most influence operational performance and safety as well as occupational risk. Intrusive tasks are therefore more important than inspection tasks.

When staff turnover is high, some staff will not be registered as competent in all the tasks expected of them. Some depots manage this by regularly publishing current staff competence profiles, so production managers can deploy balanced teams and arrange oversight by fully competent staff where necessary. Published staff competence records also tend to encourage all team members to support the assessment programme.

Complete reliance on on-the-job competence assessment may lead to an insurmountable workload. Many organisations try to group tasks into those requiring common skills and knowledge but at the risk of compromising professional standards. Alternatively, competence can be evidenced by looking at finished work, i.e. using equipment condition audits. The results may be used more widely too, e.g. to:

- Validate the accuracy and appropriateness of maintenance instructions and their periodicity
- Validate training materials and the effectiveness of staff development programmes

Competence should be assessed when the condition of equipment can be closely associated with an individual and their activity. (Depending on the task, this can be assessed after the work is done, making it easier to manage the assessment workload).

7.1.5 Staffing level

The need here is to ensure sufficient capacity – enough to enable and sustain long-term reliability growth. ReFocus studies support the finding that depots with more staff per unit deliver higher levels of reliability. Deferred work trends can also be a good indicator of whether there are sufficient frontline maintenance staff (assuming optimal management, etc.).

7.1.6 Location

It is important to deploy staff effectively. Line of route support should be carefully thought through to avoid giving drivers and fitters an excuse to delay a train in traffic (rather than doing cut and run), unless outbased maintenance staff are only at terminuses, where there is sufficient downtime to fix issues which might otherwise cause cancellations or delays. Best practice is for fitters to meet and greet all drivers only at terminuses where there is enough time to make repairs without causing service delays (and still don't dabble with doors!).

7.2 Depot capacity

7.2.1 Sufficient for outputs required

Depot capacity is a matter of design. Operator Contract obligations, fleet mileage, structure of the maintenance plan and availability targets must be used to quantify the capacity and capability needed from the depot(s) to maintain the fleet and to support out-of-course activities, including potential fleet modifications. The role the depot will play in the real-time railway should fit with scheduled work commitments. As *Section 6* explains in detail, the process for planning maintenance work and ensuring that trains are diagrammed to return according to an achievable work plan should be agreed.

Depot capacity does not just depend on the number and type of vehicle berths and equipment. The progression of vehicles through the facility and the sequencing of work and vehicle downtimes are equally important, as are team structure and their working methods.

Inappropriate depot design is likely to jeopardise the quality of defect investigations, encourage the deferring of work to ease production pressures and risk not meeting availability targets with serviceable vehicles. In these circumstances, it is difficult to expect frontline managers to effectively execute the processes outlined in *Section 3*, which are critical to improving reliability, and it will be harder to identify root causes whilst resolving the depot's latest emergency. Overall, inadequate or inappropriate design will encourage a depot organisation to be increasingly reactive and this should be monitored using appropriate KPIs (e.g. deferred work level, number of vehicle moves around the site between routine arrivals and departures). *See Appendix K.*

Example: TfW Rail quantified necessary depot capacity in South Wales and restructured the workforce to introduce well-organised team arrangements. The depot's operational role was also reviewed and an improved planning process was drawn up with operations colleagues.

Example: Northern maps the transit of every train through its facilities to ensure that all work can be fully completed, and throughput matches depot capacity.

7.2.2 Light maintenance

In simple terms, there should be no trains in the depot(s) unnecessarily - to ensure the right units are at the depot for long enough to rectify them properly.

Example: SWR have fleet staff in Operations Control who take the final decision on diagram swaps, i.e. which units really need to go to depot that night.

A depot may be filled with units for stabling, making it difficult to access units for maintenance. This is because depots are often convenient for parking defective or failed stock. Although depots should of course provide this type of support, internal arrangements must ensure that it does not disrupt production processes beyond planned limits (*see Section 6*).

7.2.3 Heavy maintenance

Examples of questions to ask include:

- GTR: Can we bring all maintenance in-house? (rather than contracting it out, to capitalise on economies of scale)
- VTWC (now Avanti West Coast) Longsight: Can we bring critical component overhauls in-house? For example, HVACs, cardan shaft balancing, most bogie repairs, toilets, pantographs, traction auxiliaries, traction interference testing (to reduce travel time and number of bits needed, to enable a common sense of urgency)
- Bounds Green depot: Do we need our own wheel lathe? (to minimise vehicle downtime and optimise wheel life)

Optimal use (for Rules of the Depot, i.e. coordination with train planning, *see 6.1*)

- Detailed depot maintenance work planning can optimise use of the depot, its people and facilities.

Example: Central Rivers grouped exam work into powered down, powered up and work arising. This enabled the detailed occupation of individual depot slots to be pre-planned and shunts to be done at the same times each day, in accordance with the plan, enhancing the capacity of the site.

Example: GWR improved depot efficiency without loss of traceability by placing inspection measuring and test equipment at the point of use in tool vending machines. These control and record the issue and return of equipment whilst having it readily available at the point of use.

Example: GWR's internalisation of heavy maintenance enabled the depot to take greater ownership of vehicles, as well as improve staff understanding of systems and increase availability through no lost time moving trains to an outside workshop.

Example: At Longsight, planning of the workload on nightshift was a well-developed manual process. The plan allocated which road each set will go on at what time, for how long, what work will be done, and which staff will do it.

Similarly, detailed analysis of servicing and maintenance workflows (everything other than the exam work itself) in the depot can be effective for capacity gains.

Example: Neville Hill depot developed a bespoke computer programme to model the depot, including time to:

- Fuel and water
- Go through carriage wash-plant
- Empty CETs
- Get into the maintenance shed
- Get out to the departure siding

The arrival and departure times for each train for any proposed timetable change were fed into this programme for viability.

Spare capacity should also be considered for contingency, testing scenarios, such as out-of-course damage repair requirements on a particular unit, through to the unavailability of another depot within the TOC (e.g. through flooding), and developing plans accordingly.

Again, the capacity delivery of the depot should be measured, and trends analysed to understand changes and developments as they occur, and to identify the need/opportunity for further changes. Suitable measures might be: berth occupancy percentage in the maintenance shed, late starts off depot by cause.

Appendix H includes an example of a checklist for monitoring depot departures.

7.3 Depot facilities

Good facilities for vehicles and people aid productivity and boost morale to enhance maintenance quality. Guidance Note for the Development and Design Considerations of Passenger Rolling Stock Depots (GIGN7621), sets out considerations which seek to support the commissioning of a useful and operationally efficient depot.

Recognising that good maintenance facilities and practices are essential in order to provide reliable trains, Appendix B describes the high-level requirements for a high-performing depot.

8. On-Depot Fault Finding

This section covers No Fault Found (NFF) process and systemic faults that often materialise as repeat defects. This section contains information to help with the diagnosis and rectification of these faults.

8 On-Depot Fault Finding

This section explores root cause analysis and the development of a permanent solution for the fault, which may be:

1. Additional training and development of staff
2. Updating maintenance and overhaul manuals
3. Addressing supply chain quality issues
4. Modifications to the train design

Topics covered in this section are as follows:

8.1 Standardising fault-finding

8.2 Novel testing and inspection equipment

8.3 Developing the establishment of fault-finding within an organisation

Other sections of the 20PP related to on-depot fault-finding are:

- *Section 7* – The Depot, which includes details on the human resources aspect of depots
- *Section 9* – The Vehicles, which describes good practice in data collection and analysis, repeat defects and trends

8.1 Standardising fault-finding

One of the most effective ways to define a process is through a continual improvement loop. Jumping to conclusions when fault-finding often leads to incorrect diagnosis and repeat faults. For example, if a driver reports that the train will not move, then a hasty assumption that there is a fault with the traction could be wrong; there could be any number of reasons, such as a fault with the door interlock system.

The flow chart below shows the 5 high-level steps for fault-finding and is based on two principles: DMAIC and OODA. The OODA loop (Observe, Orientate, Decide, Act) is a continuous cycle used when the correct solution to a problem needs to be found fast with several iterations and is useful for depot maintenance. DMAIC (Define, Measure, Analyse, Improve, Control) is part of the 6 Sigma process and is more useful when time is not a constraining factor. By combining these principles, the flow chart gives guidance on how to arrive at the root cause of the problem quickly whilst creating learning points for future processes.

Step 1: Identify the features and conditions of the fault

a) Asking the right initial questions is vital to speeding up the fault-finding process. Whoever is creating the work order must give and receive the correct information.
b) What are the **symptoms**? Collecting and processing information from sources such as OTDR, TMS, CCTV or drivers' reports produce more accurate diagnosis.
c) Broken components are not necessarily the root cause in themselves and may be a symptom of another fault in the system. A system-based approach is best, whereby inputs, processes and outputs are compared to the component specification; there may be an issue between the train and the component.
d) It is important to carry out visual inspections as well as functional tests using existing VMIs and VMPs.

Step 2: Check the vehicle history and documentation

a) Using the vehicle history, faults can be identified as intermittent, repeat or hard. This will determine how to proceed and whether the fault is active.
b) When dealing with repeat faults, any previous work carried out should be reviewed. This relies heavily on the reporting process, which is covered in a later step. For intermittent faults, the process should be accurately logged so that it can be referenced if the fault occurs again.
c) Historical data of the fault should be reviewed, including change control, modification levels, drawings, etc., as should the vehicle's Failure Mode and Effect Analysis (FMEA).
d) As a minimum, fault-finders need wiring diagrams, all system schematic diagrams, software schematics, functional specifications and interface specifications for the systems they are working on.
e) Industry groups, such as fleet comparison user groups, are helpful to compare fleet issues but information obtained from these sources should be treated with caution and should not replace existing industry processes (such as raising an SRD or NIR).

Step 3: Make an informed hypothesis as to what the fault is, create a work order and repair the fault

a) The fault-finder should have a starting point for further investigation, and broadly know the scale of it for maintenance planning and resource requirements. The key now is to work systematically and record all information relevant to the root cause.
b) When testing the failed component, the VMI and fault-finding guides should be followed; experience can sometimes be a hindrance. The root cause can be overlooked if fault-finders are too hasty in diagnosing the fault without considering the symptoms.
c) Any modifications or changes must be approved by all relevant parties (maintainer, owner, operator), recorded and added to keep drawings up-to-date.
d) It is vital that the fault can be simulated to confirm the diagnosis.
e) If the fault cannot be found, an expert opinion could be sought from the warranty team and the supply chain; whichever party overhauled the system should be consulted in the initial instance.
f) By now the fault-finder should have identified the nature and cause of the fault. Once the failure mode is known, a plan can be created to decommission the train, repair and then recommission it.

Step 4: Testing and reporting

a) The repair needs to be tested thoroughly to ensure it has been rectified and no other new fault modes have been introduced as part of the investigation.
b) A functional test should be carried out to confirm that the system is now functioning correctly in accordance with the VMI as this is the certified maintenance plan supporting the safety management system.
c) Where a component is continually showing NFF, asset tagging should be used to find rogue offenders. Components can be tracked in several ways, by asset tag, bar code and component serial number. Monitoring equipment such as data loggers or temperature indicator strips can also be used.
d) Reports should as a minimum replicate each phase of the process and the key findings.
   i. Test data and parameters should be included in electronic format for further analysis. Scanned copies of written reports are acceptable providing they are filed correctly.
   ii. Where fault-finding has been limited by testing equipment then a process to allow recommendations on how to improve testing equipment should be made.
   iii. The report should focus not only on the technical aspects of the job but also on softer elements, such as teamwork and listening to feedback from operations.

Example: Lockheed Martin have developed their own test rig, the LM-STAR. It is adaptable, can easily integrate new testing capabilities tests all components from the supply chain on the same rig. If there are any quality issues, Lockheed Martin can address them and does not accept an NFF.

Historical Example: London Midland used the Equinox IT system to report and record faults. Technicians populated the system with their repair notes and all defects were coded and grouped for future reference. Repeat defects were monitored using screens connected to the network that displayed data from the last 28 days in places critical to the business. This meant that all the data was readily available to technicians. In order to make this effective, technicians should be given guidance on the level of detail required. The MMS needs to ensure the information is captured and the work report cannot be closed without sufficient information.

Example: Alstom have a test rig (shown in *Figure 1*) that can simulate a train in service in order to test the traffic management systems. This means that the root cause can be identified through trial and error without the unit failing in service. The rig has tested over 500 TMS components and over 350 CCTV components, of which only 24% and 35% respectively were assessed as NFF. All these items were returned to stores for train use and no repair costs were incurred.

Figure 8.1: Alstom's TMS simulator at Oxley Depot

Example: GWR carry out in-house overhaul and repair on certain components (e.g. load regulator electronic modules). All work, including defects, is recorded in a database maintained by the ride inspector team. This enables repeat defects to be highlighted and monitored for trends. The Electrical Test Room (ETR) at GWR also has a test rig that allows prolonged testing of any affected modules to find intermittent faults that may not be obvious under normal testing conditions. The test rig also allows for live testing of high-voltage electrical equipment under controlled conditions away from the vehicle, allowing the vehicle to stay in service while defective components are found.

Step 5: Review, rectification and training

a) Fault-finders need to own the problem and find a permanent solution.
b) VMIs and fault-finding guides should be regularly updated and reviewed in light of work carried out, especially where the fault could have been identified as part of routine maintenance.
c) The vehicle's FMEA may also need updating to include any new failure modes identified during fault-finding.
d) Training and competence need to be assessed to ensure that lessons have been learnt.
e) Information on any changes needs to be passed on to all relevant personnel, including fleet operations, as maintenance may have affected the way guards and drivers interface with the equipment. There may be an issue with operation of the defective equipment that could be a training issue for the whole industry.
f) The use of QR codes, such as on the stickers on Northern's trains, can help increase the likelihood of a fault reported by the public.
g) Skills availability across teams and shifts needs to be balanced to ensure there are always adequately skilled staff for fault-finding work. A skills matrix to manage skill shortages/deficiencies across shifts is one way of managing skill availability.
h) Fault-finders should not make any modifications without the correct engineering change approval.

Example: Alstom use a Root Cause Analysis (RCA) as part of their review process. If a unit fails in service and the fault is a suspected repeat failure or due to previous incorrect intervention, an RCA should be raised against the relevant department or site. This allows the business to understand the root cause and put in place preventative action. After the RCA has been completed and the root cause found, the report is added to a tracker which is distributed to Head of Operations and Fleet Engineer.

8.2 Novel testing and inspection equipment

To support systematic fault-finding, equipment to access train wiring to test for inputs and outputs and monitor functions should be a minimum requirement. Train wiring schematics/diagrams can help locate a feed from the relay panel, but actual test looms may require fabrication to break in' to train wiring. Where PLCs and control units are used, specialist diagnostic equipment will be required to test processes and fault-finders may need specific IT training to support these specialist diagnostic tools.

Example: Alstom use a Health Hub scanner in conjunction with a Fleet Health application to monitor fleet performance. After the unit has passed through the scanner, information on wheel profiles, brake pads, pantographs and component position is collated into the health checker (as seen in *Figure 2*). This allows them to monitor defects and build an accurate database of faults and where they occur on the network. The monitoring software also allows TMS events to be recorded in real time.

Figure 2: Alstom train management tool

8.3 Developing the establishment of fault-finding within an organisation

8.3.1 Establishment of fault-finders

The following should be considered at the beginning:

a) What are the volume, nature and type of faults experienced?
b) What type of fault-finders are required; fleet or system?
c) How many fleets or systems will each fault-finder be accountable for?
d) How long will it take to rectify a fault?
e) Have training courses/days been planned and is there adequate cover for these periods?

By considering these points, depots can plan how many fault-finders they are looking to recruit or develop from existing maintenance technicians. Once that has been decided, technicians need to be incentivised to become fault-finders with enticements such as career progression, increased responsibility and rewards.

Once potential fault-finders are identified (desirable skill sets are detailed later), a clear training and development programme needs to be set out to chart their skills and allow them to understand the role properly. Succession planning is a vital element to ensure that there is a continuous flow of experienced fault-finders to mentor new fault-finders. The apprentice levy is an excellent opportunity to facilitate this.

8.3.2 Features of a fault-finder – soft skills

Soft skills are important as often fault-finders must work as part of or support a maintenance team and be able to clearly explain faults to their peers. They need to explain the fault clearly to non-technical staff and be confident enough to challenge design elements of the system, e.g. by evidencing facts using data.

They must be inquisitive by nature, be able to reflect on their own performance and identify their strengths and weaknesses. Fault-finders should be disciplined, organised, accurate and methodical and be able to confidently express their ideas.

Examples: Southern use a core group of team technicians for fault-finding who support each maintenance team.

8.3.3 Features of a fault-finder – technical skills

Their ability to see the bigger picture and understand the consequence of a poor or late job should motivate them, as should their ability and desire to learn new skills and progress in their career. Fault-finders need to have experience of complex systems engineering, such as commissioning experience. A good basic knowledge of electricity and mechanical systems combined with computing are essential core skills. Along with knowledge of train systems, fault-finders should have some operational knowledge, so they can judge the standard of an acceptable train in service and understand the reason for their work. They will naturally become more specialised in a certain area due to over-exposure to a specific system. In this case, it is important that they:

a) Can pass their knowledge on to other people using their strong communication skills
b) Retain their knowledge of the entire train as staffing numbers and the depot may require them to work on any part of the train. Knowledge is best retained through recording work done and running refresher courses on the different subsystems on board.
c) Consider how the work they are doing can be broken down into chunks (train/subsystem for fleet/systems engineers)

With the introduction of new trains, there is an immediate need for fault-finders to have a solid understanding of IT and software for trains with advanced telemetry. It is increasingly vital for fault-finders to be able to support and maintain their own diagnostic equipment as IT departments typically do not have the skillset to do so.

8.3.4 Training and development

Depots should make use of all available training methods, such as simulators like Alstom's TMS test rig and Interactive Virtual Training such as 5lamps (shown below). Using different training methods allows for subject-specific training whilst still appreciating the whole system. As an extra incentive for training and development, some depots offer technicians the opportunity of gaining recognised qualifications in engineering and maintenance.

Example: GWR have an in-house testing facility for central door-locking equipment, electrical converters, HVAC and some catering equipment. As well as providing a controlled test environment for fault-finding, these facilities also provide an ideal training facility for new starters and apprentices as well as enhancing fault-finding skills for depot staff.

Example: Alstom provide their technicians with a Level 3 training programme for train systems (traction, AWS, HVAC, etc.). It is based around PowerPoint presentations and supported by a

question paper. Technicians have to successfully complete the question paper prior to commencing the competence assessment process.

Figure 3:5 5lamps software simulation

The above simulation was made for East Midlands Railway. The short video shows the location of the on-board fire extinguishers, the different types of extinguishers and when to use them. It is used by train drivers and on-board staff for training. Using simulations is a powerful tool as components can be disassembled and analysed quicker in a virtual environment than in real life. There are simulations for different operators, Network Rail and other industries available at: 5 Lamps Media

Training does not have to only be delivered on depot. OEMs, supply chain, overhaulers, consultancies and the UK Rail Research and Innovation Network (UKRRIN) can be used for expert training as well as collaboration on research projects to increase depth of understanding. Companies may not wish to disclose commercially sensitive information, so compromise may be necessary.

The use of bespoke testing equipment for verifying a NFF diagnosis can also benefit training as well as lowering the cost of sending components back to the supplier for fault diagnosis.

Finally, a feedback loop with periodic reviews should assess the quality of training. Fault-finders should be encouraged to be honest with their reviews and all feedback should be taken into consideration when reviewing the training material and programme. The information gathered needs to be shared with the appropriate people to bring about change and ensure that fault-finders are receiving the best level of training possible.

9. The Vehicles

It is all about effective repeat defects, deferred work and configuration control management and developing a robust maintenance regime.

9 The Vehicles

9.1 Data collection and analysis; repeat defects; trends

Reliability data is needed to understand what is happening where to concentrate effort and how effective that effort is. All TOCs feed into the common high-level reliability measures set out in *Section 2*. These are useful for looking at trends across the national fleet (and are reviewed at regular ReFocus meetings).

Within each TOC, more detail is needed for effective fleet management. Fleet engineers should actively design performance recording systems to:

- enable and encourage staff to record unambiguously details of operational events, the defective equipment condition which caused the event and the corrective actions they applied; and
- support subsequent statistical analysis and the identification of an appropriate long-term engineering response

Many operators call this type of record a Failure Mode Analysis (FMA). Best practice FMAs include:

- the operational event and impact, using TRUST and other data
- the observed failure characteristics related to actual equipment defective condition
- unambiguous identification of the failed component within the vehicle structure
- precise specification of the failure mode
- identification of the cause of failure
- the corrective action taken

Subsequent analysis is easier if:

- standard coding for all vehicle components underpins the recording system
- free format reports are minimised (difficult to analyse)

The above can be facilitated by an appropriate computerised maintenance management system.

Maximise/optimise data volume and integrity (capture all failures and as many potential failures as possible): sources of failure data should be drawn together:

- TRUST incidents (for failures which cause reportable in-service delays)
- Control logs (for failures which affect passenger comfort, e.g. air conditioning)
- Driver feedback (for failures which affect their working environment)
- OTDR, TMS, CCTV; modern and retro-fitted vehicles capture huge volumes of data. Off-train CCTV is also used for some incidents (e.g. to demonstrate that a door incident was caused by a passenger and there are no problems with the door itself, further investigation not required).
- Infrastructure data (particularly on shared systems, e.g. AWS, *see Section 11*

Historical Example: Class 455 TAPAS retrofitted on GTR (with Eversholt). This system used enhanced OTDRs to collect equipment performance data and wireless networks to communicate routinely with an analysis database. It was possible to detect incipient fault conditions and identify precisely the components involved (using GTR's vehicle/train model). When faults did occur, TAPAS could define the failure mode of the train.

Example: Alstom have used digital pens at West Coast depots for arrival audits to enter defects (especially on passenger comfort) straight into SAP (their enterprise resource planning system).

Maximise depth of data (understand each failure): beyond the raw list of failures more data is required to understand each one fully. The underlying root cause must be identified and recorded in an FMA-type document. Periodic analysis and review using proper statistical techniques will then point to the long-term solution, e.g.:

- Inadequate fault-finding guide
- Defective material (supplier feedback, engagement)
- Error in vehicle maintenance instruction
- Insufficient understanding of personnel (training need)

Example: A number of TOCs use Fleet BUGLE to collate and analyse failure data.

Find the root cause – do not accept a "No Fault Found" without thorough investigation.

Example: TPE use TMS, OTDR, CCTV, door control unit histories, etc. to help identify what actually happened, with feedback to traincrew if necessary.

Example: Southeastern hold a root cause meeting to dig down and highlight lessons learnt in a reliability brief. This includes: top 5 Repeat Embarrassing Defect (RED) units, staff actions (e.g. recording any temporary repairs) and technical actions (e.g. develop new repair procedures, mend test equipment).

Optimise data sharing (get the right information to the right people at the right time to mitigate impact).

Example: War rooms are in use at many depots, with the longest established at East Ham. It is located where staff sign on and is also used for the daily morning meeting. If major problems arise on the fleet, there may be a 2-hour meeting there to keep all abreast of the situation. C2C seek a quickly implementable mitigation, minimising the effect on the service and allowing time for a longer-term solution to be devised.

Repeat defect management (dealing with the same apparent root cause).

- Provide the information to make clear it is not a repeat booking

Example: SWR's Aide Memoire supplements a heritage fleet data management system. Aide Memoire faults are coded by effect (not cause). This identifies repeat faults which would not otherwise show up due to incorrect initial diagnosis and is an effective supplement to root cause analysis work.

Example: Alstom (Formally Bombardier) modern fleets are fitted with Mitrac which incorporates effective repeat defect flagging.

- Implement the management process for maintenance staff to be thorough, disciplined and consistent.

Example: Sole users of electronic components often track serial numbers, e.g. for static converters, so repeat defects at component level can be resolved (Bounds Green on Class 91 and Mark IV, Slade Green on Class 465). Soho openly display a 28-day rolling history of each unit and each technical system.

- Create staff development programmes to teach technicians about investigation and analysis. Do not expect key investigative staff and skills to materialise without nurturing and developing potential (*see Section 7*).

Examples: Tyseley's level checks have been widely adopted and depot engineer authority is required for a train to return to service after 3 failures of the same apparent root cause. Alstom (formally Bombardier) Central Rivers depot does not accept more than two No Fault Founds for the same defect: the train is not released until something relevant is found. The result is fed back into fault-finding guides.

Close the loop (analyse trends to ensure continued effective solutions and processes; identify promptly any need for further action or emerging problems).

Example: Dynamic Variance Charts developed by TPE, have been adopted (as Modus) in First Rail TOCs. Modus relies on measuring the actual performance against a standard or predicted level, so new or divergent trends can be rapidly identified. The system works well where there are multiple variables, e.g. on mid-life fleets where defects may have become embedded and their effects overlap, making it hard to understand the contribution of each.

Top 10 technical issues (target efforts rather than trying to fix too many defect root causes at once).

Example: Pareto analysis is generally applied to identify the 20% of work to fix 80% of problems. For technical issues, failure data tends to be grouped by system/function (e.g. door gear electrical, traction interlock system, door gear mechanical, AWS/TPWS equipment) and scored by severity (e.g. number of incidents, number of impact minutes). The systems with the highest scores are the top priority and progress should be reviewed regularly.

Example: EMR have used Fleet BUGLE to feed a DRACAS (Defect Reporting Analysis and Corrective Action System) database.

The most frequent types of failure are given a DRACAS code and carefully monitored. Each has a champion who develops actions for improvement and progress is monitored at regular four-weekly meetings.

For example, DRACAS code X001 is 'unsolicited brake applications'.

There are 9 recommendations arising from X001, including modifications, changes to VMI, compliance with existing instructions, staff training and track levels where units are coupled.

The benefits of each action are predicted and prioritised with progress against plan colour-coded.

Top 10 non-technical issues (reliability improvement is not just a matter of modifying trains).

Examples: At C2C, every TRUST incident is discussed with operations at a daily conference. A list of actions is produced to ensure follow up and close out. Sometimes C2C engineering may write a driver instruction to mitigate an issue. In addition to standard fleet metrics, at Groningen in the Netherlands, train faults are measured by driver diagram mile by depot. This highlights those who are unhappy/lack training/too rarely drive particular stock and enables remedial action to be taken.

Condition monitoring (how to prevent defects by gathering relevant data and feeding it into effective management processes).

Proactive data-sharing and trend-spotting can identify potential failures, which can be managed by sophisticated electronic call ahead or simple measurement systems and hence prevent actual failures.

Historical Example (sophisticated): Remote Train Monitoring (RTM) was fitted to all AGA Class 90 and DVT vehicles. Any non-conformities against pre-set parameters show up in red and a history of previous defects can be called up.

A mimic of the cab layout shows the position or display of each switch, handle and gauge. A 'live' electrical schematic can be called up, showing which parts of circuits are currently energised.

This is used to advise a driver what steps to take to get a failed train on the move as soon as possible.

It also provides invaluable help with fault-finding, as the history of what parts of which circuits were energised when, is available for future reference.

Example (simple): FCC (now GTR) measure traction motor brush changes to identify rough commutators for grinding, reducing the risk of flashover. Brushes changed earlier than normal are flagged in red on XV (their maintenance management system). Diesel operators measure coolant top up at all locations to identify leaks for remedy at the next B exam.

Historical Example: Southern have proven that OTDR data can be used to obviate the need for routine maintenance of brakes. They also invested in bodyside door monitors on Class 455s (now ceased) to obviate routine maintenance and improve performance as the automatic system with SPC filtering is far more accurate than human beings.

9.2 Deferred work

Specific repair activities are sometimes deferred until the necessary vehicles, parts, personnel or other inputs are available. Vehicles with less deferred work tend to be more reliable.

Work can only be deferred where it is both safe (any risks acceptably mitigated) and commercially acceptable (running to timetable, toilet provision) to do so and TOCs have relevant decision criteria.

Once work has been deferred, best practice is:

- Weekly review of outstanding deferred work
- Lean review of process: GWR have created headroom in planned maintenance exams for defect clearance

- Each maintenance team shift briefed on which items to do
- Target zero deferred work off exam; each team monitored and benchmarked against this target (East Midlands Railway)
- Feedback briefing to frontline staff (e.g. in communications room)
- Monitoring deferred work trends:
    - Number of items per vehicle (rate of decrease, although some TOCs had initial increases, as reporting improved)
    - Types of deferred work
    - Vehicle system affected
    - Reasons for deferred work (material unavailable, staff shortage, depot berth unavailable)
    - Number of operational events that can be attributed to deferred work

Deferred work trends are a measure of adequate production capacity and require action if the trend is not downwards.

Example: Soho have had a deferred work database where the root cause of deferring each item, e.g. material shortages, is recorded to ensure that required materials/equipment are available before the unit is stopped for exam.

9.3 **Configuration**

The modification status of the vehicles and the parts fitted to them are required for a stable benchmark for reliability performance and meaningful fleet comparisons.

It is also crucial to know what materials to order, what maintenance regime to follow, etc., especially when fleets are split and combined across different franchises and ROSCOs. Clear records of configuration (vehicles and drawings) help with heavy maintenance, ensuring that the correct spares are ordered, and successful modifications are not undone. A standardised change management process should be used to control this (*see Section 3.5*).

9.4 **Maintenance regime**

UK rail vehicle maintenance has a long history of preventive examinations and corrective repairs, generally based on RCM principles, but there is always room for improvement. Triggers for change include:

- Feedback from failure data – extra/different maintenance may prevent failure
- Modifications which require less/different maintenance (part of configuration control)
- Condition monitoring which obviates routine failure-finding activity and identifies superfluous maintenance tasks
- Exploiting opportunities to make changes – testing changes in maintenance to check they are as beneficial as expected (e.g. more frequent filter renewals to prevent failures)
- Fundamental assessments of operational and business risks (*see Section 3.2- Risk evaluation)*

Example: Southern applied a proactive risk-based approach to their maintenance plan and identified that air system components had an inadequate overhaul regime and therefore posed a long-term risk. The result was a maintenance plan revision to enhance safety and performance standards. Risk-based assessments also identified intrusive activities which introduced more risk than routine inspections but were inadequately addressed in the maintenance plan. This motivated improved instructions for intrusive activities and led to their inclusion in the competence assessment regime.

Developments in communication technology and data storage offer an unprecedented opportunity for radical change in rolling stock maintenance. By careful design of data and analysis, maintenance activities have been modified based on data trends. This approach permits maintainers to eliminate many routine maintenance tasks, simultaneously reducing train downtimes, increasing rolling stock utilisation and releasing depot and resource capacity.

It is important to match the time for preventive examinations and corrective repairs to the downtimes agreed for service availability requirements. Exams may be *balanced* into even sized blocks (to fit in more easily with train downtimes and staff rostering) or *cumulatively* built up to more significant activities (where it is easier not to compromise the quality of work to fit too tight a downtime) (*see also Section 7.2*).

Examinations may be driven by time, mileage and/or duty cycles: the best driver often varies by train system, so the overall maintenance regime is often based on a mixture of all these. However, the more accurately the optimum periodicities for each individual activity are applied, the more complicated the regime is to manage, e.g. if excessive visits to depot are required. A compromise of grouping activities together is generally reached (for more details see *Section 12.4*).

Older rolling stock used to have a clear demarcation between light Level 4 maintenance and heavy Level 5 overhaul. Generally, Level 4 could be done in-situ between diagrams or at most when the train is stopped for a few days, whereas Level 5 required taking the vehicle out of service. Level 5 work often involved lifting the vehicle to change bogies, engines or perform a C4, or work on the body of the vehicle itself, including painting and C6

Modern vehicles rarely need Level 5, compared to some Mark 1 stock requiring annual (although mileage-based) bogie overhaul because of wear in moving metal parts. Modern vehicles run several years between bogie overhauls (which remain fundamentally mileage-based) because of advances in suspension materials and technology.

Integrating Level 4 and Level 5 saves vehicle downtime but requires tooling up formerly Level 4 depots, e.g. with lifting equipment and painting facilities. Integration encourages holistic maintenance (easier to trial changes, fewer parties to negotiate with, risks and benefits seen by same party).

Example: Work was completed to extend Class 357 C4 from 450 000 miles to 1.5 million miles. The key to this is wheel condition. Wheel flats are very rare with modern WSP and planned reprofiling. The frequency of reprofiling was increased so that the depth of cut could be reduced.

Example: At Onnen depot in the Netherlands, reprofiling was completed at 40 000 miles, a light cut to maximise wheel life. This is thought likely to be best practice for the UK too.

9.5 Understanding availability

A consistent and reliable level of availability must be established to prevent excess vehicles being unnecessarily leased or persistent failure to deliver to timetable.

Availability is affected by factors such as:

- Maintenance workload (including heavy maintenance and running repairs, i.e. all vehicle downtime)

- Modification workload (can be significant for the first few years of new trains, e.g. safety software upgrades)
- Diagramming (e.g. increasing the number of remote overnight stabling locations)
- Incidents (vehicles requiring significant repair can wait for months; a contingency plan must reflect the risk of these repairs on a particular route)
- Depot capacity and capability (*see Section 7*)

Example: GWR have a detailed 15-week plan showing all exams, heavy maintenance, etc., which is critical to ensuring a steady maintenance workload.

Example: At C2C, a 15-month painting programme required two units to be away for painting at any one time. Agreement was reached within the TOC to reduce the traffic requirement by two diagrams by de-strengthening and thus avoiding an impossible target.

Measuring availability. Availability has traditionally been measured at a particular time of day, typically just prior to morning and evening service peaks, e.g. '0600 stop position'. Availability requirement in the UK is often expressed as a percentage of the total fleet. Some TOCs include hot spares in the requirement and these may be shown as less critical. In other words, if the hot spare(s) is/are unavailable, traffic is not short but service delivery resilience is impaired *[Note that on the continent there are softer measures, e.g. number of trains supplied for traffic compared with plan, drawn from a much larger fleet. As ever, understanding exactly what is being measured is crucial for any meaningful comparison.]*

Example: Alstom (West Coast Traincare) had taken the '0600 stop position' a step further at VTWC (now Avanti West Coast) with round-the-clock scheduled phone conferences (i.e. several availability counts during the 24 hours), which are used to plan depot slots and allocate staff to tasks on Pendolinos.

It is hard to make meaningful comparisons (especially at the high-level fleet % measures) but detailed ReFocus data has been used to justify increasing fleet size in other TOCs. The extra vehicle leasing costs to make availability deliverable were justified by reliability performance improvement. It is of course possible to make available a sub-standard vehicle, but a vehicle truly fit for purpose can only be provided through a successfully completed sequence of specified management processes. Defining these processes and understanding their relationships and dependencies is therefore necessary for sustained success. This work will almost inevitably stimulate change projects (*see Section 3.1*). As a minimum, improved understanding will help management reduce the number of times sub-standard vehicles are offered for service.

Critically, **the reasons for each unavailable vehicle must be identified, recorded and trended within each fleet/TOC** to identify improvement opportunities and measure their success or otherwise.

Typical reasons for unavailability are:

- Maintenance planning (peaks and troughs or combinations that exceed organisational capacity), e.g. B exam, C4, C6, other maintenance/repairs arising, e.g. modifications, condition-based work
- Out-of-course repairs, e.g. vandalism damage, collision damage
- Waiting, e.g. material, specialist staff, shed space, test run
- Failure investigations, e.g. repeat failures

Example: Cross Country used Wheelchex to plan tyre turning and prevent availability problems. A rolling 28-day chart (updated daily) in the planning office at Central Rivers shows any Wheelchex reports greater than 150 Nm. Impact loading increases over time, visual inspection is scheduled and then tyre turning prioritised. This modifies the baseline 250 000-mile conditioning re-profiling programme. In addition to improving availability, the use of Wheelchex data has enabled better use of the Central Rivers wheel lathe and reduced buy-in slots at other lathes.

Example: Mileage is carefully managed at C2C by using shorter or longer mileage diagrams. The tolerance on exams is set at – zero, + 500 miles. All exams are planned within the +500 miles range and done slightly late. This ensures the fleet is not over-maintained, giving best availability of units and saving costs.

Example: TPE use a 43-day plan for each Class 185 unit. The units almost due for exam are allocated to higher or lower mileage diagrams and therefore close to the target mileage, reducing waste from carrying out exams early.

Balance availability and reliability. Once the long-term level of availability is set, it is important to balance availability to ensure reliability is not compromised. Best practice is to develop a culture where repairs are done to promote reliability, rather than deferred to chase short-term availability at any price.

Example: Some TOCs have agreed contingency plans such as running 3 cars vs 6 on certain trains if necessary, e.g. carrying out thorough level checks on repeat failures (see 9.1 Repeat Defect Management).

10. Managing Ageing Rolling Stock

The purpose of this section is to increase awareness and knowledge of the factors to consider when identifying and managing ageing rolling stock. As well as how to mitigate the impacts to avoid significant reliability and performance reduction.

10 Managing Ageing Rolling Stock

All rolling stock has a predicted design life, where the fleets are expected to operate reliably and economically. However, components and sub-systems will invariably have to be overhauled, repaired or replaced along the way and the quality of this work will have a material impact on the lifespan.

10.1 Rolling Stock Design Life

The 'bathtub curve' process model (*Figure 10.1*) is regularly used to show the phases of asset service life and can be divided into four stages:

Infant Mortality - During the rolling stock introduction stage, software, subsystems and components fail because of poor manufacture, insufficient design knowledge, testing or poor communication with sub-system suppliers on systems integration. More information on this phase can be found in *Section 14: New Train Introduction*.

Maturity - Once the fleet introduction issues have been resolved, the asset enters a sustained period of performance and reliability growth. Fleet managers optimise maintenance by pushing out non-value-added activity and introducing new tasks where appropriate (*see Section 7: Depot*) and critical components are serviced and overhauled (*see Section 17: Overhaul Management*).

Ageing – Degradation, failure rates and costs are beginning to rise as rolling stock approaches midlife, stock levels of spares dwindle, and obsolescence, structural fatigue and corrosion set in. As the asset's residual value depreciates, developing business cases for investment is increasingly difficult. At this stage, the decision must be made for replacement or life extension. With effective cost control, modifications, enhancement and maintenance improvement, the usable life of rolling stock can be extended.

