Rail Delivery Group

National Rail

RDG Guidance Note: New Trains – A Good Practice Guide

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About this document

Explanatory Note

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Other Guidance Notes or Approved Codes of Practice are available on the [Rail Delivery Group (RDG) website](#).

Executive Summary:

This Guidance Note describes good practice that organisations should consider when they are specifying, contracting, procuring, design reviewing, testing, commissioning and introducing New Trains.

Issue Record

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1	October 2019	Initial Draft for industry Comment
2	March 2020	Document updated in the light of comments received from industry consultation
2.2	March 2022	Document updated in the light of an identified deficiency with respect to the contracting of availability requirements.
3.1	March 2024	Document updated in the light of additional good practice identified at the joint RDG / Rail Partners New Fleets and Fleet Cascade Conference held in May 2023. Draft Document Issued for industry consultation.
3.3	October 2024	Further updates to the document following the period of industry consultation.

This document is reviewed on a regular 3-year cycle.

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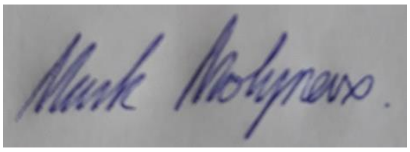

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Contents

1 Purpose and Introduction

1.1 Purpose

This Guidance Note describes good practice that organisations should consider when specifying, contracting, procuring, design reviewing, testing, commissioning and introducing New Trains.

It is accepted that typically the same organisation does not usually undertake all of these functions, but it is essential that all organisations involved clearly understand their responsibilities and importantly any 'gaps' are identified and resolved quickly.

Good Practice Example:	***A 'Responsibility Matrix' should be jointly agreed / reviewed and understood and reflective of where responsibilities are allocated.***

This Guidance Note also describes good practice that organisations should consider when in receipt of trains that are 'cascading' from another operator.

This document also attempts to identify 'good practice' in terms of how to both specify and contract for a New Train and it is the intention that it is used in combination with the existing Key Train Requirements (KTR) document, since the KTR specifies detailed requirements for the train only.

A successful New Train introduction project is very much wider than the train itself and this document is designed to cover these non-train specific aspects.

1.2 Introduction

In recent years there have been several high-profile instances where the rail industry has experienced difficulties introducing New Trains.

It is a fact that New Train projects have experienced difficulties meeting anticipated deadlines for fleet introduction. Unfortunately, there are numerous reasons for this and this document highlights the major issues that relatively recent projects have experienced.

Some of the issues are as a consequence of the procurement process, both in terms of the content of (or omissions from) the relevant contract and the train specification itself.

It is accepted that some of the issues were also a direct consequence of 'over optimism' during the historical period of Operator Contract 'Franchise Bidding', but these pitfalls will remain whatever the future New Train Procurement arrangements are developed.

Even when New Trains are introduced to service late, their reliability is often very poor. It can sometimes take several years for a New Train to replicate the reliability performance of the 'old' trains that they are designed to replace. (It can therefore seem perverse to stakeholders that hundreds of £millions are being invested to apparently make the railway worse).

It is therefore in everyone's interests that industry accelerates the reliability performance improvement of New Trains. Manufacturers benefit by the fact that they will succeed in securing new orders as a consequence of demonstrating their ability to design, manufacture and deliver a reliable train and our passengers benefit by not being subjected to delays caused by untested and unreliable New Trains.

It is therefore also in everyone's interests to improve the processes surrounding obtaining the necessary 'approvals' to introduce the New Trains into service since long delays to projects do not present the industry in a good light with the national media.

The situation is further complicated by the increasing use of software control in recent designs of New Trains. The increased complexity of these systems has often resulted in New Trains being 'debugged in public' which significantly contributes to their unreliability. This bad situation is also exacerbated by the time needed to properly validate subsequent software 'fixes'.

Between 2017 and 2022 the industry embarked on a programme to introduce approximately 7,900 new vehicles. This represented approximately half of the national fleet that already existed prior to this time.

In the light of this unprecedented volume of change and continuing problems with New Trains projects during 2018 several cross-industry workshops were held and an independent expert was commissioned[1] to undertake a review of the risks to service delivery and network performance that may arise from the high level of New Train introduction in Railway Control Period 6.

It is a fact that where New Train programmes e.g. Pendolino; the early builds of Electrostar; the Intercity Express Programme experienced significant difficulties, good progress has only been made once a more collaborative approach was adopted by the affected parties working together to resolve the problems faced (as identified in the independent expert review[1]).

This Guidance Note attempts to distil the relevant points made during previous cross-industry events and capture the salient points contained in the independent expert report[1].

This document has also been updated to include key content of the joint RDG / Rail Partners New Fleets and Fleet Cascade Conference that was held in May 2023.

Where specific examples of good practice have been identified these are presented to illustrate the point – in order to facilitate sharing with future projects for their consideration.

Similarly, where specific examples of bad experience have been reported these are also presented as Learning Points to illustrate the issue - in order to make future projects aware of the potential pitfalls.

[1] Risks to Network Performance from New Train Introduction. P. Hinde, RDG New Fleet Introduction Risk Manager 18/04/2018.

2 Train Specification

2.1 Background

If the specification of the train you require is not correct, there is little chance of achieving a successful outcome – since it is highly unlikely to meet your requirements. Getting the specification of the train correct is therefore absolutely critical and whilst this takes significant effort and is difficult to get 100% right, it should be considered as time well spent - since it will inevitably save time and reduce problems in the long run.

Requirements should be objective and measurable and the means of demonstrating compliance should be clear.

Learning Point:	***Too often, the question of 'What do you mean by that?' is asked at the wrong end of the programme.***
Learning Point:	***Don't generate requirements that are not really deliverable – they are simply not helpful!***

A further consideration is that due to the fragmented nature of our industry, the organisation that specifies the train is typically not the organisation that will be taking delivery of the train and subsequently having to either operate and/or maintain it in service.

There can therefore be a significant disconnect between the specifiers and operators of the New Trains.

In addition, consultancies are typically employed to develop train specifications on behalf of train procurers and it is asserted that they often have 'template' train specifications that they use as their starting point.

As a consequence of all of this, since they are not necessarily aware of the experiences of operating the trains that they have specified (often many years previously) the 'train specification templates' are often not reviewed or updated in the light of experience and the same mistakes are therefore repeated for subsequent train procurements.

Learning Point:	***There is a thought process that everything needs to be specified. Determine what you want the train to do through a functional/operational specification, let the manufacturer determine how. Do not be tempted to tell a manufacturer to alter its standard system because you know better – it inevitably leads to problems.***

2.2 Learning the Lessons - KTR

In order to address the previously identified potential disconnect between the organisations and to capture (and therefore hopefully learn) the lessons from previous train designs, the wider industry has collaborated to produce the Key Train Requirements (KTR).

KTR is intended to assist rolling stock procurers, manufacturers and system suppliers to (amongst other things) compile train procurement specifications by drawing attention to experience that has emerged from historic rolling stock projects. It is also the intention that a structured review of the KTR is used to inform which requirements are of particular relevance to the project train specification. KTR was never intended to be used verbatim for procurement purposes.

The current KTR is on its seventh iteration (v7) and can be accessed at the following link.

2.3 Specifying for Safety

It is a fact that a train that has been designed to the relevant National Technical Specification Notices (formerly Technical Specifications for Interoperability (TSI)); European and national standards (and has even been third party assured) is not necessarily safe to operate (see 2.9).

The reason for this is that interoperability is an economic initiative that exists to remove barriers to trade by establishing common standards and processes. It does not of itself provide a means of achieving the requirement of UK health and safety law of eliminating risks so far as is reasonably practicable and therefore this assurance process does not consider local technical and operational issues associated with the operation of the train including the infrastructure it is intended to operate over.

The Office of Rail and Road have stated that train designers should adopt the concept of 'health and safety by design.[2]'

Health and safety by design is to preferably eliminate, and if not eliminate to control, health and safety risks in rolling stock, equipment and processes by early consideration of potential risks and then dealing with those risks at the design stage. In addition, the Management of Health and Safety at Work Regulations 1999 impose a hierarchy of risk controls, prioritising engineering controls over, for example, procedural measures. Hazards should therefore be designed out, requiring early identification and incorporation into the design process rather than relying on them coming to light by a risk assessment once the design of the train has been established, and inevitably being managed by work-arounds.

Train specifications should therefore explicitly state that compliance with health and safety by design is a requirement.

In addition, the hazard identification process in accordance with the Common Safety Method for Risk Evaluation and Assessment[3] (CSM-RA) needs to be properly managed to ensure that local operational and technical constraints are covered and all of the hazards are being managed by the most appropriate party and that they have agreed and are therefore aware of any risk that they are expected to manage (see 4.4).

Learning Point:	***Despite being fully compliant with all relevant braking standards there was an incident on a previous New Train fleet where despite the driver selecting the service brake, these did not apply for approximately 22 seconds. This risk had indeed been identified by the manufacturer, but it had not been communicated to the operator that they were managing this risk – through the use of the Emergency Stop button. The root cause of this is as a result of the absence of assigned safety criteria for the service brake in the TSIs – that were in force when the train was specified.***

Safe integration of the vehicles with operations and the Safety Management System is the responsibility of the Operator so it is therefore essential that appropriate representatives from the Operator are involved in the design process to ensure that the operational needs are appropriately addressed. It is a legal duty under ROGS; an operator who fails to engage with the design process may be failing to comply with the law.

2.4 Specifying for Operational Resilience

It has been shown that stranded trains on the network increase the overall level of railway system risk.

As a consequence, it should be the aspiration that there should be no single point failure that results in the train becoming stranded and in need of rescue.

Practically, this is unlikely ever to be achieved. However, trains should be specified that minimise the number of single point failures.

Train designers should be requested to identify all potential single point failures related to their design that has the potential to result in a train becoming stranded on the network.

The objective is to ensure the manufacturer understands and is able to quantify the reliability risk of single point failures and to encourage them to amend their designs to mitigate single point failures

[2] https://orr.gov.uk/__data/assets/pdf_file/0009/21402/strategic-chapter-12-health-and-safety-by-design.pdf
[3] Refer to RSSB and ORR Websites for the relevant guidance on the application of CSM-RA

where a cost-benefit analysis demonstrates that it is economic to do so e.g. incorporating multiple air compressors, pantographs, etc.

In addition, trains should be specified with effective remote condition monitoring functionality that is capable of not only driving the overall maintenance requirements for the train, but also intervening when a maintenance intervention is required as a result of an emerging defect – prior to any adverse effect on service – and of equal importance with sufficient notice, so that management action can be taken to move the train to a suitable location for the necessary maintenance to be actioned.

Learning Point:	***To date, whilst Remote Condition Monitoring (RCM) Systems are commonplace on recent builds of new trains they are typically not being used to provide the biggest benefits. The vision that needs to be realised is that the RCM system should drive the fleet maintenance requirements – something that has yet to be delivered by any manufacturer.***

The issue with modern RCM systems is they typically transmit more information that is genuinely necessary. An RCM system that will provide, position, utilisation (mileage, hours etc) and any active faults (based on the TCMS messages) will generally give the best benefit for the simplest cost. The key, as this document alludes to later, is to simplify/categorise the TCMS messages correctly so that reaction to either on train or RCM messages is correct/proportionate.

