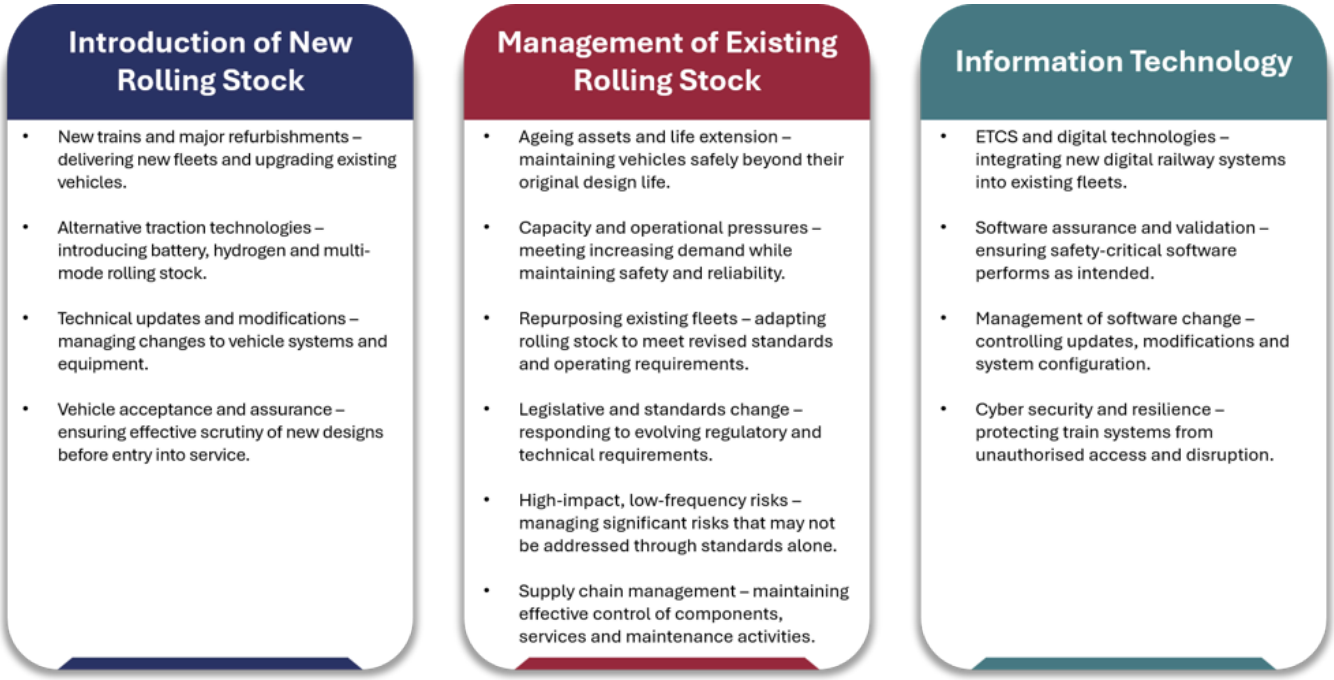
Rolling stock

Executive summary

The industry, regulator and other stakeholders have well-developed arrangements relating to the management of rolling stock risk. These include regulations, guidance and standards. With the introduction of new technologies, material developments and changes in operating practices, these arrangements will need to continue to develop and evolve.

Rolling stock encompasses self-propelled trains, traction units, multiple units, passenger carriages, freight wagons, and mobile railway infrastructure construction and maintenance equipment. The railway continues to operate a diverse range of vehicles across different operating environments, from conventional driver-operated railways through to increasingly automated systems. The safe operation of rolling stock depends upon effective design, risk assessment, maintenance and operational management throughout the vehicle lifecycle.

ORR views the following as the key current and future rolling stock challenges:



ORR will continue to use its range of inspection, enforcement and permissioning powers to influence industry to address these challenges. ORR will continue to work with industry to encourage consideration and implementation of health and safety by design from the earliest stages of project development, increased focus on engineering change, improved management of software and software-based systems, effective implementation of National Technical Specification Notices (NTSNs), and the adoption of emerging technologies where they can improve safety and performance.

ORR also encourages the development of new and novel rolling stock that manages risks throughout the operational life of vehicles, coherence between original design parameters and overhaul specifications, and continued improvement in Entity in Charge of Maintenance (ECM) arrangements and wagon maintenance management.