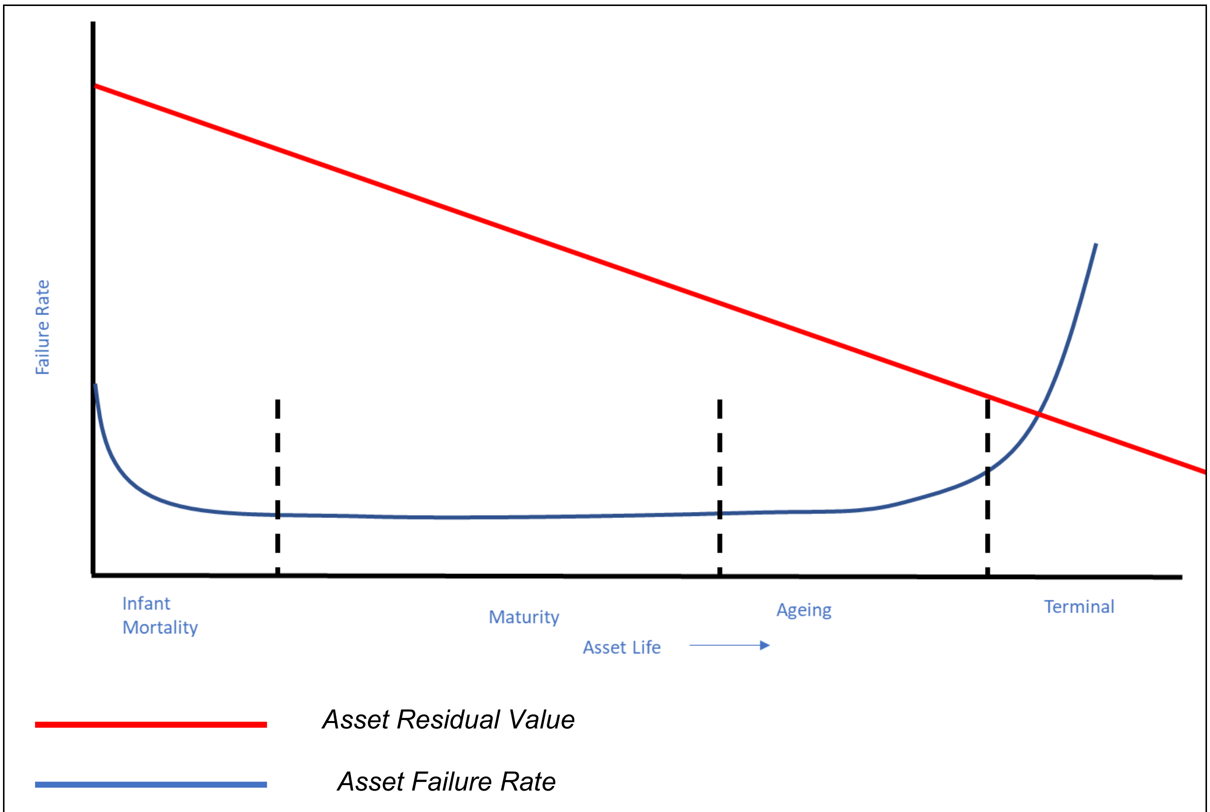
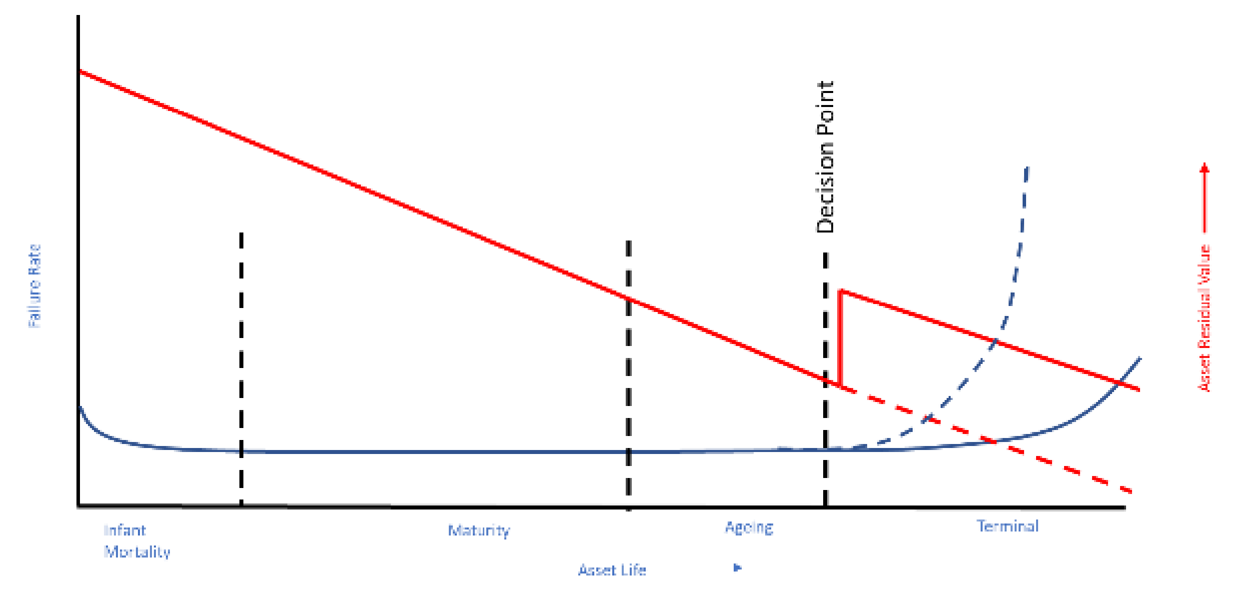


Figure 10.1: Asset Ageing Process Stages

Stages	Name	Characteristics
Stage 1	INFANT MORTALITY	• Design and manufacturing faults • Early life operating faults (training, trials) • Interface issues • Software design, integration and testing • Slow performance growth
Stage 2	MATURITY	• Prolonged incremental performance growth • Planning for servicing and overhauls • Extending maintenance periodicity • Reducing maintenance costs • Condition monitoring and condition-based maintenance
Stage 3	AGEING	• Design limits approaching • Evidence of deterioration due to corrosion and fatigue • Refits and modifications required for operation and passenger comfort • Lack of spares • Lack of skilled labour • Maintenance costs increasing • Minimal residual value • Uncertainty around remaining life • Life extension investment decisions
Stage 4	TERMINAL	• End of life based on cost of repairs or replacement and economic value extending and descoping maintenance and overhaul intervals • Selective decommissioning of units • Decommissioning for spares to support remaining fleet • Repurposing facilities and staff for new trains

Figure 10.2 shows that reinvesting at the right time will increase the rolling stock residual value; this in effect extends the maturity stage and time in operation.



	Extended residual value after investment
	Original residual value
	Extended failure rate after investment
	Original failure rate
	Boundary point (Decision Point)

Figure 10.2: Extended Asset life after Investment

10.2 **Management Process**

The rest of this section focuses on *stage 3* of the asset life (*ageing*) but is not intended to be prescriptive. The ageing management process requires proactive maintenance, including asset condition assessment, monitoring and mitigation, acceptance criteria and performance standards, corrective actions, maintenance strategy, review and feedback.

Mitigating the ageing process has been categorised into four good practice stages:

- **Stage 3a - Understanding ageing** provides insight into the characteristics and problems defined as important.
- **Stage 3b - Decision points** outline both internal and external factors to consider before deciding on the best way to handle the impacts of ageing.
- **Stage 3c - Mitigation** offers two distinct maintenance approaches to reduce and manage the ageing rolling stock and its impacts.
- **Stage 3d - Feedback and review** on the objectives and feeding back lessons learned into maintenance plans.

The diagram below illustrates the process for better management outcomes.

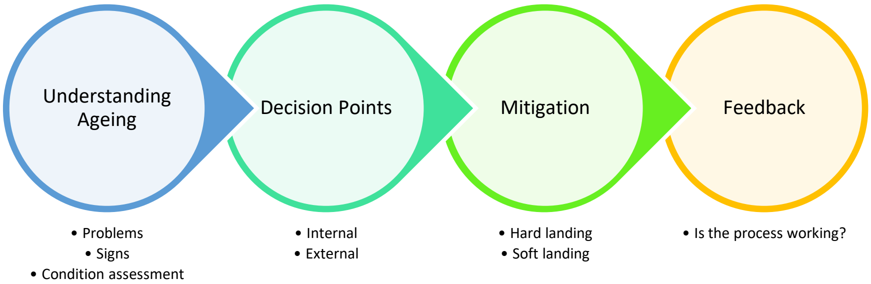


Figure 10.3: Mitigating the Ageing Process

10.2.1 Stage 3a: Understanding Ageing

The reliability and performance of the rolling stock can change during its life through age-related degradation, obsolescence and operational environment changes. Availability of the rolling stock, historical performance, reliability, maintenance and overhaul data are vital to identifying the level of ageing and monitoring performance trends. A defect identification process (see *Figure 10.4*) should be applied when inspecting the vehicle structure, systems and components *(see Figure 10.5)* where failure would have a critical and direct negative impact on operational performance, safety and reliability.

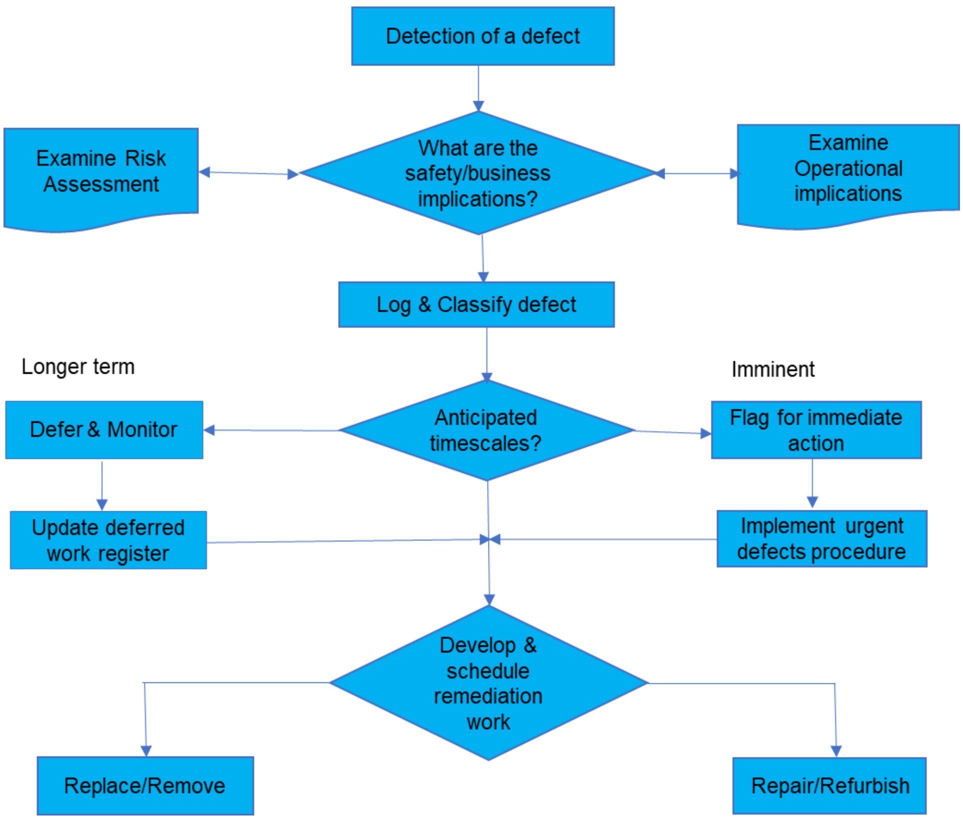


Figure 10.4: Flow diagram for reacting to defects from the perspective of managing ageing rolling stock

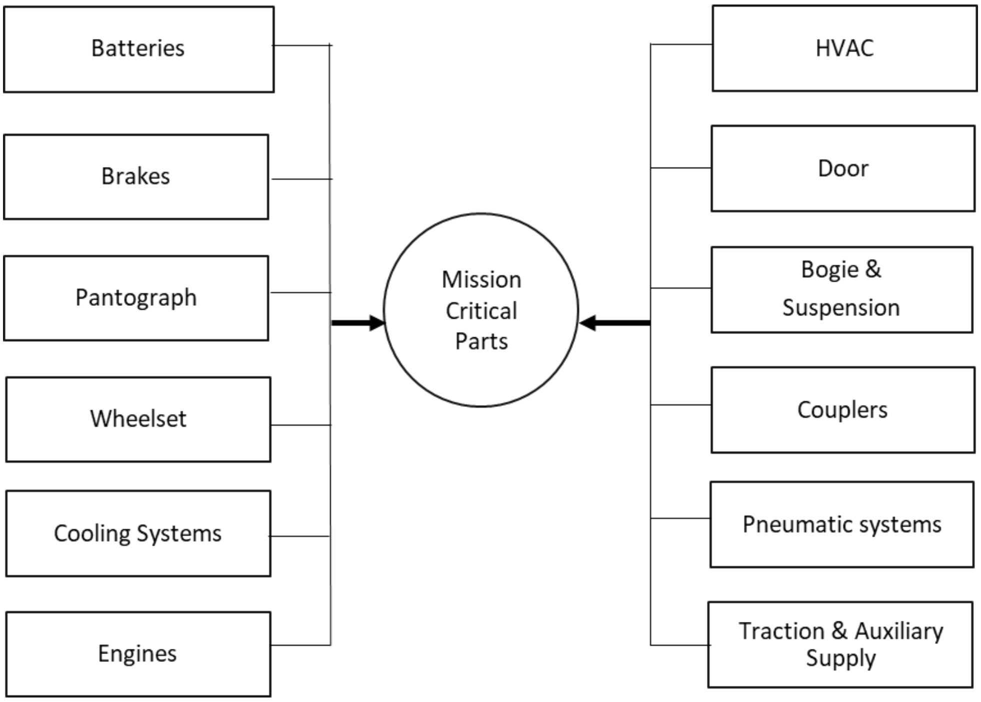


Figure 10.5: Mission Critical Parts

Some of the main degradation processes are corrosion, fatigue and obsolescence. A summary of the most common problems associated with ageing in any type of rolling stock is given in *Table 10.6*. This is not an exhaustive list but seeks to provide an insight into factors which may be overlooked.

Characteristics	**Impact**
Obsolescence	Lack of spare parts, technical support or non-existence of the original equipment manufacturer is an indicator of an ageing fleet. There is a high probability that the components and systems from the original manufacturers will disappear over the course of the asset's lifetime. If the manufacturer no longer exists, then obtaining spares, original design drawings or replacement parts compatible with the existing asset can be difficult. This is an issue for electronic components and computer systems where the market moves quickly, and hardware and its manufacturers and suppliers change frequently.
Structural fatigue	Cracking of the metal bodies and bogies starts after long in-service hours, mileage, vibration and loose fasteners due to these components reaching the end of their design lives.
High corrosion (body thinning)	This is the physical degradation of material properties as a direct result of interaction with the climate or environment and the effect increases over time. It can also affect electrical connectors and cables.
New technology	Lack of compatibility with new or retrofit technology.
High parts failure and maintenance costs	As the rolling stock ages, so do its parts and components; constant random shock failure of different parts leads to high maintenance costs.
Reliability and performance decline	Besides the MAA Mp701D reliability performance, other internal reliability and performance KPIs will help to identify and monitor any decrease in the performance benchmark of the rolling stock.

Characteristics	Impact
Intensive resource consumption	Due to the sporadic and unexpected failure of components or systems, there is an increased requirement for specialist resources such as fault-finders, system engineers, etc.
Relays & contactors	Contacts become eroded and pitted over time and can become welded together.
Wires, pipes & hoses	Degradation, blockage, corrosion; hoses wear due to vibration and movement.
HVAC	Loss of refrigerant / temperature control, reduced air quality and increased failure rate, especially in hot weather.
Wear and tear	Increase in deterioration rate, leakage.
Different lifecycle of components between overhauls	Each sub-system has a different deterioration rate; some may fail before scheduled overhaul/maintenance becomes due.
Lack of support from relevant parties (design authority/OEM)	This can be as a result of a lack of expertise, economic viability or availability of the original rolling stock documentation or protection of Intellectual Property Rights (IPR).
Lack of proper reliability management policy	As the rolling stock ages, there is the chance of a cultural shift among operators, maintainers, etc. leading to incorrect/lack of root cause analysis (tendency to tolerate failures and pass them off as the norm).
Loss of resources, skills/expert at depot & supply chain	For fear of redundancy or lack of essential skills, people tend to move to work with different rolling stock or stay with the trains and technology they know (newer or older). Due to the fleet being withdrawn, there is a lack of enthusiasm to continue.
Lack of overhaul process/visibility of part numbers	Traditionally, overhaul was performed by highly skilled staff. Lack of proper documentation in relation to part numbers (cat. no., drawings, etc.) makes it difficult to comply with overhaul standards and replace failed components or find appropriate compatible replacements during overhaul.
Lack of spares pool	Shortage or unavailability of spares because of a single operator's fleet becoming cascaded to various operators exacerbating the problem.

Table 10.6: Ageing Signs and Problems

10.2.2 Stage 3b: Decision Points

These are high-level guiding factors to be considered before committing to or investing in the future of ageing rolling stock. For detailed risk analysis see *Section 3.2 Risk Evaluation*.

10.2.2.1 Operating Contract Changes

This is one of the main driving factors. Any plans to accept or manage ageing rolling stock should be scrutinised for their economic viability towards the end of an Operating Contract and the potential plans of future prospective Operators.

Historical Example: The Renatus vehicle enhancement and life extension was developed before the 2016-awarded Greater Anglia franchise; however, the new franchise announced a full fleet replacement. Such scenarios may be difficult to predict, but a risk-based approach can help.

10.2.2.2 New legislation

Is it economically viable for the rolling stock to be enhanced to ensure compliance with new legislation from government, regulatory bodies, etc. (e.g. *compliance with PRM TSI regulations*)?

10.2.2.3 Economic viability

Asking the right and hard questions: How much life is left in the rolling stock, planned life extension, cascade options, enhancement, investment justification.

Example: Choosing to extend the life of the Class 379s (which are limited to electrified routes) vs choosing to do so on a fleet such as the Class 170s, which can operate across most of the UK network.

10.2.2.4 Stakeholder expectations

The customer service-based expectations, comfort and journey experience (HVAC, Wi-Fi, new seats, new trains, etc.) are constantly rising due to high demand from the DfT, Passenger Focus Group, etc.

Example: Simply repainting the interior of a train is no longer sufficient when choosing to extend its life. The customer expects more, including air conditioning, plug sockets, etc. A successful example is the Class 168 refurbishment, where many customers believed these were brand new trains, not just refurbished units.

10.2.3 Stage 3c: Intervention and Mitigation

This section looks at options to mitigate the effect of ageing and ensure that chosen objectives are achieved. It also looks at how to evaluate when the replacement, cascade or scrap should take place in a cost-effective manner.

Mitigation management covers many activities such risk analysis, inspections, condition assessment, maintenance strategy, enhancement and, most importantly, whether the process is efficient and cost-effective. It is useful to have a simple system tracker for monitoring the condition of critical components and systems *(Table 10.7)*.

Condition	Description
A -Good	Systems/components delivering all required functions to required levels of performance and reliability AND No signs of onset of ageing process
B -Acceptable	Asset delivering all required functions to required levels AND/OR Some evidence of the onset of one or more degradation mechanisms (excluding obsolescence) that currently pose no significant threat to the delivery of required functions
C -Poor	Levels of asset availability and/or reliability are below that required to consistently deliver required function(s) to the standard levels of performance AND / OR Evidence of (or reason to believe) significant progression of degradation mechanism(s) (including obsolescence) that are affecting or threatening key functions and need to be addressed
D -Unacceptable	Unacceptable levels of availability and/or reliability mean that the asset is currently unable to deliver the required function to the required levels of performance AND / OR Evidence of (or reason to believe) substantial progression of degradation mechanism(s) (including obsolescence) that are currently affecting key functions, or which pose an immediate threat to key functions.

Table 10.7: Components/Systems Defect Classification

10.2.4 Maintenance Strategy

To develop a robust maintenance strategy framework (*Figure 10.8: Strategic Framework*) and SMART (*specific, measurable, achievable, realistic and timely*) objectives, the current asset condition should be assessed through its historic data. The involvement of key stakeholders, both internal and external, is critical.

There are two types of process available: **hard landing** (***end of life***) or **soft landing** (***continuous in-service***). These two scenarios provide the basis for deciding whether the rolling stock continues in service, is re-purposed, repaired, enhanced or scrapped.

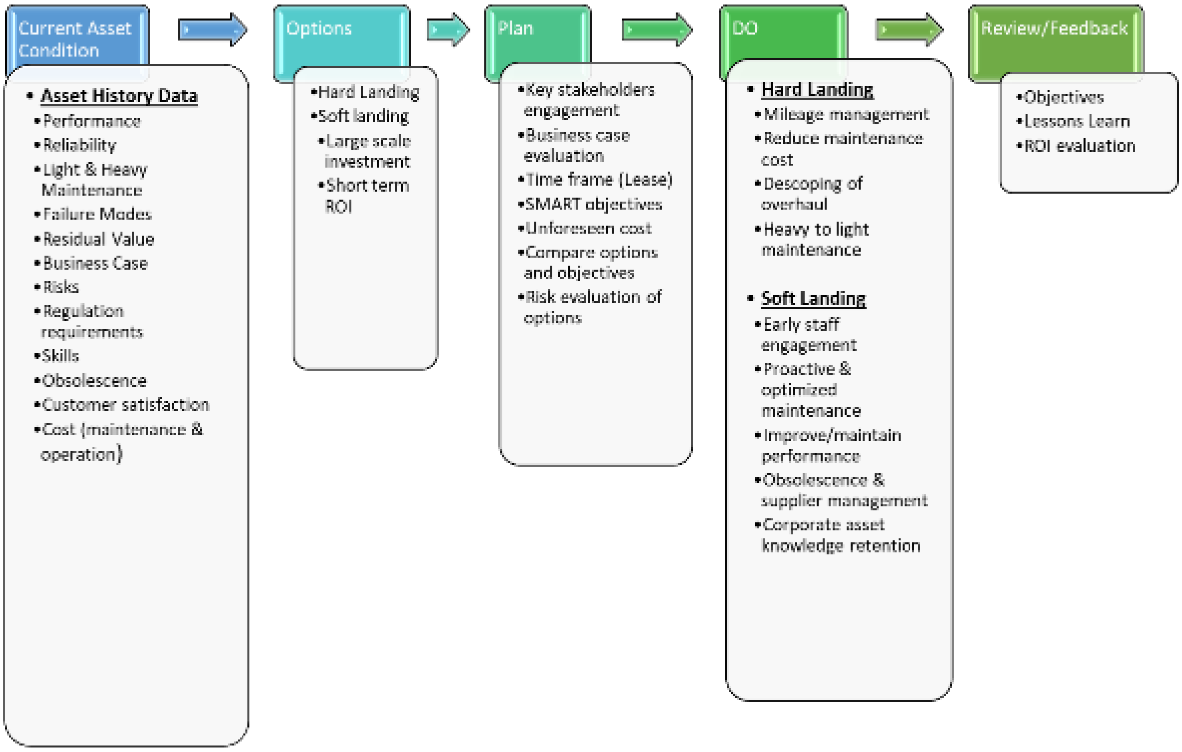


Figure 10.8: Maintenance Strategic Framework

10.2.5 **Hard landing**

This is when the TOCs and RoSCos are certain that the rolling stock is approaching the end of its life (scrap) without the option of life extension or cascade. To save maintenance resources and impact costs, alterations are needed to extract the remaining value.

10.2.5.1 <u>From heavy to light maintenance (L5 – L4)</u>

All previous planned/scheduled heavy maintenance should be changed to light maintenance to save costs.

10.2.5.2 <u>Descoping of overhaul</u>

Taking a risk-based approach instead of the normal/routine planned overhaul, skipping some tasks, repairing instead of replacing components, recycling spare parts from out-of-service units.

10.2.5.3 <u>Mileage management</u>

Prioritising units with lower milleage in service (rotational). *See Section 11.4. Optimising for duty cycle*

> *Example: Prior to their fleet replacement,Greater Anglia extended maintenance periodicities on their legacy intercity fleet to enable overhauls to be pushed back to post-handback date. This prevented costly overhauls being undertaken close to withdrawal from service. The benefits included reduced costs for the RoSCo and improved availability for GA.*

10.2.6 **<u>Soft landing</u>**

This is when the rolling stock has the option of life extension or cascade and may remain in service. It is recommended to have a minimum of 2 years (Operator contract) to plan for any significant enhancement. A review of scheduled maintenance is an essential element of the soft-landing process as it is the primary tool used to identify reliability variations and resource demand. The aim of the review should be to determine whether the maintenance policy is adequate and effective for the current condition of the rolling stock and is being correctly implemented in maintenance schedules to improve reliability.

10.2.6.1 Proactive management (C6, C4, VMI - more inspection)

The use of a condition-based assessment approach for systems, sub-systems and at component level to determine the exact maintenance regime. Deciding which maintenance regime (mileage- or time-based) is best for the rolling stock due to its age and diagrams.

This should involve identifying key locations of structural fatigue (crack mapping) and proactively looking for corrosion at midlife and during routine/light maintenance.

10.2.6.2 Body deterioration

Corrosion in steel-bodied vehicles needs addressing quickly. The use of fracture map reports and endoscope cameras is highly recommended to track and monitor the levels of damage, especially around hard-to-reach areas. Vehicles should be kept well sealed and watertight; rubber seals, floor condition, radiator water pipework and roof corrosion leading to hidden water leaks in the body should be monitored. Attention should be paid to door runners for wear, inter-car electrical jumpers and wiring for deterioration, gearbox, bogies and traction motors for cracks and loose fasteners. Other innovative repair methods, such as additive welding and the use of composite materials, should be explored (*see Section 17.2.4: Overhaul specification)*.

10.2.6.3 Different lifecycle between components and overhaul

As the vehicle diagram changes and mileage per annum reduces, components may need more regular maintenance if it is mileage-based rather than time-based. Other critical time-based components are pantographs and air seals in large air-driven contactors.

> *Running 50,000 miles per annum vs. 120,000 miles per annum makes a big difference to components such as rubber hoses, which perish over time, or air compressors which are overhauled on C4 exams that would now take place every 10 years rather than every 4 as a result of mileage reduction.*

10.2.6.4 Cascade (acceptor)

As an acceptor of the ageing rolling stock, operators should have strategic plans to maintain current performance and reliability as well as track failed components, etc. using historical data as a key performance benchmark. Door duty cycle change – cascade to a TOC with different diagram (longer/frequent) – will impact on reliability and performance. *Section 16.4: RoSCos: fleet transfer* contains more information on what to consider when accepting rolling stock from other operators.

10.2.6.5 Staff engagement

Human error is always a concern with maintenance at all levels. Managing ageing rolling stock requires a range of competencies such as familiarity with the fleet and design knowledge. Staff morale and maintenance quality might dip due to old rolling stock withdrawal (staff leaving) and new fleet introduction (with potentially a different maintenance agreement e.g. TSA).

Early staff engagement and communication are important for the efficient and effective management of ageing rolling stock. A culture where it is easy to ask questions and point out problems will suffer fewer ageing-related equipment failures than one with a fixed hierarchy and less communication. Management support for staff to learn beyond what is strictly necessary to fulfil their role will produce a more flexible and understanding organisation.

> *Example: Upon the announcement of their fleet replacement, GA conducted a campaign of colleague engagement around the network looking to reassure those who felt uncertain about the future.*

Keeping colleagues informed and engaged with up-to-date developments and taking on board any feedback helped to minimise the impact on morale, production quality and reliability.

10.2.6.6 Cultural changes

Tolerating failures and poor reliability of ageing rolling stock can become the acceptable culture, leading to reactive maintenance. A positive culture can be created through proper engagement, motivation and appreciation throughout the staff and supply chain to encourage failure root cause analysis.

Example: With the introduction of new rolling stock and a TSA contract with manufacturers, some TOC staff were not confident enough to TUPE across to the new, more technologically advanced rolling stock and prefer to work on the older fleets. This led to skills loss, cultural change and a loss of morale.

10.2.6.7 Knowledge transfer and retention

It is important to document lessons learned from successes (“Why did it go well?”) and failures (“What did not work properly and why?”) and make corrections and improvements. It is a good way of gaining trust and ensuring both knowledge retention and staff development.

There can be a wide gap in age and experience between established experienced staff and newly recruited colleagues. A lifetime’s knowledge can be easily lost upon retirement. It is therefore necessary to consider how to retain corporate memory and key equipment skills.

10.2.6.8 Skills enhancement and empowerment

Any modifications, engineering or configuration changes should be reflected in the VMI and routinely checked for better configuration management. This is an end-to-end review and should identify what skills and competencies are needed to facilitate adequate training.

Staff should be incentivised, encouraged and given opportunities by management to solve problems and suggest/make improvements within competence limits and take ownership.

10.2.7 **Stage 3d: Feedback**

The management programme begins with understanding the ageing characteristics and impact, investment risk analysis, implementing mitigation actions and ends with feedback for evaluating its effectiveness (see *Figure 10.9).*

This helps to ensure that the process incorporates the latest information on rolling stock ageing signs, safety issues and corrective actions.

The end-to-end process should be evaluated through correct key performance indicators such as Mp701D reliability performance and asset current condition. The maintenance approach should be reassessed if mitigation is not preventing breakdowns, the effects of ageing or poor performance and reliability.

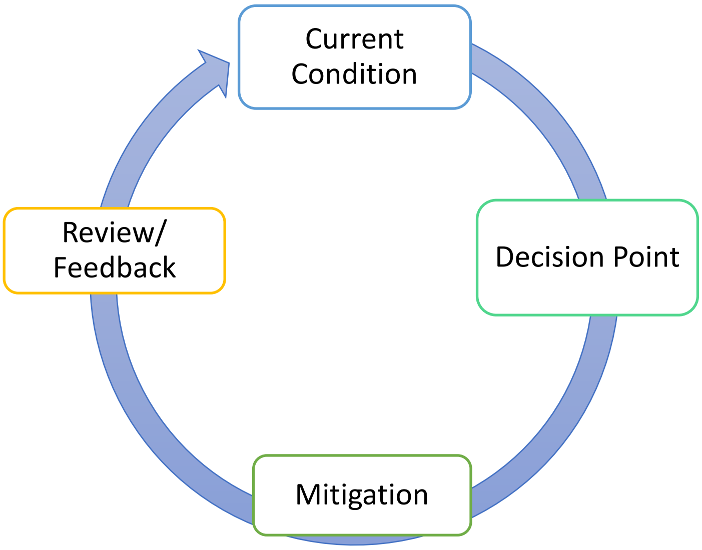
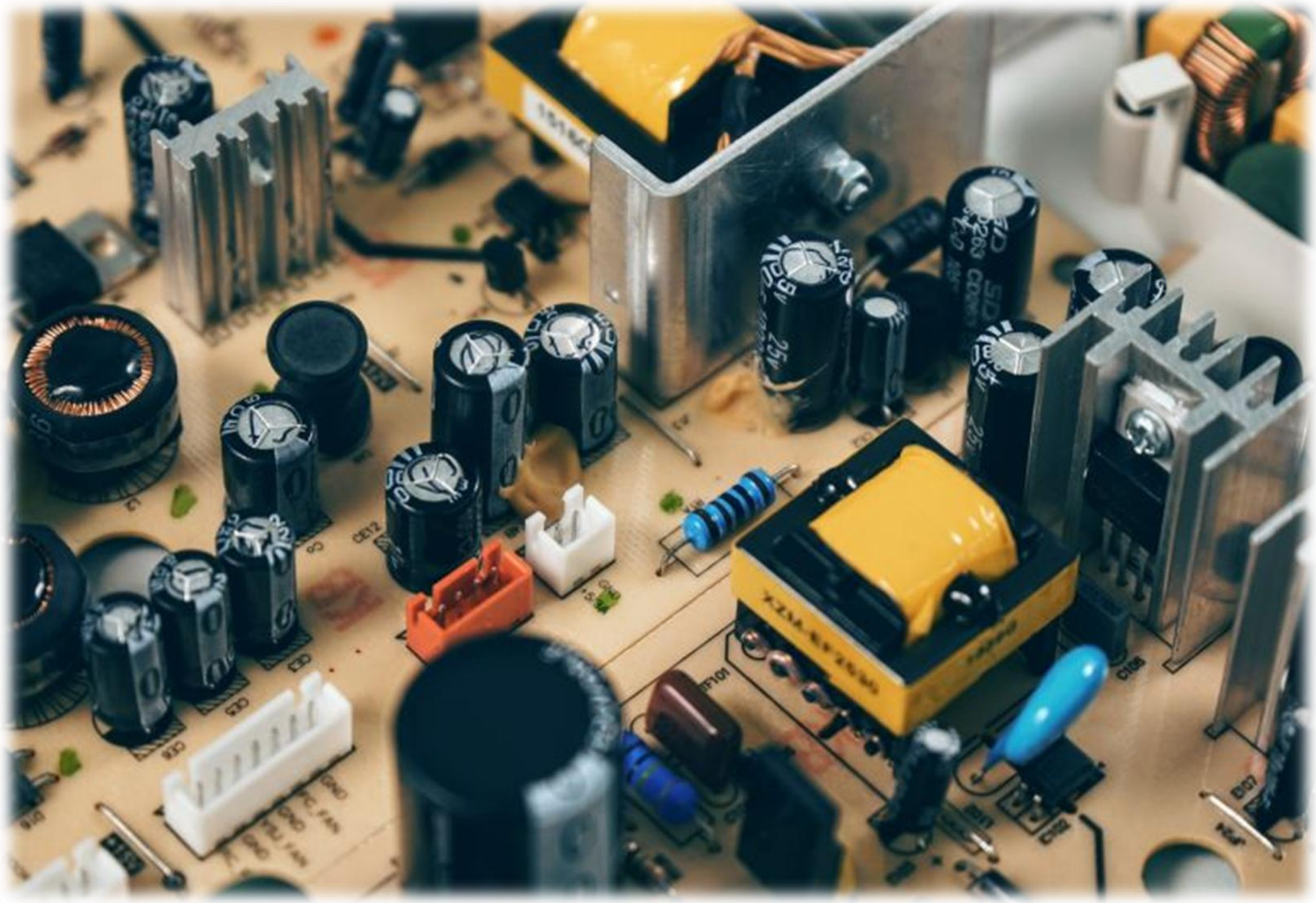


Figure 10.9: Feedback Loop

11. Electrical & Electronic Overhaul



This section covers the key areas to consider regarding electrical & electronic overhaul: Planning, Sharing information and Technical investigation.

11 Electrical & Electronic Overhaul

11.1 Summary

This section was developed jointly by ReFocus members and SET Ltd. It covers the following key areas to consider regarding electrical & electronic overhaul:

- **Contracts:** Consider and establish a Contract with well-defined interfaces and expertise requirements. Set a performance benchmark to monitor electrical component reliability for a better improvement plan against cost. Ensure rigorous testing to replicate real operating conditions for new, modified or repaired electrical components.
- **Supply Chains:** Share emerging obsolescence and reliability issues promptly through User Groups (and ReFocus) to streamline and share solutions development and prevent float crises and minimise reliability hits. Consider embedding personnel/ swapping roles to enhance understanding of different priorities. Capture evidence through component logs, in-service videos to share insights with the supplier.
- **Frontline Maintenance:** Level Checks can be an effective way to maintain process control and gather data to enable fault resolution when root cause isn't immediately obvious.
- **Technical Investigations:** Using Investigative Remote Condition Monitoring (IRCM) where faults are intermittent so as to link symptoms to root cause(s). Use Predictive Maintenance tools (RCM) to identify future emerging issues earlier and consider requirements for fleet mods.

The guidelines in this section are intended to promote a structured approach to electrical and electronic systems overhaul. The document is split into four subsections to make good practice easy to adopt according to individual business needs:

1. *Planning and specifying contracts and scope of overhauls*
2. *Sharing information along repair/ overhaul/ mod supply chains*
3. *Systematic identification of root cause – frontline maintenance*
4. *Systematic identification of root cause – technical investigation*

11.2 Planning and Specifying Contracts and Scope of Overhauls

Overhauls for electrical and electronic equipment are notoriously difficult to specify at the new train build stage and may not be structured to incorporate learning from experience in service. Generic overhauls may be embedded within Train Services & Spares Supply Agreements (TSSSA), or a blanket "fit and forget" approach may have been applied. Fit and forget may become "change on failure" and could suit relatively cheap and easy-to-change equipment which has relatively low safety and reliability impact.

However, it is worth investing the effort in planning and specifying overhauls for mission-critical systems, especially when there is a significant increase in No Fault Found (NFF) defects, changes in related systems performance due to train utilisation (mileage run, stopping frequency).

Good Practice Principles for Contracts

When and where possible during overhaul contract select an overhauler with sufficient real expertise and interest in the particular equipment and/ or underlying technology. Be aware that some OEMs are focused on new build, not overhaul: whatever Key Performance Indicators are contractualised, sometimes overhaulers choose to take the financial penalty, rather than create the performance improvement.

Alternatively, many electronics repair companies in the UK are not necessarily focused on railways, but have been found to provide real, relevant expertise and deliver solutions to previously “insoluble” rail vehicle component problems.

Checklist for specifying electrical/ electronic overhauls/ repairs/ modifications

Most of the issues to consider are relevant to all component overhaul contracts, but electrical/ electronic ones should particularly emphasise:

Get an accurate enough picture to optimise the overhaul scope:

- Understand the in-service duty cycle: What is actually experienced by the component (which may differ from the original specification it was designed to meet)
- Examine the rate of component failure: Collect all available data
- Understand any previous repairs done: It can be difficult to capture information on what repairers do (the repair/ overhaul)
- Understand failures: Systematically capture relevant data and home in on actual defects
- Really understand failures: Particularly interactions e.g. software change consequences, transients impacting different components
- Make a good enough plan to efficiently deliver an overhaul that lasts:
- Consider the spares float e.g. sufficient to support overhaul/ future needs or requires injection/ reverse engineering?
- Assess obsolescence threats e.g. critical sub-component risk review
- Future-proofing e.g. opportunities to increase redundancy, improve fault handling analytics?

11.2.1 **Case Studies**

As ever in the 20PP, there is no magic bullet, but different solutions can be made to work in different circumstances, by contracting with experts either OEMs/ large corporations who design and build rolling stock fleets or small companies which have railway-compliant workshops.

11.2.2 **Eversholt and Southeastern Class 465 Traction Equipment Replacement Project**

To improve overall reliability of the fleet Hitachi was contracted to develop the new traction equipment as well as complete the running maintenance and heavy overhaul of the equipment. To encourage collaborative work across all parties Hitachi staff were allowed on Southeastern Slade Green Depot and had access to SE technical staff if required.

The Outcome:

The Class 465 Traction project was very successful given that only two equipment failures had been reported by the end of 2019 – approximately 10 years since its fitment.

Good Practice:

- Clear contractual process for tracking failures and allocating root cause
- Clear understanding of interaction with other systems – what actually happens on the train (beware unintended software consequences, being the root cause of failures elsewhere)
- Achievable performance criteria (mindful of the risk of mis-specifying interfaces and interactions, knowing that the TOC inevitably bears a higher risk of non-performance overall)
- Collaboration

Recommendation:

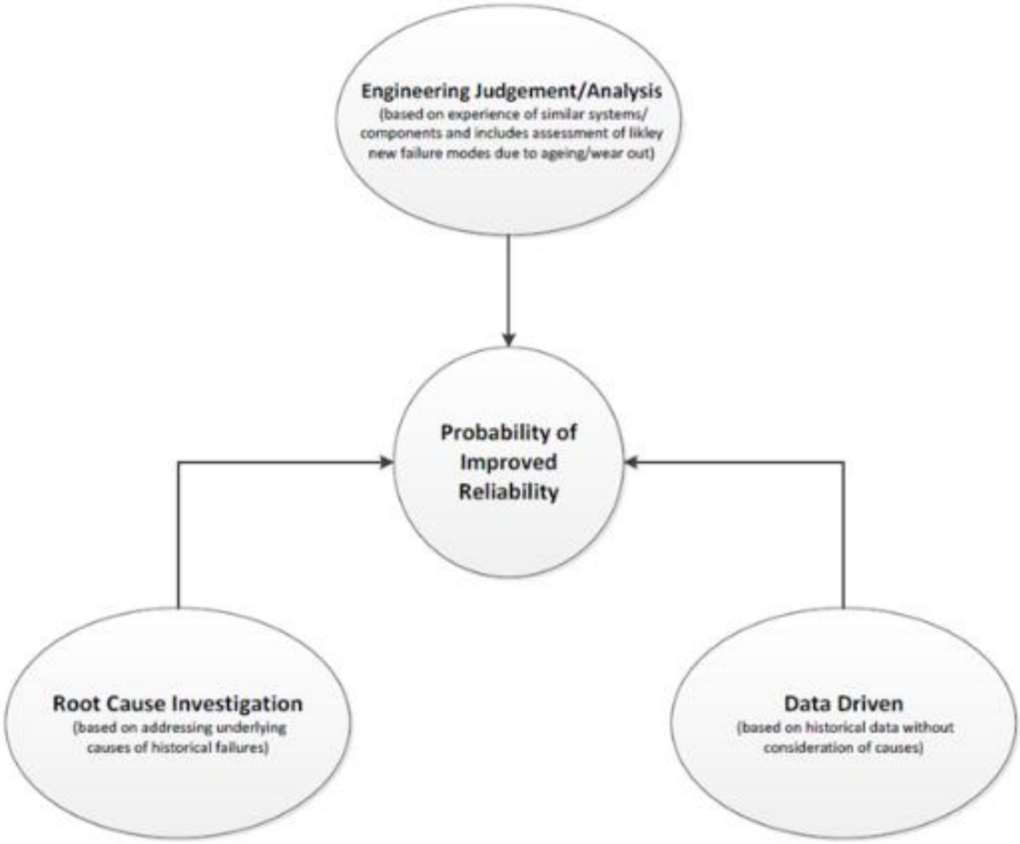
Where there is enough physical space in the relevant maintenance depot to accommodate OEM staff, and where the TOC (or whoever is maintaining the train) is able to provide technical support staff should be encouraged.

11.2.3 **Historical Example: VTEC Frequency Division Multiplexer Reliability Improvement**

VTEC contracted SET Ltd to address increasingly poor reliability (estimated 70 failures per annum from 300 units) of ageing Frequency Division Multiplexer (FDM) Racks across the Class 91 and Mk4 fleet, resulting in service delays. No overhaul had been scheduled from new, so an investigation was required to scope the overhaul needed to improve reliability (and to create from scratch a float stock of 20 reverse-engineered units to support the overhaul programme).