Another key aspect is to disconnect the use of RCM as an in service management tool from the RCM equipment for maintenance management, the two requirements can be diametrically opposed, one deciding on what to do now, one deciding on what to do at the next maintenance intervention. Mixing them up leads to vehicles being removed from traffic for issues that could be easily dealt with at the next scheduled maintenance event.

The impact of technical failures on the comfort quality of the passenger environment is often overlooked.

Functionality should be such that the impact on the passenger environment and amenities should be minimised in the event of a loss of external power supply for a specified period (dependent upon service type). The autonomy of the train should be defined in the initial specification to reflect the operator’s capability to react to a loss of external power supply such that no passengers remain on the train by the time onboard power supplies are no longer capable of maintaining the passenger environment.

2.5 Specifying for Operational Functionality

The specifier should be very clear how the train will be operated and requirements should therefore be articulated in functional requirement descriptions.

A good train specification will therefore be written in terms of ‘functional output specifications’ as opposed to input specifications. In other words, the train specification should specify the ‘what’ in order to leave the train designer to take care of the ‘how’.

The operator needs to conduct a thorough risk assessment at a sufficiently early stage of how the train will operate in the real world and also taking into account the conditions and restrictions with which they are familiar but the manufacturer is not - so that any identified hazards are managed through engineering controls.

In addition, functionality should be considered in terms of reliability since it has been suggested that the industry likes to specify new shiny things, but we don’t adequately consider why we actually need them, nor potentially consider the implications on overall reliability. ‘Keep it simple’ should therefore be the mantra.

There have been numerous occasions where the deficient specification of operational functionality has created problems once the train is in operation. This is increasingly the case with the advent of ‘fly by wire’ train control systems where complex software control systems have been designed.

Learning Point:	***A manufacturer of a recent fleet of multiple units did not appreciate that the operator intended to regularly 'split' and 'join' multiple unit formations in service. The manufacturer had assumed (wrongly) that splitting and joining would only be undertaken under controlled conditions in a depot environment Not surprisingly, this created reliability problems when the trains were introduced to service. Since the train specification did not describe the way the train was intended to be used by the Operator the manufacturer was left to make assumptions that turned out not to align with the Operator's requirements.***
Learning Point:	***The recent build of CAF New Trains were designed so that they had to undertake a 'Brake Test' every 24 hours. When they were first introduced the Operator was not aware of this requirement and experienced trains failing in service - since the trains were reporting that the brake test was 'overdue'***

It is a truism that train designers are not train operators and train operators are not train designers therefore a mutual understanding of the needs and constraints of both Operator and designer will improve the specification and delivery.

It is therefore essential to specify the operational assumptions and requirements associated with any New Train. This is often overlooked as the focus becomes predominantly about engineering requirements and the associated operational needs are addressed too late in the day and may necessitate a costly redesign.

Good Practice Example	***Operational needs should be identified during the development of the 'Concept of Operations'; and followed through e.g. via the Human Factors Integration (HFI) process.***
Good Practice Example:	***In order to assist the rail industry procure high integrity software control systems, RSSB have published Rail Industry Standard (RIS) RIS-0745-CCS: Client Safety Assurance of High Integrity Software-Based Systems for Railway Applications[4]. This RIS includes a set of principal requirements, rationale and guidance on the specification, use and management of software-related systems.***

2.6 Specifying for Diagnostic Functionality

More recent train designs typically include a Train Control and Management System (TCMS) that can monitor, control and report on the status of virtually all of the train systems.

Much unreliability witnessed with recent designs of trains has been caused by train diagnostic systems being relatively 'immature.' This is considered an aspect of train design that has frequently been neglected and is therefore worthy of increased focus by both Operators and manufacturers.

A direct consequence of these 'hypochondriac' diagnostic systems is that they bombard the driver with each and every event that the TCMS has witnessed so that the driver is overloaded and therefore confused with respect of the course of action that should be taken to resolve the situation.

Good Practice Example:	***In order to prevent confusion and therefore unreliability in service, operators are very clear that messages and alarms appearing on driver interface screens should be concise, relevant and helpful in managing a situation.***
Good Practice Example:	***Proper HFI ensures the needs of the user are met and only the relevant information is provided in a structured, salient way that the driver understands, knows how to response to and has opportunity to do so.***

As a consequence of this, the philosophy that should be specified in relation to the events that are reported to the driver by the TCMS are only events that require immediate action from the driver. This information management has the potential to affect the management of safety risks and should be the

[4] https://www.rssb.co.uk/standards-catalogue/CatalogueItem/ris-0745-ccs-iss-1

Learning Point:	***Some existing designs of trains collect vast amounts of data but ultimately provide little useful information on which decisions can be made.***

subject of formal human factors integration, which goes beyond simply ensuring the information presented is concise, relevant and helpful. This is a legal duty.

The additional philosophy that should be specified in relation to all events (including those reported to the driver) is that they should be remotely reported to maintenance control.

An aspect of diagnostics that is often overlooked is that the diagnostic data needs to be transformed into information that is able to support operations and to support the management of performance.

2.7 Specifying for Flexibility

We currently design trains to operate for typically 35 – 40 years. A lot can change in that time.

Train interiors should be specified to be much more flexible in terms of seating configuration since operators need to be much more flexible in terms of the business offering that they are able to make. It is also pertinent to highlight that trains are unlikely to stay on the routes that they were originally specified to operate for their whole life.

Good Practice Example:	***Seats that are cantilevered from the vehicle body side are considered to be a design feature that contributes to the provision of a flexible train interior.***

Ideally, train interiors should therefore be configurable so that the use of the space is optimised ‘real time’ dependent upon the needs of the service being operated i.e. high-density capacity during the commuter peak and more spacious and comfortable ‘off peak’ for the leisure traveller.

The amount of luggage space is also something that should be carefully considered.

2.8 Specifying for ‘The Future’ / Obsolescence Management

The process of train procurement to delivery takes several years. A lot can change in that time and if you are not careful, your New Train design can be out of date before it has even been delivered.

There is therefore value in asking a manufacturer to produce an obsolescence risk matrix as part of a train design i.e. how long will components be available/be supported.

Good Practice Example:	***It is considered good practice to specify continuous supply/support for the life of the vehicles ?***
Learning Point:	***Operators are already experiencing issues with obsolescence of traction equipment on 10 year old vehicles.***

Train specifications need to be cognisant of the following foreseen changes:

Climate change: More extreme temperatures and weather conditions are anticipated

Learning Point:	***One fleet of diesel trains shut down as a result of their control system detecting a temperature of 40C ambient on a particularly hot day in 2019 – which was fully in accordance with how the system was designed. The train was designed to operate in accordance with the temperature ranges currently specified for the UK in existing standards – 40C exceeds these specified limits.***
Good Practice Example:	***London Underground specify the maximum ambient temperature that trains are expected to operate as 55C.***

Political Change: The government has previously set the rail industry the challenge to decarbonise by 2040.

Good Practice Example:	***Propulsion systems e.g. Diesel engine prime-movers (and associated fuel tanks) should be installed on the vehicle as part of a 'demountable' raft so that ready replacement with future 'clean' propulsion systems e.g. batteries, hydrogen fuel cells is made a simple as possible – once equivalent performance becomes available from these technologies.***
Good Practice Example:	***Propulsion systems should be designed so that as much energy as possible can be 'harvested' e.g. during train braking for either future use by the onboard train systems or regenerated into a 'receptive' traction supply. The use of friction brake and rheostatic brake systems should therefore be minimised since these systems are wasteful of energy.***

Demographic Change: As a result of improvements in nutrition and other dietary changes people are getting bigger - that is both taller and wider. This has implications for the interior seating configurations of trains. Combined with this, due to advances in medical science, people are also living longer. This presents the potential for a future where an increasing percentage of the population will be older and therefore place higher demands on 'Accessibility' of our railway.

Technological change: This continues apace and will continue to accelerate.

Learning Point:	***The Global System for Mobile Communications – Railway (GSM-R) is technology based on 2G telecommunications technology. By the time the system was implemented on the national fleet the rest of the world i.e. the railway's neighbours were already implementing 4G technology.***

In order to be able to adapt train designs for this uncertain future, 'modularity' of systems that facilitate relatively simple changeout should be specified.

Good Practice Example:	***A precursor to the roll-out of the European Train Control System is the fitment of the 'onboard' equipment to rolling stock. Trains should therefore be specified with the expectation that ETCS is fitted (in accordance with 5.3 of KTR v7 to facilitate infrastructure fitment when required.***
Learning Point:	***GSM-R was retrofitted to the national rolling stock fleet during the course of many years. As part of the initial design, there was no requirement to make the design modular in order to facilitate future system upgrade. As a consequence, the subsequent system upgrade that had to be rolled out was considerably more expensive to implement than it would have been had 'modularity' been implemented as an initial design requirement. It has to be the aspiration that the relative simplicity of changing an automobile radio is achieved on the railway.***
Learning Point:	***The amount of technology on board trains is ever increasing. A consequence of this is that it is highly unlikely that the hardware and software systems that are currently operative will be supported through the life of the train. Such systems therefore need to be made modular to facilitate system changeout with 'new' updated versions that are able to provide equivalent functionality of the original components.***
Good Practice Example:	***It is becoming apparent that hardware dependent software to deliver discrete modular systems for multiple functions is costly to purchase and maintain and does not encourage suppliers to maintain systems or support operators. As a consequence, organisations are following the lead set by corporate IT systems by investing in on board edge servers that can be more effectively maintained and virtualising software to be hardware agnostic.***

2.9 Specifying 'Standards'

It is simply insufficient to state in train specifications that the train must comply with all 'relevant standards.'

The reason for this is that manufacturers will therefore equate this statement to compliance with all 'mandatory' standards which, from a legal point of view include only:

- National Technical Specification Notices (NTSNs) – (formerly Technical Specifications for Interoperability (TSIs))
- Any associated references to European Standards
- Notified National Technical Rules (typically contained in Railway Group Standards)

Legally, Great Britain has been prevented from making additional requirements 'over and above' those listed earlier, since it is argued that they represent a 'barrier to entry' to new users of our railway.

As a consequence, it is an unfortunate fact that requirements that have been identified in the light of our experience of operating our railway over the past 200 years cannot currently be legally enforced.

Learning Point:	***Despite being fully compliant with all relevant braking standards there was an incident on a fleet of trains where despite the driver selecting a service brake, they did not apply for approximately 22 seconds. This risk had indeed been identified by the manufacturer, but it had not been communicated to the operator that they were managing this risk – through the use of the Emergency Stop button.***
Learning Point:	***Despite being fully compliant with all glazing optical standards, the design of the windscreen of a recent train design created secondary images of signals at night time which caused a distraction to the drivers. In order to resolve the problem the original curved design of windscreen was replaced with one that was flatter.***

Beyond the requirements in standards listed in above, the law gives projects and entities a choice in deciding how to meet their legal obligations and business objectives.