Dutyholders should ensure that risks associated with rolling stock are effectively identified, assessed and controlled throughout the vehicle lifecycle, including design, authorisation, operation, maintenance, modification and renewal.

- → Next Our view of the risk

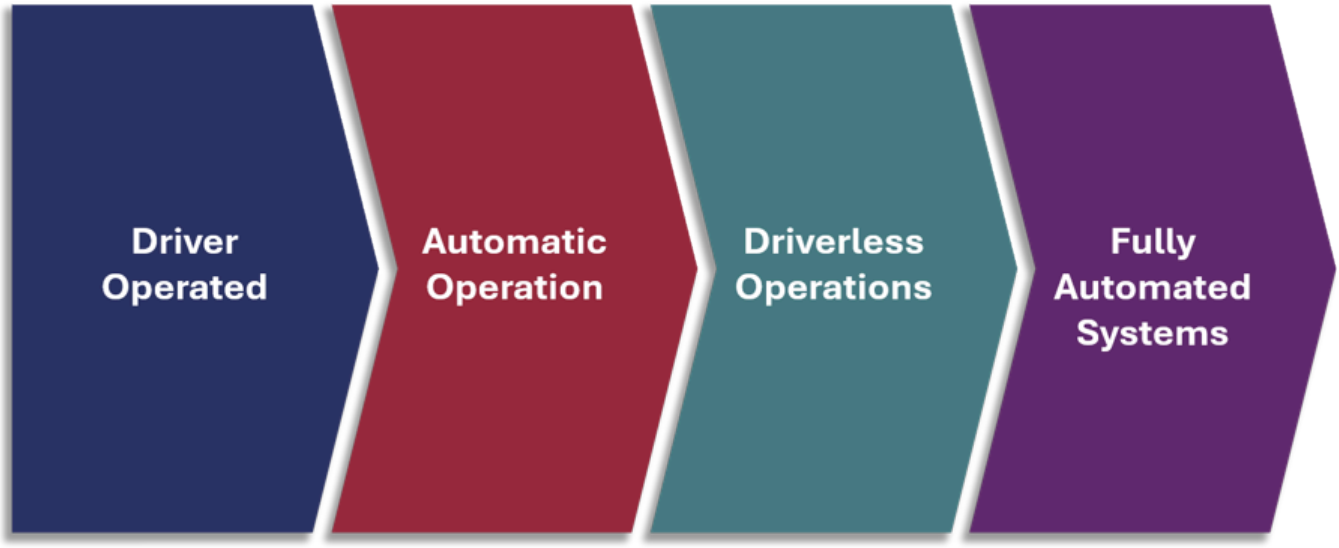
Our view of the risk

Rolling stock systems and operations

In this chapter, the term rolling stock is used to cover self-propelled trains, traction units, multiple units, passenger carriages, wagons and mobile railway infrastructure construction and maintenance equipment.

Different parts of the railway system often have different rolling stock challenges and issues to manage. These challenges are heavily dependent on the underlying railway operating systems, which broadly fall into four types depending on the extent of automation. These range from traditional rolling stock operated by a driver responding to signals, through to systems where automatic control is used for all or part of the journey, fully automatic trains operating under the control of central systems, and automated people movers where the entire operation is conducted without on-train staff.

Railway operating systems



Design, standards and safe operation

The safe operation of rolling stock is managed by a fit-for-purpose design supported by a robust risk assessment and, where required, the implementation of standards. For the mainline GB railway, compliance with some requirements is compulsory through obligations under the Railways (Interoperability) Regulations 2011 (RIR). The Regulations prescribe the use of National Technical Specification Notices (NTSNs) and National Technical Rules where applicable.

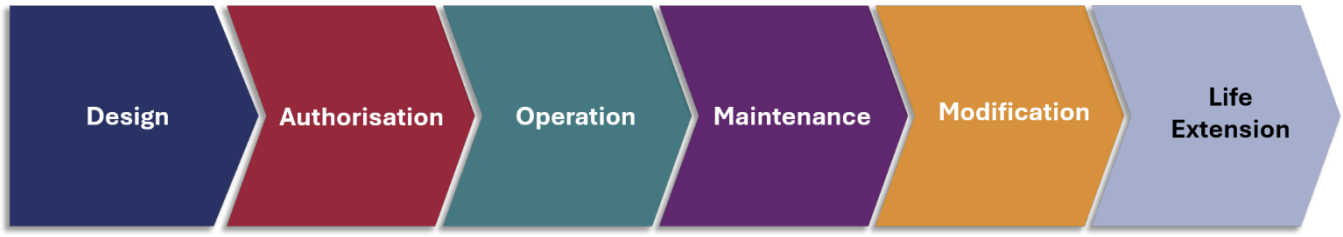
It is important to remember that conformity to NTSNs to meet obligations under RIR does not guarantee that safety obligations under ROGS or other safety legislation are met. Rail safety law requires entities making significant changes to the railway to apply the Common Safety Method for Risk Evaluation and Assessment (CSM REA), identify hazards and apply appropriate mitigations for the circumstances. This may identify that additional or alternative measures are needed to ensure the safety of rolling stock.