The Process:

Overhaul Scope definition: This required an initial investigation to identify actions with the highest probability of improving reliability, by combining three information sources:



Engineering Judgement Findings:

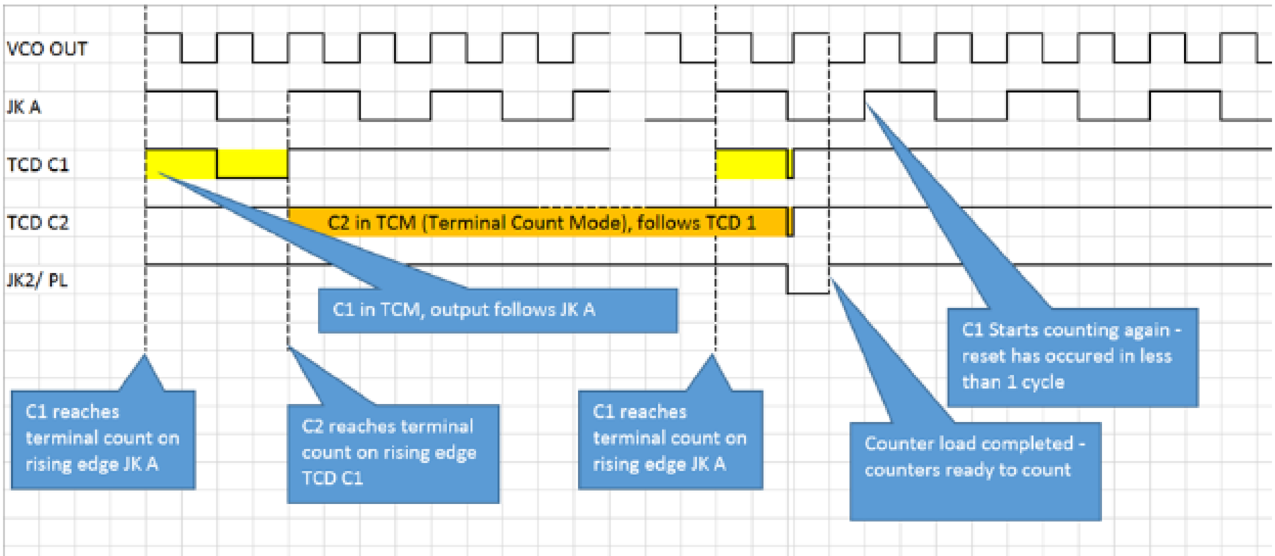
- Many ICs (should last 40 years, if operated within specified conditions)
- Electrolytic capacitors (that usually degrade within 10-20 years)
- Many electro-mechanical relays (wear with switching operations)
- Several heavily reworked PCBs (increased risk of failure from soldering)

Data Analysis Findings:

- relatively high number of failures on a few units, implying that root cause is not understood and therefore not addressed in the repair;
- more IC failures than expected, otherwise relay failures consistent with engineering judgement

Root Cause Investigation Findings:

- contrary to expectations, high IC failure rates were *not* found to be caused by transient overvoltage on the equipment supply. However, thermal trials led to the discovery of timing issues consistent with some of the symptoms reported when ICs were being replaced, see timing diagram for FDM PLL transmitter section:



A set of costed options and the likely impact of each was produced. The selected 'gold' option included:

- Replacing all transmitter cards (to address the timing issue impacting the ICs and heavy PCB rework issues found in the investigation)
- Replacing all receiver cards (to address the drift issues found)
- Replacing all electromechanical relays (based on wear-out predictions and historical failures)
- Replacing all aluminium electrolytic capacitors (based on evolving ageing issues)
- Replacing rear covers (to improve robustness and address reported damage)
- Replacing weak plastic front plates with metal ones (to address a common issue of plates and connector mountings breaking)
- Adding an earth stud (to address the issue of damaged handles)
- Cleaning all parts and recalibrating all filters
- Where possible, replacing through-hole components with surface-mounts, since they are generally cheaper, quicker to assemble, enable full automation of PCB assembly (hence more accurate PCBs), perform better under tough vibration, thermal and EMC environments

Overhaul Process: included significant enabling work to reverse-engineer, design and manufacture a complete spares float of 20 units - and to create automatic test equipment. These were in addition to undertaking the overhaul itself, which included:

- Inbound inspection, to ensure that there were no functional faults prior to overhaul
- Purchasing enough parts to cover items not routinely included in the overhaul – including full sets of electronic cards (using the float stock injection design), cases, handles etc

<u>The Outcome:</u>

Overhauled units have now been in service since the beginning of 2017, with the last units installed November 2017.

- Analysis of the few units returned shows drift to be negligible so the modification appeared to be effective.
- No problems with spurious transmissions caused by PLL instability. This was previously a problem that could result in multiple IC replacement (12% of repairs).

- Returns data following the full installation showed an 85% reduction in failure rate.

Recommendation:

When a key electronic/ electrical component is hitting your reliability bottom line, it is worth:

- Thoroughly investigating (with expert engineering judgement, data analysis and root cause hypothesis-testing) to scope any overhaul, trading likely reliability improvement against cost
- Consciously choosing between new design and overhaul (different risks)
- Replicating the original function and redundancy/ supervisory protection in any new design, to retain the main elements of the original safety case as a Direct Replacement Component (hence minimising project complexity, cost and timescale)
- Capturing the EMC performance of the original unit (where relevant), before starting any design work – and agreeing all standards, approvals, certification up front, so they're built-in to the process

11.2.4 Historical Example: Southern Class 313 Mk1 WSP Racks Reliability Improvement

The reliability their WSP Racks post Overhaul was poor due to poor quality and service from the repairer.

The Process:
Southern engaged with a new repairer (Servotech) who specialised in electronic obsolescence. They now overhaul all Southern's Mark 1 and Mark 2-1 converted WSP racks. Every repair includes a complete overhaul, irrespective of why the rack was returned.

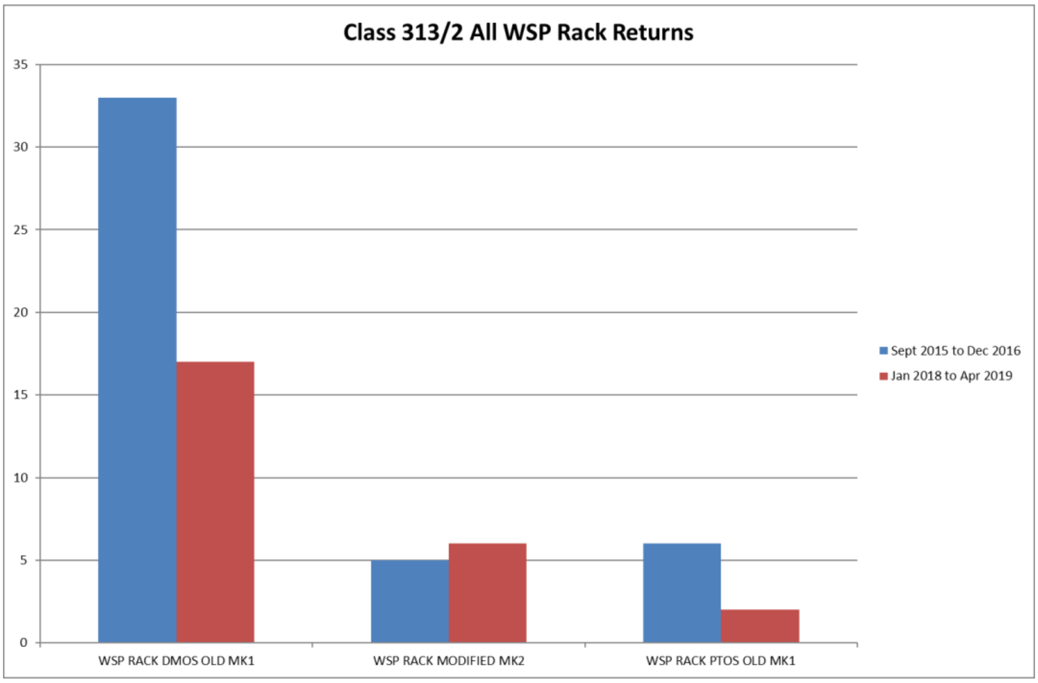
The Outcome:

The cost of each overhauled rack has increased, but the reliability has more than doubled (and availability is improving too), so Southern considers the extra cost is worth paying. The graph below compares 2016 returns from OEM repairer, with 2018-9 from the new repairer:

Recommendation:

In order to deliver the reliability needed from key systems, it can be worth:

- investing the effort to bring a new repairer into the market; and
- increasing the scope of repair to include a more comprehensive overhaul



11.3 Sharing information along repair/ overhaul/ mod supply chains

<u>Sharing Information Through User Groups</u>
Cost-effective approaches to share data, investigative effort and results are worthwhile at many levels, engaging relevant people effectively. Firstly, agglomerating from individual experience of separate sub-fleets, User Groups focus on particular fleets/ vehicle types and share common reliability challenges and solutions. They typically involve train maintainers, owners, overhaulers, but rarely component repairers/ overhaulers.

For example, despite the huge delay minutes caused by the magamps an obsolete magnetic amplifier component on the Alternator Voltage Regulator (AVR). Magamps cause unreliable start-up of the Class 15x charging system, which leads to a wide variety of symptoms in service. Through information sharing at the Class 15x User group meeting, the TOCs/ Roscos were able to understand the root cause and the alternative technical solutions; SET was able to understand their commercial constraints (e.g. longevity of the fleets, current maintenance budgets); and so, the preferred technical solution was identified, along with next steps to implementation.

<u>Recommendation:</u>

Each User group should actively seek early dialogue directly between TOCs, Roscos and repairers around reliability and obsolescence issues, so that problems can be resolved significantly more quickly, improving fleet reliability and assuring the availability of parts.

Checklist for Transparent Supply Chain Mechanisms

Long term, collaborative relationships are key to transparency, with achievable contracts that incentivise all parties to deliver a common performance improvement goal. Benefit-sharing contract mechanisms that can help create a "one team" approach along the supply chain include:

- Profit securement schemes e.g. "cost plus" – if the customer respects the supplier's need for margin, they can work together to improve the product (which improves the customer's bottom line);
- Targeted pricing e.g. "baseline and vary" – derive an average price from best historical knowledge to set the "baseline", then include a risk/ benefits sharing scheme, to incentivise reliability improvement work by paying the supplier for the contribution they make to the customer's better performance
- Incentivising Key Performance Indicators e.g. Mp701D – pay a bonus for KPIs delivered, relying on aligned business models.

Historically, success has been limited by KPIs that are disconnected from suppliers' actions (or that cap out at a pre-determined level), discouraging suppliers from investing effort (or more effort). Worse still, mis-specified KPIs may encourage suppliers to simply price-in the financial penalty without improving what they share – or what they deliver.

11.3.1 Unipart and Porterbrook Collaborative Support

Relationships between Unipart and its customers and suppliers were strained and adversarial at times. To improve the relationship with their customers and gain better understanding of impact of their activities on the customer Unipart appointed a Customer Liaison Manager.

Good Practice:

A dedicated Customer Liaison Manager is allocated to Porterbrook: who spends approximately 3 days a week at Porterbrook London and Derby offices and the remainder of their time at Unipart's T&RS Head Office in Doncaster. The dimensions of the job include:

- Optimise performance, supporting the customer with the resolution of issues / concerns and reporting of risks and opportunities with the objectives of delivering high levels of customer satisfaction.
- Support the development of new and existing product and service offerings though value-add initiatives with the customer. Working with all relevant areas of Unipart Rail's business to support the customer, resolve issues and convert opportunities.
- No staff responsibility – management by influence.

Porterbrook has found their embedded Unipart rep useful to resolve general issues affecting material supply. Noteworthy progress made in producing an Engineering Change process to support Unipart's Contract Variation requests.

Recommendation:

It can be worth dedicated human effort to aid information flows and understanding of different priorities, although this resource will only be justified where the volume of business is high enough. Short term strategic/ trainee placements/ job swaps may improve understanding and interworking more cost-effectively along supply chains.

11.3.2 **West Midland Trains Class 170s Door Control Units Failure**

After door system components were overhauled at C6 in 2015, WMT door failure rates rose. A common symptom was external passenger doors not responding to local pushbuttons, despite controls being energised to permit door opening. Several DCUs were replaced and sent to the OEM for investigation, but most were returned with No Fault Found.

The Process:

Most failures were allocated fault codes by the self-diagnostic function on the DCUs. To supplement this information, the TOC made several videos capturing as many fault details as possible and sharing them with the OEM.

Joint investigations into root cause were made at the OEM's facilities in the UK and Austria. Relevant findings included:

- In 2015, Improved understanding of the process of testing - and why faults were not found on DCUs tested (because the OEM routinely wiped the DCU fault code data, prior to loading test software to allow all inputs and outputs to be tested – thereby destroying potentially useful information)
- However, the video evidence clarified that when the Open button was pressed, the DCU would not operate – the Door Open command was not generated.
- In 2016, a non-standard testing approach was adopted to simulate the situation on the videos, and the fault captured on video was successfully replicated, identifying a programming anomaly within the software.
- During 2017, improved software was developed by the component OEM, validated by the train builder and functionally tested.

<u>The Outcome:</u>

During 2018, component usage halved, indicating improved DCU reliability:

170 Door Control Units				
Year	**2015**	**2016**	**2017**	**2018**
Components used*	**49**	**48**	**47**	**22**

Recommendations:

Overhaulers should routinely review component fault logs, and the apparently widespread practice of wiping them should be ruled out contractually, especially for safety critical components and systems. Videos can be a great way of capturing additional evidence to enable resolution of "insoluble" problems, although in this case it took years.

11.4 Systematic Identification of Root Cause – Frontline Maintenance

The classic maintainer's challenge of not being able to find fault with equipment that has apparently caused a failure in service becomes more difficult to address as the complexity of electronic systems increases.

The success probability of frontline maintainers promptly and cost-effectively diagnosing root causes is increased by identifying and capturing relevant information from operational circumstances and using it systematically.

Best Practice Principles

Many modern components and Train Management Systems log vast quantities of data which is worth extracting/ downloading at the time of any alleged incident or intermittent fault. Real time remote downloading is obviously ideal, but frontline maintainers with older and less sophisticated systems should have simple step-by-step guides to extract relevant data from units. Given a transparent and responsive supply chain, maintainers can then promptly exchange information with OEMs/ overhaulers and hopefully work together to determine and fix root cause.

Reactive maintenance approaches (to identify and correct faults) are most efficiently applied in a systematic way, with checks and downloading requirements and methods set out in Minimum Maintenance Instructions tailored to generic failures e.g. charging fault. Key to good practice is to have closed loop systems, so the instruction is promptly updated to incorporate learning from newly emerging fault scenarios and solutions.

Checklist

Reliability 'Level Checks' are a systematic process for addressing fault finding. They can ensure that repairs are dealt with in a controlled manner, by highlighting that repeat failures/ defects are occurring and working to minimise the likelihood of further repeats methodically. Level Checks aid fault-finding particularly after NFF. They engage subject matter expertise and use experience of common faults thoroughly; and escalate intervention on repeat defects by successively increasing the work done.

For example:

- Level 1 might involve downloading fault logs, reviewing data and testing key outputs in situ

- Level 2 might involve changing (or traceably swapping) a component that is known to be problematic (logically choosing first the component that is most likely, least expensive and easiest to change) and bench-testing (where facilities exist) or sending away for repair

- Level 3 might involve checking for findings on the component(s) changed/ swapped at Level 2; and then, if still NFF with the Level 2s, being sure to do something else, not more of the same e.g. changing other components – in other words, escalating the fault resolution effort applied. (technical investigation.)

11.4.1 Case Studies: West Midland Trains Systematic Approach to Fault Investigation:

Intermittent faults/ faults that cannot be replicated on depot. For example, a train fails with loss of interior lights and heating. It returns to depot for investigation, but on arrival the fault is no longer present, all systems are operating correctly.

The Process:
Level 1: Check is applied, and the train returned to service.
Level 2: If the same fault occurs, the unit returns to depot. If the fault still cannot be found or replicated, the history is checked to make sure that the Level 1 check was completed. Components are then likely to be changed or swapped at this stage, based on the experience/ expectation of different component failures.
Level 3: If the same fault occurs again, another lap round the procedure is likely to escalate the problem to joint investigation (see Case study 2.2).

	Operation	Comments	
	IF ANY FAULTS ARE FOUND, RECORD AND REPAIR BEFORE PROCEEDING TO THE NEXT STAGE.		
1	Read drivers books, record any relevant info in comments box.		
2	Start the engine and check back cupboard, look for any Generator Supply Faults or Hydro System Faults. Record any fault lights in comments box. Investigate and repair.		
3	Check all breakers, cab and cupboard, are in. Check CB-CV in underframe Auxiliary cupboard. Record whether this has tripped or not.		
4	With engine running, check the 3 LED's on the AVR. There should be a green LED. If any other colour is present, investigate and repair.		
5	If all of the above are correct, open the charger unit door (taking care of exposed capacitors) and check LED's inside. With the engine running, generally, all LED's should be green. Compare with other car if necessary.		
6	Change the AVR card and record serial numbers of the card removed and card fitted. (Usually a yellow barcode type label fitted to one of the heatsinks.)	Removed old serial number	Fitted new serial number
7	Record the date stamp on the meccalte chip. This consists of a week number and year, 46-11 for example	Removed old date stamp	Fitted new date stamp
8	Plug a laptop into the hydro box. Record any logged or current faults. Investigate and repair as necessary.		
9	Record the alternator frequency. Record the engine speed. Investigate and repair as necessary.	________Hz ________RPM	
9	Complete the following VMI job No's and record output voltage • 5.3.002 Battery electrolyte level check • 5.3.025 Battery Inspection and cell voltage check • 5.3.026 Battery charger output check	________V	
10	**Job complete. Ensure a copy of this check goes into the Fleet File for future reference.**		

<u>The Outcome:</u>
Although Level Checks impose a systematic discipline, they are a reactive measure and not an exact science, relying on continuous review and change as understanding of root cause(s) develops and ultimately to reflect component modifications and solutions. A key part of the approach is to require that the entire Level check is completed, even if a fault is identified at an early stage in the process – in order to gather the relevant information, ensuring that

multiple faults are pinpointed, and every attempt is made not simply to manage symptoms which mask root cause.

Recommendation: Level Checks are worth considering as an effective mechanism to communicate emerging fault management information, and to maintain process control whilst at the same time gathering more data for eventual fault resolution

11.5 Systematic Identification of Root Cause – Technical Investigation

Industry-standard investigation techniques include the 8 Disciplines (8D) of problem-solving which sets out a structured approach worth adopting:

1. Teamworking across all the companies involved, drawing in subject matter experts and reviewing all the data
2. Describing the problem (who, what, where, when, why, how, how many)
3. Decide a coping strategy (how to run a railway while we work out how to can fix it properly)
4. Really get to root causes
5. Develop and verify potential solutions
6. Decide which solution(s) to implement – corrective actions
7. Prevent future occurrences – modify maintenance checks, ops procedures, etc
8. Celebrate the team's success!

However, the Task & Finish Group drawing up this chapter struggled to find a succinct and complete 8D example to share, so we created an Ishikawa or fishbone diagram, which offers one of the best techniques to support teams exploring potential root causes (which is presented on page 97). Whatever technique is used, high-level engagement in a formal process can be key to ensure that the full implications (e.g. for similar equipment or processes) are understood across the business/ industry; that solutions are fully embedded; and that information is disseminated effectively.

Step 4 cannot always be rigorously applied, since 8D generally relies on the data we have already, including the teams' brains. But faults emerge that cannot be diagnosed (let alone fixed) by collecting and reviewing all known data within across-team expertise: more is needed. This increasingly applies to electronics and electrical systems interactions where intermittent and transient symptoms adversely affect performance in service but cannot be replicated in the maintenance environment.

Modern fleets often have comprehensive data logging equipment which collects the necessary data; but mid-life fleets generally do not and would benefit from selectively retrofitting Remote Condition Monitoring (RCM) to enable systematic identification (and resolution) of long-term root causes.

Best Practice Principles

Investigative RCM can be deployed when no clear picture has emerged from the structured frontline maintenance processes of Minimum Maintenance Instructions and Level Checks (testing in situ, reviewing logs, and systematically assessing the impact of swapping components). Essentially, RCM can be the Level 4 Check, as faults aren't found, and the symptoms continue to arise. Transient symptoms (e.g. intermittent driver's warning light) can often be traced to a root cause which turns out not to be the "suspect" component (e.g. the AVR), but another (e.g. in the engine control system).

RCM can be applied to continuously collect and record all relevant system states but may need a significant amount of work to identify the detail required. It is worth remembering that an RCM approach is likely to be taken for the most intractable problems, when all the obvious potential solutions have failed.

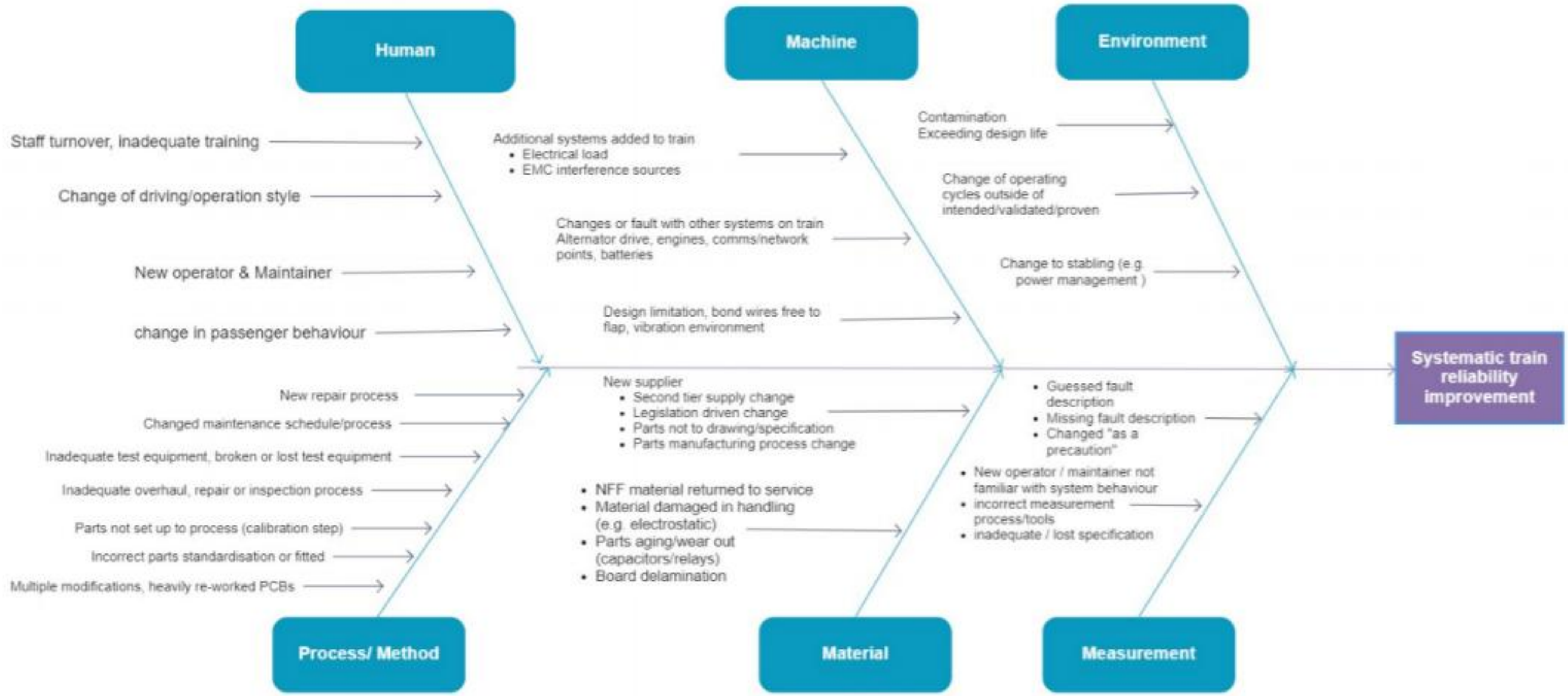
Once the fault(s) is found and resolved, RCM can continue to add value, potentially forming a basis for overhaul specification, or identifying cost-effective changes to procedures instead of an overhaul. RCM findings should inform future predictive maintenance. RCM investigations may even uncover fundamental design issues, requiring upgrade rather than overhaul, if equipment is not (or no longer) capable of delivering requirements.

<u>Checklist</u>

A typical RCM investigation needs to be specified carefully to add value, based on:

- Establishing the fault symptoms to be investigated, based on historic failures and actions taken (noting that the component exhibiting the fault may not be the root cause e.g. IGBTs blowing up because of thermal fatigue cracking in a component on a distant control board);
- Understanding the system states (including characterising relevant systems where documentation is inadequate e.g. conditions that could lead to the symptom "battery charger lock out" weren't set out in OEM information, so responses under various input/ output conditions were modelled).

Once specified, the data analyser needs to be designed and configured to capture each system/ sub-system state in enough detail for states to be correlated with fault symptoms. Given the nature of the operation, sufficient robustness should be built-in e.g. remote re-set facilities, watchdogs etc.



Ishikawa Diagram

11.5.1 **Case Studies**

11.5.2 **SET Investigative Remote Condition Monitoring (iRCM) on Turbostars**

The Turbostar fleet had variable symptoms, including ‘battery charger lock-out” and “intermittent loss of vehicle lighting”. Various theories had evolved over 10 years, and replacement of the AVR has become the first line of response for vehicles with power generation symptoms, often followed by battery charger replacement/ recalibration and alternator replacement.

The Process: SET Ltd broke the deadlock of not being able to identify the root cause of the symptoms experienced by undertaking:

- Bench testing and detailed investigation of suspect AVRs that had been repeatedly replaced/ swapped in response to intermittent or transient fault conditions;
- Designing and installing a remotely accessible datalogger (iRCM) to monitor all relevant system states continuously (this required the characterisation relevant systems e.g. the conditions that led to ‘battery charger lock-out” were inadequately specified within the OEM battery charger documentation and it was therefore necessary for SET to characterise the response of this unit to various input and output conditions).

Custom RCM unit installed under a vehicle:

The Outcome:

Key Findings: No evidence was found for intermittent AVR failures being the root cause of the train faults. RCM data has shown that complex subsystem interactions explain the power generation symptoms seen. Correlating fault symptoms with system states has shown a sequence of events starting with driver actions and leading to temporary loss of lighting:

- Driver changes power request from engine
- Imperfections in the driver’s control unit mean that the request contains unwanted transient states
- The engine control system responds to the requested change, with momentary deviations from ideal behaviour – potentially exacerbated for the transient states from the driver’s control unit
- The hydrostatic coupling/drive (engine to alternator) responds to the engine speed fluctuations – attempting to maintain a constant alternator speed. Occasionally the hydrostatic drive output speed drops significantly as the engine speed dips, and takes a second or two to recover

- The AVR detects the low alternator speed and drops the alternator output voltage as a protective measure
- The battery charger detects the low input voltage and performs a power cycle reset.
- The load-shedder unit detects the loss of DC supply from the battery charger and switches to emergency lighting, until the battery charger has reset.
- The driver's warning light illuminates when the battery charger output is lost

In total, there are 5 cascaded control systems involved in generating the symptom of lost vehicle lighting – each with its own specifications, calibration and maintenance processes.

It is easy to see why the root cause can evade detection and the problems persist for many years, when each subsystem is often considered separately from the others, and where the troublesome interactions may be transient – meaning that they are often completely absent during depot investigations or are difficult to detect unless several system states are observed simultaneously.

So, what started as an investigation into an AVR and battery charger led to issues with the driver control unit, engine control and fuelling system, and the hydrostatic drive performance and control. Resolution involved: overhaul or upgrade of one or more of these systems; changes to calibration procedures; other maintenance activities.

Recommendation:

Consider deploying investigative Remote Condition Monitoring (iRCM) where faults are intermittent/ transient and symptoms hard to link to root cause. Existing RCM systems (if any) are often not adequate (nor sufficiently extensive) for the problem under investigation.

Building on the characterisation of systems and the collection of data in the iRCM, consider developing Predictive Maintenance tools which could lead to:

- Catching issues early – leading to individual effective interventions, and avoiding the need for fleet-wide modification programmes, which tend to be specified in a reactive manner after experiencing increasing reliability issues over a long period
- Identifying requirements for any fleet-wide changes, overhaul or enhancements (and informing the specification of any interventions already planned).

12. The Infrastructure

How to manage the engineering interfaces between vehicles and infrastructure relationships, preventing problems before they start.

12. The Infrastructure

Note: It is accepted the following section is 'out of date' in relation to Network Rail's current organisation in relation to the team of Rail Vehicle Interface Engineers. Irrespective of this, the outline principles described remain valid.

12.1 The Engineering Interfaces

The systems involved: There are many engineering interfaces between vehicles and infrastructure that can affect train performance if they do not work together effectively. The performance impact can be immediate, for example a wrong-side AWS failure that causes train delays and cancellations, or it may be subtle and not become apparent for a long period of time after substantial degradation of the vehicle, the infrastructure, or both, resulting in greater performance impact and the need for repair investment (e.g. rolling contact fatigue [on both infrastructure and vehicles]).

The main engineering interfaces between rail vehicles and infrastructure are summarised below:

- Wheel and rail (wear and adhesion)
- Signalling control (AWS, TPWS, ERTMS, ATP)
- Current collection (overhead line equipment (OLE), 3rd rail equipment)
- Loading Gauge (static and dynamic)
- Telecommunications (GSM-R)
- Infrastructure-based vehicle health monitoring systems (hot axle box detectors, wheel impact load detectors, pantograph uplift detectors)

Indirect engineering interfaces: Whilst most engineering interfaces are obvious, e.g. wheels on rails or pantographs under OLE, train performance can be influenced by interaction between vehicles and infrastructure that is less obvious. Identifying these interactions and opportunities to improve train performance can be more difficult, but regular liaison and strong working relationships between TOCs and Network Rail help.

Historical Example: AGA (now Greater Anglia) train performance suffered from a high number of AWS code 10 failures at a platform on Ilford station (10 incidents in 3 weeks) and all resulted in train cancellations. There was no AWS signalling equipment in the area concerned and the signal engineer was convinced that there was no infrastructure interaction involved. However, the relevant fleet performance engineer raised the issue with the relevant vehicle interface engineer who appreciated how both sides of the system worked and undertook a more thorough review. This joint investigation identified that the most likely cause was a 60-foot length of new rail that was stored in the 4 foot, where the rail end was partially magnetised and located such that it was visible to the AWS receiver when vehicles were stopped at the platform. At the time the rail vehicle interface engineer (RVIE) escalated the issue within Network Rail; the rail was removed from the 4 foot and no further AWS code 10 incidents were reported.

Relationships: To ensure trains and infrastructure interact safely, many engineering standards are focused on the design and maintenance of the railway system, e.g. the flange height and thickness of a wheel profile or the gauge and alignment of track. There is less focus on the wider aim of good performance and very little guidance or standardisation available when it comes to getting the most out of these interfaces and improving performance.

The variety of engineering factors and duty cycle demands on vehicles and infrastructure in the UK make generic solutions difficult to achieve. Capitalising on the assets at these interfaces requires asset stewards to work together, monitoring them and developing performance improvement plans where problems arise.

To enable the cross-company engineering relationship to be more effective, Network Rail has a team of rail vehicle interface engineers (RVIEs) with a remit to establish the engineering root cause that includes improving performance and safety around the engineering interaction of vehicles and infrastructure. This team is embedded in the Network Rail organisation and focused on engaging with TOCs to identify and facilitate the delivery of performance improvement through better understanding and knowledge-sharing across the engineering interfaces of vehicles and the infrastructure.

12.2 RVIE core activities

12.2.1 Rail vehicle monitoring

Purpose: Rail vehicle monitoring is undertaken to reduce risks, maintain safety, prevent accidents and improve performance on the rail network. It records incidents in a dedicated database, which are then subsequently resolved through liaison with the relevant stakeholders.

It is recognised that the database is not an exhaustive list of all rail vehicle imported risk incidents.

Benefit: Improved safety and reliability of the infrastructure with more efficient assets and maintaining the reputation of stakeholders to deliver a service to passengers.

General: Control centre incident logs (CCIL) are used as the primary (but not exclusive) source of information.

Incidents that carry the potential to import risk into the infrastructure are recorded under the following categories:

- Axle and axle bearing failure incidents
- Brake failure incidents
- Collision incidents
- Vehicle derailment incidents
- Vehicle component detachment incidents
- Train division incidents
- Vehicle door incidents
- Vehicle environmental incidents
- Vehicle fire incidents
- Train signal systems incidents (AWS, TPWS, ATP, ERTMS)
- Defective wheel/tyre incidents

Rail vehicle interface engineers liaise with railway undertakings to understand the root cause and confirm that incidents have been resolved. This is subject to co-operation from the relevant railway undertakings. Details of resolution and/or long-term mitigation to prevent re-occurrence are recorded in the database. Incidents are closed out in the database. A route-based period report is prepared showing confirmed imported risks and steps that have been taken.

In addition, the database is used as a tool for recording vehicle performance issues that do not import risk into the infrastructure for ad-hoc monitoring requirements and trend identification.

Technical support

Purpose: Provision of engineering expertise to support internal and external stakeholders to improve performance, safety and efficiency at the interface between rail vehicles and infrastructure.

Benefit: Provision of expertise reduces time spent by non-vehicle specialists and enables expedient resolution of commercial claims.

General:

- Work with TOC fleet team and Network Rail engineering and maintenance teams to improve performance by resolving joint interface issues
- Take part in formal investigations into serious incidents involving rail vehicles
- Review and validation of TOC claims for damage to vehicles where Network Rail is responsible
- Providing technical support to route commercial teams
- Monitor implementation of HLOS schemes on rail vehicles
- Delay resolution assistance – fleet
- Work with TOC and route enhancement team to validate HLOS/CP fleet schemes
- Reporting to route director on any infrastructure-related issues and in-depth analysis of any proposed changes to rail vehicle operations in the route (NETWORK CHANGE) compatibility forum
- General vehicle technical data enquiries
- Interface working groups
- Sharing best practices and new technologies

Example: Southern and NR developed a joint process (facilitated by RVIE) where investigations into engineering root cause were concluded within seven days. This joint approach saved the industry time and focused on resolution, eliminating the need for independent investigations.

Example: Sharing data and knowledge from new and existing technologies to improve the reliability of the network, i.e. pan monitoring on Avanti West Coast Class 390 Pendolinos, RETB base stations in Scotland and third rail interface monitoring equipment on Southern Electrostars.

12.3 Customer liaison

Purpose: To build and maintain close working relationships between internal and external stakeholders to provide a platform for communication, understanding and resolution of rail vehicle risk and performance issues.

Benefit: Engineering staff in the TOC and NR can discuss and resolve engineering issues, enabling reduction in risk and increase in performance. RVIE is a team of experienced and skilled engineers that can provide resources for investigations that may not exist elsewhere.

General: Liaison should be regular according to the business requirements of all stakeholders. There should be further liaison when required utilising all communication links available.

Historical Example: Southern fleet technical services alerted RVIE to a wheel damage problem on their fleets; small indentations were seen at various locations around the circumference of one side of the train's wheelsets. Southern supplied possible locations to check on the infrastructure, RVIE pursued track engineers and the location of the problem was found with matching rail damage. Although the exact cause was not identified, it was thought to have been a small piece of hard material which was later picked up by a train wheelset and dropped elsewhere, as there were corresponding indentations found on the rail head at 2.5m intervals. Southern carried out independent testing and confirmed the wheel damage was fine to continue until run out by normal running.

Historical Example: ScotRail reported an aggressive flange wear problem affecting their fleet. RVIE pursued maintenance and maintained daily contact with the delivery units and ScotRail to ensure daily actions and updates until the problem was resolved.

Historical Example: RVIE offers everyone in fleet an “in” to NR. It has often been stated that having a single point of contact is a great asset.

12.4 Interface working groups

Purpose: To improve the performance of the interface by identifying areas of poor performance and to ensure that Network Rail and the train operators are working together.

Benefit: Identification of interface performance status leading to improvements in asset life for both rail vehicles and infrastructure; knowledge hub of system interface engineering; close working relationships with stakeholders.

General:

- To establish root causes
- Identify jointly beneficial solutions
- To provide a focal point for groups to input interface issues as they arise
- To share knowledge and best practice
- To improve the efficiency of the network resulting in a reduction in delay and cost to the industry
- Improve customer satisfaction
- To identify interface capabilities and limitations, challenge those where appropriate
- Harmonise vehicle/infrastructure interaction

Historical Example: First Capital Connect (now GTR) reported that wheel flanges were not as populated with grease as they had been previously and enquired to RVIE in the Anglia route. RVIE alerted track engineers who found a faulty flange lubricator and scheduled an immediate repair, preventing a much larger issue of rail and wheel damage.

12.5 Preventing engineering interaction problems before they start

The Network Rail RVIE team is also able to provide engineering support, bringing the right engineers together, e.g. when identifying the impact of train modifications or new fleets on the compatibility between trains and the infrastructure. Whilst there are formal processes for this, e.g. assessment of compatibility as per GERT8270, the local RVIE can engage with the local infrastructure engineers during the early stages of the engineering change process to identify any issues that can be resolved in advance of committed work being carried out. It is important to recognise that this collaboration sits alongside the formal process of ensuring compatibility between both asset types.

Historical Example: The Anglia RVIE provided technical support to NXEA (now Greater Anglia), assisting in the assessment of compatibility of their Class 360 fleet (now run by EMR) for route clearance to Orient Way sidings.

13. Managing the Impact of Fleet Incidents

Some incidents can cause major disruption to the network .The impact may be lessened by following some simple guidelines that innovative TOCs have developed, and by planning for such occurrences.

13 Managing the Impact of Fleet Incidents on the Railway

13.1 Introduction

The purpose of this section is to give guidance on how fleet incidents can be better managed. It has been developed jointly by fleet and operations through a series of workshops and meetings to document how a joint approach to fleet incident management can reduce incident times and improve performance.

It should be noted that the best practice featured in this section is irrelevant to control type and is designed to be compatible with all TOCs following the "Plan, Do, Review" process.

13.2 Definitions

Primary delay: A Primary delay results from an incident that directly delays the train concerned, irrespective of whether it is to schedule (schedule includes booked platform or line) at the time the incident occurred, i.e. the delay is not the result of another delay to the same or another train.

Secondary delay: Secondary or Reactionary delay results from an incident that indirectly delays the train concerned, i.e. the delay is the result of a prior delay to the same or another train.

13.3 Plan

Good practice in planning for the management of technical incidents is having competent, well-trained individuals who can come together as an incident team supported by the elements of good practice described below.

13.3.1 Roles and responsibilities

It is important that all staff are clear on their position in the incident management team, what their and others' roles and responsibilities are. They should be fully trained and assessed regularly. It may be helpful to produce a RACI for the incident management team so members know who is Responsible, Accountable, Consulted and Informed for each task.

Incident management can be an intimidating environment for the driver and is a reactionary situation. Some drivers will be unfamiliar with certain incidents which can lead to panic and in turn an extended overall incident time. It is critical to have good plans in place which are regularly practiced and point the driver or controller in the right direction.

Example: A number of train operators employ a 'phone a friend' policy, where the driver is expected to contact control for technical support within a few minutes. It is important that these friends have up-to-date knowledge of the traction and recent incident alerts. For the friend to be as approachable and helpful as possible, Southern have recruited the expertise of a call centre trainer to develop clear protocol for dialogue between the driver and the technical expert 'friend'.