Rail Industry Standards (RISs) are railway-specific standards that contain requirements, or they set out rules about how systems should be operated or managed. RISs are managed on behalf of the industry by RSSB Committees and have been developed to be used by projects to define functional or technical requirements that are not covered by the standards listed earlier, where a common industry approach is considered beneficial.

In 2019, ORR made amendments to the Licence Conditions for both Network Rail and Operators with respect to expecting these organisations to comply with RISs[5]. With respect to train design there absolutely no reason why compliance with relevant RISs cannot be made a requirement of train specifications.

The licence requirements to comply with applicable RISs are legal duties and ORR can take action in the event of non-compliance. In addition, measures set out in a RIS may be identified as a means of managing safety risk, and therefore they become enforceable through health and safety law. The responsibility falls to the Operator i.e. there is no legal duty on the manufacturer to comply with RIS and that such provisions should therefore be set out in the Contract

Learning Point:	***The manufacturer has no legal duty to comply with NTSNs, ENs and NTRs either – the only duties relating to authorised subsystems fall to the operator. The driver for the manufacturer to comply is the wish to have an authorised subsystem that can be sold.***

Indeed, compliance with RIS should be seen as helpful in that since they are developed by formal industry processes that reflect industry agreed good practice, they can effectively be considered as a 'code of practice' and therefore used by a train operator to demonstrate that the design of the train has been undertaken in line with the Common Safety Method for Risk Evaluation and Assessment.

Learning Point:	***Projects have experienced difficulties demonstrating compliance with non-notified Technical Rules – since these were not included in the 'mandatory' standards list.***

Whilst it takes a significant amount of effort, it is considered good practice to comprehensively list in the train specification all the legislation and standards (including versions) that the train is contracted

[5] https://orr.gov.uk/__data/assets/pdf_file/0011/40403/letter-to-licence-and-snrp-holders-re-rssb-and-rgs-conditions.pdf

to be compliant.

In order to assist train operators in relation to applicable European Legislation the Community of European Railways and Infrastructure Managers (CER) regularly updates a list of relevant legislation.

It must also be stressed that all standards are open to challenge and should specifiers consider that a standard contains 'onerous' or even 'obsolete' requirements they should be challenged for that very reason. This challenge should ideally be made at the earliest opportunity i.e. potentially at the specification or bidding stage.

Good Practice Example:	***The challenge may be in the form of a request to revise the standard or for specific cases to request to deviate from the standard when the intent of the standard can be achieved by other means.***

Conversely, there is no restriction on specifying a higher level of performance than that required by standards where there is an operational need or benefit, since sometimes the outcome of the 'standardisation process' could be considered to result in the lowest common denominator, or only define minimum expectations.

The application of these 'lowest common denominator' standards may result in a failure to eliminate risks so far as is reasonably practicable, and therefore a breach of health and safety law. While standards are helpful, the Operator needs to understand their limitations in managing risk and be cognisant of the potential safety management implications.

2.10 Specifying for Infrastructure Compatibility

Whilst it is possible to manufacture New Trains that are fully compliant with current standards and other legislation, it is a fact that the infrastructure that they will typically operate over (unless they are being procured to operate solely on a brand-new line) is unlikely to be compliant with the latest infrastructure standards in force.

This is because standards do not apply retrospectively and continue to evolve, so railway systems introduced before a particular standard was published are therefore likely to have been built to earlier standards. Additionally, there will always be legacy aspects of the GB mainline network that are not captured by requirements in any national standards due to lack of knowledge about those assets; inherent uncertainty and variability of performance; and/or lack of industry agreement on key design parameters.

This therefore presents a real challenge for manufacturers, since it is the aspiration that the train must also be compatible with the physical assets of existing track, platforms, signals, power supplies, trackside structures, bridges, tunnels, depots, sidings and not to mention the human factors related to passengers, drivers, traincrew and maintainers.

The compatibility process to be followed is described in RSSB Rail Industry Standard RIS-8270-RST: Route Level Assessment of Technical Compatibility between Vehicles and Infrastructure[6] which sets out requirements and responsibilities for the assessment of technical compatibility at route level for vehicles and infrastructure.

Learning Point:	***A class of train was designed to be compatible with the cab sightlines specified in current standards. Unfortunately, it was discovered that the positioning of a platform signal on legacy infrastructure was arranged so that the driver could not actually view the signal when stopped at the platform. Until the signal could be repositioned, in order to introduce the New Train into service, an additional person to the driver had to be provided in the cab. The lesson here is that legacy infrastructure is not necessarily compliant with current standards.***

It is therefore of prime importance to ensure that train specifications are very clear with respect to the specific routes and the associated technical characteristics of those routes for particular design parameters. This is especially true of areas/aspects where previous vehicles may have encountered issues during introduction or operation.

[6] https://www.rssb.co.uk/standards-catalogue/CatalogueItem/ris-8270-rst-iss-1-1

Good Practice Example:	***An Operator reported that specifying all required routes by Engineers' Line Reference (ELR) / Line Of Route (LOR) was considered critical and time well spent, both from a performance and later compatibility point of view. For a vehicle that is expected to operate over all of the GB rail network, whilst this is hard work it was found to reap significant benefits.***

The specified routes should also be reviewed by the operator's planning team since apart from the routes the New Trains are intended to operate over, it is important to identify depot / stabling access routes, diversionary routes and routes to access a wheel lathe.

In addition, this review should also identify any locations requiring temporary access, particularly during the commissioning / acceptance phase where it is likely that there is insufficient capacity to stable both existing and new fleets during the transition.

A robust set of parameters and description of route constraints (or an activity to identify the route specific constraints and challenges) is essential in any procurement specification. This will ensure that the vehicles being procured can, at the very least, be compatible to operate over the legacy infrastructure of those routes or only have to modify the absolute minimum infrastructure where necessary.

Particular attention is therefore needed with respect to signal sighting, train stopping positions at stations and stepping distances - since all legacy signals and platforms are not necessarily compliant with current standards.

Learning Point:	***A class of train was designed to be compatible with existing wheelchair ramps. Unfortunately once the train was introduced to the network it was found that due to the location of the wheelchair accommodation being at the outer extremity of the trainset, due to the taper that was present at the platform end, there was insufficient platform width available at the end of the wheelchair ramp for the wheelchair to safely use the ramp and therefore the stopping position had to be changed.***
Learning Point:	***One Operator had to assess the compatibility of a New Train at over 200 platform locations at 41 stations on the route they intended to operate. These platforms were often bi-directional and shared with other Operators. To further complicate matters they had procured three different configurations of the New Train each having a different length and consequently had to consider the stopping positions of the access doors for wheelchairs, catering and cycles in all of these configurations.***
Learning Point:	***One Operator discovered that you 'could not rely on the published data' in relation to platform lengths and stopping positions. As a result they had to visit and measure the platforms themselves.***

In recent years there has been a proliferation of different designs of 'Stop Markers' on Platforms. In order to improve the level of standardisation across the network and to facilitate collaboration amongst Operators, RSSB developed on behalf of the industry RIS-3782-TOM: Car Stop Markers – Provision on Station Platforms[7]

New Train compatibility is not only in relation to the fixed railway infrastructure, it must also be specified that the New Train must be compatible with the other trains already in operation over the routes. Factors to consider in this respect include Electromagnetic Compatibility (EMC); power demand; passing clearances; coupler compatibility etc.

Learning Point:	***A class of train was initially tested on a route without problem. Once more trains of the same design were commissioned and in operation on the route it was only then that Electromagnetic Compatibility problems with lineside equipment became evident. In order to resolve the problem, there was a need to retrospectively modify the train (by the addition of a line inductor) combined with extensive infrastructure***

[7] https://www.rssb.co.uk/standards-catalogue/CatalogueItem/RIS-3782-TOM-Iss-1

	works.
Learning Point:	***Following the introduction of a new fleet of trains it was found that emissions from a legacy vehicle type interacted with the overhead power supply in such a way that it created an EMC interference issue with the new vehicle type in specific circumstances. The specific circumstance was whilst the new train was stabled drawing power which generated sufficient EMC interference causing a shutdown. This was a condition that was never considered and would never have been identified or simulated.***

Other local environmental factors also need to be considered e.g. the presence of sea spray or other potential contaminants.

Learning Point:	***A class of train was found not to be compatible with the 'sea spray' that was present along the sea wall at Dawlish. The salty water created earth faults on roof mounted resistors that caused the static converters to trip and resulted in the trains becoming stranded. Until a technical solution could be found, these trains were blocked for many years from operating over the affected route during conditions where sea spray was present – causing significant unplanned disruption to passengers.***

In terms of maximising residual value it might initially appear attractive to specify a train that is able to operate everywhere on the GB mainline network, but this train would therefore have to be compliant with all the known gauging 'pinch-points' on the network in terms of tight clearances and would therefore be sub-optimal for the proposed routes of operation. There is therefore a balance to be struck since a train specified for a single network is unlikely to secure the necessary funding whilst there are associated cost and time implications to demonstrating compatibility for 'all routes' and on the infrastructure side the entire network would have to be maintained to accommodate a train it might never see. However, sometimes 'all routes' compatibility is required – e.g. for a freight locomotive.

Another aspect to compatibility is to acknowledge the fact that the compatibility process that is currently employed in Great Britain differs significantly from that undertaken in mainland Europe. It is therefore sometimes difficult for new entrants to the GB rail market to understand and navigate the potential pitfalls.

Learning Point:	***Whilst it may be the case that it can be difficult for new entrants to understand GB's compatibility processes it has been commented that it is the attitude of the proposer to the demonstration of compatibility that has more of an effect on the measure of success than how established a company is in the GB marketplace.***
Learning Point:	***The GB Requirements specified in GERT8006: Route Availability Number for Assessment of Compatibility between Rail Vehicles and Underline Bridges are only applicable for speeds up to 100mph. A specific bridge resonance assessment is necessary for speeds greater than this.***

Compatibility should never be considered a 'one off' to be demonstrated once and therefore in some way 'completed', since this is something that needs to be maintained through the whole life of the train.

It is hoped that the 'Key Interface Requirements' document that is under development (see 5.1) will assist with this.

2.11 Specifying Power Supply Requirements

There is currently a relatively circular problem in respect to traction power supply capability for electrically powered trains.

Traction power supply capability needs to be considered wholistically in that it incorporates all the needs of the other users of the network and not only those services that will be operated by the New Train fleets.

In addition, consideration for future battery charging capability at terminal stations and/or dynamic charging when on the move and commensurate reduction in regenerative braking power returning to the OLE.

Total power supply requirements are not considered for compatibility, since the power supply for one unit is not the same as the power supply required to operate a proposed timetable.

The amount of power drawn by a New Train fleet is therefore heavily dependent upon the timetable that is planned to be operated – as opposed to being something that can solely be attributed to the train design.

Learning Point:	***Some New Train project introductions have been delayed by the fact that there was not enough electrical traction power available to operate the proposed timetable. This is something that was only discovered towards the end of the programme.***
Learning Point:	***New electrical sub-stations cost around £5M at current (2024) prices and around 5 years to install.***
Learning Point:	***Whilst NR undertake Regional Power Supply assessments, NR are not able to deal with this in isolation. There is a need for all stakeholders to collaborate in order to effectively address this issue.***

It is therefore important that the train specification includes a description of the routes (identified previously in 2.10), the infrastructure managers, train formations, stabling plans and the proposed timetable to be operated.