Compliance with National Technical Specification Notices (NTSNs) does not automatically demonstrate compliance with wider railway safety duties.

If the designer's risk assessment processes are not sophisticated enough to identify gaps, a train that meets the NTSN may not meet the legal standard for safe operation under operational or geographically driven local constraints or freedoms. Risks identified should be assessed and managed through design so far as is reasonably practicable. The designer should identify and document residual risks that they are proposing to transfer and ensure that the operator or asset owner is fully aware of, and accepts, those risks. Similarly, the train operator needs to conduct a risk assessment at a sufficiently early stage, considering and, if necessary, challenging risks identified by the designer that are proposed for transfer.

Further guidance is provided in the health and safety by design strategic risk chapter.

Safe introduction of rolling stock



New or significantly upgraded rolling stock must be authorised before it is placed into service on the GB mainline railway. Rolling stock authorised in an EU member state requires additional authorisation before entering service in Great Britain. GB-specific requirements for safety and technical compatibility must be met regardless of whether an authorisation has been issued elsewhere.

ORR has a specialist team of professional engineers who support inspectors in the oversight of

train operators and the rolling stock they operate. The team is responsible for authorising new, upgraded and renewed rolling stock and provides guidance on the authorisation process under RIR. ORR also carries out inspections to ensure operators apply the principles of the Risk Management Maturity Model (RM3) when managing the systems that underpin the safety assurance of rolling stock.

Freight wagon safety

Freight wagons play a critical role in the movement of goods across the railway network. Their safe operation depends on effective maintenance arrangements, appropriate loading practices and the management of the interface between vehicles and infrastructure. Failures in any of these areas can increase the risk of derailment, disruption and environmental damage.

In recent years, there has been an increase in the number of freight wagon derailments. Causal factors have included offset loads and locked wheelsets that increase the propensity to derail, particularly on twisted track or at crossings. While correct loading remains essential, the interaction between wagon condition, loading configuration, adhesion and track conditions can significantly influence derailment risk.

Investigations into freight derailments at Llangennech, Ferryside, Llanharan and Petteril identified locked wheelsets as a major contributory factor. The RAIB report into the Llangennech derailment found that a mechanical separation between the interfaces of the brake relay valve and the distributor resulted in a partial brake application, leading to a locked wheelset. Low adhesion is also considered a significant factor in the development of wheel flats and subsequent derailment risk.

The industry continues to develop technologies capable of identifying emerging defects before component failure occurs. This includes trackside equipment designed to identify unequal wheel loading across axles and other conditions that may indicate an increased risk of derailment. Such technologies have the potential to provide early warning of developing defects and support more effective maintenance interventions.

Case Study: Llangennech derailment

On 26 August 2020, a freight train travelling from Milford Haven to Theale derailed near

Llangennech, Carmarthenshire. The derailment and subsequent damage to wagons resulted in a significant fuel spill and fire, causing extensive environmental damage in an area designated as both a Site of Special Scientific Interest and a Special Area of Conservation.

The subsequent RAIB investigation identified deficiencies in wagon maintenance and monitoring arrangements by Entities in Charge of Maintenance (ECMs) and certification bodies. In response, ORR carried out a programme of inspections of selected ECMs to examine maintenance arrangements and determine whether similar weaknesses existed more widely across the freight sector.

ORR's inspection programme found that ECMs generally applied established engineering practices to maintain mechanical components, but there was limited coordinated activity across the sector to address low adhesion as a precursor to wheel damage and derailment. The findings reinforced the importance of effective maintenance management, condition monitoring and industry-wide learning.