Potential roles within the team are shown below:

Controllers	British Transport Police (BTP) liaison	Signaller
CCTV operators		

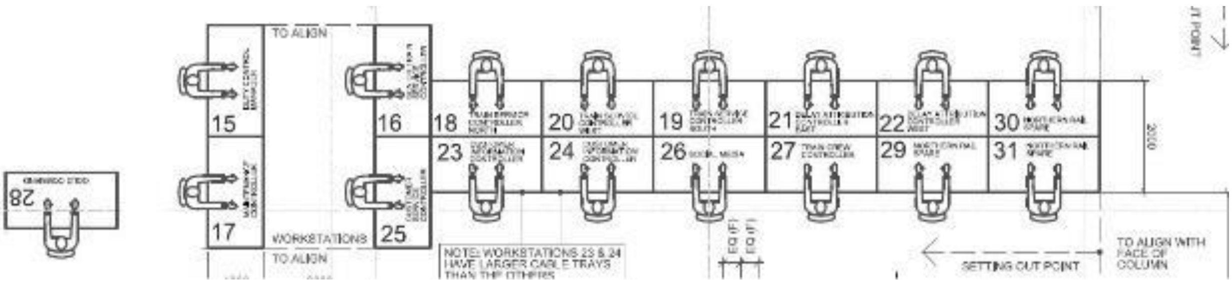
Social Media managers (X (formerly Twitter, Instagram etc.)	Passenger information system controller	Fleet controller	Phone a friend
Technical support	Planner	Electrification	

> Example: LNW Route has found it beneficial to liaise closely with BTP and a 'police on bikes' initiative has been implemented. In areas with high incidences of fatalities, this close liaison limits the delay by having BTP on site sooner and a BTP officer familiar with railway operation reducing the chance of the location becoming a crime scene with increased line closure time. Forward facing CCTV (FFCCTV) has helped significantly in this respect and has also made a significant contribution to identifying the root cause of OHLE failures.

> Example: Southern, London North Eastern Railway (LNER) and Northern have noted benefits from having a Network Rail presence within control. Southern have taken an integrated approach with NR staff sitting with TOC staff. LNER and Northern are co-located with NR, sitting separately but in the same room.

It is important when designing roles and responsibilities that staff are protected from distractions in order to perform their specific role in an incident without disruption. Team members should be able to communicate quickly and easily (*see 12.3.2*).

> Example: Southern and Northern benefit from a strategic seating plan. It demonstrates a clear line of authority with service delivery managers at the head of the tree (in both cases separated from the main spine of control to prevent frequent interference and micromanagement). The rest of the main spine positions staff next to relevant personnel for handling an incident. The layout and the added benefit of sound ergonomics makes communication easier. Northern's layout is illustrated below.



Important roles that an incident team needs to have:

- Passenger management. It is critical to keep passengers informed of and updated on disruption to ensure that they remain calm and avoid uncontrolled evacuation and prolonged delay.
    - Excessive passenger loadings on trains may influence the way an incident is managed and recovered. On some types of train, excessive passenger loadings may inhibit access to cupboards and equipment located in public areas.
    - Excessive passenger loadings on platforms may influence the way in which an incident is managed due to restricted access underneath the train.
    - It is important to remain consistent when managing periods of disruption, particularly when communicating with customers. Inconsistency can lead to a lack of confidence in the TOC's ability to manage incidents.
    - Social media should be used to its maximum potential. Using X (formerly Twitter) and Facebook to distribute details of incidents, particularly via photographs, can improve the response from customers, resulting in fewer social media complaints and increased customer acceptance.
    - Throughout an incident and its management, the impact on customers should be considered a priority.
- Events planning. Every TOC should ensure that control centre staff making decisions on managing incidents have access to information that provides details of events that may cause passenger loadings to be outside normal levels, e.g. large sporting events. This may change the way in which an incident is managed.

Driver availability is crucial to delivering any plan and can have a pronounced impact, particularly at night when fewer drivers are available.

13.3.2 **Clear lines of communication**

In an incident, clear lines of communication should be established with a good infrastructure using email, telephone and other electronic formats. Virtual conferencing is also a useful tool where incident management team members are not co-located, enabling them to share and interact with information.

Example: Southern have a visualisation area formed of whiteboards relevant to each department, including a route diagram board. These make members of the team aware of all current activities. The board is updated as and when new information is available prior to weekly updates.

Southern also use a fleet incident management flowchart, detailing all process from incident conception through to review. This document describes all the necessary actions/tools at each stage of the management process.

Example: For the Class 390s there is a visualisation board within the control that illustrates weekly maintenance plans. This board is updated as incidents occur or as other alterations are required. Every member of the team is aware of updates on technical or non-technical issues as and when they arise, thus ensuring adequate information at all times to avoid miscommunication. The clarity of the board allows control staff to quickly assess the availability of units in the event of a set swap or other such service alterations.

Driver/signaller relationship: Many TOCs have trained drivers to standardise communications with signallers. The driver simulators and voice recordings ensure that correct protocols are used, and colloquialisms are avoided. In addition, voice recordings are reviewed by control to ensure that the standard is being maintained. The standard should focus only on key areas which cause train delays. This would not be necessary between drivers and fleet.

Example: GTR apply a similar standard to communication between drivers, fleet engineers and train managers in terms of language and terminology used.

13.3.3 Training and competence

Incident management team member training should cover not only their roles and responsibilities but also those of others in their teams. All staff members should be familiar with the company's procedures and the Rule Book. The aim should be for team members to demonstrate unconscious competence such that they can maintain a level of situational awareness.

In high-pressure scenarios with complicated tasks, it is inevitable that mistakes will happen. Decision support tools and checklists[1] for incident management can help reduce the likelihood of these mistakes. Extensive work has been performed by the fleet community in this regard and good practice is detailed in *Appendix I*.

Fleet engineers in control centres will be covered by the TOC Competency Management System (CMS) and assessed as per the TOC standards. They should have sufficient opportunity to spend time on depots and on the route, in order to maintain their competence and refresh their fault-finding skills and fleet knowledge. There are a number of ways this can be achieved. One example would be to use spare days, planned refresh days or other competent staff to cover the office role. Any new staff in the role would undertake a training needs analysis and be passed as competent prior to undertaking the role. There must be a process in place to ensure CMS is kept up-to-date.

RDG's Good Practice Guide (GPG005) on Controller Recruitment - Training and Competence exists to encourage the consistent application of established good practice across TOCs. It sets out the following two objectives:

- Act as a good practice guide that TOCs can use as a benchmark for controller CMS
- Provide good practice suggestions for recruitment assessments

Example: London North Eastern Railway use exact imitations of control desks and role-play of past incidents involving all members of the incident management team for team-building and new staff training.

Example: Southern has deployed an extranet to guide technical staff through decision trees during the phone a friend process. It also helps keep track of time, provides quick links to the "Defective On Train Equipment (DOTE)" and recovery procedures and can be audited. Systems such as this enable staff with less technical experience to talk on-train staff through processes during an incident.

The most effective decision trees are designed so that the most likely scenarios are eliminated first. It is vital that decision trees are updated as soon as incidents happen.

Example: Southern's Three Bridges ROC features a simulator to enable the rigorous training of new members of staff in a real-life scenario using the same equipment on the control floor. This ensures that

[1] Atul Gawande: The Checklist Manifesto

staff are fully equipped to handle the situation quickly, effectively and professionally.

Example: East Midlands Railway ensure technical support staff return to depot to undertake shop floor work to reinforce competencies on a regular basis. This enables fleet knowledge to be fresh in their minds and improves their ability to deal with faults during a phone a friend scenario.

Line of route fitters should ensure that they are fully equipped with the relevant tools and equipment. They are primarily employed to get the vehicle moving at the earliest opportunity. Several incidents have been recorded where the line of route fitter has extended an incident by trying to fix the train. The West Coast mainline has engaged in a work stream which allows the MOM to carry the equipment to site. This allows all personnel to work together by ensuring tools are on site quicker and rescue locos can get to site. It also wants drivers to have flexibility to drive alternative rolling stock for short movements.

Example: In order to minimise incidents, Train Operators employ a Defective On Train Equipment (DOTE) procedure. This allows for the expedient management of incidents with rules for isolations and running rolling stock in a degraded mode, allowing the stock to continue (as safety as possible) without incurring or exacerbating a delay.

13.3.4 **Resources**

In an incident, a number of resources should be available for staff to use.

Disruption during the middle of the day may allow ‘peak period’ units to be brought into service in lieu of displaced units. If substitute/displaced traincrew are not available, this contingency plan is not viable. Timely recovery of the train plan is dependent on the availability of replacement traincrew/vehicles and well-managed manipulation of disrupted resources. The ease with which replacements can be provided is dependent on factors unique to each location in addition to time of day, weather conditions and other such issues.

The ‘cut and run’ procedure is then invoked. The objective is to return the running line to normal, safely and as quickly as possible in the event of a train failure. With safety considerations being of the highest priority, this will cause customers the least possible overall inconvenience and disruption and help maintain the highest possible performance level.

In some scenarios, using such a procedure may not be possible, e.g. where numerous TOCs operate through a highly congested area. It is therefore advisable to plan for the worst-case scenario. Where multiple TOCs are likely to be affected, Network Rail should lead the development of the cut and run policy, bringing all affected parties together to develop contingency plans. Consideration should also be given to the inclusion of FOCs into such discussions as incidents regarding freight services can often cause significant delays or exacerbate existing ones.

Example: Northern face causing substantial delays if a unit fails on the approach to Manchester Piccadilly. Due to the layout of the approach to the station, limited opportunities are available for units to be routed around any stranded unit causing a significant accumulation of delays. The variation in rolling stock operated in the region (as much as 5 types) prevents the possibility of rescuing the failed unit with nearby stock.

Northern and TransPennine Express have, over the past 2 ½ years, developed a joint contingency plan to mitigate the impact of an incident. This document details according to certain route sections how services should run under categories including total blockage, reduced capacity and one line running. On top of this, specific instructions are given on how to handle any special circumstances.

An example is between Manchester Victoria and Milner Royd Junction where Biomass freight services to Drax power station are given priority during periods of reduced freight operation due to the nature of their cargo. These cannot be treated like historical coal trains and must run sooner rather than later.

Example: Train operators on LNW routes have been working together to discuss contingency plans for that route. This has been led by Network Rail, taking a lead from the Anglia route.

The contingency plan not only details actions for partial/full line blockages (including actions for the am and pm peaks), but also roles and responsibilities during an incident, such as route control managers, shift signalling managers and TOCs. Special instructions are also given regarding items such as holding trains at stations, light engine/empty coaching stock moves and engineering possessions. Communication is also detailed regarding what should be relayed both internally and externally to customers, including alternative transport arrangements.

There has, however, been limited consideration by NR of diagram complexity or fleet implementation.

Thunderbird concept – a fleet of locomotives specifically equipped to rescue a TOC's main fleet of trains. The fleet is not normally used for traffic but is deployed at strategic locations to minimise the time it takes for the locomotive to reach the failed unit. It can also cover for infrastructure failures where AC or DC electrification has failed (dropped wires, etc.).

Example: Network Rail has a set of strategically positioned thunderbird locomotives on their route. Due to the relatively linear nature of their operations, the location of these locomotives is perhaps more evident than for TOCs such as those south of London. They are positioned at Edinburgh, Newcastle, Doncaster and London Kings Cross. At 90 minutes apart, this means that a failed unit will be reached within 45 minutes. These Class 67 thunderbirds are leased from a FOC but driven by LNER staff. In the event of a failed unit retrieval, a relay takes place.

For example, a failed unit at Edinburgh will be taken by the Edinburgh locomotive to Newcastle, where the driver will take the Newcastle locomotive back to Edinburgh, and the Newcastle driver takes the locomotive and unit to Doncaster where a similar process is repeated until the unit reaches Bounds Green depot. The rolling stock controller is responsible for the deployment of these thunderbirds.

A consistent starting point for incident mitigation is vital for managing the impact of fleet incidents efficiently. Having an initial framework means that all involved know their responsibilities and changes depend solely on the nature of the incident.

Example: Southern use a system whereby each section of the route is pictorially represented on a slide with details of the incident management process for each area. These are mounted on a transparent stand on which anything can be written, from the nature of the incident to any changes in the management process. This has been found to yield a measurable improvement in the impact of an incident.

13.4 **Do**

A number of processes need to be implemented when an incident occurs and several of these are detailed below. Details on decision support tools can be found in Appendix I.

To use these processes effectively, it is imperative to clearly identify the common goal (e.g. moving the train or fixing the fault) so that a critical path can be established. The route control manager must ensure the plan is communicated effectively to all staff involved.

Where an incident may be managed in one of two ways, depending on the outcome of an event (e.g. a technical examination), it is good practice to develop the two plans in parallel in order to minimise the overall length of the incident rather than starting with plan A and moving to plan B.

- Promote practice of early notification of defects/issues ("Report it first!")
- Clear the line and use cut and run
- Assume worst-case scenarios and take action accordingly
- Mobilise or prime maintenance staff at earliest opportunity
- Whilst maintenance staff are working to recover a unit to operation, control staff can be preparing for other eventualities such as rescue (e.g. via use of thunderbirds)
- Balance long-term and short-term objectives, e.g.it may be better to incur a slightly longer delay today in order to return units to depot for maintenance and allowing a return to planned service tomorrow
- Use of train location information
- Use of remote condition monitoring (RCM) data
- Emergency services may be required to assist in certain instances; where this is the case, it must be remembered that the emergency services will give priority to the passengers and the scene. This may prolong the incident and, therefore, increase the time for recovery of the network
- Huddles – bringing the relevant personnel together to discuss incidents and the plan of action

Example: Southern bring the control personnel together into a 5-minute huddle covering details of the incident and what each person's responsibilities will be to recover service.

13.4.1 **Avoiding incidents and robust maintenance**

Ad-hoc maintenance requirements (e.g. unit defects, modifications, component changes) are prioritised according to their urgency. An internal contract ensures that the delivery of fleet engineering's depot requirements align with the service delivery requirements of operations. The contract for planned delivery will aim to maximise the notice period of any work to be undertaken and be agreed between engineering and operations according to the diagrams available.

Example: A challenge for Northern is their fleet of 3-car Class 158s. All are allocated to Neville Hill (Leeds) depot Monday – Friday and there is a requirement for seven units to be in passenger service with one unit in routine maintenance. With the exception of one unit, six end their working day at another location. The arriving unit is delivered on 5T93 2209 Leeds – Neville Hill 2220 (NL197 diagram). It is therefore necessary to plan sufficiently in advance that any unit requiring maintenance is allocated to the correct diagram so that it returns to 5T93 on the correct date.

Example: AWC are limited to 6 units out of service to undergo maintenance. It takes careful planning and communication between the fleet engineers and control staff to ensure the whole team is aware of which units are scheduled for maintenance, where they need to be and when.

Deferred maintenance must be carefully managed with regular dialogue internally within engineering and externally with planning and control staff. The crucial link here is the maintenance controller who acts as the intermediary between engineering and operational colleagues in the control centre.

13.4.2 **Dynamic risk assessment**

Primary delay - if the fault is catastrophic and brakes require isolating for movement, ensure that any movement fits within the Special Moves Plan (SMP) and that the NR representative informs Network Rail control. When a controlled evacuation is required, all on-site personnel must agree a plan and inform Network Rail; emergency services may be required to assist. When planning for evacuation, where possible consider moving the unit (under assistance) if necessary to a safe point, i.e. siding, station or away from the main line and any rail traffic. As previously detailed, cut and run policies allow for the affected unit to be isolated in some incidents to minimise the disruption the unit may cause to the overall network.

Emergency coupling – it is critical that the emergency coupler is pre-fitted/extended to the failed unit prior to recovery. Some TOCS have emergency couplers strategically located across the network. Assisting a train from the front using a wrong direction move is normally faster than trying to assist in rear with a non-compatible unit. The emergency coupler is often the first port of call rather than a wrong direction move.

It should also be remembered that not all emergency services will be familiar with the rules of the railway and communication between all parties is critical.

13.4.3 **Monitoring plans and possible changes**

Ensure live monitoring of the initial recovery plan is in place, be in touch with the staff on site and have a primary contact. Confirm that Network Rail understand the safety implications involved in DOTE when dealing with a significant failure. When estimated times for movement are available, use communications systems to relay this information to all concerned and, when robust estimates are achievable, communicate this to ground staff. A faster recovery will be achieved when a proactive stance is taken from the outset.

13.5 **Review**

Following an incident, it is important to evaluate the management and processes used to reduce the impact and restore service to normal. This section provides good practice for reviewing a technical incident with the aim of improving future response to similar incidents.

- Agree only a few timely actions from an incident review
    - These should be leading, measurable and carried forward
- Merge technical and operations reviews (focusing on the right area)
- Always use targeted, meaningful and (if possible) tailored feedback
- Education: offer explanations, in particular to traincrew (e.g. why engineers have given certain advice or control have cancelled a specific service)
    - Share the mission using a customer focus

Example: Southern examine routes to identify areas of high disruption to understand which customers have been affected and why.

Example: Southern perform a ’hot review’ less than 6 hours after an incident.

Example: LNER perform cross-function mock-ups of incidents for all levels of staff, from crew to senior management. These not only build confidence but allow cross-functional teams to develop their relationships in a low-stress environment.

Example: Within the South Western Railway control, Incident Learning Reviews (ILR) are utilised by Network Rail to review significant performance-impacting incidents. ILR is triggered by incidents of 1000-minute delay or more. It can, however, be used for any incident where it is agreed there are lessons to learn.

An ILR template is completed as part of the review and aims to capture 6 key learning points and 8 key actions.

SWR use an action tracker to report open and overdue actions at both performance group (head of functions forum) and performance board (exec forum) level. All ILRs are approved by the most appropriate functional director, ensuring value is added in each instance.

13.5.1 **Incident review**

A final review and feedback to local operations managers and all staff involved serves learning and best practice sharing. Creating a knowledge pot comprising contingency plans can lead to a one stop advice shop where ideas and experience can be shared. It is crucial to use all available tools when reviewing incidents and implement recommendations from third parties such as the Rail Accident Investigation Branch (RAIB).

14. The Supply Chain

Having the right parts when and where required (spares holding, floats, forecasting measures, change control, obsolescence, and improving the quality of the parts through effective closed-loop relationships.

14 The Supply Chain

Not having the right parts results in non-availability of vehicles for service and reducing the volume of accessible spares to a level which increases the likelihood of a vehicle having to wait for a part is a false economy.

The best approaches to spares holding involves hard thinking (about how parts are used) and analysis (what the vehicles need when) to produce the right combination of location and accessibility for different items. It also involves trust (keeping all the parts under lock and key is at best less efficient in terms of access). Best practice is to create trolleys of materials, tools and instructions for each type of routine activity (e.g. B exam).

14.1 What is the rail industry supply chain?

The rail industry supply chain is complex and includes organisations which may not be primarily regarded as suppliers, for example TOCs and ROSCOs. Essentially it consists of a huge network of smaller supply chains which are linked or integrated to varying degrees. The length and complexity of an individual supply chain is dependent on the product and/or service. *Figure 13.1* below illustrates a typical supply chain for undertaking maintenance on a soggy lease fleet.

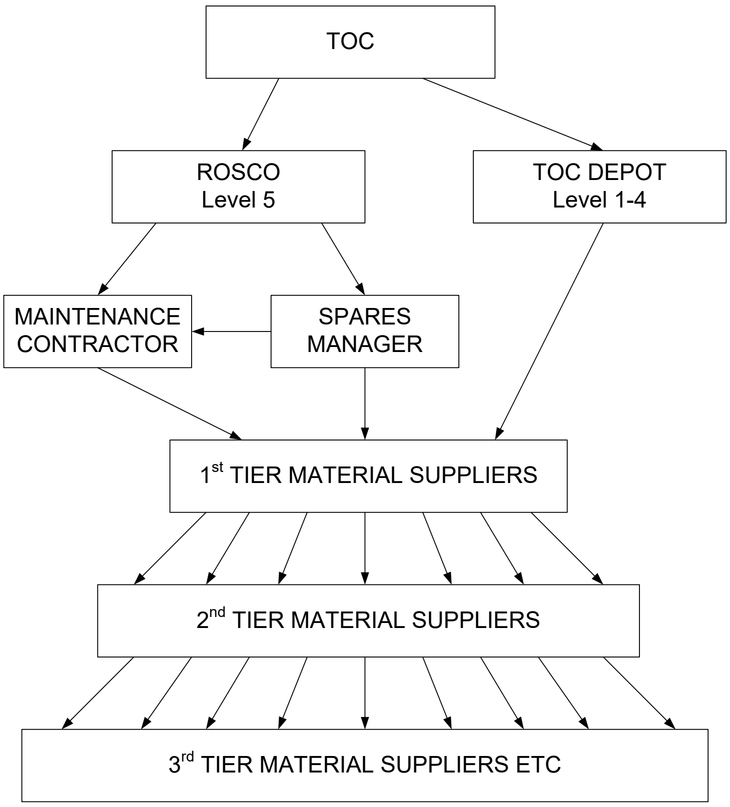


Figure 13.1 – Typical supply chain for undertaking maintenance on a soggy lease fleet

Most organisations within the rail industry are either customers or suppliers (or both) within supply chains and thus have a role to play in their management.

14.2 **How does the supply chain affect fleet performance?**

Supply chain activities can significantly influence national fleet performance in terms of the reliability, availability and performance of the rail vehicle components, products or services.

It is essential to understand the interdependencies and interfaces between different supply chains, particularly those that involve sub-systems and equipment used across multiple fleet types and affecting multiple TOCs, owners, OEMs and maintenance providers. (One example of such interdependency is a brake actuator common to a number of fleets).

14.3 **What are the characteristics of an effective supply chain?**

An effective supply chain will:

- Understand, provide for and anticipate the needs of current and future rolling stock operations across the UK
- Have the capacity and skills to deliver targeted asset enhancements that will underpin and improve fleet performance
- Provide effective and efficient through-life material supply
- Have a culture of continuous improvement that seeks to adopt best practice from other railways and industries as appropriate
- Understand the wider implications of its decisions and actions
- Be cohesive, i.e. a linked chain with aligned interfaces, management processes, priorities and objectives.

14.4 **What factors influence supply chain performance?**

A supply chain that does not function effectively will have an adverse effect on fleet performance.

A number of generic rail industry factors also affect supply chain performance, such as:

- Operator contract change management
- Configuration management
- Component robustness, testing and tracking
- Material support contracts and availability
- Economies of scale
- Adoption of relevant best practice from rail and other industries

A detailed list of issues to be considered within these areas is provided in Appendix C and is intended as a checklist for stakeholders to manage supply chains, assess their applicability and determine opportunities and priorities for improvement.

Businesses that demonstrate best practice in supply chain management undertake regular reviews of process effectiveness, staff competency and customer/supplier interfacing to ensure that these are appropriate for the constantly changing environment.

14.5 **What are the cross-industry priorities for improvement?**

Whilst stakeholders within an individual supply chain can achieve worthwhile improvements, there are some key cross-industry enabling factors which need to be in place for supply chains to function effectively.

Some factors do however require resolution for further improvements to be made, as detailed below:

1. Train operator should provide information on the volume of materials (both train- and non-train-borne) used by the depot to give suppliers an accurate measure of consumption to help forecast future demand.

2. Clear allocation of material for maintenance work level (i.e. level 1 to 4 or level 5) to further enhance the quality of information for a supplier to better forecast future demand. Likewise, maintenance schedules and seasonality factors should also be shared with suppliers to provide advance notice of requirements. A planned maintenance schedule should have a review point to analyse the actual percentage of on-condition replacement levels used part way through the programme, to enable suppliers to replenish stocks to appropriate levels for future deliveries.

3. Lists of critical parts (that could cause a stopped vehicle) and service critical parts (to ensure continued customer service) should be shared with suppliers to create a master list of parts that require buffer stocks.

4. Parts supplied in kits that are to be repaired and are time-critical for the repair to be achieved, should be highlighted to the customer so that they are returned in time for the repair to be completed.

5. Supplier should aggregate data from multiple users of the materials to establish trends and set appropriate stocking levels for the benefit of all users to increase availability and reduce lead times. First tier suppliers are responsible for communicating customer maintenance and demand schedules to sub-suppliers to ensure that requirements are aligned across the supply chain.

6. The supplier should communicate to the customer as early as possible if a part is not available due to a delay in the supply chain; the impact on train availability should be minimised by remedial action on the part of the supplier.

7. The supplier should provide feedback at regular intervals to TOCs where current demand levels do not match historical trends, causing over- or understocking.

Additional areas for improvement are:

- Management of ‘rogue’ components (repeat offenders)
- Configuration

The work streams are detailed in *Appendix D.*

14.6 How does the industry manage obsolescence?

This is an important issue, not exclusive to the rail sector, and we seek out best practice in obsolescence management from other industries.

In the rail sector, there are a number of different reasons why a component may become obsolete:

- Technical obsolescence, where the technology has been superseded by a new design, e.g. 1980s microprocessors.
- Supplier obsolescence, where the manufacture or repair of a component is no longer possible. This could be due to a supplier going out of business or removing a component from their product range.
- Commercial obsolescence, where it is technically possible for a supplier to make a spare part, but the cost is prohibitive.
- Substance obsolescence, where a material has been designated as obsolete through regulation or best practice for safety, environmental or other reasons.

Regardless of the cause, best practice is to actively manage obsolescence throughout the life of the vehicle.

Principle 1: Agree ownership for obsolescence. Technical and design authority as well as commercial responsibility for obsolescence should be clearly defined from the start. This could reside with the ROSCO, TOC, maintainer or first or second tier supplier, depending on the fleet, material type or component.

Example: Porterbrook sets out ownership for obsolescence in a TOC-specific fleet management plan that is agreed with the TOC at the start of the lease and forms the basis for ongoing commercial and technical reviews throughout the lease period. Responsibility for obsolescence is contractually documented and will depend on the type of lease in place. For a soggy lease, Porterbrook will continue to manage obsolescence for major components on the fleet. For a dry lease, this becomes the responsibility of the operator. In all cases, the operator will manage obsolescence on level 1 to 4 items. Porterbrook retrospectively put in place a design authority agreement with Bombardier (now part of Alstom) related to Electrostar and Turbostar fleets to ensure continued access to the fleet manufacturer's knowledge base.

Principle 2: No one party has all the answers to obsolescence. Good management requires input from a number of stakeholders: TOC, FOC, OEM, ROSCO, maintainer, first and second tier suppliers.

Historical Example: The Brake Code Conversion unit (CCU) hardware originally installed in the Class 313, 507 and 508 EMUs (now all ceased) became obsolete and was no longer supported by the original manufacturer.

Unipart Rail redesigned the CCU to be a direct replacement for the original unit incorporating modern relay components that are more reliable, have lower power consumption and weight as well as reduced failure modes.

Throughout the development of the product, Unipart Rail worked closely with First Capital Connect (now GTR) to ensure that the final design met the expectations and specifications of the train operator and their maintenance teams.

Principle 3: Establish a process for identifying obsolescence risks as part of good fleet management. This can be through fleet user groups, supply chain reviews, maintenance or overhaul planning or NIR investigation.

Example: Porterbrook's fleet technical reviews include obsolescence as standard. This gives Porterbrook or the TOC a chance to share any concerns and identify obsolete components early on. In one example, the Class 150 alternator was becoming increasingly expensive to maintain. Angel and Porterbrook invested in a solution with a new supplier and a trial was conducted in 2014/15.

Principle 4: Create a plan to manage and prioritise risks. Agree a governance approach.

Example: Unipart Rail has an obsolescence risk register for specific TOCs which is reviewed regularly and features new and priority products. This ensures the controlled progression of obsolescence issues, the tracking of samples, trial fits and the ability to assign projects to internal development teams.

Unipart Rail uses it as part of its supply chain and logistics reviews with both second- tier suppliers and customers to progress the timely replacement of the product prior to the obsolete part causing operational issues.

Principle 5: Tell everyone. Best practice includes communicating obsolescence risks to engineering groups, suppliers and materials managers across the supply chain, e.g. via user groups, PADS, NIR close out or the RISAS website.

Example: The HST users met quarterly and attendance includes the relevant ROSCOs, TOCs and Unipart Rail. In total, 12 different organisations were represented. The agenda covered incidents, technical issues and NIRs as well as solutions for obsolescence issues. The aim was to identify issues early and develop a common approach. For example, a component overhaul company had identified an obsolescence risk due to a lack of spares. Solutions such as injecting more float material, by either manufacturing new spares or pooling spares held by other parties, were considered. The issue of the IPR of the equipment was also discussed.

14.7 **What are the various roles?**

Optimising the supply chain to underpin and improve fleet performance involves many people and many organisations across the industry. No one individual or organisation has all the answers.

All parties must:

Reflect on the principles and sentiments described in this section

Evaluate their role within the supply chain(s)

Question whether their approach is supportive and aligned to the principles and sentiments outlined in this section

Discuss and implement opportunities for improvement internally and with respective supply chain(s) stakeholders

Keep abreast of and participate in ongoing work by ReFocus to agree on industry-wide supply chain priorities for improvement

Where can I find examples of good practice?

Appendix E provides some current examples of best practice in supply chain management and will be updated on a rolling basis to include the results of current workstreams.

15. New Train Introduction

How to buy a new train to get the best “out-of-the-box” service performance and risks associated with whole fleet behaviour following introduction.

15 New Train Introduction

This handbook for reliability improvement will concentrate on how to buy a new train fleet to get the best out-of-the-box service performance. It is written primarily from the perspective of TOCs as key players in the procurement of new trains. They have the best knowledge of what they and their passengers need and want and will be first in the firing line if the product and reliability fall short. There are lessons learned based on recent procurement experience, but these are not comprehensive and are intended to raise awareness of issues which can inform future thinking. This section may be equally applicable to the installation of new train equipment.

Two powerful lessons learned to maximise reliability are:

- The effective deployment of significant train operator resources. This costs money but pays reliability and other long-term dividends; and
- Adequate timescales and sufficient contractual rights to enable the TOC to demand that deliverables are right at each stage of the project (to avoid time or financial pressure from other stakeholders to accept an inferior product).

Note: Since this section was originally published in the 20pp, RDG has produced RDG-ENG-GN-008: Guidance Note: New Trains – A Good Practice Guide which provides much more detailed guidance in relation to the management of New Trains. The latest version can be accessed on the RDG website.

15.1 **Pre-contract – product selection**

15.1.1 **Planning**

It is worth investing serious time and energy in this phase of the project, hence the lengthy recommendations in the pre-contract and contract sections. Some are legal requirements but the focus is on practical steps to improve reliability based on positive and negative experiences.

Critical to efficient implementation of the eventual train service is the early and effective engagement of the TOC's operations and commercial functions, e.g. what the needs of the passengers on the route are, what the roles of on-train staff are, how other trains at that TOC work, etc. It is best if the TOC frees up some of its own staff who know how their railway operates, its constraints and opportunities, rather than hiring consultants (although long-term secondees can be valuable if integrated into the TOC team).

A one-team integrated approach should be adopted early on, bringing together operational staff, engineering and commercial aspects of the business, and be cross-organisational, preferably with knowledge and experience in fleet introduction. It can also be worthwhile to include representatives from Network Rail, front line staff and the driver body in cross-company workshops.

No matter how tightly the contracts are written, the TOC always has risks that cannot be fully passed back to other parties:

- Safety - the ultimate responsibility to run a safe train falls to the TOC
- Overall business risk - performance regimes with manufacturers to deal with poor performance are invariably capped and based on an estimate of possible TOC losses made years before the trains enter service.

In recognition of these risks a detailed train specification (setting out how the manufacturer will deliver a product compliant with the TOC's functional specification) should be agreed before any preferred supplier is nominated. The more time invested here, the more successful train implementation has been in terms of fewer (expensive) variations to the contract during the project; higher reliability out-of-the-box; lower risk of an overspent manufacturer being unwilling (or unable) to finish the job properly.

Further, there is a correlation between the time available for the whole project and successful implementation: heroic timescales are less likely to produce good trains. This gives the TOC the ability to say no (or even to credibly threaten to say no) at critical milestones in the development and delivery of the fleet, providing real leverage to ensure quality requirements are met.

15.1.2 **Specification development**

The process can be either prescriptive (by invitation to tender) or co-operative (by invitation to negotiate, as in the Eurostar example given below).

> Example: Eurostar's process of tendering for new fleet was unique in that it issued a tender to negotiate for a suitable high-speed TSI-compliant platform. They then worked with the supplier to build the specification around what was possible.
>
> Eurostar are fortunate in that their infrastructure is largely TSI-compliant so there was good knowledge in the supply chain of system requirements and products available that could be easily modified.

The core requirements should cover:

- Train technical issues, e.g. route-specific performance parameters such as top speed and kinematic envelope;
- Train passenger issues, e.g. passenger carrying capacity, ambience, facilities;
- Train depot issues, e.g. fuel, coolant, sander and toilet interfaces for servicing; and
- Train station issues, e.g. water filling, ability to use emergency coupler in platform road.

Subsequent steps:

- Understand what is available on the market. Aim for proven design rather than a trial stage of product development. For example, TPE based the Class 185 on the Class 180 below the solebar and Class 360 above. Is there an opportunity to use an existing production line? This can save ramp-up time and costs.
- Determine the level of innovation. Southeastern's Javelin, for example, was considered very high performing but not very innovative as it used 1980s/90s traction technology. There is a line between innovation, such that your customers really see this as a new train, and out-of-the-box reliability. Understand best practice and industry codes of practice and do not be afraid to challenge outdated or irrelevant standards. Also allow time for necessary derogations.
- Understand the functional needs, e.g. how passengers, crew, maintenance staff and other stock will interface with the new train. Obtain input from operations colleagues within the TOC as well as engineers. For instance, take the train specification detail right down to the level of a driver or guard opening and closing doors (including SDO). Does this fit with station dwell times? How does the train's diagnostic system report faults to the driver? What does it tell them to do? How long will it take them to do it? Is the remote downloading capability sufficient? Every detail could cost money and compatibility with other stock may be critical.
- Specify no single point failures and consider the train as a whole. For example, the Thameslink Class 700 units are 8 or 12 car fixed formation units, which means that a single damaged window can potentially take the unit out of service. Is there the ability to isolate or make safe such failures to allow the unit to complete its journey?
- Be clear on requirements for data management systems on the train, including data formats and downloads.
- Ensure the right to participate in final design reviews. This will be an opportunity to clarify any grey areas left in the specification (*see 15.3 below*).

15.1.3 **Commercial strategy**

Recommendations from experience are:

- Start with 5 or more train suppliers and run with at least 2. Reach at least train specification and heads of terms agreements with both to facilitate a contract with either. This is to maintain competitive pressure and mitigate the risks of opting for a preferred bidder too early (it is more difficult to return to the non-preferred). Keep two suppliers engaged to have a credible alternative

right up to the point of contract conclusion. Consider the manufacturer's order book– success can breed success but also stretch the supplier's resources.
- Decide whether to manage procurement in-house or outsource it. If outsourced, how much control should be retained? Is it viable to buy the trains and then apply for re-financing?
- If appropriate, approach 5 financiers and develop 2. Decide between different forms of relationship.

Examples: ROSCO and TOC speak with one voice to the supplier with a clearer focus on reliability and other essential requirements as a result.

In the historical South West Trains Desiro project, the TOC was contracted to manage ROSCO's interests in the procurement process. For the Southern Electrostar programme, a TOC/ROSCO team was formed where the ROSCO engineer was contractually designated the TOC engineer's assistant. Both arrangements required individuals to develop good working relationships and rely on clear and acceptable contracts.

15.1.4 **Maintenance strategy**

- Decide what the product is, e.g. train and spares only/train and specialist support/design-build-maintain/train-service-provider/availability contract
- Set targets for overhaul cycles and routine maintenance periodicities as these will be key drivers of both maintenance costs and train availability
- Be aware that a whole life maintenance plan may not be available at this stage and great care must be taken at later stages to ensure that subsequent development of the plan does not present additional risks
- If an aftersales division of the supplier is providing any of the services, what is their relationship with the manufacturing arm, and how committed is the latter to supporting the former? Is there an internal contract in place? What level of the supplier's management structure decides on cross-division support?

Example: Be wary of the split of responsibilities between operators and suppliers.

Siemens are responsible for all maintenance of the GTR Class 700s at both Three Bridges and Hornsey Depots. The existing arrangement at Hornsey had GTR drivers who managed the washing and moving of trains. Three Bridges copied this approach and had Siemens maintaining trains but was reliant on GTR for movements and the wash side. GTR had to recruit new drivers and a management team for Three Bridges.

This was a missed opportunity at the contracting stage. Both parties had to work around the issues, but a strict contract made this difficult. Handover from maintainers to drivers, for example, is very prescriptive.

15.1.5 **Procurement process**

- Develop a risk allocation matrix – who is responsible for what
- Plan support services – allocate enough resources with the right knowledge and incentives. The person who reviews the bids should be the person who lives with the product. This includes the operators, e.g. ensuring the driver manager and head of onboard staff sign off the specification.

From considering the primary roles of TOC, manufacturer and financier, the roles of other players can be inferred. Two key ones are listed below. (The TOC may arrange for other parties such as catering contractors to deliver aspects of their service.)

15.1.6 **Role of the Operator Contracting authority**

- If new train procurement is a requirement in an Operator Contract, then enough time should be allowed prior to implementation to enable a robust procurement process to be set up and delivered.
- Core specification policy decisions should be timely to set the framework and key interfaces (using the criteria set out, e.g. extent of compatibility with other stock) to enable the TOC to undertake the

detailed work (and negotiate with the operator contracting authority on core requirements if they appear unduly costly).

Example: What is specified may be found at a later stage to be unfeasible or undeliverable.

Connected Driver Advisory System (C-DAS) was specified by the DfT for the Class 700 but did not include details. Siemens fitted their generic solution as a consequence and difficulties were experiencing interfacing with the Traffic Management System as a result.

Both Greater Anglia and Northern found themselves in a similar situation with 'ETCS-Ready', which DfT had specified but not formally defined.

15.1.7 **Role of the infrastructure manager (commonly Network Rail)**

- Work with Network Rail and other operators on station design and platform lengths, etc. Siemens worked with Network Rail on station designs throughout the Thameslink core to ensure that dwell times could be met. This included signage to optimise flow from doors through barriers and onward.
- Thought should also be given to specifying and buying space or land for depots and stabling, etc. Is the land available? Might it be earmarked for other projects or public sale?
- Work with Network Rail on plans for electrification - how likely are these to remain on schedule and be delivered? This can greatly affect the choice of traction type, with bi-mode offering security in the short term until electrification is complete.
- Specifications for overhead lines and 3rd rail parameters and interfaces with the train need to be considered as the actual infrastructure can deviate from Network Rail's specification drawings.

15.1.8 **The contract**

Delivery (what you get) and finance and train performance (how you pay for what you get and protect yourself from not getting it).

It is worth discussing some cultural differences at this juncture. A cultural disconnect between commercial and engineering departments in different countries can often be of benefit but there can also be a disconnect between project delivery teams and design teams in organisations set up with individual business units which must work together on new train introductions. This is a problem when technical experts are in a different country.

15.1.9 **Recommendations around acceptance and delivery**

- Delivery profile is crucial and TOCs should insist on delivery gateways. For instance:
    - if payment milestones are spread throughout the design and manufacturing phase, choose hard evidence gateways (e.g. first article inspections, submission of type test reports) rather than ethereal ones (e.g. the supplier's internal design freezes or assembly line build stages, which can be passed with issues outstanding)
    - treat hard deliverables (e.g. special tools, initial spares stocks) and soft deliverables (e.g. technical libraries) equally and specify when (how long in advance of train delivery) they should be provided to unlock train acceptance
    - use qualified acceptance to incentivise the supplier to close out acceptance issues. This should, ideally, be linked to price retention.
    - Mature software should be a milestone
- Detail is critical. If looking at a proven product, insist on the defined performance levels achieved on other fleets. Be clear about when they are required and what happens if they are achieved (or not).
- Particularly if the rolling stock being procured is of a substantially new design, time should be allowed for evaluation of the first trains built before full fleet delivery takes place. For example, TPE gave drivers a pre-handover period (2 weeks) on the trains to test fault scenarios and see if they could break it, to enable design tweaks and process changes.
- Aim to have the external manufacturing arm treat the supplier's aftersales organisation as an internal customer alongside the TOC as external customer when setting up the acceptance process.

15.1.10 **Technical documentation and data**

- Be specific about technical and user documentation in the contract, e.g. what is meant by "all documents required to enable efficient and safe maintenance and operation". This might require an explanation of the elements of the maintenance plan, the limits on the periodicity of individual activities and the risks they were designed to mitigate.
- This would boost understanding of how to improve initial reliability and provide a robust basis for developing and refining the maintenance plan going forward. Ask for maintenance plan delivery on physical media such as a read only memory stick. Experience with web-based interactive manuals is often bitter and can conflict with the basic principles of document control.
- Be clear about how the information should be delivered. Does a bundle of A4 photocopies with suppliers' part numbers constitute a list of parts? What interfaces should be integrated with existing maintenance management systems? Similarly, request delivery of special tools, e.g. laptop-based diagnostic software at an appropriate milestone.
- Have the short- and long-term end users of the documentation agree the format. These may be ROSCOs, TOCs and the supplier's aftersales division.
- Require safety critical components to be identified for approval as such in line with best practice, e.g. RIS-2750-RST.
- Either:
    - formally review and approve or
    - require sight of maintenance and overhaul instructions, particularly for components (as railway undertakings, TOCs need to know to ensure they are credible and compatible with the maintainer's facilities)
- Ensure access rights to all data within the train management system and all off-train software needed to analyse it (contracts have varied, even between TOCs buying the same train, and a lack of information can hinder reliability growth).