It is also considered crucial that this information is shared with the Infrastructure Manager at the earliest opportunity to confirm any power supply assumptions are correct.

Grid harmonics i.e. the railway harmonics that are emitted back to the grid supply - generated by the rolling stock back into the National Grid should also be considered.

Learning Point:	***Grid Harmonics have increased as a result of the increased roll-out of more modern trains. This needs the Operator, the DfT, the New Train OEM and NR to work together on this – since this cannot be solved by NR in isolation.***

2.12 Specifying for Maintainability

It is often claimed that the manufacturer is primarily focussed on building the train i.e. facilitating quick assembly and it is only a secondary consideration that the train should be maintainable.

Learning Point:	***Whilst manufacturers are aware of the problems experienced by the fleet maintainers from their Train Service Agreements, they often don't involve these teams in their design reviews.***

The train should therefore be specified to be easily maintainable so that all maintenance activities are achievable within a specified timeframe.

2.13 Specifying Availability

The precise requirements for availability targets shall be developed and agreed in terms of whole life costs of the rolling stock.

Unrealistically high availability targets might initially seem attractive (as a result of purchasing fewer vehicles) but it must be borne in mind that overhaul programmes and unexpected damage (e.g. from vandalism or collisions) can rapidly erode any maintenance allocation - leading to subsequent difficulties maintaining service cover.

When proposing the fleet size and availability, a statement shall be provided as to what contingencies have been included in the assessed need that are not related to maintenance, e.g. driver training and collision damage.

Fleet sizes calculated solely on the basis of diagrams and planned maintenance will inevitably result in a lack of availability resulting from other actions such as driver training, modification, vandalism or collision repairs.

2.14 Specifying Reliability

Similar to Availability, specifying high reliability performance targets comes at a cost.

It is recommended that reliability performance should be specified in terms of impact to the fare paying customer and the recently adopted ‘Miles per 701D’ KPI for fleet reliability performance measurement (where 701D is the TRUST KPI Category FLEET - TECHNICAL) is considered an appropriate independent measure of this.

In relation to specifying the target reliability performance, a good starting point would be the current reliability performance of the fleet of trains that are being replaced – with a suitable ‘improvement’ factor added.

The anticipated reliability growth plan from service introduction – to full fleet introduction should be specified that ideally covers both individual train performance and the performance of the combined fleet of trains.

Learning Point:	***Experience has shown that it will typically take two to three years from a New Train service introduction to achieve the contracted levels of reliability performance.***

3 Contracts and Procurement

3.1 Background

There are no published guidelines in relation to train procurement and introduction.

The more comprehensive and explicit definition of contractual requirements reduces the risk of dubiety and therefore subsequent debate and argument with respect of commercial liabilities.

It has been suggested that it would assist the industry if a generic template for New Train procurement contract were developed. However, it needs to be stressed that each New Train project is unique and procurers need to ensure that their contract effectively caters for the specifics of their project.

Similar to the fact that it is crucially important to ensure the Train Specification is as good as you can make it, it is also essential that an equivalent amount of effort should be given to the train procurement contract.

It can be argued that there has been a tendency in recent years to 'over bid' in Franchise Commitments in terms of the delivery of New Trains. Manufacturers are compelled to offer immediate product with short delivery timescales.

Good Practice Example:	***The procurement timescales of Southeastern's Class 395 'Javelin' provides an example of where the train procurement process went well, with the following milestones:*** • ***June 2005: Contract Signature*** • ***August 2007: First Train Delivered for Testing*** • ***December 2009: Full Fleet Service***
Learning Point:	***Procurers should anticipate that it will take around three years for manufacturers to design, build and test a brand-new design of train prior to service introduction.***

Typically, what has happened more recently is that a manufacturer signs up to an 'optimistic' i.e. unrealistic programme to design and deliver a New Train. Not surprisingly, when problems are experienced in relation to the design (as they inevitably do) the original delivery timescales are not met and the relationships between the procurer and the manufacturer become strained. The added complication here is that if the delivery of the New Train is a Franchise Commitment this can place the Franchise holder 'in breach' and potentially lose the Franchise.

There have also been instances where there has been delay in closing contracts with a preferred bidder, but the end dates for delivery have not been adjusted accordingly to reflect this delay – further compressing production timescales.

It can therefore be argued that the root cause of all this 'angst' is therefore the Franchise Bidders setting (and manufacturers signing up to) unrealistic timescales.

Continuing this theme, it could further be argued, currently, that there is a need for the Department for Transport to improve their 'credibility and deliverability' review processes prior to Franchises being awarded.

This assertion is supported when it is considered that, in terms of product design and development looking at other industries it would appear that much less time is spent on this in rail – typically two years - than in either the automotive industry (3-5 years[8]) or aviation (10 years).

Learning Point:	***Class 395 – June 2005 Contract Signature; August 2007 first train delivered for testing*** ***Boeing 787 – Jan 2003: Programme Announced; August 2011 type certificate obtained.***

[8] https://www.quora.com/Automobile-Design-How-long-does-it-take-to-develop-a-car-design-from-scratch

In addition, the need for significant innovation can arise from numerous sources, e.g.:

- from the needs of the manufacturer to update their product platform to remain competitive
- from a client need for enhanced functionality
- from a government initiative or legislation[9]

Irrespective of where the need arises, if there is significant innovation then this also needs to be reflected in the associated contractual timescales.

The rail industry's very short development timescale is undoubtedly a factor in the poor reliability when New Trains are initially introduced to service. Effectively performance is poor as a result of designs that have been 'untested in the field.'

Learning Point:	***Experience has shown that it will typically take two to three years from a New Train service introduction to achieve the contracted levels of reliability performance.***

What follows are proposals that are considered to represent 'good contracting' practices that should implement some of the lessons learned from previous New Train projects.

It is also accepted that the typical 7-year franchise award period does not necessarily provide franchises with the incentive to follow the guidance contained in this section - since the following franchisee takes the financial 'hit' of increased leasing costs etc.

3.2 Train Specification

Considering the time and effort invested in ensuring that the Train Specification is as correct as possible it should be a Procurement Contract requirement that the New Train is fully compliant with the Train Specification and there should be clearly defined Acceptance Criteria to achieve this.

Good Practice Example:	***Avanti West Coast ensured that their existing employees that had experience of the introduction of the previous New Train to their business were able to influence the content of their Train Specification for the New Train they were about to procure. This was designed to ensure that the learnings of the previous New Train procurement were learned – and therefore not repeated.***

It should be a contractual requirement that the procurer (and operator) work together on the design of the New Train.

3.3 Mock-Ups

For brand-new, or significantly different variants of an established design, it is considered good practice to include as a contractual requirement the production of a full size mock-up of the driving vehicle.

The mock up would typically (at least) consist of:

- the full driving cab that includes a fully functional cab door and cab access steps
- a half-length section of the passenger saloon that includes a pair of fully functioning passenger doors and footsteps; wheelchair areas and a section each of priority and non-priority seating (both airline and bay where applicable)
- Catering facilities mock-up

There are numerous purposes that such a mock-up could be used. These include:

- to facilitate the traincrew consultation exercise by physically demonstrating the proposed arrangement of the cab to the traincrew representatives in order to involve them at the outset.
- to undertake a public consultation exercise on the arrangement of the interior e.g. that includes options for different seats or seating layouts.

[9] There is a requirement in the LOC & PAS NTSN (formerly TSI) that repeat orders of vehicles cannot use existing design certification against the NTSN after a period of seven years has elapsed. However, these provisions are changing in the revised rolling stock NTSNs.

- To understand the proposed catering offering by exploring the answers to the following questions:
  - Expectations – What does it need to deliver?
  - How will staff and passengers use it?
  - Reality - Does it match the design?
  - Have the expectations changed?
  - How many different types and sizes of coffee pots are there?
  - Do the sandwiches fit in the chiller?
  - What additional capacity is provided for 'spare' stock?

It should be a contractual requirement that the manufacturer will work with the procurer (and operator) in order to ensure a successful consultation exercise with the relevant industry traincrew representatives in relation to the design of the cab prior to the construction of the first trains.

Learning Point:	***Whilst train manufacturers have a 'product platform' for their train design they sometimes have different designs of cabs on the same platform. One operator discovered that their cab was materially different in design to that which had been previously approved by the relevant train crew representatives and therefore that approval could not simply be 'read over.'***

In order to describe their expectations in relation to cab design, the Associated Society of Locomotive Engineers and Firemen (ASLEF) have produced a 'Cab Ergonomics – Guidance Document'. The document can be accessed at on the ASLEF website here. This is considered a very useful reference document whilst undertaking this consultation process.

Whilst physical mock-ups are considered the optimal approach, virtual mock-ups could also be considered since they have advantage in terms of improved agility in terms of design and significantly reduce production timescales.

3.4 Prototyping

If you are procuring a brand-new design of train it is strongly recommended that your contract contains a requirement for the manufacturer to produce at least two pre-production prototypes (this is especially the case if they will be expected to operate in multiple formations).

Pre-production prototypes allow the manufacturer to understand how they will assemble the train – without the added complication of immediately having full production line logistics to manage. In theory, they can therefore take more time to ensure that all problems are identified at the manufacturing stage and therefore subsequently implemented during the subsequent production run.

These pre-production prototypes (after the necessary testing and validation activities) should be operated in service for a significant period of time (typically 12 months) so that all the issues identified during operational shake down are addressed and this also provides the opportunity to implement these during the subsequent production run.

Another benefit of having a distinct pre-production prototype phase is that it provides a manufacturer with increased flexibility in terms of being able to iterate aspects of the design without having to be subject to a 'full blown' formal Engineering Change Process (as outlined in 3.19).

Good Practice Example:	***When Connex procured the Adtranz Class 375 'Electrostar' they specified in their contract that the manufacturer should construct four pre-production prototype units that should run a combined mileage of 200,000 miles before the manufacturer was expected to manufacture the subsequent units. The manufacturer was also contractually obliged to implement the modifications on the production units that had been identified as needed during the construction and operation of the pre-production prototype units.***
Learning Point:	***More recently, a class of train went straight from the drawing board into the production run. There were so many reliability problems that the relevant fleet manager commented that they sometimes felt that "they have a fleet of prototypes!" In addition, the manufacturer was forced to***

	deploy a technical rider on each and every train in service in order to provide an 'adequate' level of reliability performance.
Good Practice Example:	***When Trans Pennine Express procured the Class 802 fleet, the manufacturer, Hitachi produced two 'pre-series' units in order to verify the changes when compared to previous 'AT300' builds. These changes included a larger fuel tank; a diesel engine with a higher output; a larger rheostatic brake and an alternative 'compact' catering configuration.***

It cannot be stressed enough how beneficial the early interaction is between the New Train; the operational staff; the technical staff; the maintenance staff and also the general public - in order to 'flush out' issues at the earliest opportunity. Such 'user testing' is a cornerstone of good practice in terms of Human Factors Integration.