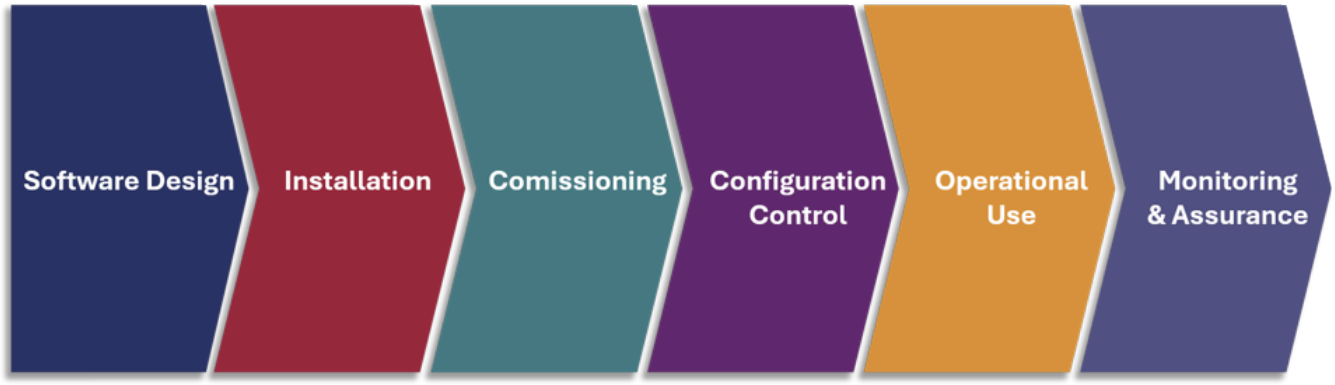
In response to the RAIB recommendations, RSSB established a steering group which resulted in the publication of:

- Guidance Note – Application of the Entity in Charge of Maintenance Regulations (GMGN2697)
- Key wagon maintenance principles

These publications support industry understanding of maintenance responsibilities and wagon management arrangements.

Software and digital safety

Software interacts with multiple subsystems within and beyond the train itself, interfacing with mechanical and electrical systems. Modern railway systems are increasingly dependent on software and there have been instances where software changes have introduced problems to wider train systems. Software changes could impact safety-related systems and therefore require effective management throughout the system lifecycle. The application of robust cyber security measures is important to prevent unauthorised access to train systems.



Increased use of Train Service Agreements, whereby the manufacturer undertakes maintenance of the fleet on behalf of the duty holder, could lead to the import of risks. The duty holder remains responsible for managing those risks and must ensure that suitably competent personnel maintain visibility of changes being made and their interaction with other train systems and subsystems.

Following a number of safety incidents involving software-based systems in operational use on the railway, where software faults were found to be a contributory factor, RSSB established the High Integrity Systems Group (HISG) to commission research into the use of high-integrity software. This work informed the development of GEGN 8650, which has since been replaced by RIS-0745-CCS Client Safety Assurance of High Integrity Software-Based Systems for Railway Applications.

ORR encourages duty holders to implement relevant industry standards and good practice when developing, modifying and maintaining software-based systems. As software, digital technologies and connected systems become increasingly important to railway operation, the industry will need to continue developing the skills, competence and assurance arrangements necessary to manage associated safety and cyber security risks.

Further information is available in the digital safety strategic risk chapter.

Adhesion and braking performance

The performance of rolling stock braking systems is critical to the safe operation of the railway. As rolling stock evolves, potential risks need to be identified, understood, and managed.

Whilst incidents due to brake equipment/component failure have become less common in recent years, there have been a number of precursor events which have mainly been caused by issues

relating to safety critical brake systems and components.

Reliable braking performance has become more important since the introduction of the European Train Control System (ETCS). It is essential that there is predictable braking performance to enable the on-train computer to determine safe speeds and thus deliver full automatic train protection (ATP). There is further work to be done to optimise algorithms and ensure that the duty holders apply the system intelligently to maximise benefits.

ORR acknowledges the development of innovative wagon technologies, including systems designed to prevent wheel flats, which have the potential to enhance safety, reduce maintenance costs, and mitigate the risk of similar incidents in the future. Engineering controls such as these that prevent wheel slide should be considered by freight operators.

In response to the need to improve adhesion in both traction and braking, the GB rail industry has elected to install on-board sanding systems to mitigate the effects of low adhesion. The use of sanding controls, including Double Variable Rate Sanding (DVRS), should be considered, particularly on busy routes where there is a need to maintain high volume of trains. The need for automatic train operation brings challenges to achieve dependable braking.