15.1.11 **Supply chain management**

Change control is particularly critical and should be guided by an assessment of fundamental risks and a standard engineering change process. There have been instances in long build contracts where inferior components have been substituted without asking the TOC. Of course, some changes are necessary and/or desirable as better products are developed or existing parts become obsolete. There should be a contractual clause to the effect that TOC agreement would not be unreasonably withheld. The TOC should also contractualise the right to audit supply without warning, but it should not be used to weaken the supplier's product responsibilities in the contract (or company processes).

15.1.12 **Obsolescence management**

As outlined in *Section 14.6* above, obsolescence risks should be identified for every train and a conscious decision taken about how to manage each one. This may include additional specific contractual requirements or responsibilities beyond the warranty phase, possibly into long-term management deals.

It is important to ask in the early stages if there is flexibility in the design. This is more of a concern for successor Operators or the rolling stock owners as they may be restricted in later cascades or route changes if there is no future proofing, e.g. procuring a diesel fleet when electrification is a possibility in 10 years' time. Perhaps a bi-mode traction type would be better for future use, even if electrification does not transpire.

A design authority or similar support arrangement should be in place for each fleet to provide a point of reference for design information and knowledge and a base from which electronic systems and the vehicle in general can be developed throughout its life (proactive obsolescence management). It will certainly include some careful consideration of electronics and software, such as life-time buys for some electronics and clear software escrow rights in general.

Electronics are not always expected to last the life of the train. This must be managed on the basis that the train needs to continue functioning. Obsolescence is also compounded by new trains being built from a kit of parts. Component drawings and design knowledge may be held at sub-supplier level and not in the public domain, making it harder to resolve future issues. Challenge existing designs where appropriate and insist on a new approach.

15.2 Financial recommendations

15.2.1 Performance

- Use standard industry measures (Mp701D, 3-minute delays and any part cancellation, delay minutes) as indicators for the performance regime. Do not allow suppliers to quote their own measures, such as technical capability, which favour their statistics at the expense of passengers. Be wary of using older performance measures, i.e. DfT specified reliability for the Class 700 using MPC (miles per casualty).
- Ensure the supplier takes responsibility for problems caused by poor ergonomics and man/machine interface (e.g. misleading messages on the train's data management system).
- Include targets and incentives for reliability of passenger amenities (toilets, air conditioning, etc.).

Example: Depending on the manufacturer, synergies can be achieved between certain requirements and targets.

With the Class 700, the DfT had specified optimised maintainability and reliability and reduced energy consumption. In fact, the lighter the train was, the more the manufacturer was paid. However, Siemens had to make sure that any savings in weight were not detrimental to maintainability or reliability (lighter yet solid). This is a benefit of the train builder and maintainer being the same entity.

- Ensure that warranties and financial incentives are clear. Set realistic and enforceable delivery targets, e.g. achieve half the eventual reliability performance on day 1 otherwise the first train will not be bought; unless Mp701D of x achieved by day y otherwise there will be no purchase or purchase at a lower price (i.e. link performance to price). Do not rely on the service organisation to get back to the manufacturer on a 'with maintenance' deal. Service organisations will always cap out their warranties on performance; retain a performance warranty with the manufacturer in addition.
- Set out the following warranty terms: what you get; what the supplier does; what you do. There should also be a strong endemic defect clause such that if you reasonably believe the product is defective, you can choose to stop buying until the issue is resolved, without having to reach a threshold of failures first.
- Set up a retention bond available to put right a major system failure should it happen, even after purchase (beyond warranty and for issues yet unknown). This risk decreases with a proven product.
- Seek timed and priced options for flexibility, e.g. to cope with future growth (inserting extra vehicles in a formation) or possible changes in future usage.

15.2.2 Payment profile

The ROSCO has a significant role in the payment profile and this can have a significant impact on long-term reliability. Bear in mind the risk of conflict between TOC and ROSCO requirements: the ROSCO wants a train that is leased and will be leasable throughout its life, whereas the TOC wants a reliable train that meets its contractual requirements. This demonstrates the need for a good relationship with the ROSCO, backed up by aligning interests contractually as far as possible:

- Ensure there are robust incentives on the manufacturer to close out all the technical issues – bonds and retentions are much more powerful than warranty agreements.
- Consider how qualified acceptance could work to incentivise the supplier and financier. If the financier withholds a proportion of payment until qualifications are removed from an acceptance certificate, then lease payments should likewise be reduced.
- Require unrestricted access to manufacturing as part of a robust acceptance process to ensure that each acceptance gateway has been achieved and the project (and payment) can proceed. It is also good to link payments to the formal approvals milestones, i.e. work closely with your Notified Body (NoBo) to define and link these. It is less desirable to link to the manufacturer's design process because this is not directly linked to milestones.
- Require pricing transparency on any variation order from the supplier to check it is fair and accurate

(e.g. over-stating the number of units required to be modified and double-counting for overheads – both in the artisan rate and added separately; including the original base design costs in addition to the costs of the actual variation). In some cases, errors have doubled the quoted cost. Good practice would be to specify an agreed 'rate of return' on VOs.

ROSCO choice may be affected by attitude to variations after contract, e.g. their treatment of TOC-led reliability improvement changes such as making the doors work better (which are relevant to the whole life of the train). Other factors include willingness to allocate an agreed lump sum up front for getting things right (i.e. to help make beneficial changes). Capital sums for these and other things (e.g. depot improvements) should be available at a reasonable rate.

15.3 The design – how the product works

This begins with the functional specification drawn up by the TOC at the invitation to tender stage.

15.3.1 Functional specification

This should identify issues that are important to operation and which might not otherwise be recognised, such as:

- Reliable quantification of the time for the train to be ready to move after 'Aux On'; splitting, joining and moving away i.e within x minutes;
- Times for door opening and closing sequences; time to shut down, change ends and open the desk; driver prep time (affects trade union agreements as well as train timing)
- Coping with short platforms (selective door opening requirements) and driver only operation;
- Any safety/compatibility management requirements that might be passed to the TOC by the supplier, e.g. daily checks needed for safety systems. This can require technical personnel at locations such as stabling sidings where they would not normally be present, adding cost and stretching resources;
- Maintenance constraints and opportunities to be included in the train design (e.g. no train components should require planned maintenance intervention between the maintenance intervals for diagrams);
- Easy re-start of electric trains after a 3rd rail or overhead contact line supply outage;
- Easy access to equipment for in-service diagnostics and fault mitigation (e.g. not putting re-settable or diagnostic devices a long way from the driver or adjacent to high voltages);
- Mechanical and electrical compatibility with existing fleets that the TOC will continue to operate.

This is crucial for successful operation in the real railway and effective mitigation of defects in service. The TOC must translate train operations expertise into design requirements. Never assume that the supplier has operational knowledge of products.

There needs to be early involvement of Associated Society of Locomotive Engineers and Firemen (ASLEF) and driver representatives in cab design. Use ASLEF's good practice guide and the RSSB Key Train Requirements (KTR) document for further assistance.

15.3.2 Design review

- Check the comprehensive technical specification from the manufacturer against functional requirements; seek first-hand experience of existing products that are being touted as proven and talk to the people who are using, operating and maintaining them. Get to know the design and request a document that describes how the door control system works.
- Do not take on design responsibility. Document scrupulously exactly what has been agreed (e.g. that option A appeared better than option B. This does NOT absolve the supplier of responsibility with respect to option A and does not alter contractual reliability requirements).
- Design freeze and standards freeze – be clear about what and when this should be to ensure mutual understanding of change flexibility before (and rigidity afterwards).
- Standards conformance – be clear whether any non-conformity or derogation from mandatory standards is required, who is responsible for it and determining what is acceptable as an alternative.
- Change control –agree all changes in writing and keep all correspondence. Do not absolve the supplier from their obligation to provide a compliant product that is fit for purpose.
- Concentrate on interfaces – with the infrastructure, traincrew, passengers, maintainers, other

trains. Focus on software functionality.

- Focus on the biggest risks to reliability and incorporate them in the design of the train management system and its interfaces to drivers and maintainers. Look at the top 10 existing and other comparable fleets and demand all available train data. For example, doors: emphasise requirements for door functional information capture, identifying incipient failures and diagnosing root causes of faults, especially intermittent ones.
- Build in redundancy for particularly critical systems where it will bring worthwhile reliability benefits (e.g. compressors; pantographs etc.).
- Design risk can be offset at performance level but a train purchase with in-house maintenance may be affected by design changes during the build that could have significant downstream costs for the maintainer (e.g. a fleet with a mixture of different repairable components under the same part number may require different maintenance specifications. This could have been avoided if there was a clear requirement not to make any design changes, even at low level not affecting the functional specification, without client approval). One TOC found that employing 2-3 people to monitor this proved worthwhile in terms of preventing downstream costs.

15.4 **Manufacturing**

15.4.1 **Theory – desktop information**

The TOC should: follow through from type approval to ensure that production roll-out is robust, seeking specific information to review as part of assurance that work is progressing (and tied into payment and progress gateways); have access to all drawings and build data and be able to review assembly processes; have access to all stages of manufacture (critical system OEMs as well as the main supplier, where relevant); and see the consistency of production and manufacturing standards.

Use first article inspections, a formal method of providing a reported measurement for a given manufacturing process, to create more direct lines of communication, especially in the case of in-house maintenance.

The TOC should likewise ensure that the supplier specifies engineering standards and has a robust staff training and competency management system. Other relevant supplier systems include goods inwards inspection and configuration database.

15.4.2 **Practical - on-site presence**

With clear responsibility for production, it is advisable to have a customer presence in the supplier's factory.

> Example: Southern found that having 2 TOC engineers in the train builder's factory and 1 at their commissioning depot was worthwhile in terms of identifying and resolving issues which could have caused problems in 10 years' time.

TOC engineers on site in supplier (and, where appropriate, sub-supplier) factories have often facilitated communications on the latest issues. This minimises the number of vehicles built with a defect once it has been identified in service, hence saving rectification work and benefiting all parties.

> Example: Train builders can be tempted to overlook manufacturing problems during construction as they believe the TOC will not see or be aware of problems that might only come to light years later during overhaul or when exchange components do not fit. Reported cases include anti-corrosion treatments, paint quality and dimensional build tolerances.

Mistakes are costlier if not addressed early. Although they cannot be planned for, risk analysis should be conducted to identify potential failures and delays to the plan.

> Example: A TOC (who were also explicitly acting for the ROSCO) found that assembly line audits were useful for residual value issues associated with passenger environment and paint quality.

Working with the supplier's service organisation can also help improve build quality. Many TOCs undertake factory gate commissioning, requiring TOC acceptance before vehicles leave the factory in addition to commissioning on-site in the nominated UK maintenance depot.

15.5 The acceptance processes

This section does not cover the safety-focused approvals process (with Notified Bodies, etc.), only customer acceptance, which focuses on reliability performance.

The gateways TOCs should set are:

- **Preliminary acceptance** at factory gate (i.e. before each vehicle leaves the factory, after 1000 miles of fault-free test track running after leaving the factory but before the TOC accepts the train).
- **Commissioning:** both static and dynamic tests to guarantee trains can run on Network Rail-managed infrastructure, accumulating mileage and proving experience. This phase enables the ambience to be assessed (e.g. noise, ride and comfort, in addition to finish and décor).
  The examination work associated with commissioning should be regarded as the "zero miles" exam in the maintenance plan. It is vital to subsequent safety and performance that it:
    - Contains every task required to permit the vehicles to run to the next scheduled examination and hence to the longest scheduled maintenance interval in accordance with the safety certificate.
    - Is performed only by people with demonstrable competence in applying maintenance plan tasks.
- **Provisional acceptance**, after which trains are fit to run in passenger service under the TOC's safety certificate (this is usually a static test after 15k miles trial running on Network Rail-managed infrastructure, supported by an engineer on the first day in passenger service). This 'shakedown' testing should look to mimic future operations and diagrams on intended routes, i.e. frequency of stopping, door opening, turn-around times, etc. At this stage, the trains are technically procured (i.e. ownership transfers from the manufacturer to the financier) but the project is not yet complete.
- **Final acceptance** 2 or 3 years on, when each unit has had all the latest modifications retrofitted and software versions upgraded; plus 20k miles of fault-free running and 3k miles of no system faults; plus, all correspondence between TOC and supplier has been closed out.

To facilitate acceptance, the TOC should have unfettered access to finished units. This should be clarified in terms of site facilities and what arrangements are made for TOC personnel on-site.

Implementing an Engineering Change (EC) before type approval risks deviating from scope, i.e. the operator has less control but also less work to process additional ECs. A protocol must result from final design review regarding type approval and commissioning to ensure that the product has adhered to what was initially promised.

Note on test tracks: They are invaluable for developing the technical safety case for a new train and validating later changes to the design. Pre-delivery endurance running on test tracks is useful as a sophisticated build quality check but a true indication of reliability only emerges from 'in service' experience on real infrastructure, which tends to draw out many more issues. It would, however, facilitate acceptance if Network Rail would more readily agree to testing on a particular track between particular times rather than having to set up a signal protection zone.

UK test tracks are in high demand and thus often unavailable. It is possible to test abroad but is difficult to replicate UK trackside to a sufficient standard (mainly due to inconsistencies between implementations).

There are two types of introduction:

- Phased fleet introduction - one strategy is to gradually replace old trains with new, perhaps even while improving old rolling stock, such as Eurostar introducing the new e320 while overhauling the e300s to match. This is particularly common with partial fleet renewals.
- Full fleet introduction – often the case under franchise commitments to replace the TOC's entire fleet with new trains within a set time, such as Greater Anglia's complete fleet renewal.

15.6 Service introduction

Some initial points of note:

- Be sensible with unit introductions: use low mileage return to depot diagrams. Siemens were forced into GTR's existing diagrams and timetable rather than optimising a diagram for testing, etc. They were running 800 – 2000 miles and 2-3 days before returning to depot. Aim for less than a day in service before returning to depot, such as post-morning peak, etc.
- Have strong contingency plans: Defective On-Train Equipment (DOTE) policy should stay with the TOC as the supplier cannot influence the 'cut and run' policy.

15.6.1 **Interface with operations**

The challenge here is to integrate the new train into the Railway Undertaking's safety certificate. There is significant and often underestimated work in this regard, e.g. training additional drivers (TOCs need more drivers to free some up for training and for driving the test runs on the new trains). This could be a 5 or 10% increase in drivers for a period prior to full service introduction.

There can be a disconnect between a project's delivery team and the next project's commissioning team as lessons do not always carry across and there is no feedback into the build line.

Operators should be realistic about the rate of change and communicate with the rest of the company. This could take the form of continuous readiness updates and briefings through the business change.

15.6.2 **Interface with manufacturer**

This is particularly critical if the TOC is taking over the maintenance of the trains, as responsibility shifts.

Example: Do not jeopardise warranties, e.g. by altering usage of door release anti-tamper catches, effectively requiring components to deliver more than their designed capacity.

Consider the length of time the supplier's support will be available. If they are contracted to perform maintenance for at least the first few years, they will have a vested interest in correct maintenance documentation.

Depending on the precise contractual arrangements, issues such as spares provision and management should be followed through and there should be regular contract meetings around all emergent issues and their resolution.

Example: TOC should aim to ensure all emerging issues are openly discussed and solutions identified by the parties before expiry of the relevant warranty period.

Gone are the days of a commissioning team of 3-4 people who know all the ins and outs of the train. Operators should have teams or even departments of people who specialise in each sub-system and its scope. This means that very few people from the manufacturer see the bigger picture. When there is a technical problem manifesting across several systems, the diagnosis and corrective action could take much longer. Ask for 24/7 on-call groups of specialists knowledgeable about the trains and the systems during introduction.

Example: Avoid training that is delivered from a sub-systems OEM point of view as this does not give maintainers the bigger picture of how systems can work together and influence behaviour.

Siemens took this approach with the Class 700 and introduced a 'wiki' resource for maintenance staff to act as a repository of knowledge, including common faults encountered, previous fixes and how systems work. Staff are incentivised to contribute by securing additions to the staff entertainment fund

15.6.3 **Interface with Network Rail**

Key to minimising the pain of service introduction is to ensure that Network Rail appoints a project manager to meet with the TOC once a week to work round any emerging problems, e.g. booking test slots. TOCs should ensure that they establish compatibility on all route sections and tracks they might wish to run a train on, either as a timetabled or exceptional move e.g. to a wheel lathe, and that statements of compatibility are published for all possible moves.

15.7 Reliability growth – delivery to the passenger

Many of the issues highlighted here are cited as good practice for existing fleets in other parts of the 20PP. However, it may be worth drawing attention to the particularly critical nature of some issues at this stage of a train's life.

15.7.1 Design for maintenance early on

Different systems can require updates at differing intervals based on supplier development, different laptops or maintenance tools and different skill sets for fault-finding and general maintenance. Eurostar's e320 still has many train wires hard-wired to the train management system (TMS) rather than using a data bus. Equally, hard-wired solutions can limit the scope for future expansion.

Software can present unique issues. There is often little understanding of why it fails, how to fix it, or the impact it might have.

Suppliers can be tempted to pass blame on to other interfaces and sub-systems, which focuses attention on the common problem of fixing the fault and not the root cause.

The operator or manufacturer needs a robust test regime after implementation of the fix to monitor success. Software updates (previous and current version) should be held in ESCROW until updates are proven successful to protect against suppliers leaving the market.

15.7.2 Measure everything – and follow it through

TOCs should not underestimate the resources needed to monitor what is happening effectively enough to identify and resolve root causes of unreliability. Effort is also required to develop efficient mitigations to reduce the impact of faults while root-cause solutions are being developed and implemented. There should be close collaboration with traincrew as they are the first to see problems and build confidence by providing feedback on how problems are being tackled.

There should be engineering support for the maintenance and operations controllers, e.g. a technician from the train manufacturer in the control room.

Exploit data from train systems and ensure it is made fully and freely available. Avoid being charged by the supplier for collecting or processing information and use the opportunity to overcome any difficulties with downloading, transmitting or formatting data.

> Example: Ensure access to RCM data even if the manufacturer oversees maintenance.
>
> On some of their legacy trains a TOC had integrated their RCM with operations and engineering which allowed them to monitor the systems and look at events from both points of view. This was very useful and enabled joint investigations, etc. However, with their new trains, they did not have access to the RCM data, making this sort of activity impossible or more complicated (i.e. if the different departments use different systems to monitor what is going on)

Again, ensure that passenger amenities such as toilets, information systems, wi-fi and air-conditioning are given sufficient attention at this stage of the project.

16. No Fault Found Warranty Claim

This chapter focusses on rolling stock component warranty claims where the supplier cannot find a fault with the returned component.

16 No Fault Found Warranty Claims

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There is a perception in the industry that these events occur too often, taking up limited time/resources across a number of different companies without ever reaching a satisfactory conclusion as to why the fault occurred in the first place. It is difficult to quantify the service impact of these events due to the way data is currently collected and stored but it is good practice to reduce the number of No Fault Found (NFF) events to an absolute minimum.

In order to understand why this issue occurs, it is necessary to understand the process which underpins warranty claims, the stakeholders involved and the environment in which this process is implemented. Only then is it possible to identify the individual causes of NFF diagnoses and then develop good practice guidance which, if implemented, will help to reduce the number of said warranty claim diagnoses.

16.1 The process

Table 15.1 is a simplified representation of the warranty return process for components where the supplier finds no fault. (N.B.: this process is not completely standardised across the rail industry).

Occasions where the TOC disputes the outcome of the warranty claim and repairs outside of warranty are separate processes not detailed in this chapter.

Table 15.1: The High-Level Warranty Claim Process

Step	TOC Operations	TOC Fleet or Train Maintainer	Logistics Company	Supplier or Overhauler
1	Train Defect Occurs			
2		Faulty Component Alleged		
3		Receive New Component	Organise Component Assessment	
4		Fitted to Affected Train		Component Tested OR Component Stripped & Inspected
5			Organise Component Return	
6		NFF Report Accepted	Component Placed in Common Pool	
7		Component Fitted to a Vehicle		

Commercial agreements between companies and fleets differ, making detailed application of the process more complex, but commercial agreements should identify information to be shared up and down the supply chain.

It is important to consider the wider context of managing component failures and how they can affect other parties not involved in managing the specific failure. For example, use of common component pools means that the TOC receiving the returned component may not be the one that sent it for testing and will not have a full understanding of the component's reliability history.

16.2 The issues and good practice

By understanding the specific issues which cause warranty claim NFF diagnoses, it is possible to identify good practices to reduce them. These are described below in more detail.

16.2.1 Behaviours and working practices

- Warranty management is not applied consistently across the industry and may sometimes be overlooked. It is good practice to place sufficient emphasis on warranty management and ensure it is a critical part of managing fleet reliability (e.g. ensuring warranty-related issues are routinely discussed at reliability meetings).
- Whilst contractual warranty terms are all different, it is important to review these prior to the start of a new franchise to ensure that they are optimised and not simply copied across to a new contract.
- Mistrust between the TOC and the supplier can foster a strictly contractual relationship. This may lead to more NFF diagnoses as they do not openly share all failure information for fear of being held responsible. It is critical for TOCs and suppliers to develop collaborative working relationships to improve the quality of failure investigations, e.g. by having regular meetings focussed on the common goal of identifying and resolving technical issues.
- Pressures to deliver a reliable service may lead to components being replaced as a preventative measure. These may then be returned to the supplier for further investigation without having validated whether the component was faulty. It is good practice to quarantine suspected components to see if the fault re-occurs, prior to returning it to the supplier.
- TOCs should avoid having a ‘change it’ culture (this may not apply to the whole fleet team and could be shift- or depot-specific). Efforts should be made to ensure that technical flow charts used for fault-finding do not exacerbate this issue. Warranty managers should work to identify those teams who are quick to change and return components by analysing the volume of claims they process and the number of components being returned for an individual failure.

Example: Many Operators hold monthly technical and commercial meetings with suppliers to discuss the main issues affecting the fleet and provide a regular forum to work together towards resolution.

Example: Virgin Atlantic has a system whereby if a failure occurs which could be caused by a number of different components and the fault cannot be diagnosed, they first change the component most likely to have been at fault and place it in quarantine for a set period of time. If the failure does not re-occur in that time, the component is returned to the manufacturer for diagnosis. If the failure does re-occur, the component is assumed to have not caused the failure and the next most likely component is removed and placed in quarantine.

16.2.2 Time taken to resolve issues

- There is a perception that it takes too long to investigate alleged component failures. It is difficult to quantify the validity of this perception due to the diversity of warranty SLAs. It may be that TOCs and suppliers have a slightly different interpretation of an SLA (e.g. whether the clock starts ticking from the moment the TOC sends off the faulty component or when the logistics company or supplier receives it). It is also important to understand that not all components are treated equally by logistics companies. Those with immediate demand or safety stock levels will be returned for repair immediately, otherwise the broken component may be stored in a warehouse awaiting future repair. It is therefore good practice for TOCs and suppliers to agree a common definition of terminologies and measure compliance against a set of agreed KPIs.
- The length of time taken to agree a failure diagnosis where there is a limited shared float available can result in availability/reliability issues at other TOCs not involved in the original failure. Pressure to conclude these matters may result in basic failure investigations and more NFF diagnoses in order to return the component to the common pool. ROSCOs should be familiar with overhaul spares floats and logistics companies likewise with maintenance spares floats. Limited floats become a greater issue at times of overhaul and need to be proactively managed (*see Section 17 Overhaul Management)*.

- Logistics companies can identify limited floats using critical spares and obsolescence forecasting; they should forecast maintenance activities to identify peaks and troughs so that limited floats can be managed proactively.
- When fleets are cascaded among different TOCs it is good practice to consider the impact this may have on component floats.
- It is good practice to identify required component floats upfront when introducing new fleets.

16.2.3 **Trend identification and information sharing**

- There is no common view of component failures across all companies involved. Each company will maintain their own asset management systems which only show part of the story. Therefore no one has an overview from NFF component diagnosis to impact on the train service. Poor flow of information from end supplier to the TOC can result in a component being returned to a common pool without the new TOC being aware of its history, or without the TOC who returned the component finding out the failure diagnosis. Shared systems can help to create a more joined-up asset history with a clearer view from root cause to passenger impact.
- TOCs routinely analyse their failure data to identify the worst performing units and systems and repeat failures. However, issues may be identified sooner if these types of analyses are routinely shared with other TOCs who operate similar fleets. TOCs with common fleets should take part in regular fleet user groups to identify common faults and work together to reduce their occurrence.
- It is difficult for TOCs to identify repeat NFF for some components as not all components have serial numbers and generally no one TOC has a complete view of the component's reliability history. Component failures and equipment issues are generally identified by TOCs as they cause problems with reliability and availability, however logistics companies and suppliers could also work proactively to identify issues which may affect train service delivery and share this information.
- Failures caused by a faulty batch may not be correctly diagnosed straight away (or initially assumed to be random failures caused by bad luck) as the onus is on the TOC to identify reliability issues. Suppliers are in the best position to identify batch issues and component NFF diagnoses. These should be relayed to logistics companies who can work with affected TOCs to manage their impact.

16.2.4 **Information flow through supply chain**

- Poor flow of fault information from TOC to end supplier can prevent the failure investigation from making a positive diagnosis. Failure information is either not provided with useful detail or can be lost in the process of returning the faulty component to the supplier. This results in the supplier being unaware of symptoms, diagnostics undertaken by the TOC or other useful information which may help them to reach a positive failure diagnosis. Sometimes TOCs may not be able to provide useful or complete failure mode information to the supplier (e.g. part of a component may have been broken and fallen off the train or the component may be an electrical box which has stopped working). This may impact on the quality of the investigation undertaken by the supplier as the testing may not consider the correct issue and therefore result in a NFF diagnosis. A thorough investigation requires a systems approach with all parties understanding what information is required and available. TOCs and suppliers should work together to identify where better information about the failure symptoms could be supplied by the TOC and agree a minimum standard for returns information. Logistics companies should ensure that all relevant information is passed on to the supplier. Warranty claim reporting templates/documentation should be updated to reflect any agreed changes to ensure that good practice becomes embedded. TOCs should have a dedicated warranty manager to ensure that claims are well managed (i.e. returned with the agreed information) and that outcome reports are followed up.
- Poor change control practices can result in component serial numbers being replaced or renewed by the supplier without the TOC's knowledge. This impacts trend analysis as repeat failures are harder to identify. To ensure component history is easily traceable, a robust change control process should be applied to managing serial numbers and there should be consistent use of tracking common pool components using a component tracker. To reduce the need to change serial numbers, components should be uniquely identified and fitted with robust serial numbers which are unlikely to fall off or become damaged.

- Sometimes a supplier may miss the warranty investigation SLA and credit is given to the TOC. If the component is being returned to a common pool, the TOC who returned the component may lack the incentive to chase an outcome report, especially as this can be time-consuming. It is difficult to quantify how often this happens because each warranty contract has a different SLA for investigating faulty components. It is assumed that there will be a higher level of NFF diagnoses in these situations. It is important that outcome reports are followed up by the logistics company and their results shared with TOCs. In order to better manage outcome reports where SLAs have been missed, it would be good practice to introduce standardised component SLAs across the industry.

16.2.5 **Testing regimes and specifications**

- It is important for all parties to agree component testing specification upfront (e.g. at the start of a new relationship) to reduce the number of NFF diagnoses and to provide a greater understanding of why faults occur and how components are required to perform. This is especially important for the introduction of new fleets and should also be considered prior to overhaul.
- Logistics companies can help to ensure that investigations result in a positive diagnosis by encouraging a systems-based approach to fault-finding (rather than component-based).
- The testing practices of TOCs and suppliers are not aligned, which can lead to different views of whether a component is faulty because supplier specifications may not represent how the component is actually used. Testing on depot may rely heavily on subjective events being observed, whereas testing at a supplier's facility may provide more ideal conditions. It is good practice to align supplier and TOC testing practices wherever practical.
- Joint investigations between TOCs and suppliers can be very productive in providing a common understanding of component failure and the steps needed to achieve a positive failure diagnosis. They can be difficult to organise if regarded as symptomatic of a breakdown in the process/relationship but TOCs and suppliers could work to develop better relationships and find a way to organise them more easily when required. It is also critical to ensure that learning from joint investigations becomes embedded in routine practice. This learning should be shared with other TOCs to prevent duplication of the investigation; failure to do so may be detrimental to a positive TOC/supplier relationship.
- Asset data can be lost through testing. Some testing regimes cause the asset history to be wiped prior to the test, thereby losing potentially useful information about the asset's performance. It is critical to identify components which are at risk of losing failure data either through the testing process or because data is only stored for a limited time (e.g. if the asset is unpowered for a certain amount of time). Methods for data download or backup need to be in place to ensure that potentially useful information is not lost prior to testing.
- Testing methods do not typically recreate vehicle conditions (e.g. suppliers may only undertake an electrical test, not a mechanical one) and do not provide a complete picture of the failure environment. It is good practice to perform tests which more accurately recreate the operational environment in which the failure occurred (e.g. putting electronic equipment through 'shake and bake' tests in which vibration plates simulate train movement and climate chambers simulate real-life weather extremes).

17. ROSCOs

ROSCOs are among the key suppliers to TOCS. There are various ways that ROSCOs can facilitate reliability improvement at different stages and from different angles.

17 ROSCOs

Note: This section was written when the railway was privatised. Therefore, some text within this section is applicable only to the franchising model. Whilst some information may still be relevant and useful, please note that this section will be redrafted in the future.

ROSCOs are key suppliers to TOCs and fleet performance depends on ROSCOs delivering effectively. Generally:

- ROSCOs own the vehicles as assets and need to take a proactive lead on reliability issues with a whole-life element;

Example: Auto-sanders which operate during braking were only fitted on Class 390s for performance reasons (not safety reasons). The VTWC franchise (now operated by Avanti West Coast) only had 6 years to run, but Angel funded the installation over 12-15 years to reflect the design life of the equipment.

- ROSCOs procure most of the heavy maintenance that is responsible for a train's reliability (for the TOC to sustain for the duration of the maintenance cycle);
- ROSCOs manage critical spares pools for most fleets (which create or destroy a TOC's ability to deliver its fleet reliably).

There are various ways that ROSCOs can facilitate reliability improvement at different stages. These are typically:

- during procurement and build of new vehicles *(see Section 15)*
- during operation of a particular fleet with a particular TOC *(in fleet management plans, see 17.1*),
- by taking a lead in the improvement of components/systems and issues/challenges which apply across several or even all fleets *(see 17.3)*
- by working with the supply chain to resolve parts issues *(see Section 14)*
- by developing and implementing step change modification packages at key stages in the vehicle's life, e.g. C6X near the end of a franchise.

ROSCO support can help prevent reliability deterioration:

- when fleets are transferred between operators but continue the same duty *(see fleet management plans and aspirations around refranchising in 17.1);*
- when fleets are moved between TOCs with different duty cycle requirements (*see 17.4);* and
- when stock is transferred between TOCs at other times *(see 17.5).*

This Section looks at these specific issues and explores what they mean, setting out current practice (including some examples of good practice) and aspirations improvement.

17.1 Each fleet with each TOC and ROSCO: fleet management plans (FMPs)

Fleet management plans are one of the most important tools for ROSCOs to facilitate long-term reliability improvement, provided that the TOC is engaged appropriately.

The common core information for FMPs was agreed between ROSCOs as follows:

- Executive summary
- Purpose and scope, e.g. relationship plan
- Fleet technical data
- Operations and maintenance policy, e.g. overhaul documents history, concessions, VOs, whole life maintenance and modification plan
- Regulatory compliance, e.g. certification and limitations
- Materials supply and obsolescence, e.g. obsolescence plan (*see Section 14.1)*, key spares
- Management of safety, e.g. live NIR matrix

- Fleet performance, e.g. performance improvement plans
- Overview of projects, modifications and enhancements, e.g. 18-month unit plan, change control and configuration matrix

One of the explicit purposes of the FMP is to facilitate reliability growth. TOCs need to share emerging performance issues with ROSCOs, so the FMP performance improvement plans can be re-evaluated, and appropriate actions identified (cost-benefit analysis and plan-do-review cycles).

FMPs are live working documents, which must be kept confidential to reduce the risk of incumbent blight at re-franchising. They should be updated at least annually and signed off by functional directors from both the TOC and the ROSCO. The detail should be reviewed regularly (e.g. at the 4-8 weekly technical review) and used as part of the lease review process.

Note: ownership of the content of FMPs varies, e.g. dry lease FMPs are updated by TOCs with their suppliers, wet lease FMPs are updated by ROSCOs/their suppliers.

Example: ScotRail FMPs with Eversholt and Angel. The implementation of the joint ScotRail-Eversholt through-franchise FMPs was considered particularly successful because 1. The FMP was constructed as a single overarching document that included all Eversholt rolling stock on lease to ScotRail and clearly set out the high-level objectives of the franchise. Separate appendices addressed the specific aspects of each individual fleet, facilitating updating and day-to-day management. 2. The agenda for the regular ScotRail-Eversholt contract review meetings was constructed around the FMP template, and an action tracker was used to monitor progress and ensure comprehensive and timely follow-up. This made the implementation of the FMP central to the relationship rather than a one-off activity.

Example: Angel and ScotRail FMPs worked well as the two businesses integrated their high-level requirements and day-to-day interaction. Ongoing lease and technical reviews were focused around deliverables within the plan. The direct link between the ScotRail Reliability Action Plan (RAP) enabled buy-in between the TOC and ROSCO long-term reliability growth initiatives. The sharing and real-time use of the process delivered much greater alignment between the two businesses.

17.1.1 **ROSCOs would like FMPs to**

- start sooner (engaging with DfT in the refranchising process) and
- develop more details (engaging more with the TOC in reliability improvement). TOCs would like FMPs to contain explicit targets for reliability, availability and cost of operation.

Starting sooner during refranchising

The following timeline for a fleet management plan is desirable.

-24 to -12 months (i.e. up to 24 months before refranchising):

ROSCOs would like DfT to engage with them in optioneering, considering key issues to resolve or improve with specific fleets. DfT should make requirements visible to ROSCOs as soon as they are published. The overview of franchise commitment does not contain enough information; ROSCOs would like to understand the context and concept from DfT (rather than restricting them to preferred bidders) in good time to get a full picture of what DfT wants to achieve.

This should enable ROSCOs to compete more effectively and provide better offers to TOCs. Perhaps 70% of the ROSCO offer would be common and 30% bespoke to the bidder, whereas the current limited information and timescale process drives bland ROSCO input.

-6 months to 0 months (i.e. during the 6 months before refranchising):

ROSCOs would like any new franchise to be signed 6 months prior to franchise commencement (instead of the shorter timescales often available), so that they can:

- Identify and elaborate franchise deliverables, working towards an outline FMP
- Identify risks and agree how to manage them, fleshing out the FMP
- Prime the supply chain, dealing with any set-up and float control issues, exploiting repeat business leverage opportunities, etc.

Although franchise requirements can change prior to the actual start date, more opportunity for set-up work would increase the likelihood of a successful and reliable franchise start. It should also enable front-end deliverables to be better supported.

ROSCOs also believe the incoming franchisee should have access to existing franchisee staff to facilitate a smooth handover and effective start-up.

0 months to 12 months (i.e. during the first year of a new franchise):

- Ratify the outline FMP (developed during the 18 months prior to franchise start, see above), i.e. what the plan is and what the agreed milestones are
- Hold technical/lease reviews on the detail and mechanisms to achieve agreed milestones
- Hold an interim review at 6 months
- Hold a formal review at 12 months, including measurement data in a feedback loop to modify the plan

This contrasts with spending the first year of a franchise putting an initial plan together and would be facilitated by more time and data sharing in DfT's re-franchising process.

Steady state (mid-franchise)

Develop and evolve the FMP to improve performance and pick up on more detailed issues, *see 17.1.2.*

Last 12 months (to franchise end or stock transfer):

Take the opportunity to avoid stop-start by continuing existing programmes, subject to support from DfT and the new franchisee, once announced. A handover plan needs to be agreed, detailing arrangements to clarify configuration of vehicles and provide all support information, e.g. NIR resolution status, *see 17.5* below.

Sometimes FMPs have been written to maximise the effectiveness and smoothness of a relatively short TOC/ROSCO relationship.

Historical Example: Eversholt agreed short-term (12-month) FMPs in 2005 with National Express London Lines for the Silverlink and WAGN (now GTR) franchises on Class 313, 321 and 365 fleets. The well-established process was used successfully and carefully to ensure the commercial confidentiality of potential improvements, given the ongoing franchise competitions. A joint fleet planning workshop established stakeholder priorities and agreed joint targets and action plans for performance improvement. The limited timescale available for implementation meant that only 'quick wins' could realistically be taken forward.

17.1.2 **More details during the life of the FMP**

ROSCOs would like to have more detail in FMPs to better support TOC performance improvement:

- Generally, improve interfaces for data transfer and communications (primarily from TOCs to ROSCOs)

Historical Example: AGA (now Greater Anglia) had good data flows agreed with both Porterbrook and Eversholt including delay minutes, cancellations, miles-per-5-minute technical delay and trends every period. They also shared with the ROSCOs their specific targets such as PPM during Challenge 90, which prioritised some service quality issues over reliability.

Example: EMT (now EMR) held monthly performance meetings for all their fleets attended by Angel and Porterbrook engineers who obtained all the data and participated in reviewing performance and determining actions.

- Specifically, agree reliability targets with TOCs based on aligned strategies so stakeholder priorities can be aligned, i.e. agreeing activities and resources required (people, training, depot improvements).

The heavy maintenance programmes delivered by the ROSCOs are fundamental to creating the capability for the rolling stock to perform reliably over the rest of the maintenance cycle. TOCs therefore often seek to establish reliability targets for fleets undergoing heavy maintenance or other ROSCO-led programmes.

ROSCOs recognise that TOCs want *optimum* reliability for their business model/DfT requirement, not necessarily *maximum*. For example, TOC priorities might be their bigger fleets, longer-term vehicles or perhaps even passenger environment and security (rather than reliability) in the first instance. DfT priorities might preclude TOC investment in depot improvement. The FMP should reflect these stakeholder priorities, but also note opportunities for reliability improvement beyond the current plan. ROSCOs should consider facilitating the work required.

It is important to note that changes to vehicles may be only a small part of a TOC's reliability growth plan, e.g. Northern's plan for only 15% of improvement from vehicle modifications.

Incorporating the TOC/Network Rail relationship, the performance improvement model for TOCs is typically *(Figure 17.1):*

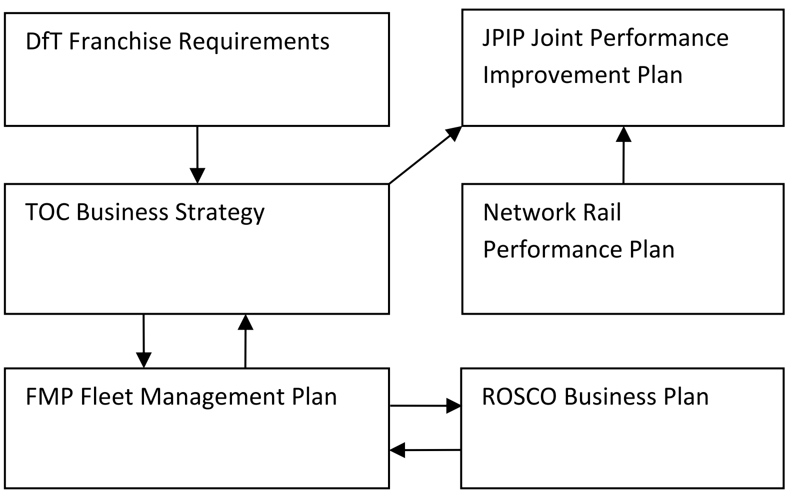


Figure 17.1 Vehicle level comparisons and user groups

ROSCOs can help join up thinking and make constructive comparisons between different TOCs and ROSCOs with the same/similar vehicle classes (on new/recent builds, this involves engaging the manufacturer in ongoing issue resolution).