Undesirable functionality often only reveals itself in service.

Learning Point:	***On one recent design of train the Passenger Information System functionality was only discovered to be not what the TOC wanted until it was already in operation and the TOC representative stated "Who wants to see an overview of London Underground Tube information as the New Train heads off towards the coast?"***
Learning Point:	***On one recent design of train, despite the bodyside door system being designed to current standards, once the train was introduced to service it was found that it was possible for members of the public to damage the door mechanism by simply obstructing the door on closure.***

Once the period of pre-production prototype running is completed the manufacturer can then commence building the production series with increased confidence and can undertake the necessary retrospective modifications on the pre-production prototypes. An added benefit of this is the reduction in retrofit work necessary to implement any modifications on the subsequent fleet which therefore reduces the overall costs to the industry.

It should be a contractual requirement for the pre-production prototype units to be retrofitted by the manufacturer to be subsequently redelivered to production status.

Another advantage of pre-production prototype running is that the operator is able to build up a small core of expertise on the New Train in terms of operational, technical and maintenance personnel that can be used as 'super-users' or 'ambassadors' once the production trains start to be delivered.

There should be no need to include a contractual requirement for a prototype if the train you are procuring is an 'established design' that comes with a 'proven pedigree' of acceptable performance. However, procurers should be wary of manufacturers changing their sub-system suppliers for subsequent orders of supposedly the same 'Class' of train.

Good Practice Example:	***Procurers of 'tried and tested' product platforms e.g. Class 387 Units that were the final incarnation of the 'Electrostar' product platform were buying a proven product.***

The need for pre-production prototypes therefore depends upon the degree of deviation from the mature design. A simple re-configuration of a well-established train design with many units successfully in service should not need a pre-production prototype as such, but significant new systems added (or significantly different control software) for upgraded communications systems to the base design may require pre-production prototypes to be produced.

3.5 Contracting - Payment Milestones

Historically, contract payment milestones have been based upon the manufacturer building hardware e.g. a watertight bodyshell with bogies.

It is important that incentive or penalty regimes are properly thought through since as a result of unintended consequences they can often lead to 'perverse' behaviours from organisations.

It is recommended that there should be contract payment milestones related to the publication of an agreed Operator Statement of Compatibility and receipt of a Network Rail Summary of Compatibility for the train that is (ideally) without restriction, but at the very least is acceptable to the vehicle procurer.

There should also be contract payment milestones based on the New Train demonstrating adherence to an agreed reliability growth plan i.e. staged payments based upon increasing reliability performance of both an individual train and the fleet as a whole.

It is also recommended that a benefits 'share' mechanism should be included in order to incentivise the manufacturer to work with the operator to accelerate the reliability performance of their New Train.

Good Practice Example:	***A typical example of this could be a payment that is made once the reliability of the fleet of New Trains has exceeded the reliability of the trains that they have replaced.***
Good Practice Example:	***Another approach that is often adopted is the 'Performance Bond' approach. This is where payments are made by the procurer into an escrow account and the subsequent payment is made to the manufacturer once the reliability has reached an agreed level.***

The final contract payment milestones should only be made once the contracted reliability performance has been delivered for a consistent period and that all 'service affecting software bugs' have been eradicated through software updates.

For all of these milestones there should be clearly defined Acceptance Criteria that the supplier needs to meet.

3.6 Contracting – Liquidated Damages

Historically, penalties or 'Liquidated Damages' (LDs) are included in contracts that are designed to protect the procurer against non-delivery and therefore incentivise the manufacturer to meet committed delivery dates.

However, these LD's are typically capped, since excessively severe penalty clauses serve no purpose if this causes the manufacturer to file for bankruptcy.

Learning Point:	***Recent experience has demonstrated that whatever LDs are currently written into contracts they haven't prevented late deliveries of New Trains. As a consequence whether LDs as currently defined in contracts are therefore 'fit for purpose' has to be called into question.***

3.7 Contracting – Human Factors

It is important that procurers (and Operators) ensure that the manufacturer understands how the train will be operated.

Learning Point:	***On one recent design of train the manufacturer specified operator responsibilities that could not be complied with e.g. following an air conditioning trip, the crew were expected to open a locked cupboard and reset a circuit breaker that was behind a cover that only maintenance personnel had access to.***

It should be a contractual requirement that manufacturer should comply with the operational requirements for the train and state how they have been met.

There should be opportunity for the procurer, Operator and manufacturer to discuss the requirements and check the manufacturer's understanding. How the manufacturer has purported to have addressed the requirements should be assessed against established Acceptance Criteria before the product - the train - is accepted.

It should be a contractual requirement for the manufacturer and procurer to agree both which diagnostic events and the actual text that is reported to the driver on the Train Management System – as described earlier in 2.6.

3.8 Contracting - Safety Strategy

It is important to recognise that if the designer's hazard identification and risk assessment processes are not sophisticated enough to identify gaps, a train which meets the NTSNs may not be fully safe to operate under specific constraints or freedoms e.g. which are local in nature and operationally or geographically driven – as highlighted earlier in section 2.9.

All participants from designer to end use Operator (via ROSCO, ECM etc..) should therefore be engaged in an end-end risk management programme to ensure that:

1. All hazards/risks are captured
2. All participants understand which risks are exported across interfaces and who is responsible for their control.

It should therefore be a contractual requirement that the manufacturer should identify and fully document those residual risks that they are proposing to transfer to the operator/asset owner.

It is also important that the manufacturer ensures that the operator/asset owner is fully aware and accepts those risks that the designer is proposing to transfer, which should also be a contractual requirement.

It is a legal requirement[10] that the Common Safety Method for Risk Evaluation and Assessment is undertaken jointly by the manufacturer and operator to ensure that both the operator and manufacturer are very clear in relation to the allocation of the risks associated with the operation of the New Train and that any operational requirements related to route specific issues are identified and agreed.

For absolute clarity, it is the responsibility of the Operator to demonstrate 'Safe Integration' of the New Train and therefore will require the manufacturer to be engaged to ensure that this happens in practice. This will help to clarify whether safety risks are addressed by the design, operating practices or a combination of the two.

In an ideal world, there should be no single point failure or set of external circumstances that will result in a train becoming a safety hazard. Pragmatically, it is unlikely that a manufacturer will be able to comply with this requirement.

It should be a contractual requirement that manufacturers state all failure modes or external circumstances that will result in their train becoming a safety hazard, for subsequent review and agreement by the procurer.

Learning Point:	***There have been recent incidents related to propulsion package traction capacitors exploding. Historical traction equipment had pressure switches installed in the capacitors to mitigate this risk, but more recent equipment designs have not included this design feature. This issue has been addressed very recently by the replacement of the affected capacitors with a 'segmented' design that is claimed to eradicate the risk of explosion.***

The Safety Strategy is further complicated by the need to nominate the Entity in Charge of Maintenance (ECM), which dictates the level of influence of that the Train Operator has over the Maintenance Regime (see section 3.11)

An additional consideration is that manufacturers are required to identify safety critical components to the ECM.

It should therefore be specified in procurement contracts that the manufacturer should advise the procurer and ECM of the details of all Safety Critical Components, provide an explanation why those components are critical and specify what needs to be undertaken to keep them safe to the procurer and ECM.

[10] Refer to clause 1.2.1 of COMMISSION IMPLEMENTING REGULATION (EU) No 402/2013 on the common safety method for risk evaluation and assessment

3.9 Contracting – Resilience Strategy

As previously identified (in 2.4), stranded trains increase the level of rail industry system risk and are therefore to be avoided if possible.

In an ideal world, it should be a contractual requirement that there is no single point failure or set of external circumstances that will result in a train becoming stranded and in need of rescue, but pragmatically, it is unlikely that a manufacturer will be able to comply with this requirement.

However, it should be a contractual requirement that manufacturers state all failure modes or external circumstances that will result in their train design becoming stranded and in need of rescue, for subsequent review and agreement by the procurer (and operator).

It should also be a contractual requirement that the manufacturer documents the rescue and recovery procedures for subsequent review and agreement by the procurer (and operator).

3.10 Contracting – Availability Strategy

As previously identified (in 2.13) specifying the correct number of trains needed is often a pragmatic compromise. Whilst the bare number of trains required to meet the planned timetable is easy to identify sufficient spare trains need to be procured to cover the unexpected – especially damage incurred from object strikes on the track or more severe collision damage.

In addition to ensuring sufficient trains are procured in the contract, it is also essential that the contract is written so that there are adequate incentives for the train service provider to ensure the timetable is delivered day-in-day out – since contractual content has been found to drive unexpected behaviours which results in a lack of focus on the simple delivery of the correct number of trains for service.

The contract should:

- incentivise rather than penalise
- avoid mandating aspects that are not within the party's control

Learning Point:	***A recent contract for a fleet of new trains did not adequately capture the effects of damage and vandalism on availability e.g. object strikes. The contract permitted the train service provider to declare that trains that were subject to damage and vandalism as 'outside the availability regime' – since they could not be held responsible for the damage to the train. Insufficient trains were available to meet the service provision, but there was no penalty (or incentive) for the train service provider to repair the damaged trains.***
Good Practice Example:	***Following availability problems with the Class 185 fleet, a contractual side-letter was agreed between Trans Pennine Express and Siemens that funded additional units and improved the engagement and collaboration on availability by buying out the non-availability clause thereby restoring the fleet availability to a level to meet the service requirement.***
Learning Point:	***Recent experience has demonstrated that train service providers are unprepared to deal with the repairs required for crash damaged vehicles. This is in respect of both materials provision, knowledge and readily available repair procedure methodology.***
Good Practice Example:	***The LUL Northern Line contract included 3 additional trains that were owned by Alstom to cover availability as part of a 30-year service agreement.***

3.11 Contracting – Testing Strategy

For projects that have not had the benefit of running pre-production prototypes in service it is important to ensure that the testing programme is appropriate.

It should be a contractual requirement that the manufacturer and procurer agree an appropriate testing plan. This plan also needs to include arrangements for software testing.

Whilst recognising the benefits to be gained through introduction to passenger service as soon as practicable, the testing plan should incorporate:

- Software testing incorporating the whole development lifecycle i.e. needs to extend throughout the life of the train.

Good Practice Example:	***It is recommended that software development should proceed in accordance with the following:*** • ***Functional modelling (to minimise the lines of code to be developed)*** • ***Software integration testing with other connected software systems that will be on the New Train*** • ***Combined testing including 'aerospace Iron Bird' concept which incorporates representative cabling and connectors*** • ***Provision of test bench(es) for use at the depot.***

- Maximising the use of non-mainline infrastructure where appropriate. (This recognises the need that access to the network can be difficult). However, it is also helpful if the test location can replicate as much of the mainline characteristics as far as possible.
- Realistic tests reflecting the anticipated duty cycle foreseen and passenger misuse and abuse tests.
- Stress testing of the train systems in abnormal situations to identify any potentially dormant issues that the train might encounter during its life.

There should be no barrier to the manufacturer demonstrating the provenance of subsystems already used on other designs that obviates the need for tests, but this needs to include documented evidence of satisfactory performance and also agreed with the procurer.