Case Study: Talerddigg

Recent events, such as the collision at Talerddig on the Cambrian Line, underscore the critical importance of ensuring train sanding systems remain operational. This depends on effective maintenance practices reducing the possibility of hidden or undetectable failures so far as is reasonably practicable, which would compromise braking performance where adhesion relies on sand delivery.

To meet these challenges the industry will need to innovate and understand the impacts of new technologies and systems. Electro-magnetic track brakes and eddy current brakes are alternative braking technologies that are now in use in several European countries.

As these technologies develop and more information is gathered from successful implementation, the industry should continue to assess the suitability and viability of these and other approaches to address low adhesion conditions in line with the Rail Technical Strategy. The wider implications of low adhesion are discussed in detail in the strategic risk chapter on interface system safety.

Train door safety

Train door-related incidents remain a significant safety concern. The two principal risks are trap and drag incidents, where a door system fails to detect an obstruction, and passengers stepping or falling from incorrectly opened doors. Whilst door technology continues to improve, effective procedural controls remain essential to manage residual risk and to ensure safe train dispatch.

	Trap & Drag	Incorrect Door Opening
Risk	Obstruction not detected	Wrong-side release
	Passenger entrapment	Off-platform opening
	Injury or fatality	Passenger fall
Technical Controls	Obstacle detection systems	Correct-side enable systems
	Door interlocks	Door control systems
Operational Controls	Train dispatch procedures	Dispatch procedures
	Staff vigilance	Driver/guard checks

There have been issues with obstacle detection systems on some passenger fleets which have required modifications to door systems. For this reason, ORR continues to encourage the industry to improve door systems, including the adoption of new technology where reasonably practicable.

However, increasing reliability of door systems should not lead to reduced vigilance. Procedural controls remain an important safeguard where safety depends on train dispatch activities and human intervention.

Passengers may also be exposed to risk if doors are opened incorrectly, including opening on the wrong side at stations, outside platform limits or outside station areas. ORR continues to support the development of correct-side door enable systems to reduce these risks.

Particular risks remain on charter and heritage operations involving MK1 and MK2 coaches without central door locking. Hinged doors may open whilst a train is in motion, creating risks to passengers on board and people standing on platforms.

Key message

Improvements in train door technology can reduce risk, but safe train dispatch continues to depend on effective operational procedures, staff vigilance and appropriate controls for older rolling stock.

Historical rail vehicles

The heritage sector is diverse and includes heritage vehicles, historic rail vehicles and other older vehicle types operating on both standard and narrow gauge railways. It continues to grow and, by its nature, relies on rolling stock operating well beyond its original design life. Heritage organisations and operators of older vehicles therefore need a clear understanding of asset condition and effective safety management arrangements to identify and control risk so far as is reasonably practicable.

Many heritage railways operate former mainline vehicles which typically require more intensive inspection, maintenance and overhaul than modern rolling stock. The challenge is often compounded by difficulties obtaining replacement parts and retaining the specialist engineering skills needed to inspect, maintain and repair ageing equipment.

Table 1: Key challenges facing historic rail vehicles

Challenge Area	Key Risks and Considerations
Ageing Assets	Corrosion, wear, fatigue and deterioration of structures and components
Skills & Competence	Retaining specialist knowledge to inspect and maintain ageing traction and carriage stock

Challenge Area	Key Risks and Considerations
Parts & Materials	Obtaining replacement parts and suitable substitute materials
Engineering Change	Managing risks arising from repairs, modifications and replacement components
Legacy Hazards	Asbestos, slam doors and droplight windows
Modern Equipment	Introduction of newer traction and rolling stock technologies into the heritage sector

Maintaining expertise within the sector is an increasing challenge. Whilst arrangements for managing the risks associated with steam and diesel locomotives are generally well established, the capability to manage the risks associated with ageing carriage stock is less mature, particularly regarding inspection, structural integrity and long-term asset management. ORR continues to work with the Heritage Railway Association (HRA) to encourage the development of guidance and good practice in these areas.

Historic rail vehicles often contain hazards associated with older designs and construction methods. Many items of traction and rolling stock built before the 1980s contained asbestos. Although much of this has been removed, some vehicles may still contain asbestos-containing materials and operators must maintain suitable management arrangements to control the risks to workers and the public.