Specific comparisons can facilitate understanding, which in turn drives productive change.

Historical Example: Eversholt held joint technical reviews with TOCs from different owning groups on Classes 313 and 321 (operation of both now ceased). The review included: discussion (and development of people/relationships), comparing trends, identifying best practice, pre-empting issues on particular fleets, smoothing any fleet/vehicle transfers. Variation in Class 313 performance across different TOCs was positively correlated when successful compressor modifications were implemented.

All user groups should have clear remits and agreed levels of attendance from all invited stakeholders. They should all cover reliability improvement and risk mitigation issues as well as sharing safety concerns and advice.

Historical Example: Northern led the setting up of a refreshed mid-life DMU user group in 2008, modelled on the Electrostar User Group, with a proactive approach to reliability issues and better engagement from key players.

Example: An Electrostar User Group was set up, with the following terms of reference:

- To provide a forum for periodic stakeholder high-level review of Electrostar fleet performance
- To identify emerging issues and trends and ensure that action plans are in place to address identified areas of concern
- To provide strategic direction and guidance on these issues to the TOC, ROSCO and Manufacturer teams responsible for delivering Electrostar fleet performance
- To identify and encourage the implementation of industry best practice and lessons learned from other fleet programmes to the benefit of overall Electrostar performance.

Example: Porterbrook coordinates the Turbostar user group, sharing best practice in maintenance, operations and reliability initiatives.

17.2 Common issues

ROSCOs are in a unique position to take a lead in the improvement of components/systems and issues/challenges which apply across several or even all fleets.

Some of this will be achieved most effectively in ongoing user groups (e.g. Cummins' QSK-19 user group, Voith Transmission steering group). Other challenges are better addressed with a specific working party. The ROSCO role can be one of pump-priming to resolve specific issues.

Historical Example: Oil carry-over on Sprinters and Pacers. Angel and Porterbrook led the development of a design solution and set up a project-based TOC/ROSCO group. They then progressed to installation designs for each vehicle class, and trial fits, cooperating with candidate TOCs.

17.3 Optimising for duty cycle

ROSCOs facilitate the transfer of maintenance plans. If well-documented and understood, these can be particularly useful when fleets are moved to undertake different duty cycle requirements, whether within the same franchise, or TOC to TOC.

ROSCOs are well placed to observe practical examples of duty cycle-related maintenance and share best practice.

Historical Examples:

Class 317 fleet (operation now ceased) maintained at Hornsey depot. Most of the fleet operated frequent stopping services whilst a small, dedicated Stansted Airport fleet ran faster, longer-distance services with only limited intermediate stops. Door maintenance frequency of the Stansted fleet was reduced relative to miles run to reflect the reduced number of door operations per unit mile; traction motor maintenance was also adjusted to reflect the higher-speed running and the reduced number of high-current starts.

To help maximise DMU availability and avoid changing wheels between bogie overhauls, C4 mileages were related to wheel life. Where wheel life was driven by tread wear caused by braking, this related to stopping patterns in service. For example, at Newton Heath in the mid-1990s, Class 150 C4 mileage was 325,000, whilst Classes 153 and 156 were 350,000 miles, reflecting the different duty cycles.

Three examples of duty cycle-related maintenance are:

- Class 91 (Eversholt)
- Class 170 (Porterbrook)
- Desiro fleets (Angel)

Example: Eversholt commissioned a strategic maintenance review to identify the theoretical maximum exam periodicity for each element. This involved extensive condition assessments, gathering data and using failure modes and effects analysis (FMEA).

The output was an integrated maintenance regime involving some time-based elements (e.g. things inside the vehicle, such as contactors, relays) and some mileage-based elements (e.g. bogies, running gear, traction motors). This was all contained in one document including all level 1-4 and level 5 maintenance. The same document was used by Eversholt, Bounds Green and Wabtec.

The result is that periodicities are optimised based on the current duty cycle of the fleet. The TOC's 'little and often' policy means a lot of exams, although if two larger exams are due around the same time, they are combined to reduce downtime. If, in future, fewer larger exams were preferable for the service, or duty cycles were to change, the data is available to inform relevant maintenance plan adjustments.

VTEC (now operated by London North Eastern Railway) agree that the result is good, but believe it could have been achieved more quickly if the ROSCO had engaged more with the TOC initially.

Angel have since supported Siemens' unified maintenance manual drive, where core maintenance requirements are identified, reflecting the various sub-fleet mileages and duty cycles. Condition assessments are being conducted to increase knowledge of wear patterns and deterioration to determine optimum life for different components.

Historical Example: A Value Improvement Programme (VIP) was carried out on the Greater Anglia Class 170 fleet at Norwich Crown Point, involving Porterbrook, Bombardier and depot staff. The VIP brought together a group of people and, in a structured way, encouraged obvious actions. The behaviour of the senior people from each company can make the difference. VIPs generally solve relationship and process problems; this one contributed to a maintenance regime review too. The review in turn led to some reduction in planned workload and released resources for fault-finding. The Turbostar User Group shared duty cycle optimisation for 170/171 fleets, building on the work carried out by Bombardier, Porterbrook and Greater Anglia.

Example: The Desiro fleets include the Class 350 at West Midlands Trains, Class 360 at EMR, Class 380 at ScotRail, Class 185 at TPE and the SWR's Class 444 and Class 450. Angel was particularly supportive in facilitating Siemens' performance on Class 360 introductions, providing powerful technical support, insisting on modifications and escalating issues where appropriate.

17.4 **Fleet transfer/cascade**

17.4.1 Smooth transition of rolling stock transfer/cascade and introduction to service

When a transfer of rolling stock takes place from one TOC to another, there are many elements to consider, which cross many business functions including engineering, operations and commercial. Good management of these elements will lead to a successful transfer of rolling stock in either receiving or returning vehicles.

Whatever the reasons for transferring stock between TOCs, a handover plan should be agreed by all stakeholders. The following details some of the key areas which must be considered in order to manage the initial planning and introduction/transfer stages as well as the introduction of units into service.

Required timescales vary depending on the type of cascade. For example, introducing a fleet of unfamiliar units to the new TOC will require significant preparation time for training and possibly depot enhancements whilst a short-term emergency hire of one unit can be arranged swiftly if it is familiar to the receiving TOC and subject to a similar maintenance regime to those already carried out on other fleets. Even where the unit type is known to the receiving TOC, it is important to recognise that there may be detailed differences with the specific unit(s) being transferred.

This section provides guidance on aspects related to the preparation and planning of any stock transfer. It is not a complete plan. All stock transfers will have their own unique elements that must be considered and managed. It should also be emphasised that good communication and collaboration with the delivering/receiving TOC and other key stakeholders is critical to a successful transfer.

17.4.2 **Type of cascade**

- Small fleet versus whole fleet
- Short-term versus long-term

17.4.3 **Initial planning phase of stock transfer (time prior to receiving/transferring rolling stock)**

Outline plan development:

- Identify key milestones and the critical path to achieve the project timescales
- Identify fleet compatibility and special requirements
- Consider inclusion of TOCs, ROSCOS and OEMs, e.g. stock transfer support teams (small short-term teams with access to specific fleet experts)

Initial pre-delivery condition survey:

- Establish and agree with the leasing company the condition of the unit(s) being transferred, including position in heavy maintenance cycle(s) and any non-standard equipment
- Establish what the impact on current fleets operated is:
    - Adequacy of spares
    - Ownership of spares (split fleets and/or different ROSCOS)
- Involve key stakeholders such as:
    - TOCs (sending and receiving)
    - Operations:
        - Simulators
        - Driver/guard training

        - Software (interactive/system)
        - Sanding system configuration
        - Through gangways (operational safety and revenue protection implications)
- Commercial:
    - Lease type (wet/dry)
    - Hand-back condition
- Seating configuration and passenger reservation requirements
    - Can current booking systems be changed to accommodate new fleets with different seating configuration?
- Train planning:
    - Sectional running times
    - Station dwell times (including door control configuration and method of door operation)
- Network Rail (route/station suitability)
- Passenger focus (service expectations)
- ROSCO (maintenance plans and spares)
- Department for Transport (are the trains suitable and timescales for stock transfer achievable?)
- RSSB (derogations)
- PRM/RVAR (derogations)
- Local community (short-term increase in noise levels, etc)
- Rolling stock library (train configuration)
- Rebranding
- Changing the livery of rolling stock can be a very time-consuming process and could require considerable planning as a separate project. Consideration should be given to the length of time, i.e. short-term vs. long-term transfer. Rebranding of rolling stock can also have implications with regard to PRM TSI regulations (contrasting colours, etc.)

17.4.4 **Preparation of stock transfer and stock introduction**

- Service introduction path for new stock
- Service level introduction of rolling stock (whole fleet or staggered introduction); even the best planning and preparation will not preclude some initial introduction failures
- NIR resolution
- Are there outstanding NIRs?
- Are there outstanding fleet checks to be completed prior to transfer?
- Maintenance support planning
    - What maintenance support comes with the vehicles (OEM support, warranty support, etc.)?
    - Are special tools required for maintenance of systems/components?
    - Is special test equipment required to maintain systems/components?
- Maintenance documentation
    - VMI, VMP, COI, VOI, etc.
    - Unit history files
    - Exam and overhaul history
- Materials planning and additional spares
    - OEM support
    - Second tier supplier support
    - Modification levels of spares
    - Special tools required to fit spares
- Reliability growth plans. With the introduction of unfamiliar/new rolling stock, it should not be expected for the units to work out of the box. With this in mind, reliability growth plans should work towards steady growth.
    - Review process (regular and detailed reviews of defects)
    - Trend analysis (by system and component)

    - Sharing reliability data between the existing and the new TOC will help develop reliability growth plans
- Stabling of additional units and overnight berthing arrangements
- Is sufficient capacity available? Passenger information systems
    - Uploading new route information
- Training programmes for staff to maintain unfamiliar rolling stock (consider where a limited number of initial units are available or where training must take place prior to stock transfer)
    - Conflict may become apparent between the requirements of engineering and operations where unit availability is required for engineering/driver training at the same time
    - What training manuals and other aids are available from the previous operator and can these transfer with/ahead of the stock?
- Rolling stock configuration
    - Selective door opening
    - Mandatory modifications
    - GSM-R
    - Modifications for route compatibility
    - Driver only operation (DOO), etc.
    - Driver cab configuration
    - Defect log books
    - Aide-memoires (fault rectification)
    - Other modifications, experiments and trials, specifically non-standard equipment
- Route compatibility
    - Are stopping boards in the correct position?
    - Monitors/mirrors for DOO
    - Signal sighting distances
    - Stepping distances (heights and offsets / raised platforms) may vary for different stock

17.4.5 **Rolling stock reconfiguration/re-formation**

There may be instances where the rolling stock being received by the TOC, whilst suitable, is not in the correct configuration to meet the business need. For example, Northern received 3-car Class 150 units. This did not fit with the Northern diagrams and planning requirements. The units were therefore reconfigured to 2-car 150 units. This must be implemented with the full co-operation of the train owners (ROSCOS). Reconfiguration/reformation also introduces many other aspects previously mentioned but consideration must be given to the introduction of systems which have not been enabled for an extended period of time. For instance, Class 150s have a driving cab in the middle of a three-car formation. When a re-formation takes place to convert to a two-car unit, the middle vehicle will be used as a driving cab in a 2-car train. This will require all the cab functions and other systems to be enabled which had previously been isolated. There is also a requirement to inform the rolling stock library of any re-formations so unit numbers and mileages can be changed and tracked. Maintenance plans and documentation must also be aligned with the new train configuration.

17.4.6 **Facilities**

In order to maintain the transferred rolling stock, it is critical that the maintenance facilities are suitable. A compatibility check against current stock maintained is an ideal position to start from. Where non-compatibility is identified, detailed assessment will identify possible maintenance facility changes:

- Space envelope
    - Length of vehicle
    - Maximum length of train set
    - Height of vehicle

    - Weight of vehicle
- Lifting and jacking equipment
- CET facilities
- Wash plant/roads
- Primary power source
    - AC traction
    - DC traction
    - Diesel
        - Fuel station and rigging
        - Extraction (exhaust fumes)

17.4.7 **ROSCO**

Arrangements to clarify the configuration of vehicles should be detailed, including all supporting information for each vehicle, such as:

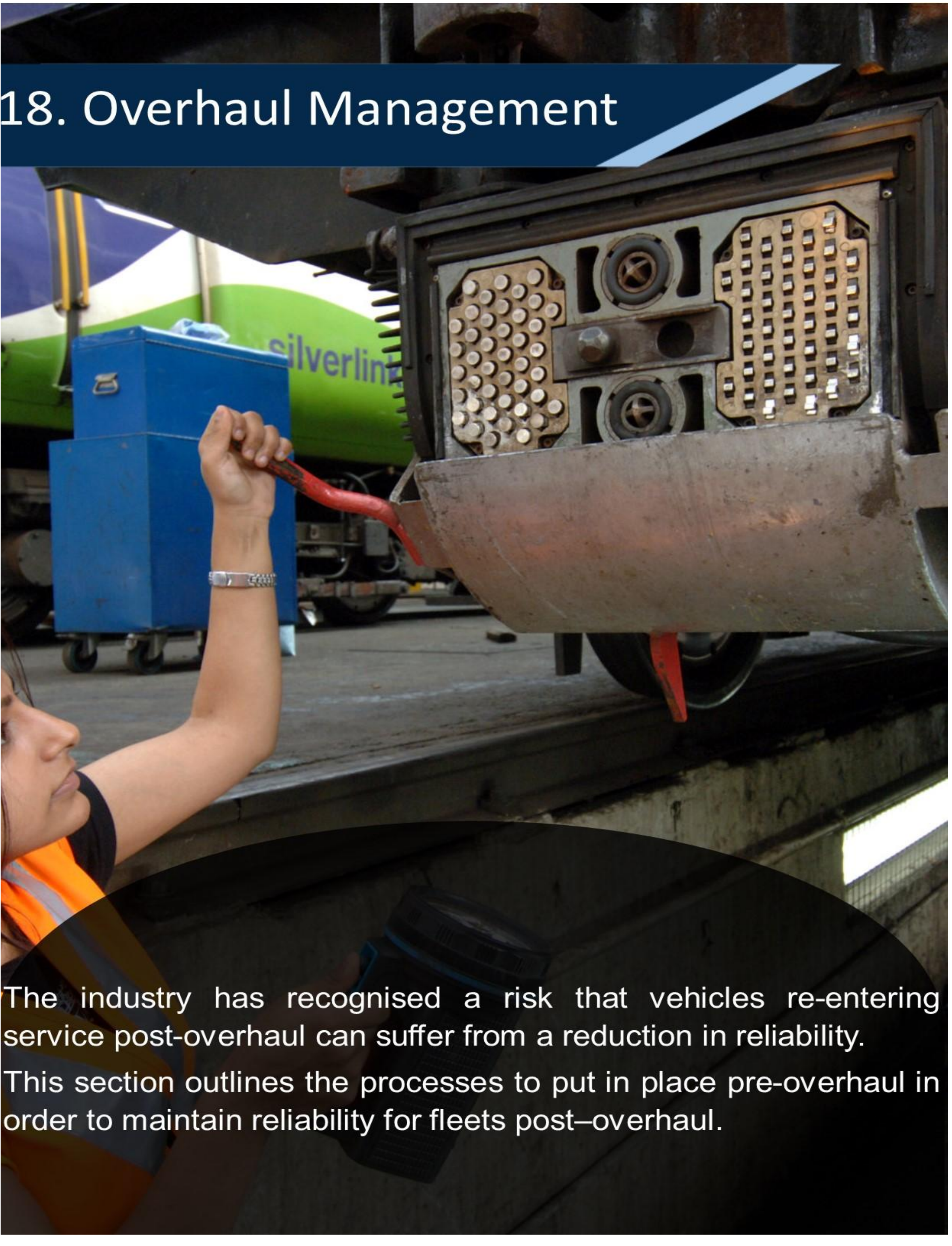
- NIR resolution status
- stage in maintenance plan, e.g. last balanced B exam
- any deferred work
- any outstanding defects or open repairs
- any known problems or special control measures

The ROSCO is responsible for eliciting and transferring the above data from all maintenance providers. In the past, third-party maintainers have not always been asked to supply the information they hold. In practice, the ROSCO may actively arrange for direct data flow between depots, but it retains responsibility for the completeness and quality of the data provided to the receiving TOC. Obviously, with dry leases, the outgoing TOC has a greater obligation to provide details compared with wet or soggy leases.

Negative examples exist to underline that an agreed TOC/ROSCO FMP can be effective in preventing reliability drop-off as stock is transferred to another operator. They also highlight the benefit of having 'headroom', i.e. additional stock and/or time. A risk workshop can be an effective tool to manage smooth stock transfer and minimise potential impact on reliability.

17.4.8 **Checklists**

Checklists can be a very useful tool to ensure that all elements of the task have been completed. Northern developed several key checklists from numerous fleet transfers. Appendix F contains examples of such checklists. They are only to be used as guides and should be adapted for the individual TOC and type of rolling stock.



18. Overhaul Management

The industry has recognised a risk that vehicles re-entering service post-overhaul can suffer from a reduction in reliability.

This section outlines the processes to put in place pre-overhaul in order to maintain reliability for fleets post–overhaul.

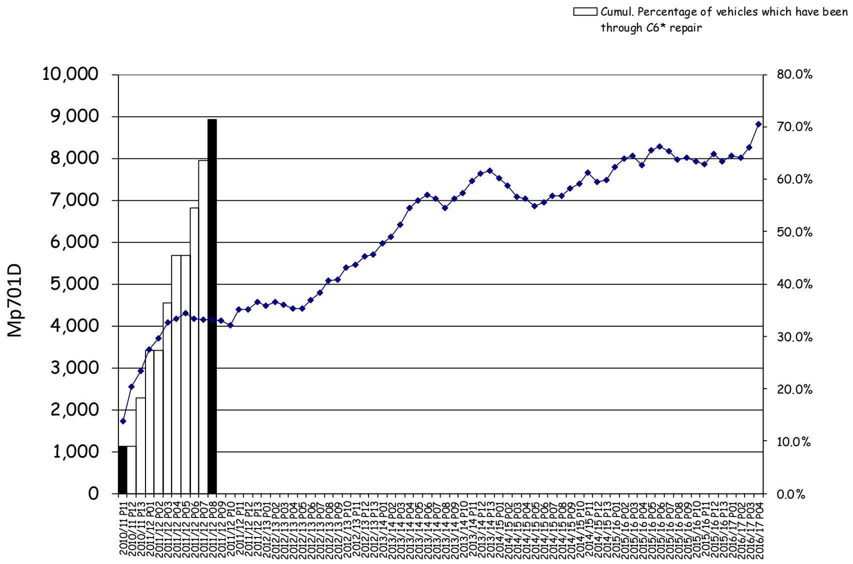
18 Overhaul Management

This chapter focuses on the overhaul of rolling stock and/or their components[2].

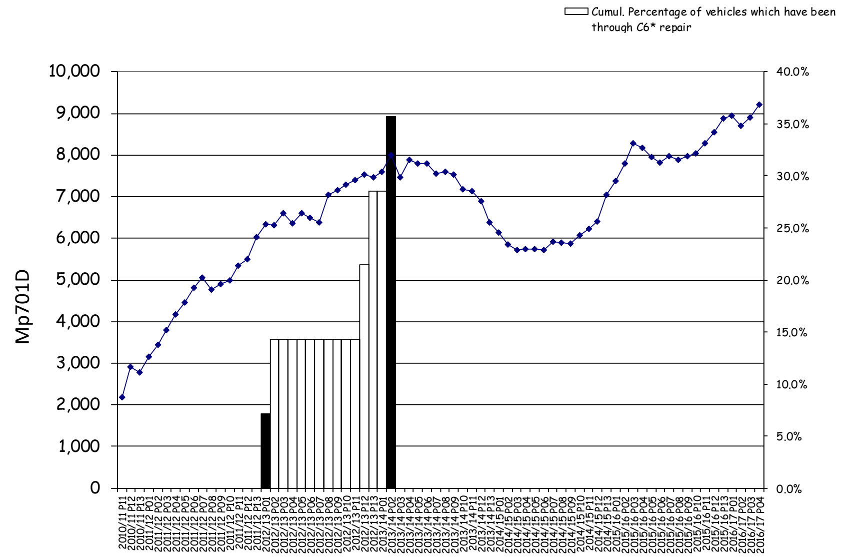
The industry has recognised that vehicles re-entering service post-overhaul can suffer from reduced reliability.

Analysis shows that reliability for fleets coming out of overhaul can vary widely, with there being no overall correlation between pre- and post-overhaul reliability.

Graph 1: An example of a fleet with improving reliability immediately post-overhaul



Graph 2: An example of a fleet with declining reliability immediately post-overhaul



The good practice identified in this chapter aims to address the issues which cause fleets to have a post-overhaul reduction in reliability and to help ROSCOs, TOCs, maintainers and overhaulers ensure that overhauls optimise fleet reliability.

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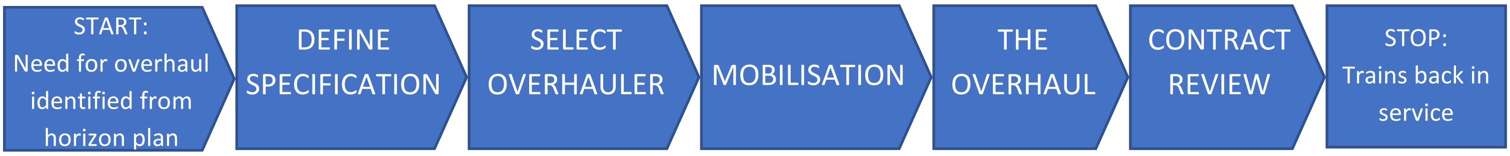
[2] E.g. doors, bogies, gearboxes, engines, etc.

This chapter is structured around a generic high-level overhaul process (*Figure 1*) with good practice identified at each stage. Each overhaul will have its own complexities[3], so the guidance should be followed with consideration of the individual circumstances.

Figure 1: The high-level overhaul process



18.1 Need for overhaul identified from strategic plan

The publishing of strategic plans is good practice, particularly if they are reviewed and updated to incorporate recent developments. It enables the industry to form a more complete view of overhaul plans and timescales nationally. Conflicts of resources can be identified quickly and efforts made to smooth out demand. It also provides the supply chain with information to secure investment for future bids.

18.2 Defining the specification

The purpose of defining the overhaul specification is to make clear to all parties what is expected from the overhaul process. If done well, it reduces the likelihood of:

- unacceptable performance delivery during the overhaul,
- undesirable reliability post-overhaul,
- additional/unforeseen costs to the overhaul,
- delays/late delivery and
- poor quality delivery,

all of which can bring reputational damage to the industry and have a negative impact on passengers.

This section will be split into four sub-sections for the good practice recommendations:

1. Timescales for creating and agreeing the overhaul specification
2. Method for creating and agreeing the overhaul specification
3. Content to be included in the overhaul specification, and
4. Clarity over the intended outcome of the overhaul.

18.2.1 Overhaul specification timescales

The time required to create an overhaul specification will vary from project to project, based on factors including:

- the complexity of the overhaul,
- the number and experience of stakeholders involved
- the initial scope, and
- lessons to be learned from previous overhauls.

It is critical that the overhaul specification is developed prior to contract award in order to avoid late-notice contract variations which can result in additional costs and delays.

18.2.2 Overhaul specification method

A truly collaborative approach[4] to developing an overhaul specification should create an environment where

[3] E.g. C4 exams are historically more predictable than C6 exams (frequently a minefield presenting numerous potential additional challenges).

[4] BS11000 is a collaboration standard.

all parties are properly engaged in the overhaul process and its outcomes.

ROSCOs and TOCs should aim to learn from previous overhauls to ensure specifications are created in appropriate timeframes. This includes considering removing tasks which no longer add value[5].

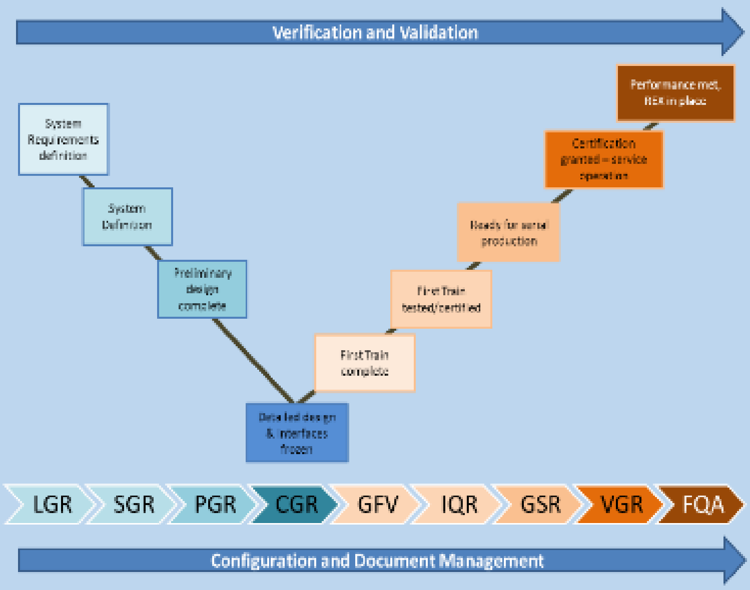
It is recommended that the overhaul specification should be jointly developed by overhaulers, OEMs, ROSCO(s) and TOCs/maintainers, setting the process on a collaborative footing. A horizon plan can help overhaulers create a case for investment in this process, but framework agreements are also a good solution.

The tri-party approach to overhaul specification may also need to be extended to include other parties, particularly where a fleet is common to other TOCs and ROSCOs. ACOP/EC/01006 – *Approved Code of Practice - Management of Rail Vehicle Engineering Change* - provides a framework for multi-party engineering change and fleets should be standardised unless there is a valid business case to the contrary, e.g. duty cycles.

Development for quality is a good framework for an overhaul specification.

Example: Alstom uses a V model (for more information, see EN 50126) to plan their overhaul design and delivery. This development for quality (DfQ) process is used to verify project maturity and re-evaluate risks at pre-determined stages.

The process is a series of formal, checklist-based reviews, emphasising the importance of the project team identifying and making transparent any potential risks at each stage of the project. The DfQ model is illustrated as follows:



The overhaul specification should be jointly owned and periodically reviewed by the engineering teams within both ROSCOs and TOCs/maintainers during the operation of the fleets to capture lessons learned and best practices. All changes in condition should be noted for the next overhaul. All good practice should be shared by ROSCOs, e.g. updates to drawings or engineering change (EC) process details should be incorporated in future specifications.

[5] Subject to an appropriate risk assessment.

18.2.3 Overhaul specification content

The expected train condition should be set out in the specification. Significant differences in asset condition can lead to delays while it is agreed how they will be accommodated. Therefore, condition assessment prior to overhaul is essential for specifying the overhaul regime. It must occur during or prior to tendering and again just prior to the actual overhaul, to have an up-to-date record. As a minimum, it may require a survey and audit of at least one or more vehicles.

It is good practice to involve TOC operations staff to ensure that opportunities to make improvements to the train from the users' perspective are taken into account.

A risk-based approach should be taken when planning for corrosion. Technology such as endoscopes are cheap and can be used to inspect hard-to-reach areas.

Former British Rail overhaul specifications may assume a level of competence which does not reflect modern maintenance practices and so additional instructions or changes to the overhaul specification may be required.

A good specification should consider how testing will be performed and what test equipment is required. This should include pre-testing of relevant systems by the overhauler in advance of component removal/overhaul. Testing should be done on the train at system level, prove functionality and involve components that were not directly overhauled but which form part of systems that were overhauled. Any issues identified in testing should be analysed for the root cause and used to review the overhaul specification to eradicate or minimise the issue. Consideration should be given to which components may/will be disturbed during testing and what might need to be removed. Best practice would be to test all disturbed components (pre- and post-overhaul) to ensure functionality. The specification should require data captured during overhaul and testing to be easy to manipulate and process. For example, electronic data is easier to analyse and manipulate than paperwork, scanned documents or PDFs.

The specification should also consider capturing images prior to and during overhaul so that the condition can be retrospectively reviewed.

18.2.4 Overhaul specification outcomes

It is very important that the TOC, ROSCO and overhauler have a clear and consistent understanding of desired outcomes.
Specifiers should focus efforts equally on:

- improving the reliability of the entire train as appropriate[6],
- restoring its condition back to that of a brand new vehicle as appropriate[7] and
- incorporating changes to ensure the vehicle is fit for purpose and easier to operate and maintain.

The performance of the fleet with respect to these points pre- and post-overhaul should be measured.

In addition to reliability outcomes, the financial outcomes also need to be considered. These include:

- the cost of the overhaul itself
- life-cycle costing, and
- future maintenance costs (including consideration for equipment/systems which do not currently have a maintenance plan but may require one).

18.3 Select overhauler

The ITT should ensure suitable service level agreements to incentivise correct behaviour from all parties. This could include penalties to operators who fail to present a unit for overhaul on time and penalties for

[6] Taking into account the level of overhaul required and a scrutiny of the TOC fleet class reliability.

[7] This may not be practical for older vehicles which may require a level of accepted tolerance.

overhaulers who fail to return units to the customer on time and in a suitable condition.

An overhauler is recommended to respond to the procurer's questions using a compliance matrix.

Good practice shows that a number of different criteria[8] should be used to assess the quality of a bid. These can then be compared to the price to establish which bid presents the best value for money. Some options to consider are shown below.

- **Alignment of business models**
  Do the business values of potential overhaulers match the business values of the party concerned? If not, could this cause problems in the future as and when issues need to be resolved?

- **Capability**
  How capable is the potential overhauler of doing the work? Will specialist skills be required? How is the potential overhauler planning to cover them (in-house or sub-contract)? It is important to be confident that a potential overhauler can reliably undertake the work.

- **Capacity**
  Can the bidder adequately demonstrate ability to take on additional work? While it is important to a supplier to maximise the use of its facility, it is likewise important that this does not impact on deliverability.

- **Deliverability**
  Is there confidence in the potential overhauler's ability to deliver on time? Late delivery can cause operational and therefore reputational damage to TOCs. Bidders should submit an overhaul programme which demonstrates how experience will be gained (either through learning from the first unit, having a 'glass case' train or utilising pilot runs as relevant) prior to increasing production.

- **Quality and standards**
  How will potential overhaulers guarantee an acceptable quality standard?[9] Will accredited suppliers be used? Is quality process management an embedded part of the operation?

- **Cost of overhaul and impact on whole life cost**
  How does the cost of the overhaul impact on the whole life cost of maintaining the fleet? It may be tempting to choose the overhauler offering the lowest price, but it may turn out to be a false economy. Elements such as warranty and impact on maintenance costs need to be factored in.

- **Location of overhauler's facility relative to the fleet's base depot**
  Is the potential overhauler close to the fleet's base depot? It can be difficult and expensive to transport fleet around the country, so it is important to consider how it will be done and what impact any fluctuations in the overhaul schedule will have on the ability to move fleet.

It is also good practice to involve a number of stakeholders in the evaluation of the proposal. When an overhauler is rejected, they should be clearly informed why their bid was unsuccessful and what they would have needed to be successful.

18.4 Mobilisation

Good practice is for mobilisation[10] to commence at least a year in advance of a major overhaul. The

[8] These should be requested in the ITT.

[9] This should be defined in the overhaul specification.

[10] i.e. the time between agreeing the contract and receiving the first unit.

specification should also be defined within the same timeframe.

Example: Alstom uses 12 months to plan between H exams and builds on previous experience.

This time is required to:

- create a robust overhaul plan
- ensure there are enough staff with the correct competencies, and
- ensure that the facility, materials, documentation and tooling are ready.

18.4.1 **Creating a robust overhaul plan**

Overhauls can be very complicated and have a number of constraints, not all constraints of which can be easily removed. These include (but are not limited to):

- learning from previous overhauls
- programme risks
- interdependencies with other projects
- critical path
- critical resources
- impacts of long lead times
- human resourcing
- site layout, and
- the need for specialist work to be undertaken off-site.

A robust delivery plan is key to the successful delivery of an overhaul programme. Critical chain project management is a useful tool to ensure a plan is deliverable.

As many overhaul activities as possible should be co-located to minimise transportation times. Where necessary, customers should perform a 'make versus buy' analysis to decide where and why to outsource overhaul activities. This also applies to third-party suppliers.

Transporting trains to an overhaul location by rail barrier wagons/translators is a logistical problem as there are only seven pairs on the GB rail network. Good practice is to avoid the use of these wherever possible.

Example: Southeastern utilises the Rail Operations Group to move their Class 375 units for overhaul to Derby. The need for barrier wagons is negated by using a modified Class 37 locomotive with Dellner couplers.

Overhaulers will aim to reach the steady throughput rate[11] as early as possible to reduce the total overhaul time and minimise the time assets are out of service.

In order to achieve the steady throughput rate, it is a good idea to perform a pilot run[12] prior to receiving the first asset from the TOC. It is also a good way of exposing staff to overhaul tasks pre-overhaul which will support their personal development and familiarise them with the process, tasks and materials.

Example: Wabtec bought a spare Mark 3 coach in order to trial fit new exterior powered sliding doors supplied by Vapor Stone Rail Systems prior to the arrival of coaches from GWR for modification at Wabtec, Doncaster to a higher 'Persons of Reduced Mobility (PRM)' standard. This enabled Wabtec to gain confidence in the fit and performance of the doors without using rolling stock required for

[11] i.e. the time taken to overhaul most assets.

[12] A pilot run is a preliminary study conducted to evaluate feasibility, time and adverse events in an attempt to improve upon the process design prior to commencement of a full-scale programme of works.

passenger service.

Where it is not possible to perform a pilot prior to overhaul it is still worth trying to simulate as much as possible to identify any issues. Production bottlenecks should be reduced/eliminated to ensure maximum throughput and lean techniques can be used to improve throughput. *See Appendix J for more detail*.

Example: Historically, Wabtec at Doncaster invested in a new paint shop as this stage of overhaul was creating a bottleneck for production. Their Class 321 facility was built to allow vehicles to be lifted over each other to remove bottlenecks within the facility.

Example: Alstom's Longsight depot is set up around a pit-stop strategy, where all materials are located close by where they will be required. This is due to the depot overhauling specifically Class 390 units. Historically, Wabtec, at Doncaster was capable of overhauling a wide variety of rail vehicles and therefore a strong planning process ensured that, if a similar strategy was to be implemented, plenty of time is assigned for planning where materials will be located.

It is recommended that overhaulers implement a longer-term continuous improvement plan to build on the learning from successive overhauls.

18.4.2 **Human resourcing and competency**

When planning an overhaul, the timing of staff recruitment is important, as is identification of the skills and competency they require. A RACI[13] can help set out clear roles and responsibilities for staff.

It is good practice to ensure skilled project managers are one of the first additions to any overhaul team. When considering the standard of project managers, a date should be set around specific qualifications (e.g. APMP) and they should have experience of lean techniques.

For all staff recruitment, it is good practice not to rely on CVs and interviews to assess competence (although these things are important) but to also use testing procedures involving genuine examples of overhaul work to score candidates' capabilities and identify training and development needs.

KPIs can also be developed based on these competency assessments if they are revisited periodically.

Example: Alstom requires all new contractors joining the overhaul team to undergo a competence assessment to verify that their skills match their CVs. A record is kept of the skills each new contractor possesses and is used to form a framework to match required skills for each task to those available and enables the reporting of shortages as a KPI.

BR-built units are usually hand-built and therefore there are differences between units. Staff should be granted additional pre-series exposure to become familiar with the variances in vehicle manufacture prior to undertaking overhaul. Training should also be provided on the use of key pieces of overhaul equipment[14].

Where contracting staff are used, it is good practice to consider providing incentives towards the end of the contract to retain the essential skills required for completion.

Example: Alstom utilises a tool retention bonus to ensure that no tools are lost. In short, the fewer tools are lost, the greater the bonus. Tool stores are therefore checked twice daily.

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[13] A matrix which identifies who is responsible, accountable, consulted and informed for the activities undertaken.

[14] Some equipment requires training & certification.

Where the overhauler's workload may fluctuate over time, it is beneficial to try to retain key staff during downtimes, as this will help to ensure consistency and minimise skills loss.

Mobilisation should plan for quality checks throughout the overhaul process from component arrival to final testing and unit return. Good practice is to use peer reviews so each team owns responsibility for passing on quality work.

18.4.3 Non-human resources: the facility, components, tools and documentation

The facility should be set up to ensure the overhaul process flow is designed according to lean principles (*see Appendix J*) to maximise flow and reduce process-based errors.

It is important to consider the impact an overhaul could have on small, commonly shared component floats as it could negatively affect (other) operators. Therefore, the float of components required for overhaul should be bolstered to ensure that the level is sufficient to cover the overhaul cycle and continue supporting normal operation.

To ensure that good-quality components are procured and used for the overhaul, all suppliers should be approved within the customer's procurement system. This applies for ROSCOs, TOCs/maintainers[15] and overhaulers. Approvals should cover change management.

Components used in overhaul should be of a sufficient quality to fulfil their purpose. This should be included in the specification and suppliers should be made aware of the consequences of quality issues with their materials. The supplier should likewise actively engage with the customer(s) to identify quality issues.

Components should have a warranty appropriate to the overhaul specification and, where practicable, for the period between overhaul cycles (e.g. C4 to C4).

Where obsolescence materialises during overhaul it should be managed as set out in *Section 13.6*.

Each workstation should be equipped with tools appropriate for the activity and compliant with the relevant standards. Staff should have the correct training to use the tools provided. For smaller tools liable to be lost/damaged, shadow boards should be used to reduce loss/damage.

It is good practice to ensure that all documentation available to shop floor staff and supervisors (e.g. work instructions, designs, drawings, checklists, etc.) fully back up the overhaul specification, are up-to-date, change-controlled and easily available.

18.5 The overhaul

This stage considers delivery of the plan created during mobilisation to the standard defined in the specification. Each time an overhauler goes through this process it provides an opportunity to make improvements, also for future overhauls, using lean techniques.

In order to identify where efficiencies may be made (without negatively impacting on quality), overhaulers need collect relevant data.

[15] Maintainers are classified as organisations undertaking the day-to-day maintenance of rolling stock on behalf of a TOC.

In order to provide clarity around the good practice recommendations, this section has been split into four areas:

1. Receiving the train
2. Working on the train: a lean process
3. Working on the train: the culture
4. Evaluating the results

18.5.1 **Receiving the train**

Transportation of the vehicles to and from overhaul facilities is a critical element of the overhaul. It is important that the mobilisation specifies this element early and it is managed carefully as alterations can result in repercussions for all other plans, including missing vehicle movement slots; often the next available slot is not for another week.

When trains or train components arrive for overhaul, they will be tested to check that their condition meets expectations as part of the acceptance process. A status of conformity should be agreed between the overhauler and the provider. This extends to parts and materials which should be thoroughly inspected to ensure no faulty goods are accepted. A risk-based approach is best as it is impossible to check all materials and components. Goods inwards should arrive with a certificate of conformity.

If the asset condition is not as described prior to the provider releasing to the overhauler, the asset provider should consider:

- starting discussions with the overhauler about the asset condition at the earliest opportunity in order to minimise delays; or
- releasing a different asset which meets the specified condition, allowing the provider and overhauler time to agree a plan for the non-conforming asset (without affecting the critical path for overhaul delivery)

18.5.2 **Working on the train: a lean process**

The overhaul plan will typically allow more time for the first few assets going through the process in order for staff to gain confidence and identify any issues without creating delays in the overall programme of works. This is a good opportunity to monitor the effectiveness of the process, especially if a pilot run was not possible. Lean techniques can be employed to identify and correct process problems.

> **Example:** London Underground treats the first two units to pass through an overhaul programme as 'glass case' examples. The purpose is to trial, fine-tune and finalise implementation techniques and processes. It also allows additional time and resources to be allocated to check that assumptions about fleet condition and the overhaul plan are correct and ensures that the plan is achievable for future units.

Where there is confidence in the overhaul tasks, the process can be made more efficient. The overhauler should analyse all activities (including waiting or downtime) and seek to minimise those which do not directly improve the asset as per the overhaul specification.

18.5.3 **Working on the trains: the culture**

It is good practice to utilise the knowledge and experience of staff when trying to identify and implement process improvements. Staff should perform the same task in the same way. If a member of staff identifies an improvement to the way a task is undertaken, there should be a clear process to implement the change. This will ensure that everyone benefits from improvements and learning is standardised and embedded.