3.12 Contracting - Maintenance Strategy

With the implementation of the 'Fourth Railway Package' in Great Britain in June 2020, there is a need for a 'Certificated Entity in Charge of Maintenance' (C-ECM) for each fleet of trains.

Some recent train procurements have nominated the manufacturer as the ECM, whereas others have the Train Operator nominated as the ECM.

However, there are important implications of this decision, since if the manufacturer is nominated as the ECM, the Train Operator has very little influence over the content of the maintenance and overhaul documents.

Train procurement contracts should therefore clearly state the arrangements in terms of C-ECM for New Train fleets.

The initial maintenance plan is only ever an 'educated best guess' of the manufacturer and sub-system suppliers in terms of anticipated maintenance requirements for the life of the rolling stock.

It is also the case that maintenance requirements are often 'over prescriptive' in terms of protecting manufacturers and sub-system suppliers 'warranties.'

In any event, the actual maintenance requirements are heavily dependent upon the duty cycle of the New Train and are therefore typically optimised over a period of many years.

Components that are over maintained are wasteful of resource, especially where resource could be better employed maintaining components that might have been overlooked in terms of the maintenance plan and therefore impact on fleet reliability.

It is also a matter of fact that there are components installed in rolling stock that will not last for the life of the vehicle that are also not included in the initial maintenance plan. Examples of this are electrolytic capacitors, battery 'back ups' on printed circuit boards, relays etc. only have a finite life – sometimes in the order of 5-8 years and will therefore undoubtedly need to be replaced at a point in the future-preferably just prior to them all reaching the end of their 'useful' life.

It should therefore be a contractual requirement that manufacturers identify all such components and provide an indicative life for their replacement.

It is therefore suggested that a 'benefits share' mechanism is established between procurer and maintainer in order to facilitate the ongoing maintenance optimisation process that will be necessary.

This mechanism provides a real incentive for all parties to establish an optimised maintenance regime which both optimises fleet reliability performance and represents real value for money – for which all parties are beneficiaries.

Another aspect of maintenance that is often overlooked is the provision of 'special tools' or maintenance diagnostic software applications necessary to maintain the New Train. It should therefore be a contractual requirement that the manufacturer identifies all such 'special tools' or software applications.

It should be a further contractual requirement that the manufacturer provides the relevant maintenance diagnostic software in a form that enables its use by depot staff.

3.13 Contracting – Depot, Stabling and Berthing Strategy

In an ideal world, New Trains should be procured with a new depot specifically designed for their maintenance.

Good Practice Example:	***A useful source of information in terms of depot design is GIGN7621: Guidance Note for the Development and Design Considerations of Passenger Rolling Stock Depots.***[11]

However, the realities of life typically get in the way in that new fleets of trains are expected to replace existing fleets and therefore be maintained at an existing depot.

It should therefore be a contractual requirement that a joint assessment (by the manufacturer, maintainer and the procurer) is undertaken of the existing depot facilities for the manufacturer to identify what modifications are required to existing depot facilities in order to maintain the new fleet of trains.

The review should encompass: inspection pits; sidings; headshunts and wheel lathes; carriage washing machines; Controlled Emission Toilet (CET) aprons and other servicing locations; etc.

This is especially pertinent if the length of the New Train set differs significantly from the existing fleets being serviced and maintained and have e.g. engines and water tanks in different positions.

Learning Point:	***Changes in stock formations can have a significant adverse impact on depot, stabling and berthing capacity e.g. 5-car sets that replace 4-car sets dictate that only one set can be accommodated in an 8-car siding - that could previously accommodate 2x 4-cars.***

It should be a contractual requirement that the electrical shore supplies required for the New Trains are compatible with the supplies already in use at the depot unless there is a clear benefit to making changes to the depot equipment e.g. for safety reasons. This compatibility assessment should also include the assessment and confirmation that there is sufficient power available to service the needs of the New Train fleet at the depot.

It should be a contractual requirement that the connections for the replenishment of consumables e.g. fuel, water, potable water, sand, Controlled Emission Toilet (CET), AdBlue, coolant, windscreen wash etc. are compatible with the systems already in use at the depot unless there is a clear benefit to making changes to the depot equipment e.g. for safety reasons.

Good Practice Example:	***Physical tests to verify the operation of the depot systems with the New Train should be undertaken to confirm suitability.***

[11] https://www.rssb.co.uk/-/media/Project/RSSB/RssbWebsite/Documents/Registered/Standards/2020/09/16/10/38/GIGN7621-Iss-1.pdf

It should also be a contractual requirement that any depot modifications are completed prior to the delivery of the first production New Train. If the New Trains programme is subject to the running of pre-production prototypes, this provides the necessary 'window' to complete the necessary works.

Good Practice Example:	***A useful source of information in terms of depot design is GIGN7621: Guidance Note for the Development and Design Considerations of Passenger Rolling Stock Depots.*** [4]
Learning Point:	***The introduction of a new fleet is probably one of the most stressful times for a depot. Not only have the existing fleet to be maintained, but there are the new build vehicle deliveries to accommodate and therefore space, not only at the depot but at stabling and berthing facilities across the network is at a premium. If the depot facilities are also being rebuilt at the same time to accommodate the new fleet then the situation can rapidly become untenable.***

It should therefore be a contractual requirement that a joint assessment (by the manufacturer, maintainer and procurer (and operator)) is undertaken of the plans for stabling and berthing of the new fleet. This plan should be reviewed periodically as the New Train deliveries progress and the existing fleets are cascaded elsewhere. (Refer to 7.6 for more specific guidance on Fleet Cascade).

It should be a contractual requirement that sufficient time is given to training the maintenance, control and technical teams on the New Trains and the requisite number of trains should be delivered in order to support this training. This will be made considerably easier if the new fleet of trains have been subject to the running of pre-production prototypes (as per section 3.4)

As a result of late New Train deliveries, the time available for staff familiarisation and training is typically an aspect that comes under significant pressure to compress timescales in order to have trains in service. This must be resisted as far as possible - as doing so is often a false economy since the introduction of New Trains into service when the people tasked with operating, maintaining and providing technical support are not really ready simply generates more problems than it solves.

3.14 Contracting – Documentation Strategy

Notwithstanding the ECM arrangements outlined earlier in section 3.11, there is often a perceived reluctance from manufacturers to produce sufficient documentation that will support the operation and maintenance of the train for the whole of its life. This inhibits the operators, technical teams and maintainers from really understanding how the train is designed to work and often makes subsequent fault finding almost impossible.

It is therefore very important to agree the arrangements for the provision of Design Authority and technical support responsibilities for the whole life of the train.

As a minimum it should be a contractual requirement that the manufacturer and procurer (and operator) jointly develop the following documentation:

i. Train Operating Manual
ii. Technical Information Manual
iii. Technical Drawings
iv. Illustrated List of Components
v. Fault Finding Guides - including the use of diagnostic software applications
vi. Electrical Schematics
vii. Software Schematics
viii. Vehicle Maintenance Manual that includes:
    - Vehicle Maintenance Schedule
    - Vehicle Maintenance Instructions
    - Vehicle Maintenance Procedures
    - Vehicle Overhaul Instructions
    - Component Overhaul Instructions

Good Practice Example:	***A 'cloud storage' solution assists the collaboration process, storage and version control of these documents.***

3.15 Contracting - Power Supply Strategy

For electric trains, it should be a contractual requirement that the manufacturer will work with the procurer (and operator) to obtain confirmation from the Infrastructure Manager that there is sufficient electrical traction power available to run the proposed timetable of the New Train fleet.

It should also be a contractual requirement that the manufacturer will work with the procurer (and operator) to obtain confirmation from the Infrastructure Manager that there is sufficient electrical traction power also available at all stabling / berthing locations.

It should also be a contractual requirement that the manufacturer will work with the Infrastructure Manager to confirm that any potential Grid Harmonics generated by the rolling stock are acceptable to the National Grid.

In the event that there is not sufficient power supply available, it should be a contractual requirement that the manufacturer should review their train design with the aim of reducing power consumption.

It is accepted that there is a practical limit to what a manufacturer can potentially achieve with this.

If it is ultimately determined that there is indeed insufficient power available, alternative strategies such as reduced timetable demand or power supply upgrades need to be considered.

Learning Point:	***There have been many instances where New Trains have suffered a delay to service introduction as a result of power supply limitations that only became evident at a very late stage in the project.***

3.16 Contracting – Simulator Strategy

It is considered good practice for driving simulators to also be procured – since this will significantly reduce the amount of time needed to train the necessary drivers.

Learning Point:	***Expensive high-fidelity simulators are not always necessary. Some training needs can be effectively delivered with lower fidelity simulation e.g. laptop simulation.***

It should be a contractual requirement that manufacturers also provide the necessary details to support the software on the simulators in order to ensure that updates to the functionality of the trains in service is simultaneously replicated on the simulators and that therefore the simulator software is kept up to date.

3.17 Contracting – Commissioning Strategy

The Operator will only ever be able to commission a specific number of trains at a time dependent upon their available resource – or the resource of their commissioner if they have sub-contracted the commissioning to another organisation.

Learning Point:	***As a result of delays to the delivery of New Train fleets from different manufacturers the Operator found that the number of New Trains they had to commission was becoming unmanageable.***
Learning Point:	***As a result of the delivery profile of New Trains exceeding those that the operator could use in service, a large proportion of a recent build of new trains had to go directly from the factory into storage. The trains could not be used by the operator since they had yet to be fully approved for passenger use and they also needed significant rework prior to the units being commissioned.***

It is therefore considered good practice for there to be a contractual requirement for procurers (and Operators) to agree with the manufacturer the number of New Trains that will be commissioned at any one time – so that the expectations are clearly laid out at the outset.

The New Train commissioning plan should facilitate the New Trains operating a specified number of miles of ‘fault free running’ on the mainline before the next New Train can be offered by the manufacturer for commissioning.

It is considered good practice that the commissioning has two phases, with phase one in 'non-passenger shadow running' to ensure that all of the train systems are correctly functioning without passengers on board, whereas phase two will involve the trains operating in passenger service.

The precise number of 'fault free miles' will have to be determined based on the operational diagrams that are possible to ensure that the overall commissioning plan is achievable.

Good Practice Example:	***In the late 1980's, the much later batches of the Class 321 fleet manufactured by BREL York were introduced directly to passenger service from the production line.***

It is accepted that, compared to legacy fleets the number of on-train systems that need to be tested and commissioned has increased rapidly and therefore commissioning a more modern design of train compared to 'legacy' fleets could be considered more complex. However, this is counteracted by the fact that increased levels of diagnostics are installed that can be used as a guide as to whether systems are functioning correctly.

Learning Point:	***There have been instances where contractual 'fault free' running has amounted to only 500 miles. This has led to the fleet of trains replicating this unacceptably low reliability performance level once introduced to service.***
Learning Point:	***There have been other instances where 'mileage accumulation' has been undertaken for suburban passenger stock where the commissioning did not test the passenger doors. As a consequence, once the trains were introduced to passenger service the door reliability was very poor.***
Learning Point:	***Once New Train deliveries start there is often 'acceptance pressure' placed on operators to take trains that are 'sub-standard' so that manufacturers can receive payment or to fill a looming shortfall of existing vehicles that are no longer available to the operator since they are approaching the end of their lease.***

There will also need to be some contingency factored in to reflect the fact that 'shakedown' faults will occur and therefore the 'fault free' clock will have to be reset on occasion.