Table 2: Legacy safety risks

Legacy Feature	Principal Risk	Typical Control Measures
Slam Doors	Passenger falls and accidental opening	Door locking systems, dispatch procedures and operational controls
Droplight Windows	Passengers leaning out of moving trains	Engineering controls and window restrictions
Asbestos	Exposure during operation, maintenance or restoration	Asbestos management plans and controlled removal programmes

Case Study: Twerton

Fatal injuries have occurred when passengers have leaned from droplight windows on older rolling stock, including the incident at Twerton. Following RAIB recommendations, rolling stock operating on the mainline network with droplight windows has either been withdrawn from service or modified with engineering controls to prevent windows being opened whilst the train is in motion. This reinforces the importance of engineering controls where the potential consequences of error are severe.

Many of the challenges faced by the mainline railway are also present within the heritage sector, although often in a different context due to the age and historic nature of the rolling stock. Historic railways continue to operate steam, diesel and electric vehicles, together with a small number of battery-powered vehicles. By their nature, historic rail vehicles do not comply with current standards and therefore require proportionate risk assessment and management throughout their operational life.

Steam locomotives present additional challenges associated with boiler integrity and compliance with the Pressure Systems Safety Regulations 2000 (PSSR). Diesel-electric locomotives introduce

electrical hazards that require appropriately trained and competent staff. As more modern rolling stock enters preservation, heritage operators must also manage risks associated with high-voltage systems and newer technologies that were not previously encountered within the sector.

New build and reconstructed vehicles

There is a growing trend to build new heritage-style vehicles. These include new builds and the assembly of parts from existing vehicles to form another vehicle. Any new vehicle (whether a new build or assembled from parts from existing vehicles) must demonstrate it is safe to use before it enters service. Depending on the intended use of the vehicle, there are a number of approaches to determining the appropriate level of assessment. They include compliance with original standards, comparative assessment and evaluation from first principles.

Whilst ORR has no formal role in approving new build vehicles for operation on the heritage networks, we will maintain oversight of them and engage with heritage railways to encourage a level of assessment commensurate with the intended operation. We expect that projects can demonstrate use of approved designs and that change from the original designs are effectively considered and assessed.

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Compliance expectations

The law

Health and safety legislation relevant to the management of rolling stock assets includes, but is not limited to, the following:

- Health and Safety at Work etc. Act 1974 (HSWA)
- Railway Safety (Miscellaneous Provisions) Regulations 1997
- The Provision and Use of Work Equipment Regulations 1998 (PUWER)
- Management of Health and Safety at Work Regulations 1999
- Railway Safety Regulations 1999 (RSR)

- Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS)
- The Railways (Interoperability) Regulations 2011 (RIR).

HSWA places responsibilities on duty-holders to reduce risks to their employees, other workers and members of the public, so far as is reasonably practicable. Everyone working on the railway should ensure that they comply with the relevant requirements set out in health and safety legislation.

In addition to the management of health and safety regulations, statutory provisions exist in respect of rail vehicle accessibility. They impose design and operational requirements on operators to ensure that rail vehicles are broadly accessible to passengers with a wide range of reduced mobility:

- The Railways (Interoperability) Regulations 2011 (RIR)
- The Rail Vehicle Accessibility (Non-Interoperable Rail System) Regulations 2010
- Accessibility NTSN (formally the Persons with Reduced Mobility NTSN)

Entities in charge of maintenance

ROGS requires an identified Entity in Charge of Maintenance (ECM) to be responsible for managing the maintenance of railway vehicles and ensuring they are in a safe state of running.

ROGS requires anyone placing a vehicle in service or using it on the mainline railway to make sure that an ECM is assigned to it. The ECM also needs to be registered on the National Vehicle Register (NVR). If the vehicle is a freight wagon, the ECM must obtain an ECM certificate from a competent certification body to demonstrate that they have established a maintenance system and meet the conditions for holding a certificate in Schedule 10 of ROGS or Commission Implementing Regulation (EU) 2019/779 (depending on the certificate issued). ECMs responsible for freight wagons in domestic service must hold ECM certification issued by a UK certification body.

Each ECM must ensure that its vehicles are regularly maintained to be safe to run on the mainline railway. The regular maintenance of vehicles must be carried out in accordance with:

- The maintenance files for that vehicle
- Applicable maintenance rules
- Applicable NTSNs and NTRs.

All ECMs must comply with the retained Common Safety Methods for monitoring (CSM Monitoring) and risk evaluation and assessment (CSM REA).