It is good practice to ensure that there is accountability at all stages of the process and that defects/quality issues are identified, recorded and rectified as early as possible, but without creating a blame culture. Using ad-hoc peer checks (or peer mentoring) to inspect work at each stage can be beneficial to both new and experienced staff. A fresh pair of eyes helps combat work blindness, whereby flaws may not be evident to the worker, but they are to a third party.

Example: Wabtec utilises coloured overalls to easily identify the competence levels of staff. Where more senior technicians identify staff, who may require assistance/advice, they have a useful visual indicator to understand which skill level they are addressing.

Documentation is vital to record accountability and increase ownership of work. Names signed next to records of work or the use of swipe cards will ensure traceability. Sign-offs should be managed so as to not delay the overhaul process or encourage blame simply because a defect can be traced to an individual. Documentation should be produced in a format which is easy to analyse (e.g. .CSV file, not free text format).

Ensure service affecting failures (SAFs) are constructively fed back to staff and included in the process of eradication. Consistent bad news can reduce morale and should be balanced with good news stories.

Example: Alstom provides a plasticised booklet to all staff indicating previous SAFs/mistakes. These provide an 'incorrect vs correct' point of view to provide a positive message to staff and hopefully eliminate these issues.

It is also good practice to sign off all consumables (where appropriate).

Example: Alstom requires all staff to sign off the use of Loctite, including type and expiry date, to combat the use of out-of-life consumables.

Implementing formal handovers at each stage provides the opportunity for defects to be identified before more work is undertaken (thereby reducing the impact of any re-work). Using a formal handover checklist is ideal, as it will help to ensure clarity and consistency.

18.5.4 Evaluating the results

At the end of the overhaul, all trains are tested in preparation for return to passenger service. It is good practice to involve the TOC in this process. The following points should be considered:

- Quality: This is the final opportunity for the overhauler to identify any quality issues and correct them prior to returning the train to service. A systems approach to this final check is critical. If issues are discovered after the train has been returned to service, it is much more difficult and costly to investigate and fix them.
- Time: Is the train being returned on time? If it is late, it is important to identify why. The overhauler and TOC need to be realistic about whether these issues can be improved upon or whether the end-to-end time for overhauling a train needs to be revised. An honest and evidence-based approach needs to be taken when revising the plan for future trains.
- Documentation: The overhauler should provide the TOC with the engineering measures and results for the overhauled train, along with details of any deferred work (as per the overhaul specification). While it is convenient for all parties to provide these results in electronic format, it is worthwhile both parties reviewing them jointly.

18.6 Contract review

The contract review provides an opportunity for all parties to make a joint and structured assessment of the entire overhaul programme.

The review should look at whether intended outcomes were achieved and if not, why not. It is important that feedback is balanced and fair. If there were a number of problems, the review should not be overly negative as this will discourage open assessment. Overhaulers should supply a number of metrics which can be used to evaluate the success of their programme in terms of quality, time and cost. The review should assess what went well so that good practice can be embedded.

The review should also seek to assess whether the tri-party relationship worked as intended or whether it could be improved. It is a good idea for all parties to provide feedback on the contractual incentive/penalty conditions and how they were managed. It is important to ascertain what impact, if any, they had on the overhaul outcomes. It may be worthwhile asking an independent party to facilitate this discussion.

Lastly, the review should look at the overhaul specification to understand how it might be improved. Test results should be fed back into the overhaul specification, providing an enhanced outline of work based on experience from both completed units and initial condition assessments.

18.7 Trains back in service

This is the point at which the overhaul programme is effectively over. The post-overhaul review between the ROSCO, TOC/maintainer and overhauler will have been completed and normal fleet management processes will have resumed for the whole fleet.

This is a good opportunity for individual stakeholders to conduct an internal review of the overhaul and identify good practice/learning for the future.

TOCs/maintainers can use the opportunity to review their standard fleet maintenance processes to ensure that they remain fit for purpose for the overhauled fleet.

It is also good practice for TOC performance teams to check whether the overhauled fleet is delivering the projected performance and reliability improvements agreed as part of the performance improvement process.

The data used during the overhaul can also be used to shape future maintenance, fault-finding and engineering change.

19. Outsourced Maintenance

Guidance for TOCs outsourcing maintenance. The section provides good practice guide in understanding required ‘skills and competences’ for a efficient project delivery.

19 Outsourced Maintenance

This section contains best practice for managing outsourced maintenance beyond the obvious case of a TOC sub-contracting all engineering to another company. Some issues are just as important to a TOC that keeps most work in-house but engages a contractor to carry out a modification programme in an addition to normal maintenance.

The principles can be applied to:

- Service provision contracts – the train is totally under the control of the maintenance company until handed over for service at the depot outlet
- Full maintenance contracts – the depot is operationally controlled by the TOC but all engineering work is undertaken by the supplier
- Joint ventures – management of maintenance is shared commercially and the workforce may be drawn from both the TOC and the supplier
- Extended warranties – a rolling stock manufacturer has a continuing on-site commitment to rectification of defects
- Technical support contracts – a rolling stock supplier has a long-term obligation to provide depot-based technical support
- Special projects – a team of contract staff is retained for a modification or reliability improvement programme

Any of the above may include supplying spare parts for maintenance and repairs.

Many of the points are also relevant to the management of heavy maintenance, which is in effect outsourced if it is done through the ROSCO or another outside contract.

Whatever model is chosen, the contract arrangements should be clear and simple so that accountability for service delivery is unambiguous. This is particularly important in a joint venture where it can be easy to forget who is responsible for what.

19.1 Reasons for choosing outsourcing

Outsourcing is a strategic business decision taken by the train operator. The purpose of this section is to help anyone who has already decided on outsourcing to make a success of the arrangement. However, any company going down the outsourcing route needs to be clear why they are doing it and what they expect from it. The TOC should check that the contract delivers at least one of the following advantages:

- to offset the technical risks associated with a new train fleet and ensure the train builder has a long-term stake in the success of its product
- to obtain expertise and resources not available to the train operator without disproportionate effort or expense, or to share commercial or logistical risk with an established partner (this point may be especially relevant to smaller or independent train companies)
- to obtain additional short-term or marginal resources and expertise

19.2 'Golden Rules'

The three main principles for successful outsourced maintenance are:

1. Relationships. The 'join' at working level between maintainer and train operator needs to be as seamless as possible to deliver a consistent and high-quality product to traincrew and passengers.
2. Ownership and engagement. The TOC (as the Railway Undertaking) continues to 'own' the delivery of a safe, reliable train, e.g. effective management of safety and competency issues.
3. Application of the 20PP. The advice in this document is just as relevant to a contractor as to an in-house maintainer. Supplier and client need to work together to put the 20PP into practice. For example, outsourcers may be managing maintenance plan risks which relate to both companies.

19.2.1 RULE 1. Relationships – partnerships for performance

Major outsourcing contracts are distinctive in that the customer may have difficulty switching supplier in any but the longest term. Failure by the supplier to provide the service could be a potentially fatal business risk to the client. Finding an alternative provider is even harder where a maintenance contract is linked to new train procurement.

This means that many of the usual sanctions (e.g. termination, renegotiation, introducing competition) may not be realistic options. A different approach is needed to ensure that the parties continue to work together, whatever difficulties arise along the way. In such cases, a partnering approach is not simply desirable but essential for a successful outcome.

It is also important to be alert to financial, industrial-relations or other problems in the supplier's organisation. With a partnering approach, such problems are less likely to appear at the last minute, and it may be easier to work out contingency plans. The 'no surprises' rule works both ways – an informed supplier may be better able to help a client in a difficult situation.

The relationship can extend beyond partnership:

Example: VTWC (now known as Avanti West Coast) sees relationship management models moving through the following stages:

- Combative – hardball negotiations to get what you want at the expense of the other party
- Co-operative – an ongoing exchange of services on mutually acceptable terms
- Partnership – seeking to maximise value from productivity and joint developments
- Collaborative – creation of competitive advantage for both parties

VTWC/Alstom considered the following a sign they had reached the collaborative stage:

- Close relationship with shared values and common goals
- Working together to develop trust between the parties
- Performance regime changed to incentivise even small improvements
- Contract amended to reflect how the parties actually work together

Whatever the relationship, the elements that need to be tackled by both parties can be grouped as follows:

Organisational

- Making sure that the client and supplier organisations are complementary, i.e. that they fit together in a coherent way and responsibilities are clearly understood.
- Empowering local contract managers to make all the necessary routine decisions and giving immediate backup when needed. It is very important for the supplier to provide a one-stop-shop to the customer.
- Escalating any genuine commercial disputes promptly to senior level so that front line managers and engineers can concentrate on working together to provide the train service.
- Making contract arrangements appear as joined-up as possible. It should not matter to a member of traincrew, a passenger or a third party such as Network Rail, who is doing what to resolve a particular problem. The joint output is what matters.

Cultural

- Encouraging the supplier and their workforce to identify with the client's success through team-building sessions, joint training initiatives, joint branding, etc. and by making sure maintenance staff get the chance to ride the trains in service and see performance from the passenger point of view.
- Ensuring the suppliers fully understand the business and operational needs of the client.
- Maintaining regular liaison at senior management level, even when things are going well.
- Building trust; both partners must ensure their local management teams have the confidence of their counterparts.

Example: key to the excellent Class 357 fleet performance is the relationship between c2c and Bombardier (Now Alstom), which is carefully nurtured. The same information systems are used by both parties, depot procedures are jointly developed, rather than imposed, and many joint social events are arranged.

19.2.2 <u>RULE 2. Ownership and engagement - integrating the supplier into day-to-day operations</u>

Teamwork – part of running the railway

The real-time nature of a transport operation means that there is no time for contractual discussions or arms-length relationships. If the supplier is only a partial player in the overall maintenance activity (as is the case with warranty and technical support contracts), they should be treated simply as a division of the TOC's maintenance resource. If outsourcing is more extensive, then the supplier should work closely with the train operations delivery team to provide the service.

Example: The maintenance controller/technical rider team on TPE is seamless, working on one roster, although some are paid by the TOC and some by Siemens.

The relationship with traincrew and their managers should be strong so that problems at the driver/train interface are dealt with quickly, openly and effectively. This may involve joint fault-finding guides, staff briefs and user manuals, whereby the TOC and the supplier have equal parts to play.

At another level, the outsourced provider should be an integral part of the rail industry as a whole. Where relevant, the supplier should participate in industry reporting systems (such as National Incident Reports) and be active participants of industry initiatives such as ReFocus and fleet user groups.

Safety and competency

It is essential that safety and competency are proactively managed by the TOC as the Railway Undertaking. In particular:

- Ensuring competency assessments are based on outputs through audits and process checks based on operational risks and hazards, not just on training records.
- Ensuring competency requirements extend to the supplier's managers and team leaders, not just front-line staff.
- Insisting on strong follow-up for technical safety problems so that both long-term as well as immediate solutions are implemented.

If the depot is still managed by the TOC but used by contractor's staff, then occupational health and safety is an important issue.

- Ensuring the maintainer's method statements and risk assessments are relevant to the location involved, and not too generic.
- Working together on routine health and safety activities such as safety tours and accident investigations.

Example: c2c work closely with their maintenance supplier Bombardier (now Alstom) on competency and HASAW issues at East Ham Depot. Initiatives include:

- Auditing each other's health and safety arrangements
- Using common procedures for occupational safety matters (e.g. depot protection, accident investigation)
- Joint training programmes for all staff
- in-process checks of supplier's personnel

19.2.3 <u>**RULE 3. Application of the 20PP**</u>

Two key areas to highlight here are performance regimes and maintenance planning:

Performance regimes and performance management

A robust and relevant performance regime does two things. It encourages the supplier through financial incentives and it provides a yardstick to judge the overall success of the contract. It should never be seen as a way of punishing the supplier.

In structuring the contract, the performance regime must:

- Reflect the key performance indicators by which the TOC itself is judged
- Have individual penalties that are sufficient to concentrate the mind of the supplier, and match the business risk to the TOC, but are not punitive (disproportionate penalties may constitute unfair conditions and be legally unenforceable)
- Not cap the total performance payment level at too low a figure

The financial value of a performance regime should be enough to allow the supplier to build a business case for investing in necessary improvements to the product or service.

The performance regime must also cover the availability of customer services on the train (e.g. toilets, heating, ventilation and Air Conditioning (HVAC), information, catering). To achieve satisfactory results in this area, the train company will have to set up reliable fault-reporting systems and put personnel in place to monitor quality and operate the systems.

For successful performance management, both parties must:

- Adequately resource reporting, measurement and monitoring systems
- Establish the facts of any incident as quickly as possible
- Settle routine claims promptly, escalate any disputes, and avoid a backlog of unresolved disagreements

However, a performance regime alone is no guarantee of success and may not always be appropriate for small contracts where there is less money at stake. The supplier should not find it preferable to pay the penalty rather than fix the problem. Financial compensation is very much second prize compared to good contract delivery, especially if reputations suffer. To be successful, the performance regime must be backed up with positive contract management and a will to succeed.

> Example: The performance of Northern's Class 323s significantly improved following a tender won by Alstom. Factors behind this included: an agreed performance improvement plan in the contract; Northern removing their site engineer from Longsight so Alstom can manage more freely and transfer their culture change to Class 323s; the presence and engagement of Washwood Heath engineering expertise at Longsight.

Maintenance planning

TOCs should ensure the best possible maintenance schedule. Even if the supplier carries the financial risk of the work, the client will still see a major business benefit if reliability and availability are maximised through optimal maintenance. To help achieve this, the TOC should exercise its rights of approval as the Railway Undertaking over the maintenance regime. There may also be obligations on the rolling stock owner to check that maintenance is carried out properly.

Points to watch include:

- Checking that train maintenance frequencies promised in the original offer are being met

- Checking that all parts and sub-systems of the train are adequately covered in the maintenance regime
- Insisting that the maintenance schedule is fine-tuned to the service requirements of the particular fleet – generic schedules may under- or over-maintain equipment relative to usage
- Exercising rights to approve changes to the schedule
- Seeking C4 to C4 warranties where appropriate

Active involvement in maintenance planning and allocation to operational diagrams is important. Particularly on a complex network, day-to-day operational requirements can upset the carefully crafted programmes of maintenance planners. It is therefore best if all operational decisions are taken by the TOC so that the risk of units running out of fuel or overdue maintenance are managed by the people accountable for overall service delivery.

In the case of contract staff undertaking modifications or reliability improvement programmes, it is important for the TOC to have a clear view of progress. Such work is sometimes carried out on an ad-hoc basis at a number of locations: the TOC should control when and where each modification is completed on each train.

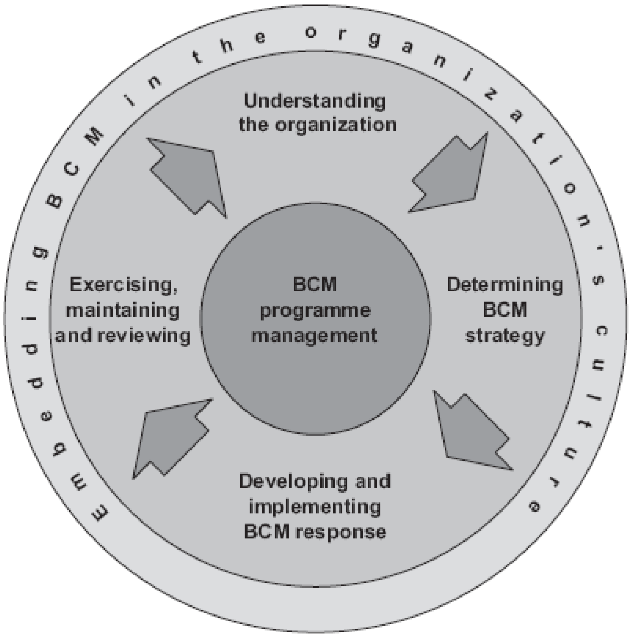
20. Business Continuity Management

Business continuity is the strategic tactical capability of an organisation to plan for and respond to incidents and business disruption in order to continue business operations at an acceptable pre-defined level.

20 Business Continuity Management

Business continuity is the strategic and tactical capability of the organisation to plan for and respond to incidents and business disruptions to continue operations at an acceptable pre-defined level.

Business continuity management follows a cyclical process of analysis to understand threats and requirements, determine and implement contingency strategies and validate planned response through testing and exercising.



BSI BS25999 life cycle

Note: BS25999 has been superseded by ISO 2231.

Before implementing a BC programme, it is advisable to obtain buy-in from top management and key staff, define and win approval for a project budget and set detailed timelines.

20.1.1 Programme management

In order to implement and maintain an effective business continuity programme, the TOC must establish a Business Continuity Management System (BCMS). Whilst this should be under the co-ordination of a designated business continuity manager, it is vital that the BC programme is sponsored at the highest level in the organisation, and the following documentation should be signed off by top management:

20.1.2 Definition of scope

- Services and locations covered by the business continuity programme
- Organisational objectives and obligations
- Acceptable level of risk
- Planning assumptions
- Statutory, regulatory and contractual duties
- Interests of key stakeholders

20.1.3 Business continuity policy

- Strategic prioritisation of assets and services
- What the organisation will undertake to implement and maintain the BCMS
- Roles and responsibilities
- Statement of endorsement by top management sponsor

- BC programme communication and awareness programme

20.1.4 Policies for establishing, maintaining and reviewing plans

- Provision of resources
- Competency of BCM personnel
- Business impact analysis
- Risk assessment
- Incident response structure
- BCM exercising, testing and training
- Maintenance and review of BCM arrangements
- Internal audit
- Management review
- Preventative and corrective actions

20.1.5 Understanding the organisation

Implementing appropriate contingency strategies requires a structured approach to understanding critical business needs. The two main tools applied here are risk analysis and business impact analysis (BIA). These help to give a full understanding of the threats and resource dependencies for the activities that make up the key services of the TOC.

20.1.6 The risk analysis process

In most organisations, a formal risk analysis process is already undertaken and it is vital that operational risk outcomes from this process are understood in the context of the business continuity programme. It should include:

- Gathering data on threats and previous incidents
- Scoring threats against likelihood and impact
- Assigning a plan for individual risks (treat, tolerate, transfer, terminate)
- Assigning responsibility/deadlines for treatment plans
- Regular formal review of risk analysis by a defined committee (as defined in the BCMS)

20.1.7 The business impact analysis

The BIA is the single most important, and generally time-consuming, process in the business continuity programme. Its purpose is to define the criticality of the activities that make up the TOC's services and identify the resources on which these activities depend (N.B.: the data from this process is most valuable at activity rather than service level). The data-gathering should:

- Identify services and departments defined in the BCMS scope
- Define the impact of activity disruption and therefore acceptable period of activity disruption
- Define all resource dependencies (location, staff, IT support, technology, etc.)
- Define the minimum resources required to re-commence activity over time
- Define recovery times for each resource on which the activities depend; ensure that the recovery time is less than the tolerable period of disruption

20.1.8 The incident response structure

Each team within the incident response structure should have a plan. Typically, organisations will follow a three-tier gold (strategic), silver (tactical) and bronze (departmental) command structure. All teams should have trained executive support.

The incident response structure should identify processes to:

- Confirm the nature and extent of an incident
- Trigger an appropriate BC response
- Develop plans, processes and procedures for the activation, operation, co-ordination and communication of the incident response
- Have resources available to support plans, processes and procedures to manage an incident
- Communicate with stakeholders

The roles of these teams are:

Gold (Strategic)	• Overall incident management • Setting strategic aims & objectives • Media • Communications & liaison (internal/key stakeholders) • Resolve Silver-/tactical-level resource issues • Plan for recovery
Silver (Tactical)	• Assess risks • Allocate and manage resources to achieve strategic aims/objectives • Plan and co-ordinate operational activity • Communications & liaison (internal/key stakeholders) • Resolve/escalate Bronze/operational-level resource issues
Bronze (Operational)	• Undertake tasks and activities as directed by Silver • Escalate resource constraints to Silver • Communications & liaison (largely internal)

20.1.9 The plan

The plan itself should be a useable document available to all response teams at the point of need. All responding staff should be familiar with it and all teams identified in the incident response structure should have ownership of their own plan. Each plan should:

- Have a defined purpose and scope
- Be accessible to and understood by all those who will use it
- Be owned by a named person who is responsible for its review, update and approval
- Be aligned with relevant contingency arrangements external to the organisation
- Identify lines of communication

20.1.10 Key tasks and reference information

- Defined roles and responsibilities for people and teams with authority during and following an incident
- Guidelines and criteria regarding which individuals have the authority to invoke each plan under what circumstances
- Invocation method
- Meeting locations and alternatives, up-to-date contact lists and mobilisation details for any relevant agencies, organisations or resources

- Process for standing down
- Essential contact details for all key stakeholders
- Details to manage the immediate consequences of a business disruption, including:
    - Welfare of individuals
    - Strategic and operational options for responding to the disruption
    - Prevention of further loss or unavailability of critical activities
- Details for managing an incident, including:
    - Provision for managing issues during an incident
    - Processes to enable continuity and recovery of critical activities
- How the organisation will communicate with staff, their relatives, stakeholders and emergency contacts

20.1.11 Details of the organisation's media response

- Incident communications strategy
- Preferred interface with the media
- Guideline or template for drafting a statement
- Appropriate spokespeople
- Method for recording key information about the incident, actions taken and decisions made
- Details of actions and tasks to be performed
- Details of the resources required for BC/recovery at different points in time

20.2 Maintaining and reviewing plans

A plan can only be considered reliable once it has been exercised. It is also vital that it is maintained in line with the policies documented in the BC management system.

Procedures should ensure a structured approach to exercising, corrective and preventative measures, management review and (internal) audit.

Exercising the plans at departmental, tactical and strategic level is the most effective way of ensuring that key staff are familiar with the response strategy, and that the plans meet their aim. All plans should be exercised at least annually according to a progressive exercise schedule. Exercises can be as simple as a desktop walk-through of plans through to complex simulations. It is recommended that the complexity of exercises develops with the confidence of the teams. The organisation should:

- Exercise to ensure BCM arrangements meet business requirements
- Develop exercises consistent with the scope
- Have an exercise programme approved by top management to ensure they are held at regular intervals/after significant changes
- Undertake a range of exercises to validate the overall BC plan
- Plan exercises to minimise the risk of them causing disruption
- Define the aims and objectives of every exercise
- Undertake a post-exercise review to assess achievement of aims and objectives
- Produce a written report of the exercise – outcome, feedback and actions required

20.2.1 Corrective and preventative measures

The organisation should guard against potential incidents and prevent their occurrence (or re-occurrence). Preventative and corrective actions should be appropriate to the potential problems. The documented procedure should define requirements to:

- Identify potential issues and their causes
- Determine and implement the actions needed
- Record the results of actions taken

- Identify changed risks and focus attention on significant changed risks
- Ensure that all those who need to know are informed of the issue and actions
- Prioritise actions in alignment with the RA and BIA

20.2.2 Management review

Management should review the business continuity management system and programme at planned intervals and when significant changes occur. The review should look at opportunities for improvement and changes to the BC management system. The results of the reviews should be clearly documented.

20.2.3 Audit

The audit processes for the business continuity programme should be consistent with the TOC's organisational audit procedure. It is however strongly recommended that any auditor undertaking a review of business continuity plans at the TOC has appropriate experience within the field of business continuity.

Any audit programme should be planned, established, implemented and maintained by the organisation taking into account the BIA, RA control and mitigation measures from the results of previous audits.

Audit procedure(s) should address:

- The responsibilities, competencies and requirements for planning and conducting audits, reporting results and retaining associated records
- The audit criteria, scope, frequency and methods

20.2.4 Conclusion

However diligent the risk analysis, however well managed the health and safety programme is and however well-maintained stock is, incidents will always occur.

The ability of an organisation to respond to an incident is significantly improved by a structured business continuity programme. The reputation of the organisation will be under close scrutiny in the aftermath of an incident; plans must be well executed and meet the pre-determined continuity challenges of an organisation.

21 Useful Links

21.1 The Rail Sustainable Development Principles

The sustainable development principles represent core values of the rail industry and are fundamental to delivering a sustainable railway at the centre of a transport system that meets the travel needs of society without compromising future quality of life.

Rail sustainable development principles

21.2 A Guide to RSSB Research in Sustainable Development.

This includes reference to research programmes for driver advisory information for energy management and information (T724) and eco-driving: understanding the approaches, benefits and risks (T839).

RSSB – T724 and RSSB - T839

21.3 Research Brief: Investigation into the use of bio-fuels on Britain's railways T697 August 2010.

The research has examined the advantages and disadvantages associated with the use of bio-fuels in the rail industry.

RSSB - T697

21.4 The European web portal for energy efficiency and renewable energy in buildings

Build up (portal)

21.5 Standards

British standards are available from the British Standards Institution: BSI Standards

PAS 2050 2011 Specification for the assessment of the life cycle of greenhouse gas emissions of goods and services provides a method for assessing the life cycle of GHG emissions of goods and services.

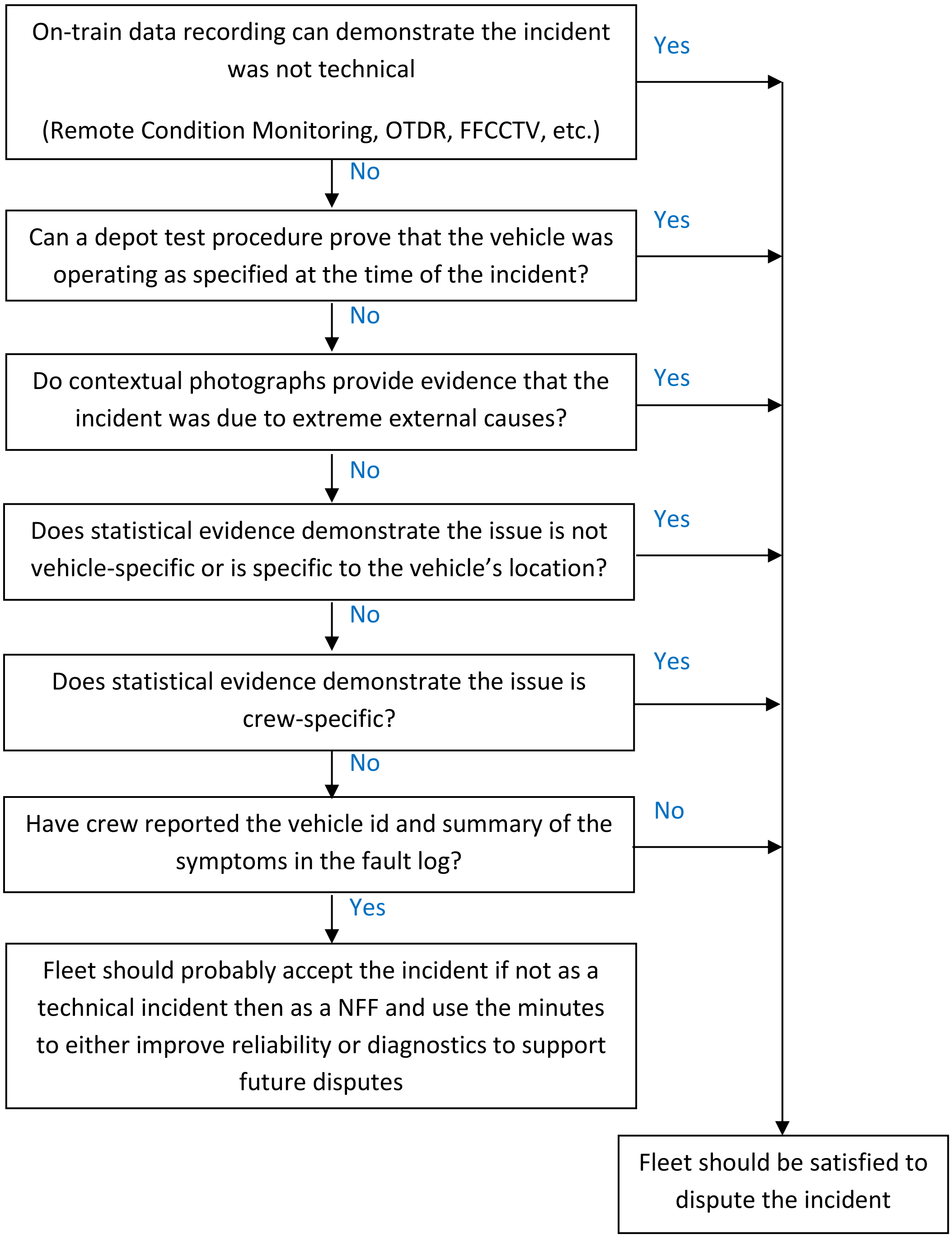
21.6 Railway Group Standards

RSSB Standards Catalogue

GMRT2132 Issue 1 September 2010 On-board Energy Metering for Billing Purposes sets out the energy metering requirements when electric traction units are fitted with an energy metering system that provides data for billing purposes.

Appendix A - Evidence Flow Chart

This flow chart can be used to help decision-making where fleet believe an incident should be disputed and there is no evidence on first examination of the fault log to indicate the incident was due to a technical casualty. It is worth bearing in mind a few factors. Firstly, can any other responsible manager better deal with the incident than fleet? Secondly, the purpose of delay attribution is primarily to collect data on asset failures - would the dataset be better or worse without the incident?



Appendix B – High-Performing Depot Specification

INTRODUCTION

The idea for this specification arose from a cross-industry workshop in December 2007. The aim was to challenge fleet to deliver the next big step change in reliability. Asset improvement was one of the key issues, noting that good maintenance facilities and practices are just as important in providing reliable trains as modifications to vehicles themselves. This specification for high-performing maintenance facilities has subsequently been put together by a sub-group.

The list of depot requirements includes all the elements expected from a modern, purpose-built train maintenance facility and is in line with the rest of Europe. However, one size does not fit all and requirements should be customised for each project with new or significantly upgraded maintenance or servicing facilities.

It is accepted that in some cases it will not be possible to justify all the features on the list. However, when producing business cases, the true cost of not providing certain features should be taken into account. For example, not having space for storage of consumables at point of use could add several man-years' lost productivity over the course of a franchise. Further, ReFocus has case studies of reliability improvements achieved by point-of-use stores freeing up people to resolve root causes, address deferred work, etc.

The scope and design of new or upgraded maintenance facilities should take full account of depot flow (e.g. to minimise the number of movements between the different facilities within the depot), minimise unproductive time and maximise touch time on vehicles.

There also need to be clear plans for the overhaul and renewal of maintenance facilities. It is recognised that vehicles themselves have a finite design life with periodic overhaul, after which they are renewed. The same principles need to be applied to facilities for rolling stock maintenance (although the design life of the buildings and equipment will be different). The responsibilities of the infrastructure manager and lessee for renewal, overhaul and maintenance need to be clearly defined, as they are for rolling stock.

MAINTENANCE DEPOTS

Maintenance berths

- Separate berths for servicing, light maintenance, heavy maintenance and lifting/major component change.
- No more than [80%] utilisation of any bay (based on down time for both planned and unplanned activities, average unit mileage and maintenance frequencies).
- Some flexibility regarding the use of bays for different activities.
- All berths to have extraction equipment for diesel emissions (DMU depots only).
- Able to isolate OHLE or 3rd rail for each road separately (EMU depots only).
- All berths to have shore supplies, air supply and battery charging points.
- All berths to have pneumatic supply and power points.
- Foot-printed areas to be provided next to each bay for oil storage, etc.
- Suitable pit lighting to be provided.
- Access to pits to be provided at each end and at intermediate points.
- [Where justified] a bogie drop pit to be provided in at least one maintenance bay. It should be possible to place any bogie within a normal unit formation over the drop pit without fouling other roads or having vehicles outside the building.
- All clean fluids (oil and coolant) to be piped to point of use.
- All waste fluids (oil and coolant) to be piped from point of use.
- Side and centre pits to be provided in all servicing and light maintenance bays. Centre pits only to be provided in heavy maintenance bays. Pits to be designed to suit the type of rolling stock being maintained.

- Fixed roof access equipment in at least one berth; further berths to have roof access in line with the production use of the berth.
- At least one set of jacks suitable for a synchronised lift of a full unit in normal formation should be provided. Where justified, separate jacks should be provided for heavy maintenance and planned component change.
- Each berth should have depot protection designed around one unit of normal length (depot protection required across the whole site).
- An overhead crane to be provided in at least one heavy maintenance bay and on any jacking road.
- Fork lift truck access should be possible on both sides of each bay.

Paint facility

- As a minimum, one berth to be provided with extraction equipment to allow touch-up painting.
- For larger depots, consideration should be given to providing a dedicated paint facility.

Fuelling facilities

- Fuelling roads should be long enough to accommodate maximum length of formation of arrivals on depot.
- Fuel road capacity should be based on each road being turned over no more than [6] times per night.
- Fuel dispensing equipment to allow all vehicles on a fuel road to be fuelled simultaneously.
- The fuelling area should be covered.
- All pipes should be suspended off the ground and trays provided to collect spillage.
- IT system at fuel point to allow fuel registration or input of defects.
- Equipment should allow fluids to be topped up at the fuel point.

Underframe cleaning facility

- Automatic underframe cleaning equipment should be capable of cleaning the full length of a unit in normal formation.
- Lances to be provided to allow localised cleaning of the underframe.
- Access to the underframe cleaning facility should be provided direct from the depot arrival roads.
- More than one boiler should be provided to give an element of redundancy to the underframe cleaning equipment.
- Availability of diesel and fuel additive

Wheel lathe

- The wheel lathe should be capable of exporting data to industry systems.
- A ground wheel lathe should be provided [on a ratio of 1 lathe to 300 vehicles].
- The wheel lathe road should be long enough to allow any vehicle of a normal unit formation to be placed on the lathe without the need to split the unit.

Wash plant

- Should be capable of working at temperatures as low as 0°C
- A device should be provided to warn drivers if they exceed the required speed, except where it would distract drivers, as exit signals are present.
- Should be capable of cleaning the vehicle roof and side skirts.
- Wash plant brushes should cater for all types of vehicle allocated to the depot.
- Should be capable of working on detergent or water only.
- Should be fitted with a basic underframe cleaning system and full biohazard kits to deal with fatalities.
- Provision should be made for automatic vehicle identification.

Controlled emission toilet emptying

- Should be capable of simultaneously emptying all toilets in a typical rake.
- Should be capable of emptying a CET tank from full in no more than 5 minutes.
- Covered accommodation should be provided for the operator.
- A facility to manually discharge CET tanks should be provided.
- The CET emptying facility should be at the fuel point if necessary.

Stores, etc.

- Covered storage to be provided for all components, including large items such as engines and gearboxes.
- Space should be provided adjacent to each bay for the storage of tools, low-value consumables and other components for efficient exchange at the point of use.
- An area to be provided where major components can be built up.
- Workshop facility to be provided for in-house component overhaul.
- Electronics clean room to be provided.
- Jobbing shop, including small welding facility, to be provided.
- Adequate workshop and mess facilities for subcontractors.
- Load bank or dynamometer facility.

Office/staff accommodation

- Sufficient accommodation to be provided in the form of offices, mess rooms, meeting rooms and classrooms.
- There should be a mixture of open plan and enclosed offices.
- Easy-to-maintain mess and locker room facilities should be provided.
- Mess room to be shared with traincrew if possible.
- An area should be provided for communications and start-of-shift briefings, etc.
- A depot IT network should be provided that is fast, efficient and future-proof (including IT at the maintenance berths).
- Space for traincrew cab simulator (better to have at maintenance depot to ensure fleet and operations relationships are cemented).

Cleaning facilities

- Cleaning facilities to be covered where possible.
- Access platforms to be provided.
- Shore supply to be provided.
- Hot and cold water to be available adjacent to vehicles.
- 13-amp power points to be provided.
- Storage facilities to be provided.
- Mess room to be provided adjacent to cleaning facilities.
- IT facility to be provided to allow input of work done.
- Dry room for seat covers, carpets, etc.; dry cleaning facility, where justified.

Stabling facilities

- Sufficient stabling berths to be provided that, under normal planned circumstances at peak time for departures, will not be more than [90%] utilised.
- Ideally each departure road should not accommodate more than 2 rakes of units.

Access to depot

- Access between the main line and the depot arrival road should ideally be provided at both ends of the depot.
- Each arrivals road should be long enough to accommodate the longest foreseeable rake of vehicles.
- The depot should have a simplified signalling system that is operated from the production office, but complex depots may require a more substantial control panel.
- Electrified depots should have an independent power supply such that off-depot isolations do not affect depot supply.

Depot environment

- Adequate lighting and safe walking routes to be provided around the depot.
- Depot to be securely fenced.
- Security facilities to be provided at the depot entrance.
- CCTV to be provided covering the depot entrance.
- Sufficient car parking to be provided for the depot workforce.
- Road access to be provided for a low loader (moving vehicles by road).
- Lorry turning circles for stores access and road access for stores at the correct end of the depot, without the need for isolations or line blocks.
- Depot to be very close to a triangle, or within one, to enable reorientation of train sets or vehicles.

Light maintenance depots

At a typical light maintenance depot, the facilities under fuelling facilities, cleaning facilities and controlled emission toilet emptying should be provided as a minimum. At least one light maintenance bay should be provided, as described under maintenance berths.

Servicing locations

At a typical servicing location, the facilities under fuelling facilities, cleaning facilities and controlled emission toilet emptying should be provided as a minimum.

Appendix C - Supply Chain Sub-Group Issues List

Category	Issue
Franchise change management	Consideration of spares management arrangements and spares float issues affected by vehicle cascades (float transfer/ownership/access)
	Order cover for long-lead items during franchise transition periods
	OEM consultation in franchise discussions relevant to fleet or spares issues
	Also consider non-franchise routine transfers/sub-lease arrangements
Configuration management	Confirm a configuration base, i.e. robust component/product configuration information, including up-to-date: procurement/overhaul/repair specifications (refer back to OEM specifications where relevant) configuration (modification) status Differentiation of approach between reparable components and consumable items may be necessary. Consumable management may be more straightforward – a quick win?
	Maintain the integrity of the configuration base by having a robust and linked 'management of change' process between industry stakeholders, i.e. • between supplier & TOC/ROSCO customers (changes can be initiated either way) • between suppliers, i.e. 1st, 2nd, 3rd tier (changes can be initiated either way)
	Design authority responsibilities defined for components/products/software
	Software management

Managing repeat offending or rogue components	Warranty return and diagnostic testing processes which can replicate faults, supporting root cause diagnosis and preventing NFFs (*generic process/flowchart needed to benchmark existing processes*)
	Is there a difference in approach for components in or out of warranty, and if so, why?
	Managing ‘repeat offender’ product failures (rogue components)
	How are discrete component repairs managed with respect to component overhaul cycles?
	Supplier awareness of product/component operational reliability issues via TOC/ROSCO feedback
	Processes for continuous improvement
	Supplier involvement/feedback from fleet user groups
	Suppliers challenging product specifications if weaknesses are identified
	Preventing product-specific NIR issues or other technical problems re-occurring on similarly designed products (i.e. dealing with the full spectrum of an issue, not just a localised issue)

Managing material availability	Awareness by TOC logistics/spares managers of the existence and execution of spares management contract frameworks and agreed obligations
	Consideration of spares requirements during major projects, mandatory modifications or new build procurement
	Consideration of material requirements for whole life of vehicles
	Managing float condition (clean/dirty), both ongoing and at lease end, to maximise availability
	Pooled resources (material floats)
	Appropriate scaling of spares if fleets are leased to >1 TOC
	Ensuring appropriate and accessible storage of material at the point of use, e.g. a depot
Economies of scale	Standardised and rationalised products where possible to increase volume and resulting economies of scale
	Could existing pooled spares arrangements be combined in the future to increase spares accessibility?
Obsolescence	Suppliers proactively advising industry of product obsolescence issues
	Being proactive about whole life required of components (supply risk, research into alternatives, re-baselining components which have reached the end of their natural life (e.g. a VCB)
	Potential vehicle life extension considerations – common cross-ROSCO fleet issues/common solutions/increased certainty of component life requirements
Adopting relevant best practice from non-UK passenger rail	Benchmark against other rail – UK freight, European rail, Hitachi, Siemens, etc. (maybe for specific categories or issues, but taking account of differing public/privatised frameworks)
	Benchmark against other transport industries – airline, bus, car (e.g. Nissan logistics)
	Benchmark against non-transport industries – food, MoD, logistics, utilities

Appendix D –Industry Supply Chain Workstreams

Timely supply of material

Issue	Solution
Critical material supply issues - what and where are the critical material supply issues (pinch points, key components, etc.)?	Poll TOCs to identify their key material supply issues and concerns, including their perceived reasons for the issue or problem. Identify next steps to overcome any identified issues or problems.
Supply and demand – material supply for planned requirements perceived to be generally ok, but contingency material supply for unplanned requirements is often problematic, including seasonal factors (levels 1-5). Suppliers sometimes struggle to meet volatile demand.	Poll TOCs to identify problem areas. Review and agree the contingency strategy requirements with the supply base.
Material requirements planning – what is the best practice model for customers and suppliers to adopt for forecasting, ordering and supplying material?	Define and update the 20PP to include a model that takes account of customer consumption (planned and unplanned) forecasting, leading to proactive order placement and timely supply, taking consideration of lead times. Organisations can then self-check against this model.
Stock on shelf – how are minimum stock-holding levels defined, e.g. BSI auto-couplers?	Decision criteria needs to be understood to ensure they reflect demand requirements for the industry as well as individual users. Problem areas need to be identified.
Dirty/clean status of float material – concern that current supply arrangements do not always promote the stocking of clean (usable) and available float material on the shelf at suppliers. Poor component return condition can also inhibit this.	The industry needs to adopt an approach that maximises the usability of available float material (for which there is a demand).
Making best use of small material floats – how can small material floats be used most effectively? For example, minimising float turnaround timescales or standardising and combining similar floats where possible.	Identify 'small float' problem areas and review their utilisation as a basis for recommending a way forward, both on a specific component basis and in terms of general best practice principles.