It is also essential that high standards of fault reporting are required when things go wrong so that problems can be identified quickly and followed up. A small pool of test drivers (potentially supported by test engineers) for the initial 'shakedown' commissioning runs would be able to provide more detailed fault reports.

It is a fact that problems are bound to occur. It is therefore how agile organisations are at responding to these problems that will dictate how long it takes to expedite the necessary solutions.

The latter stages of the commissioning phase are also very useful for dovetailing in with the driver training programme so that drivers are exposed as soon as possible to the operation of the train under controlled conditions on trains that have demonstrated a level of reliability performance.

Learning Point:	***Initial reliability performance of New Trains fleets is often poor as a result of 'staff unfamiliarity' with the New Train systems (otherwise known as 'finger trouble') and utilising the driver training programme for commissioning is a way to improve drivers' understanding of the train systems.***
Learning Point:	***Whilst priority is typically given by operators to the training of drivers, the training needs of on-board staff are of equal importance in order to reduce incidents in service e.g. in relation to the operation of new door control panels.***

3.18 Contracting – Driver (and on-board staff) Training Strategy

Ensuring the correct number of drivers (and on-board staff) are fully trained when the New Trains are ready to enter service is often a major headache for operators.

It should be a contractual requirement that sufficient time is given to training drivers (and on-board staff) on the New Trains and the requisite number of trains should be delivered in order to support this training.

3.19 Contracting – Engineering Change Strategy

Often, due to their large number, it is often difficult for procurers (and operators) to ensure proper scrutiny of proposed changes that the manufacturer is making to the train design.

In order to ensure that a robust Engineering Change Management process is established at the outset it should be a contractual requirement that the procurer and manufacturer (and operator) agree a specific date for 'design freeze' of the design of the New Train.

The Engineering Change process transition from when it migrates from completely within the manufacturer to the inclusion of the TOC is a process that needs to be carefully managed – as does the involvement of drivers in relation to functionality/operability changes related to software changes.

Any changes to the design of the train that are made by the manufacturer following this date would therefore be the subject of a formal Engineering Change from the manufacturer to the procurer (and operator).

It is therefore very important that an efficient process is established between all the parties to ensure that the agreement of Engineering Change does not become a bottleneck.

It is therefore important to establish a clear set of ground rules for the definition of significant changes i.e. those that need to be communicated and agreed as opposed to minor changes that support manufacturing or correct non-functional errors that genuinely do not need to be the subject of the Engineering Change Process.

It is equally important that the procurer (and operator) have sufficient resource available to deal effectively with the amount of documentation that Engineering Change can generate.

There is a need for all parties to agree what the Engineering Change process is; what the requirements from the manufacturer to support are; what the feedback from the EC party looks like and how all this feeds into the new vehicles technical file.

In order to assist Train Operators to understand good practice in terms of Engineering Change, in 2015 ATOC produced RDG-ENG-ACOP-01006: Approved Code of Practice – Management of Rail Vehicle Engineering Change which describes an approach for the effective management of engineering change to rail vehicles together with aspects of inter-company cooperation requirements.

In order to assist the wider industry implement the effective verification of conformity of engineering change, RSSB has published RIS-2700-RST: Rail Industry Standard for Verification of Conformity of Engineering Change to Rail Vehicles.

3.20 Contracting – Spares Supply Strategy

It is important to determine the additional components that should be procured to support the fleet through whole life and these should be listed in the Contract.

These additional components are necessary to facilitate overhaul programmes and unforeseen events such as collision damage or electrical burn ups.

4 Aspects of Train Design

4.1 Background

A train manufacturer does not (typically) understand how their train will be operated. A train operator does not (typically) understand how the train is designed to operate. A train owner needs to maintain the integrity of the train throughout its full life cycle. Therefore, each party has a unique perspective and therefore has something to offer in relation to ensuring an effective introduction to service.

Operators should not therefore leave manufacturers to 'get on with it' during the design phase and good relationships need to be established at the outset with a cooperative balance being struck.

The irregular cycle of 'famine and feast' in terms of train procurement has potentially led manufacturers to wait until New Train orders are received in order to fund the development of their next 'product platforms.'

A consequence of this is that there is a conflict here between manufacturers wanting to develop radically new designs i.e. from a blank sheet of paper, whereas operators would prefer designs that have evolved from previous designs e.g. evolution and not revolution.

An effective Design Review process therefore relies on transparency and openness from all involved. What follows is considered to be 'good practice' in terms of the Design process and the associated process of Design Scrutiny.

4.2 Learning the Lessons - KTR

In order to learn the lessons from previous train designs the wider industry has collaborated to produce the Key Train Requirements (KTR). KTR is intended to assist rolling stock procurers, manufacturers and system suppliers to (amongst other things) review designs by drawing attention to experience that has emerged from historic rolling stock projects.

The current KTR is on its seventh iteration (v7) and can be accessed on the RSSB website here.

It is the intention that KTR is used as a 'Design Review Checklist' to ensure that aspects that are of particular importance to each specific project are considered at the Design Review stage.

4.3 Design Review

Manufacturers (both Original Equipment Manufacturers (Tier 1) and sub-system suppliers (Tiers 2 and 3)) should be much more open to the procurer (and operator) playing a much more active role in the design review process in order to improve the outcome of the design scrutiny process. Whilst this takes considerable effort to undertake effectively, both the manufacturer, supplier and operator will benefit from the output, resulting in an improved design.

Design review meetings should be constructive, objective and focus on assessing the suitability of the design to achieve the agreed requirements. They must also respect the contractual design timescales.

Learning Point:	***The Design Review process is only effective if parties not only listen to concerns, but also react. There have been examples where concerns that have been raised on project mock-ups have not been addressed in the final product.***
Learning Point:	***Design Reviews that are convened purely as a result of the need to satisfy contractual obligations often become meaningless or become 'competitions' to demonstrate who knows the most about the product.***
Learning Point	***Direct Rail Services reported that it took two or three goes to get the message clearly understood with Vossloh/Stadler in relation to the Class 68 & Class 88 locomotives. However, once they understood that there were benefits in it for them (we understood UK operation,***

	standards and compliance better than they did), it worked really well.

4.4 Design - Hazard Identification

The Hazard Identification process needs to be properly managed as previously identified in 2.3. There is a need to look beyond the legal and commercial obligations since these cannot be relied upon alone to assure safe operation.

As previously identified in 2.3, it is important to recognise that if there are gaps in the train specification and / or the train designer's risk assessment processes are not sophisticated enough to identify gaps, a train which meets the NTSN (or even any other agreed set of requirements) may not be fully safe to operate under specific constraints or freedoms e.g. which are local in nature and operationally or geographically driven.

It is also important that the manufacturer ensures that the operator/asset owner is fully aware and accepts those risks that the designer is proposing to transfer.

Similarly, the train operator needs to conduct a thorough risk assessment, at a sufficiently early stage, of how the train will operate in the real world, taking into account, and if necessary, challenging any risks identified and documented by the designer proposed to be transferred to the operator/asset owner and also taking into account the conditions and restrictions with which they are familiar but the manufacturer is not.

It is therefore considered good practice for a suitable and sufficient risk assessment meeting the requirements of Common Safety Method for Risk Evaluation and Assessment (CSM-RA) and respecting the hierarchy of risk controls set out in the Management of Health and Safety at Work Regulations 1999 to be undertaken jointly by the manufacturer and operator to ensure that both the operator and manufacturer are very clear in relation to the allocation of the risks associated with the operation of the New Train (as highlighted earlier in 3.8).

The hazard identification process is also a very good tool to identify failure modes that are generated from unexpected operational scenarios, but to be fully effective it relies on all the right people being at the table, including designers, manufacturers, operators, end users, safety specialists, project engineers etc.

4.5 Design for Human Factors

As stated previously, train designers are (typically) not train operators and train operators are (typically) not train designers.

Operators therefore need to work with the manufacturers to ensure that they both completely understand how the train is intended to be operated.

With the advent of ever-increasing software control this has magnified the extent of the problems that can occur.

Problems with software functionality therefore typically arise due to the software designer not being aware of how the system will be operated in practice and as a consequence making incorrect assumptions.

It could be further argued that the root cause of this is a 'systems integration issue' as opposed to being purely a 'software issue'

Good Practice Example:	***Arriva Rail London provided a dedicated resource to work with the manufacturers' train control software development team to review any assumptions made by the software developer in terms of how the train would be operated.***
Learning Point:	***A software developer assumed that a driver would not be able to change ends of a six-car multiple unit in less than 10 seconds. The multiple unit had two pantographs. Unfortunately, the software developer had not considered that another driver might be waiting on the platform to 'hop aboard' the rear cab at a terminal station and therefore it was indeed***

	possible to change ends within this timescale. This implicit assumption, led to physical damage to the train as a result of the rear pantograph being lowered in an energised state in close proximity to the vehicle roof.
Good Practice Example:	***A day in the life of the train scenario/workshops are a good way of engaging and flushing out Human Factors issues.***

Aspects that therefore need to be reviewed in terms of Human Factors control functionality include:

i. What happens if the process is undertaken too quickly?
ii. What happens if the process is undertaken too slowly?
iii. What happens if the process is undertaken in an incorrect order?
iv. What are the critical processes? i.e. those that potentially need to be analysed in specific detail e.g. train despatch
v. What is the operational functionality of the process under degraded conditions?
vi. Is it physically possible to undertake the process?

Learning Point:	***A manufacturer assumed that following an air conditioning trip that the traincrew would reset the relevant circuit breaker. The circuit breaker was not accessible to the traincrew since the manufacturer had it positioned in a locked in a High Voltage cupboard.***

4.6 Design for Operational Resilience

Unless a defect generates a high safety risk condition, there should be no failure mode that can result in a train becoming stranded due to a 'protective shutdown.' Effectively, systems should be designed to reset if the circumstances that initiated the protective shutdown have changed - as opposed to becoming permanently 'locked out.'

Learning Point:	***A design of train went into 'protective shutdown' as a result of the 25kV Traction supply frequency momentarily dipping below limits. Once the traction supply was restored the trains were stranded as a result of the design of the software control causing the train to permanently 'lock out'. The only way to reset the affected trains (in the order of 27 around the affected network) was for a technician to attend the train in person with a laptop – which proved a real challenge since some of the failed trains were located in tunnels.***

4.7 Design for Appropriate Software Criticality

For obvious reasons Safety Critical Software requires more rigorous testing and validation than less critical systems – which takes considerably more time.

Learning Point:	***Software is not mandatory. It is possible to design Safety Critical systems without any software. This could provide greater resilience, albeit perhaps to the detriment of innovation/simplicity. However, since train design is about managing risk and speed of introduction it can be argued that simple is generally quicker.***

Communications networks used by software controlling safety critical train systems should therefore be kept separate from networks used by software controlling non-safety critical train systems.