Regulation 18A of ROGS extends the scope of offences under section 33(1)(c) of the Health and Safety at Work etc Act 1974 to include an offence committed by:

A person who places in service or uses a vehicle without:

- An ECM being assigned to it;
- The ECM being registered in the National Vehicle Register;
- The ECM holding an ECM certificate if the vehicle is a freight wagon; and
- The ECM ensuring that a vehicle it is responsible for has been maintained in a safe condition and is safe to run on the network.

ORR expects ECMs who have responsibilities for vehicle maintenance to review their risks, including reviewing the effectiveness of processes put in place to ensure all systems and components (particularly safety critical ones) are fully functioning and correctly maintained. This is to ensure vehicles are maintained in a safe condition and are safe to run on the network, through co-operation between those that operate it and the end user.

ECMs should review the technology and systems currently used to identify how improvements can be made to detect and support defect investigation and management. This should include, where appropriate, software and supply chain management and engineering change management processes.

ORR's regulatory strategy for vehicle maintenance and our reasonable expectations of ECMs when operating in the UK require anyone placing a vehicle into service or using it on the railway to:

- Select a competent ECM and establish a working relationship with that ECM;
- Ensure all the necessary information is provided to enable the ECM to carry out its duties;
- Specify any particular conditions of use of the vehicle (e.g. type of goods transported);
- Ensure that the vehicle is put at the disposal of the ECM to perform maintenance activities consistent with decisions concerning the Fleet Maintenance Management; and
- Ensure, where technical problems are detected, corrective action is taken by the ECM.

Changes to ROGS were introduced by The Railways and Other Guided Transport Systems (Safety) (Amendment) Regulations 2023 with effect from 30 June 2023 to require ECMs of freight wagons used in the UK to hold an ECM certificate issued by a certification body accredited by the UK

accreditation body UKAS.

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- → Next Continuous improvement

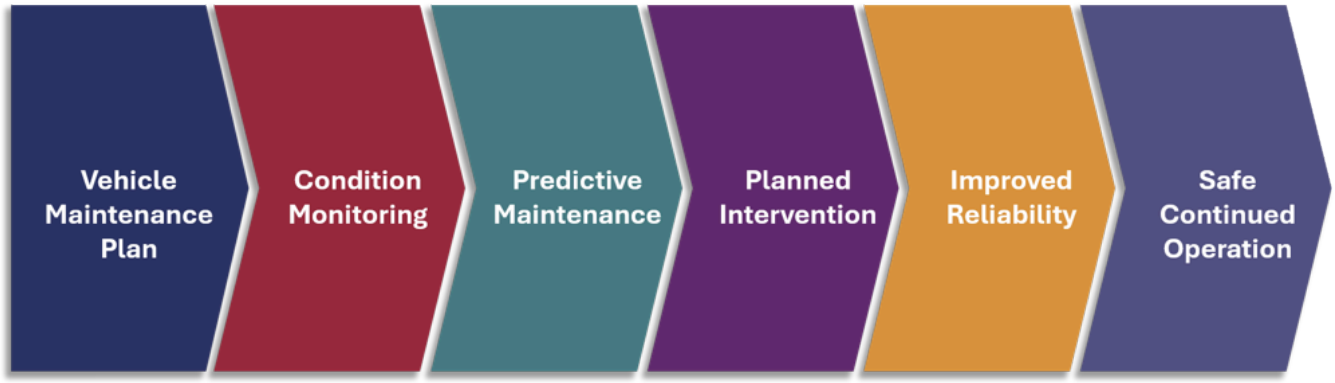
Continuous improvement

Maintenance and asset management

Most maintenance of rolling stock is governed by a vehicle maintenance plan specific to the type of rolling stock. These plans prescribe maintenance activities and frequencies, although variations may be required to reflect differences in operating conditions and service cycles. Any revision to Vehicle Maintenance Instructions (VMIs) should be subject to appropriate change control processes.

Some rolling stock operating on the mainline railway is nearing, or has exceeded, its original design life. Maintenance and life extension will therefore remain important challenges for the industry. Whilst appropriate maintenance can ensure continued compliance with original design requirements, older vehicles may not achieve the same safety performance as modern rolling stock, particularly in areas such as crashworthiness. When undertaking overhaul and life extension activities, duty holders should consider opportunities to improve safety and performance, particularly where concerns have been identified during operational service.