Management of 'rogue' components (repeat offenders)

Issue	Solution
Providing consistent defect information to suppliers – how can component failure information be robustly and consistently provided to suppliers to maximise the chances of successful defect root cause diagnosis?	Develop a generic template or checklist (drawing on current best practice from new-build and legacy fleets) for inclusion in the 20PP to enable the industry to adopt a more

Reporting and warranty return requirements between suppliers are different, as are TOC approaches.	consistent approach for defect reporting across the TOC/ROSCO/supplier interfaces.
Defect investigations on components out of warranty – some suppliers do not investigate defects occurring on products out of warranty. Valuable information and knowledge are at risk of being lost, and the risk of keeping defective components within the supply chain is increased.	Suppliers to ensure their defect investigation processes are not dismissive of components failing outside their warranty period.
NFF at suppliers is excessively high – this denudes float during the fault-finding process and increases the risk that defective products might be re-fitted to vehicles. More prevalent on safety systems where precautionary change-out often takes place. Concern that TOCs are not always aware of intelligence held by suppliers on product performance, and that TOCs do not always take full advantage of fault-finding with a component in-situ.	Poll suppliers to identify which components have high NFF rates. Use these components as joint case studies for TOCs and suppliers to better understand each issue, and to ensure TOC and supplier fault-finding processes are aligned and supportive of each other. Suggest beginning with new-build OEMs and then extend to legacy fleets. Use the output of this as the basis for an industry best practice model to be included in the 20PP.
Serial number tracking – concern that serial number tracking is not being used as effectively as it could be for managing NFFs.	To be considered as part of NFF case study review.

Configuration

Issue	Solution
The industry needs a robust configuration base – different stakeholders have different pieces of the configuration base. It is important for this to be consolidated somehow and to define what is meant by configuration, i.e. drawings, specifications, modification status.	ROSCOs need to be responsible for vehicle configuration history and ensure it is updated to reflect changes made during heavy maintenance and enhancement programmes. TOCs must also provide ROSCOs with comprehensive and accurate configuration information for all changes made during their lease. The supply base needs to have a robust view at component and product level.
Responsibilities for component and specification information – components and specifications need a responsible owner; this can be especially unclear for older vehicles.	Each component and specification need to have a defined responsible owner to keep configuration information up-to-date.
Link between overhaul periodicities and component duty cycles – there is no defined link between the specification of a component's duty cycle, the extent to which duty cycle is re-base-lined by the COI, and the prescribed use of a component within a vehicle overhaul specification (which also does not define the vehicle overhaul periodicity). This could lead to incorrect management of component condition.	Component specification information needs to include details about duty cycle limitations of the component. The overhaul periodicity associated with vehicle overhaul instructions (VOIs) needs to be visible to suppliers (not always included in VOI).
Making component and specification information available to relevant stakeholders within the industry – PADS is used to an extent and has recently had an upgrade, making it more user-friendly and accessible via the internet. Some fleets use other systems, but the principle of enabling stakeholder access to information should be similar. Porterbrook is implementing a document tree initiative in PADS to link primary fleet overhaul documentation to COIs, components and drawings; this concept could be of use to other organisations.	The recent functionality enhancements of PADS need to be made known to the industry. There may be a value to the industry increasing its use and adoption of PADS where appropriate to provide a consolidated configuration base. Porterbrook's document tree initiative to be explained as a tool for supporting the enhancement of document control. Could non-PADS fleets ghost their information into PADS to create a single reference source? Could the Network Rail performance fund be used to support some of these initiatives?

Integrity of PADS component information – need to ensure that PADS contains correct component information, for example modification status, QA rating. Some older components are very sketchy on detail, and in some cases drawings and/or specifications do not even exist.	Deficiencies of component information/detail need to be addressed by the responsible owner. A review is needed to understand the scale of this issue. Confirm that QA ratings in PADS agree with ACOP standards. Confirm PADS is able to store component modification status. Ensure that the processing of part number information and associated detail in PADS has engineering input and is not purely administrative.
Changes to the configuration base need to be well managed – management of changes to configuration, particularly between multiple stakeholders, needs to be carefully controlled. The current industry approach appears to vary in its application and is not fully joined up.	Review application of change management at organisations where this is perceived to be undertaken well (e.g. Siemens for Desiro). Use this as the basis for prescribing a best practice model against which organisations can self-check. The effectiveness of existing ACOP guidelines needs to be tested.
Software/firmware management – a consistent industry approach is needed for software/firmware management including modification strike/configuration recording methodology and ESCROW considerations. There is a perception that an education gap exists in some areas of the industry with respect to software/firmware management, and support may be required to close this gap. There is best practice, for example software for Desiro component hardware is not installed until the point of vehicle fitment, and component modification strike status is for hardware only (software is handled separately).	Review the application of software management at organisations where this is perceived to be undertaken well (e.g. Siemens for Desiro). Use this as the basis for prescribing a best practice model against which organisations can self-check. Seek advice from outside the industry if necessary. Method for raising awareness throughout the industry of software/firmware management to be considered. Poll TOCs to seek their views on whether any problems are perceived to exist with ESCROW management.
How can industry-wide approvals be streamlined? The approval of industry-wide procedures or common component enhancements is extremely time-consuming and problematic. It is difficult for suppliers to implement a revised procedure until all stakeholders have signed it off, resulting in stakeholders who have signed off a procedure becoming frustrated that it has not been implemented during the approval process.	A more effective industry-wide process is needed for approval of common procedures or common product upgrades. The effectiveness of ACOP guidelines needs to be tested. Suggest progressing via existing cross-industry forum, e.g. TSRG?
Responsibilities for updating configuration information: when a change is made, updating drawings and documentation can sometimes be problematic.	The process and responsibilities for updating configuration information following a change needs to be defined. There is recognition that no one party necessarily has overriding responsibility.

Sharing best practice – product performance and consistency of product configuration would benefit if the industry shared product development information across similar systems on different fleets.

A partnership approach respecting commercial boundaries should be promoted where possible.

Appendix E – Examples of Best Practice Supply Chain Management

Example: Timely Supply of Material – Spares Holding

The best approaches to spares holding involve hard thinking (how the parts are used by people) and analysis (what the vehicles need when) to produce the right combination of location and accessibility for different items. They also involve trust (if all parts are kept under lock and key, it will be at best less efficient). Best practice is to create trolleys of materials, tools and instructions for each type of routine activity (e.g. each B exam). Trolleys should include shadow boards for location of items. Parts used can be automatically booked to the vehicles.

Typical options for different types of parts for work arising/repairs integrate with depot facilities and include:

- Lineside vending machines for low-value items with shelf life, e.g. Loctite; the machine dials the supplier when a refill is required
- Bins in the shed for low-value bulky items, e.g. white overalls
- Lineside supplies of frequently used items, e.g. wiper arms
- Designated place(s) in the shed for bulky but expensive parts (and their paperwork), e.g. autocouplers, air-conditioning units

Example: Timely Supply of Material – Float Status

Southeastern monitors floats of critical items, e.g. compressors and each wheelset type, broken down into:

- At depot, serviceable
- At supplier, serviceable
- At supplier, under repair
- Not serviceable

First Rail are accredited to BS 11000 collaborative business relationships. This has assisted in building collaborative working and improving customer/supplier communication, as well as defining roles and responsibilities. It supports collaborative decision-making leading to more valuable business partnerships.

Example: Management of ‘rogue’ components (repeat offenders) – providing consistent defect information to suppliers and defect investigations on components

Unipart Rail undertook a 6 sigma project on carbon brush pigtails coming out during service and causing delays. Working with the TOC and the supplier, a problem was identified with the sample test methodology. Analysis of the supplier’s data using 6 sigma principles enabled new test limits to be recommended, solving the problem. Northern have monthly meetings with Unipart, plotting failure rates of key components and reviewing actions to improve them. First Rail identified performance data for Unipart to pass down their supply chain to facilitate improvements to key components. West Midlands Railway has seen material issues resolved when TOC, Unipart, supplier and ROSCO are all engaged.

Unipart Rail has a very simple high-level performance measure which shows what welcome progress has been made. Component reliability, in total defects per million components (DPMC), based on warranty claims made (whether rejected or accepted).

YEAR	1998	2002	2003	2004	2006	2007	2008
DPMC							
Target	N/A	N/A	N/A	2,500	3,900	3,400	3,100
Actual	20,000	3,900	3,400	3,700*	4,500^	3,100	

* down to 2100 if lighting inverters are excluded (these accounted for 30% of total warranty claims and arose from Unipart being forced to re-source away from the OEM because it no longer wanted the business. The new supplier actually worked to the drawing, which was subsequently found to be inadequate).

^ Lighting inverters are still a high-volume issue – the latest versions are not actually failing, but protection operating, i.e. if the power is removed and reconnected they work again. Another big issue in June and July which affected the year's figures were fasteners that hadn't actually failed but were of sub-standard quality in some cases.

Example: ScotRail asked a Unipart facilitator to help Haymarket depot management team implement a communications cell. They began by deciding what and how to measure in order to help achieve delay reduction commitments. Boards displaying key performance indicators for people and vehicle maintenance processes compared to plans and targets were implemented to share information and improve problem-solving. Delays were significantly reduced, and staff morale rose.

In addition, Unipart Rail has undertaken initiatives such as policy deployment with their suppliers.

Example: Unipart Rail was concerned that the culture inherited from the pre-privatisation era was leading to sub-optimal relationships with its main suppliers. They wanted to replace buyer/seller relationships based on price with partner relationships based on mutual interest. One-day exercises with each of their 4 main suppliers helped them draw up a shared policy deployment matrix and derive 3 joint projects from it. Feedback was positive, with clearly defined common goals and specific actions for achieving them. The mutual trust developed has led to further joint projects and more collaborative relationships at all levels.

Example: Eversholt's high-level supplier management strategy has been developed with the input of people within its business, its key suppliers and several TOCs to ensure that it is more reflective of TOC requirements, including current and generic requirements, such as RIS-2750-RST and RISAS. The objective is to develop the market place to meet Eversholt's and its customers' current and future needs.

Five key management tools are deployed:

* A structured communications strategy

* Implementation of account plans

* Supplier evaluation

* Segmentation

* Market analysis

These business level tools are underpinned by project-specific management regimes that provide Eversholt's supplier community with visibility of TOC performance requirements and key performance drivers, ensuring alignment of stakeholder objectives. Supplier senior management commitment to fleet reliability improvement is fostered through steering groups with clear terms of reference, which give a perspective on performance trends and any emerging issues. Successful examples are the 3-way groups with Bombardier, Eversholt and NXEA (now Greater Anglia) for Class 315 C6X, and GTR for Class 365 (now ceased).

Appendix F - Fleet Transfer Checklist

A/ Depot Acceptance Checklist

DEPOT ACCEPTANCE CHECKLIST				
Location Parameters	Location Details	Vehicle Parameters	New Stock Parameters	Comply Yes/No
Depot name		Unit Class		
Sectional Appendix no.		Unit Class cleared for route in sectional appendix?		
Maximum length of vehicle (m)		Length of vehicles (m)		
Maximum height of vehicle (m)		Height of vehicles (m)		
Maximum width of vehicle (m)		Width of vehicles (m)		
Maximum lift weight (tonnes)		Weight of vehicles - bogies attached (metric tonnes)		
RA code		RA code		
Primary power source (AC/DC/diesel)		Primary power source (AC/DC/diesel)		

Applicable unit and vehicle details should be entered in the new stock parameters boxes.

Details must be less than or equal to those in the location details to comply (“YES”). If details exceed those in the location details, then it does not comply (“NO”).

Any non-compliance indicates the vehicle does not fit the proven envelope of the depot concerned and a more detailed assessment is required.

B/ Acceptance of rolling stock – checklist.

Item	Yes/No	Comments
1. Commercial arrangements Do the terms and conditions deviate from TOC X's standard terms? Are the terms and conditions clearly understood and agreed? Are the customer contact details known? Has a purchase order been raised? Is insurance cover in place? Have commercial arrangements following the condition survey report been made? Are the warranty arrangements clearly understood and agreed?		
Specification Is the specification clearly understood and agreed? Does it meet TOC X's requirements?		
3. Delivery requirements Is the delivery date known? Have movement arrangements been made? Has a fitness to run certificate been provided?		
4. Depot acceptance check Has the depot acceptance check been carried out? Does the vehicle comply?		
5. Facility changes Will delivery require changes to: buildings? plant equipment? sidings? tooling/equipment? Is capacity/resource available?		
6. Training/competency Will formal training be required? Are new competency standards required?		

Item	Yes/No	Comments
7. Depot change Are depot changes required? If ‘yes’, is regulatory approval required?		
8. Safety and environmental Is safety validation required for the supplied services (ACOP1003, RISAS, etc.)? Are there any environmental issues to consider? Are these units approved for route and gauge clearance to RIS-8210-RST? Has a copy of the existing engineering certification been received and reviewed?		

C/ Rolling stock entering service – checklist.

Item	Yes/No	Comments
1. Maintenance documents Has a copy of the maintenance plan been obtained and reviewed? Will the supplier's VMI or in-house VMI/block cards be used? Has a copy of the existing block cards been obtained? Has the unit(s) modification status been obtained and reviewed?		
Vehicle history and maintenance records Has a copy of the following history and maintenance records been received: next exam due? last A and B exams? UAT mileage? deferred work and outstanding defects? outstanding NIRs and special checks? major component mileage? heavy maintenance arrangements (C4/C6)? electrical wiring schematics?		
Databases Has the rolling stock library been informed? Have R2 and GENIUS been updated? Have the technical databases been updated?		
Has a safety check been carried out on the vehicle?		
Has a date been advised when the vehicles will enter service?		
Has the NRN or other radio account been transferred to the new operator?		
Have diagramming, stabling and maintenance arrangements for outstations/sidings been agreed and briefed?		
Has a vehicle information brief been produced and distributed to all staff?		

D/ Return of rolling stock – checklist.

RETURN OF ROLLING STOCK - NORTHERN CHECKLIST			
No	Item	Checked (Y/N)	Comments
1.	Have re-delivery arrangements been made?		
2.	Has the status of the maintenance regime been advised (VMI, VOI, bulletins, temporary procedures)?		
3.	Has the commercial arrangement been agreed following the condition survey report?		
4.	Are there any commercial arrangements concerning surplus material?		
5.	Have the vehicle records been returned?		
6.	Have all databases been updated and defect entries closed out? Has a list of open defects, checks, modifications and NIRs been forwarded to the appropriate third party?		

Appendix G - Incident Decision Support Tool Customer Requirement Spec.

Introduction

This document sets out the requirements for an information technology decision support tool which can be used to establish with a driver, or other crew member, the symptoms of an alleged train fault, and combine these with fleet-specific technical knowledge to advise the driver based on the time and location of the fault. The tool will most likely be a computer in a control room, but may take other forms, such as a mobile device for traincrew.

This document has been split into 'must haves' and 'nice to haves' to create a customer requirement specification to pin down the exact product our members require.

Requirements

Commercial must haves:

1. The supplier shall agree to a third-party source code escrow arrangement that ensures the licensee obtains formal access to the system source code when maintenance of the software cannot be otherwise assured. The arrangement shall de defined in contractually agreed terms and conditions.
2. Access to the system shall be offered under a minimum 1-year fixed term contract between both parties along with support services as per local agreement.
3. A service level agreement shall be commercially negotiated but will be circa 99%.
4. If the main channel to access the system fails, some form of locally stored decision support should be available for users to access instantly until access to the database is restored.
5. The super user shall be able to populate/modify/change the contents of the database at no extra cost as and when required.
6. Both parties shall propose change requests and evaluate them on commercial grounds.
7. The system shall suffer no more than 5 incidents per year.
8. The supplier shall provide a service level agreement covering:
    a) Performance
    b) Quotes for different features
    c) System updates
    d) Configuration
    e) Change control
    f) User assistance
    g) Training packages

Technical must haves:

1. Shall be functional or accessible on a range of off-the-shelf IT solutions (e.g. tablets, mobile phones, laptops, desktop computers, etc.).
2. The supplier shall provide a standard template fault tree which the super user can populate with textual or pictorial information and upload to the system (e.g. a diesel multiple unit may have fields for power packs, gear boxes, hydrostatics, etc.; and an electrical multiple unit may have fields for traction motors, transformers, propulsion electronics, etc.). The supplier shall agree with customers the fields comprising the standard template.
3. Shall automatically progress through the fault-finding process based on feedback from the user in the form of question and answer prompts.
4. Shall provide user security.
5. Shall commence a timer when the standard template fault tree has been accessed and flag the user when 5-minute intervals have elapsed.
6. Shall provide a link to defective on-train equipment rules.
7. Shall provide a link to information on assistance policy for recovering vehicles with another in-service vehicle.
8. Shall be interactive and easy to use:
    a) Dependent on local bandwidth, the page should appear within 5 seconds.
    b) Home screen should be configurable, including shortcuts to variable elements in the database.
    c) Ability to build relationships with dataset within the system (e.g. hyperlinks, wiki, etc.).
    d) Demonstrate bandwidth minimisation for page loading.
9. Shall take account of time and location of the incident when providing triage advice (e.g. 17:00 at Waterloo Station; get the unit moving as soon as possible/14:00 country end try to reset the faulty equipment).
10. Customer needs to appoint a super user with the authority to:
    a) grant access to other users within the organisation.
    b) change the content of the database.
    c) amend historical information on events.
11. Shall automatically send an email containing a link to change the password every 90 days.
12. Shall time out:
    a) With super user access after 30 minutes of inactivity.
    b) With user access after 12 hours of inactivity.
13. The system provider shall provide training material to the customer.
14. Shall have a training package which will require users to log in to update their skills.

15. Shall be capable of recording information, including free text notes for export to other systems (e.g. HTML, CSB, etc.).

16. Shall be downloadable to Windows and android or web-based devices.

17. Shall alert super user when a user is accessing the system.

18. Shall be compliant with all applicable legislation, including periodic server updates and requirements for the use of proxy servers, DMZ and geographic redundancy services where applicable.

19. Shall be internet-based.

20. Shall alert the user when the system is offline and not recording (basic information should be uploadable to the live system).

Nice to haves:

1. Could store information when:

    a) Drivers raise a fault on the system if the solution is provided to crew on a hand-held device and then transfer these files to another system.

    b) Where available in the system, provide drivers with feedback on the remedial action required.

2. Could provide a feature to flag up to the user any ongoing fleet incidents.

3. The system to link to TRUST incidents, along with open interfaces for other systems.

4. The system to link to BUGLE.

5. A health check that recorded the last export, files received and records of dialogue and information exchanges.

6. Built-in help and user guides would be useful.

7. Whilst an internet-based system should be a must have, it would be nice for it to be external (operational offline) and require a single standardised template for submissions.

8. Engagement with drivers as they should have visibility to check whether the issue has been resolved. It was noted that visibility would shape behaviours.

Appendix H – Example of a Checklist

SOUTH WEST TRAINS	THE SOUTH WESTERN RAILWAY	NetworkRail
Right Time Railway Assurance Check - Fleet Depot Staff		

Details of the Right Time Railway Assurance Check	
Name of manager carrying out the check	
Date and time of assurance check	
Location of assurance check	
Which depot manager's patch is this location on	

The Right Time Railway Five Activities for this staff member
I make sure units are prepared and in the right position
I advise control of short-forms at the earliest available opportunity
I confirm the correct formation
I make sure the train leaves the blocks on time
I make sure the train presents at the exit signal at the right time & is brought back to the depot promptly on return

Observation work to be carried out	**✓ or X or NA**
Has the staff member signed on in good time?	
Is the staff member and are units at the correct location for departure?	
Have the pre-departure checks been carried out?	
Has the member of staff been in contact with the driver?	
Has the preparation sheet been given to driver?	
Has the service departed at the right time?	
Have any incoming arrivals been brought back to the depot promptly?	

Questions to ask the staff member	**✓ or X or NA**
Have you been briefed on what the Right Time Railway Five Activities are for your job?	
Do you know what the Right Time Railway Five Activities are for your job?	
Why is it important that units are prepared and in the right position?	
Why is it important to advise control of short-forms at the earliest available opportunity?	
What is important to confirm the correct formation?	
Why is it important to make sure the train leaves the blocks on time?	
Why is it important to make sure the train presents at the exit signal at the right time?	

Calculation of the Right Time Railway Assurance Check Score	
Number of ✓ recorded	
Number of **X** recorded	
Total of these two numbers above	
Percentage of total which were recorded as ✓	

Record here (or overleaf) any suggestions/observations which arise in conversation with the staff member which may be important for Right Time Railway Groups, Performance Team or Area Manager to progress and try to improve.

Return to: Anna Langford, Performance Reporter, 7th Floor, Friars Bridge Court.
No copies need to be kept or signed for.

Appendix I - Decision Support Tools

Introduction

A vehicle incident Decision Support Tool (DST) is normally used in a revenue service environment to help train drivers and fleet control/maintenance centre support staff isolate train system faults expediently and determine the most effective course of remedial action based on prevailing network circumstances.

The implementation of a systematic, computer-based DST is considered business critical by many TOCs and forms an important part of any modern fleet management programme. Whilst the degree of system functionality may vary significantly between organisations, it is generally acknowledged that the principle objectives of the system should strive to:

- Continuously develop fleet/operations relationships.
- Encourage traincrew feedback on technical issues affecting revenue service.
- Minimise network service delays.
- Promote a culture of transparency and mobility of information.
- Conform to railway authority regulations where required.
- Drive reliability growth.

The benefits of implementing a DST are numerous, and feedback from TOCs with live systems suggests that:

- There is a genuine return on investment/the process adds real value.
- Delays per incident are improving.
- The best systems incorporate Defective on Train Equipment (DOTE), assistance guide, event timer and facility to export data to other TOC systems for post-incident review.
- User engagement is increasing.

Example: GTR reported an incident data capture rate of circa 60% and Southern 90%.

System automation and staff interaction

Ideally, the DST system should be internet hosted and Microsoft Windows-compatible, relational and accessible from a range of proprietary IT devices, including tablets, smartphones and laptops.

Some form of interactive DVD or virtual image architecture can also be employed to aid incident management such as the Interactive Virtual Train (IVT) tool.

It is recommended that suitable interactive training materials or modules are included as an integral part of the system to ensure user skills are recorded and maintained. This may form part of a separate competence database or internet hosted facility.

Timing monitoring

When a train fault occurs, and the DST system is accessed, a timer should commence to flag the elapsed time to the user at predetermined intervals, normally 5 minutes. This allows the time associated with fault diagnosis and corrective action to be monitored and/or recorded and subsequently used to inform reliability metrics e.g. Mp701D.

Location and time specificity

The system must be able to account for the time and geographic location of a technical incident when communicating service critical information between driver and control centre so that effective decisions can made quickly based on prevailing circumstances.

Example: It would be critical to move a unit as soon as possible if there were a rush hour incident at Waterloo Station; conversely, during a rural off-peak incident, the fleet management team may attempt to remove power and reset the faulty equipment in the first instance.

Ideally, the DST should be compatible with existing Global System for Mobile Communication – Railway (GSM-R) technology.

Interfaces

Links to DOTE and assistance/vehicle recovery:
Where a DOTE or similar management system exists, the DST should have relational functionality to respect the rules for isolations and running rolling stock in a degraded mode. The link should also permit the communication of information governing vehicle recovery, in particular the assistance policy relating to the recovery of vehicles with another in-service unit or consist; preferred fleet configurations; available maintenance facilities and platform constraints.

Links to maintenance management systems and other data:
Ideally, the system should be sufficiently flexible to permit communication with/access to information from other maintenance management systems and databases (e.g. TRUST, Bugle, Equinox, Genius, etc.). Some typical methods are an html internet-based tablet/smartphone system, which supports remote access; downloading fault logs for manual input into the maintenance management system; links to the incident history database for trend analysis; an engineering developed online wiki-based system linked to trainborne remote condition monitoring devices.

Links to trainborne condition monitoring:
Some of the most advanced systems utilise trainborne remote condition monitoring technology (RCM), which can be accessed remotely to diagnose faults, recognise tolerances and identify potential faults before they occur.

Example: Southeastern fleets have been fitted with RCM. As soon as a fault is logged, a breakdown of train systems and failure modes is made available, which the driver can then communicate to the control depot. The depot can subsequently access the system, obtain a cab view, isolate the fault, diagnose the problem and recommend a solution.

Recording system usage:
It is important that post-event data is recorded and made available between systems so that it can be subsequently consolidated to inform performance analyses and reports including common reliability trends and metrics, return on experience, lessons learned, etc.

<u>Change control and information maintenance</u>

Whenever business critical information is distributed within an organisation, it is necessary to formally control its maintenance by establishing suitable review, approval and issuing mechanisms/authorities. The same is true when implementing a DST system, regardless of whether it is paper- or software-based, as it will ensure that fleet management/maintenance staff are working with accurate and current information. The challenge for TOCs, however, is to develop a practical application commensurate with its needs without losing control of technical content.

Whenever new fleet technology is introduced, or existing fleets undergo a modification programme, consideration of the impact on the DST should be part of the change control process.

<u>System implementation</u>

Strategy and funding:
To ensure a fleet DST system is implemented successfully, it is important that it is addressed at strategic level and justified by a robust business plan. Once a suitable business case has been approved, a top-down management approach is recommended to ensure all the necessary resources are made available (e.g. manpower, planning and training; investment and funding; development, validation and integration requirements; regulatory compliance, etc.).

TOCs may wish to consider funding sources such as Innovate UK, RSSB Grant, etc.

In-house development:
One cost-effective solution may be to develop a system utilising existing in-house engineering and IT resources. This method can provide greater flexibility and has the added benefit of ensuring that system requirements are customised to meet specific business demands. A number of proprietary virtual assistant technology tools exist for managing customer conversations across mobile, web and social media channels.

Existing system utilisation:
A number of TOCs already employ DST systems and these are described in more detail in *Section 13.6.7.4* below. It follows, therefore, that if mutually acceptable terms were agreed, the development of existing system architectures could be explored as an alternative to the in-house method outlined in *Section 13.6.7.2* above. Such agreements would normally necessitate the drafting of formal contractual documents to safeguard any commercial and Intellectual Property Right (IPR) arrangements (e.g. non-disclosure and licensing requirements, copyright protection, patent and trademark registration, etc.).

Overview of existing TOC systems:

Some examples of specific decision support tool applications:

- Southern has a 'Managing Train Fault' database (MTF) that provides consistency for fault rectification. It includes a defect matrix and spreadsheet of on-call engineers. Drivers are taken through a step-by-step guide of what to check for in different scenarios. If it is unclear what the failure is then key critical questions are asked in the early stages. All drivers on the Southern network have access to mobile phones.
- Southeastern has an extensive online 'wiki'-based system that utilises on-train remote condition monitoring. Remote access is via tablet or smartphone. A 'yard-board' gives an overview of depot activities and restrictions.
- c2c has complemented their paperback aide memoire system with an internet-based flowchart application that is available on tablets and smartphones. A teleconference facility between drivers, signallers, controllers and technicians is also undertaken.

First Group has an extensive web-based fault tree system that permits external access. Remote access trials are underway using tablets. A dashboard gives visibility of all live incidents

West Midlands Trains adopts a general training aid that identifies critical systems and components using photographs and schematics.

Generic customer requirement specification (CRS):
A generic CRS for a vehicle incident decision support tool has been developed by RDG in collaboration with various industry stakeholders and is included as Appendix G of the 20PP. The CRS addresses both commercial and technical requirements and can be used as a guideline for DST development/procurement.

<u>Incident reduction tools</u>

Below are some examples of incident management tools used by several different TOCs. The list is not exhaustive but shows where certain concepts could be developed to meet individual requirements. It should be noted that all the concepts shown below can be used on several different media (paper, smartphones and tablets, etc.).

- Interactive Virtual Train is a tool that has been designed to simulate the workings of various types of rolling stock through an interactive DVD. It contains computer generated images (CGI), video segments and written documents on a range of train-based equipment and failure modes. It can be used for various activities such as training, incident management, fault-finding and defect simulation, all in a safe environment with no need to take a resource out of traffic.
- Every TOC should have a 'defective on train equipment' standard. This will have been risk-assessed to ensure that all failure modes have suitable responses, and locations to take out of traffic are correctly documented. The standard will include mitigations needed for degraded working modes on stock (such as speed restrictions) to enable it to remain in traffic where permissible.
- Avanti West Coast use a B6 contingency planning document that details on a fleet basis how a failed train can be used for the remainder of the current journey and the remainder of the day. This document is issued to the fleet engineer, control and drivers so that everyone involved in a failure is clear on what actions are required.
- Some TOCs have online tools which show where isolation cocks are located and the procedure for carrying out the isolation. These tools are used by fleet engineers within the control centre; this information is then passed on to the driver at the incident. This enables the driver to be guided, thereby reducing the overall incident time. These online tools also contain much more information on incident reduction techniques. Southern have developed an online management of train failures tool with guides for the controller which allows for accurate information to be passed to the driver.
- Northern, Southern and SWR have a maintenance controller working 24/7 in each control office. All staff requiring technical assistance contact the maintenance controller, who will direct them accordingly and, in conjunction with the control team, make the most suitable decision to manage the situation ('phone a friend').

- Fleet cards/in-cab notices (layout of train) enable the driver to have all phone numbers critical to managing an incident. In-cab notices allow for exactly the same numbers as the fleet cards but show a layout of the train with axle numbers, etc.
- Aide memoirs are concise guide books used to remind the driver of what to do in the event of a train failure, e.g. the sequencing of isolations as well as critical information such as train layout, critical phone numbers, etc. These have proved quite successful for fleets where failures are less common due to improved reliability.
- Train position mapping often uses the Wi-Fi positioning and TMS systems to provide a map of where all the fleet are positioned simultaneously and also the positioning of a failed unit relative to access points and hazards such as canals, rivers, etc.
- RCM (remote condition monitoring) is fitted in trains in different forms and will vary between fleets depending on the TOC, the age of the fleet and the level of investment. It could be engine monitoring systems, door monitoring systems, remote OTDR downloads, GPS-based systems, electrical monitoring systems, etc. Newer trains have RCM systems fitted as standard.
- On West Coast there is an agreement that where a failed train needs to extend its couplers, a driver requesting a block will be granted it as a priority to minimise overall delay. This priority also applies to other failures where line blockages are required to inspect the train. In many cases, it is better to implement the block early rather than delay.
- Southern have a managing train fault database (MTF) that provides consistency for fault rectification.

Appendix J – Creating a Lean Process (for Overhaul)

This appendix highlights tools[16] to make the overhaul process more efficient and improve the quality of the outputs.

Create a process improvement culture

Having the right workplace culture is key to successfully implementing and embedding the process improvement techniques described below. In a workplace with an improvement-focussed culture, staff will:

- Know what the common goal is and what good looks like
- Understand the role they all play in delivering the goal
- Feel empowered to identify problems and make improvements[17]
- Be supportive of colleagues and work as a team to achieve the common goal, and
- Feel pride in a job well done.

It is critical to create a culture where staff feel able to identify problems and are involved in creating the solutions.

Identify and eliminate waste

Activities are either value adding (VA) or non-value adding (NVA). VA activities are those which:

- Transform the asset
- The customer cares about (i.e. would pay for), and
- Are done right first time (correcting a defect created within the process is not value adding).

NVA activities are also called waste. It is good practice to identify and eliminate/reduce them. They can be identified as follows:

- **Transportation**
  Transportation is movement which occurs between process steps (e.g. if the asset needs to be sent away from the main overhaul facility to another facility for specialist work, or if the asset needs to be moved from one part of the facility to another). In these examples, transportation could be eliminated (or minimised) by bringing the specialist to the main overhaul facility or by optimising the facility layout.

- **Inventory**
  Inventory is having too much stock. Good stores management will ensure that there is the right amount of equipment available for the overhaul and that larger items are ordered in a timely manner so that they are delivered to the point of use when required.

- **Motion**
  Not to be confused with transportation, motion concerns in-process movement. While the asset is being worked on, if the worker has to go to the stores to collect equipment, this is wasteful. Ideally the worker should move as little as possible and have all tools and equipment easily to hand.

- **Waiting**
  Waiting occurs as a result of bottlenecks because part of the process takes longer than others (i.e. the process flow is not balanced). In a process like overhaul, which typically has only one asset being worked on at a time, bottlenecks could result in people having nothing to do whilst waiting for colleagues to finish. Multiskilling staff or combining process steps are ways in which the process flow can be balanced, and bottlenecks removed or reduced.

- **Over-processing**
  Over-processing is doing more than required to the asset. To prevent this, there should be standards or guidelines for each task so that it is clear what is expected and that it is done

[16] This is not intended to be a comprehensive summary of all lean techniques.

[17] This does not mean making unilateral changes without involving anyone else.

consistently by all members of the team.

- **Over-production**
  Over-production may not be a common form of waste in the overhaul process. It is typically where more items are produced than required. This could be a symptom of process problems which cause variation in quality.
- **Defects**
  Defects are mistakes. There are many reasons why mistakes occur (e.g. having the wrong tools, equipment, plans or training). It is important to identify defects early in the process and be able to identify the underlying cause, otherwise they could re-occur. Process handovers are a good opportunity to identify defects early and reduce the impact of the asset reaching the end of the process and requiring correction.

Another way to eliminate waste is by using 5S. It is a particularly good technique to improve in-process activity:

- **Sort**
  Ensure that the workstation only has the tools, material and work instructions required for the activity being undertaken at that workstation. This reduces the risk of defects caused by using the wrong work instruction or tool.
- **Set**
  Arrange items to ensure efficient workflow and eliminate time looking for tools or materials.
- **Shine**
  Ensure the work area is clean. This reduces the risk of contamination and enables defects to be spotted more easily.
- **Standardise**
  Where possible, ensure consistency between workstations (e.g. use of shadow boards, electronic version-controlled work instructions.)
- **Sustain**
  Ensure that improvements are embedded in standard procedure so that they are not forgotten about once a 5S drive has ended.

Root cause analysis

There are many reasons why defects occur, and it is important to consider all factors before attributing cause. Too often, individuals are blamed for causing a defect without considering other factors. This can harm employee relationships and will not necessarily prevent the defect from re-occurring in the future. In order to identify the true causes behind a defect, it is important to engage those involved to utilise their expertise and obtain their buy-in to implementing any changes.

- **Cause and effect[18] analysis**
  This is a useful tool to identify all possible causal factors for a defect. It helps prevent individuals assuming one particular cause without considering other possibilities.
- **5 whys?**
  This is a useful technique to apply after the cause and effect analysis. It helps to identify the true root causes, which is important if the solution is to be properly embedded within the process to prevent the problem re-occurring in the future.

Once the causal factors have been identified, it is important to select the most likely root cause(s). This can

[18] Also commonly known as a fishbone diagram or Ishikawa.

be done by data collection or group to vote[19] (as appropriate).

Evaluate the outcome

Yield is a useful measure. There are different ways of calculating yield, so it is important to decide which is the most appropriate for the operation in question during the mobilisation stage.

- **Process yield**
  Gives the quality at the end of the process and can be used as a proxy for customer satisfaction[20] but does not take into account re-work.
- **First-time yield**
  Gives the quality at any point in the process.
- **Rolled yield**
  Gives the probability that an item will pass through the process defect-free.
- **Normalised yield**
  Gives the average yield per process step.

[19] Use n/3 voting where n is the size of the group. Each member gets the same number of votes and can cast them on the cause and effect diagram using sticky dots. This can be done in silence (to prevent more vocal members from dominating the discussion). The issues with the most votes should be addressed.

[20] Assuming that customer (in this case the TOC) satisfaction only relates to the quality of the overhaul output. Yield does not take into account other factors such as on-time delivery and cost.

Appendix K - Performance Measurement Indicators

	Key Performance Indicator	Description	Measure	Target
Leading	**Asset life**	*This monitors the maintenance history and interventions on critical assets throughout their life. Other data recorded is component creation, usage information (hours/miles operated) and scrappage date. Assets considered are not limited to wheelsets, bogies, engines, motors, AWS/TPWS, etc.*	Preventive planning	Extend maintenance periodicities
	Wheel wear rate	*To monitor/compare the rate of wheel wear in different seasons for better understanding of seasonal impact on units. Also helps to prioritise planned maintenance.*	Preventive planning	Uptime & industrial wheels measurement limit
	Unavailability of mandatory exam kit per period	*Availability checklist of all required tools, parts & components for scheduled maintenance. Parts are usually made available to fitters as kits placed by the side of the maintenance road. This should record:* $\frac{\textit{Total number of deficient kits per shift}}{\textit{Total number of kits per shift}}\ X\ 100$	Maintenance scheduling	<10%
	Open work orders	*Monitors all open work orders for a depot across all fleets per period as a percentage of the total volume of work raised.* *e.g. wheel lathe, HVAC, doors, etc.*	Maintenance scheduling	<20%
	Available for services	*Records all units ready/available for services on daily/weekly basis. This should be measured at a particular time of day, prior to morning and evening service peaks, e.g. at 05:30*. Example TOC operates 300 trains per week and 240 trains are available. $\frac{240}{300}x100 = 80\%$	Uptime	% of the total fleet
	Repeat defects	*Measures the number of reported incidents linked to a known fault per period. Repeat defects show that the underlying root cause has not been identified.*	Maintenance strategy	<5
	Delays due to defect	*Reports total primary delay attributed to a sub-system per period and displayed as a Pareto so engineers can see which sub-system is having the largest impact on service.* *It helps to show which sub-systems need more work/fault-finding.*	Maintenance strategy	<10 delay incidents per device per period

	Outstanding defects	*Monitors reported issues, defects which have not been attended/instigated, e.g. any isolation by drivers logged in the book but not raised as a work order.*	Maintenance scheduling	<5 per unit per week
	Degraded mode	*Monitors the volume of trains per period entering service with an allowable degraded mode as per TOC's DOTE.*	Performance	<5 per unit
Lagging	**Technical issues per period**	*Records the total number of technical defects per unit per period including Mp701D and other non-service-affecting defects. It shows which unit is performing worst.*	Performance	No. of defects per unit
	Number of days taken to repair	*Monitors how many days it takes to repair/attend to a reported defect.*	Execution	<3 days
	Tweet (fault reported by customers)	*Monitors how long it takes to repair/feed back on faults/issues reported by passengers on social media. The issue must be reported/mentioned more than 5 times by at least 5 different passengers.*	Execution	<5 days
	Late on	*Monitors the sum of unit lateness per period to the depot for planned maintenance and examination. It shows how much maintenance time is lost due to unit lateness as a sum of the minutes.*	Punctuality	>3 mins
	Off-depot lateness measure	*Monitors the sum of unit lateness per period off the depot for operation. It shows how much operational time is lost due to unit lateness as a sum of the minutes.*	Punctuality	>3 mins
	Maintenance-induced failure	*Monitors the number of issues raised after light or heavy maintenance work. Some units come back worse than before (something missed or incorrectly added during scheduled maintenance).*	Performance	Total per period