Maintenance improvement pathway



The adoption of modern technologies can support a more proactive approach to maintenance. Predictive and condition-monitoring technologies have the potential to identify degrading

components well before failure occurs, allowing maintenance activities to be planned more effectively and reducing the likelihood of in-service failures. ORR encourages duty holders to consider opportunities to move beyond traditional maintenance approaches where these technologies can improve safety and reliability.

Despite established industry controls governing the supply of components and services, a significant proportion of rolling stock defects continue to be associated with supplied components, either when new or following overhaul. Effective collaboration with the supply chain remains important to improve reliability, understand recurring defects and develop longer-term improvement strategies.

The increasing use of automation and digital railway technologies may also influence maintenance requirements. Changes in vehicle operating characteristics, such as frequent transitions between traction and braking or repetitive operating cycles generated by automatic train operation, can alter wear patterns and affect component life.

Table 3: Future maintenance considerations

Theme	Key Consideration
Ageing Assets	Managing vehicles operating beyond their original design life
Life	Considering safety improvements during overhaul and refurbishment
Predictive Maintenance	Using monitoring technologies to identify defects before failure
Supply	Improving reliability of supplied components and services

Theme	Key Consideration
Automation	Understanding the impact of new operating patterns on component wear
Engineering Change	Ensuring modifications do not adversely affect maintenance requirements

Particular attention should be given to modifications made to support automatic operation. The impact of these changes on vehicle dynamics, braking behaviour and component wear should be fully understood. For example, changes in braking profiles may alter wear rates and influence maintenance intervals. Maintenance regimes should therefore be reviewed whenever significant operational or technical changes are introduced to rolling stock.

Health and safety by design

The engineering design of rolling stock should address the majority of risks associated with its use, minimising the need for operational risk controls. Standards provide a starting point for a design that is broadly fit for use on the GB network, but they must be accompanied by a clear understanding of how the vehicle will be operated and the environment in which it will be used. An effective design process identifies and controls risks at the earliest opportunity.

Failure to consider the intended use of a vehicle can result in risks being identified late in the design process. This can lead to increased costs, delays to introduction into service, operational restrictions, and the need for additional operational controls to manage risks that could otherwise have been addressed through engineering solutions. In some circumstances, it can also lead to the withdrawal of rolling stock from service while solutions are identified and implemented.

For this reason, ORR promotes the application of health and safety by design principles, including effective planning, early risk identification, compliance with standards and adoption of good practice. Early consideration of lessons learned from previous projects and advice from operators can help reduce the need for costly late-stage modifications and improve overall project

outcomes.

Risks addressed during the design stage are generally easier and less costly to control than risks identified later during testing, operation or maintenance.

Further guidance is available in the health and safety by design strategic risk chapter.

Engineering change

Engineering change is the alteration of the function, performance or physical characteristics of a vehicle. It can introduce risk where the wider impacts of the change are not fully understood or effectively managed.

Engineering change may involve physical modifications to rolling stock, such as installing new signalling equipment, altering braking systems or replacing components. It may also include changes to maintenance methodologies, such as moving from time-based maintenance to condition-based or mileage-based maintenance regimes.

Duty holders should ensure robust change management arrangements are in place to assess the impact of proposed changes, identify associated risks and implement appropriate control measures. Effective engineering change processes are essential to prevent new risks being introduced into rolling stock systems and maintenance arrangements.

Engineering change should be managed as a whole-system activity, taking account of impacts on vehicle performance, maintenance requirements, operational practices and safety-critical systems.

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Annex A: Glossary

Acronym	Definition
ATP	Automatic Train Protection
ECM	Entity in Charge of Maintenance
ETCS	European Train Control System
HISG	High Integrity Systems Group
HSWA	Health and Safety at Work etc. Act 1974
NTSN	National Technical Specification Notice
ORR	Office of Rail and Road
PUWER	The Provision and Use of Work Equipment Regulations 1998
RIR	The Railways (Interoperability) Regulations 2011
ROGS	The Railways and Other Guided Transport Systems (Safety) Regulations 2006

Acronym	Definition
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RM3	Railway Management Maturity Model
RSR	Railway Safety Regulations 1999
TSI	Technical Specification for Interoperability
UKAS	United Kingdom Accreditation Service
VMI	Vehicle Maintenance Instruction

- ← Previous Continuous improvement

- ← Previous Continuous improvement