There are several advantages of this architecture:

i. There is no possibility of changes to non-safety critical software interfering with the software controlling safety critical functions.
ii. Non-safety critical software changes can be rolled out more quickly – since the required validation and testing is less onerous.
iii. Due to cyber-security considerations, ideally, the connectivity to the safety critical network should not be made wireless.
iv. The connectivity of the non-safety critical network could be made wireless e.g. Bluetooth / WiFi in order to speed up the process of upload / download for time critical data.

5 Interfaces to the Train

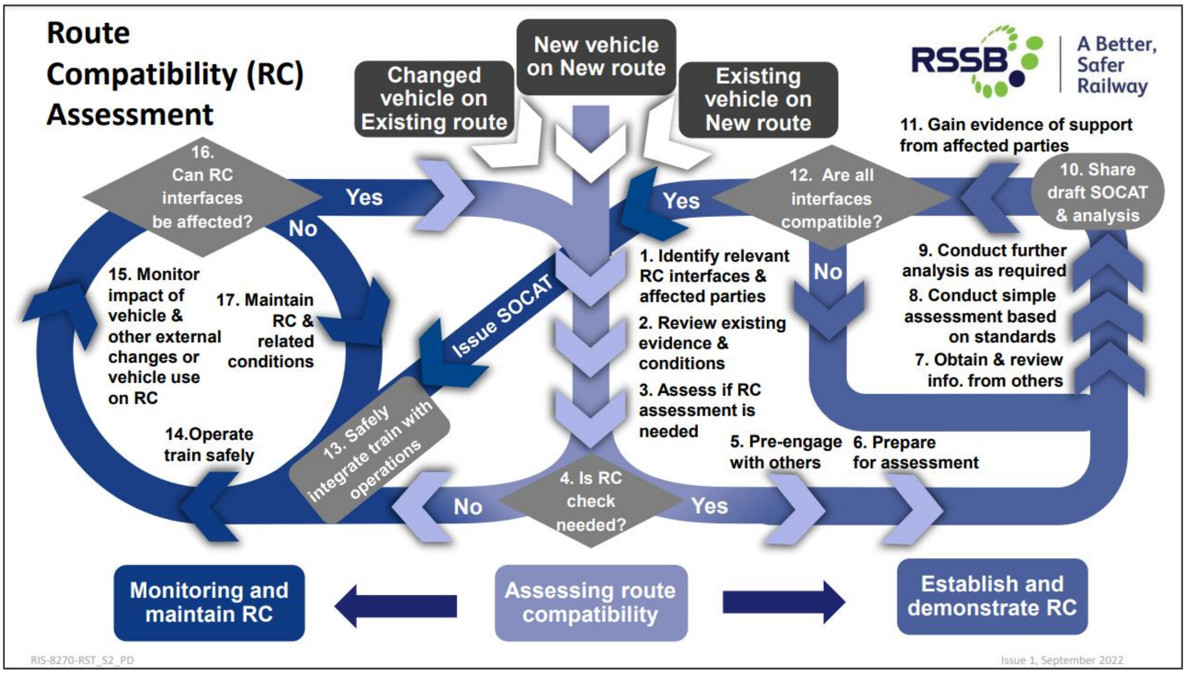
5.1 Background – The Demonstration of Compatibility

The train is only one part of the wider railway system and unfortunately compatibility problems during test runs of New Train designs are not unknown.

Unless you are fortunate enough to be introducing a New Train to brand new infrastructure that has been specifically designed to be compatible with the New Train it is highly likely that the New Train will be introduced onto to existing legacy infrastructure.

The industry has described and agreed the process that should be followed in RIS-8270-RST: Route Level Assessment of Technical Compatibility between Vehicles and Infrastructure which sets out requirements and responsibilities for the assessment of technical compatibility at route level for vehicles and infrastructure.

In addition, in the Standards Catalogue (on the RSSB website) there is additional guidance, including the following Route Compatibility Assessment flowchart:



Whilst train procurers often make the manufacturer contractually responsible for successfully negotiating the compatibility process, it remains the Operator's responsibility.

At the outset, work needs to be done to establish relationships and the Operator understanding its safety responsibilities are key.

Good Practice Example:	***Greater Anglia identified the need for and funded a specific role for a member of Network Rail staff to act as their New Train project single point of contact with NR. It was identified that a lot of time can be spent trying to identify the relevant contact within NR and it was found that it was easier for such projects to have 'someone on the inside.' It was reported that the role paid for itself in that it facilitated the joining up the relevant NR Teams.***
Learning Point:	***NR report that train operators need to be more 'pro-actively' involved with the compatibility process, since it is NR's experience that train operators only seem to take an interest and really get involved when the manufacturer is having significant difficulties and timescales are under***

	pressure.
Learning Point:	***In certain circumstances, NR has found that they are engaging with a RoSCo before a TOC is involved – which is not in accordance with the 'duty of cooperation' arrangement outlined in ROGS between the Infrastructure Manager and Railway Undertaking***

This process takes time and therefore early engagement with the Network Rail Compatibility Team is strongly recommended. The following link provides a useful guide in relation to what is needed and also identifies who should be contacted in the first instance.

Learning Point:	***It is recommended that projects adopt early engagement and open dialogue with the affected parties. This is best undertaken before things are formally needed to be done.***

There are benefits to agreeing 'up front' testing requirements with the infrastructure manager and collaborating to maximise the relevance of test-track environments to the actual routes that the New Trains are anticipated to operate over.

Good Practice Example:	***There is the opportunity to work with Network Rail to install representative infrastructure at their Rail Innovation and Development Centres (RIDC) in support of tests required to demonstrate compatibility.***
Learning Point:	***A project did not engage with Network Rail prior to undertaking tests at the RIDC. This resulted in last minute problems and delays to the project testing programme.***

It needs to be stressed that it is for the vehicle introducer to satisfy themselves that they have demonstrated compatibility to the legacy infrastructure and trains already in operation over the routes to be operated. The Infrastructure Manager has duty of co-operation with respect to facilitating this process and the vehicle introducer and the Infrastructure Manager are equal parties under the duty of cooperation defined in the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS).

Whilst the vehicle introducer is not seeking 'permission' from the Infrastructure Manager for the New Train to operate, the duty of co-operation applies both ways in that any legitimate concerns expressed by the Infrastructure Manager should be satisfactorily addressed by the vehicle introducer prior to operation.

It is a common misconception of vehicle introducers that Network Rail is responsible for the production of compatibility statements. This is patently not the case. The vehicle operator should produce the 'Statement of Compatibility' once they are satisfied that compatibility with the infrastructure has been demonstrated.

Good Practice Example:	***Network Rail have produced NR/L2/RSE/100/04 - Issue 3 - Network Rail Assurance Panel Processes: Introduction of New or Modified Vehicles - which specifies the processes to follow when introducing a new or modified rail vehicle onto Network Rail infrastructure. It sets out how Network Rail fulfils its responsibilities both as a proposer of change, and as an affected party under the ROGS legislation and RIS-8270-RST.***

Network Rail then uses this Statement of Compatibility (and supporting evidence) to produce a 'Summary of Compatibility' for their own processes and to advise the Rolling Stock Library (R2) that the process has been followed and to communicate and record operational restrictions that apply to the train.

One common mistake is for operators to neglect to include all of the routes that they intend to operate the New Trains, so it is crucial that this aspect is ensured correct. (See 2.10 for further guidance on this aspect).

However, the demonstration of compatibility has been a problem that has afflicted many New Train projects over the years since there is not a list of clear 'pass/fail' criteria readily available that is able to fully describe what is necessary.

Learning Point:	***A New Train had a novel design of pantograph head. The relevant 'route' infrastructure manager outlined some tests that they believed were required to demonstrate compatibility. When that individual moved to another 'Route' their replacement outlined some different tests that they stated were now required, but the original tests were no longer needed.***

The direct consequence of these often opaque requirements is that the compatibility demonstration process is time consuming, uncertain and therefore expensive. In recent years the industry has recognised this problem and some progress has been made by the development of a several parts of the 'Key Interface Requirements' document – which can be accessed here [Link to be inserted when available]

When complete, the KIR will contain guidance on the following interface parameters:

- Gauge
- Pantograph/Overhead Contact System Compatibility
- Electromagnetic Compatibility
- Electrical Power
    - Grid Harmonics
    - Multi-mode changeover characteristics, procedures and signage
    - 'Novel' traction sources inc. characteristics
- Loading
    - Route Availability
- European Train Control System (ETCS)
- Signalling
    - Signal sighting
    - Signal overlaps
- Train Protection Systems
- Telecoms
- Wheel/Rail Interface
    - Track wear
- Track
    - Buffer stop assessments
- Tunnels
- Environment
- Platforms
    - Stopping positions / stop car marks
    - Stepping distances
    - Deployment of wheelchair ramps
    - Platform lengths / Use of manual or automatic selective door operation
    - Despatch arrangements
- Level Crossings
- Attainable Speed
    - Use of differential speeds
    - Vehicle acceleration and deceleration curves

Whilst the KIR is not complete, the industry has committed to a plan to add further chapters as they are developed and it is suggested that New Train projects should use the list above as a checklist to ensure that they have plans in place determine how they intend to address each of these parameters.

Learning Point:	***One New Train project, in order to provide more capacity increased the train length by several metres. This resulted in additional complexity in terms of compatibility with existing infrastructure that was not initially appreciated.***

Compatibility of the New Trains with depot and operator processes is addressed by the operators demonstrating 'Safe Integration' (see 3.8).

5.2 Electromagnetic Compatibility (EMC)

There are accepted challenges in relation to introducing both new and old rolling stock – especially in terms of EMC. The main reasons for this are as follows:

- The industry does not have a good harmonised suite of standards for EMC
- Both legacy infrastructure and trains are susceptible to EMC
- Legacy data on EMC is sometimes difficult to obtain
- More recent rolling stock power electronics switch at higher frequencies (compared to previous generations) and consequently generate increased emissions.

Learning Point:	***The Network Rail 'IDI Documents' are not definitive and are not representative of all existing NR infrastructure.***

In order to prioritise what should be done to tackle the EMC related issues the industry is currently developing an EMC Strategy – which can be accessed here [Link to be inserted when available].

It is anticipated that the EMC Strategy will be handed over to RSSB to lead the work needed to implement the EMC Strategy for the industry.

5.3 Compatibility with Legacy Infrastructure

Accurate information with respect to existing infrastructure is essential to ensure compatibility of the New Train.

The Infrastructure Manager is duty-bound to provide the necessary information to projects in respect to their infrastructure assets.

The Infrastructure Manager should also be requested to provide information of specific assets that they are aware of on the proposed routes for operation that do not comply with the current 'suite' of standards (as listed in 2.9) since this will identify at the outset the areas where demonstrating compatibility could be challenging for a project.

The demonstration of compatibility of recent designs of pantograph with legacy Overhead Line Electrification has proved problematic in recent years since these more recent designs of pantograph have different performance characteristics than the pantographs fitted to existing fleets in operation.

Learning Point:	***More recent designs of pantographs have 'open horn' and 'floating head' arrangements in order to provide the superior dynamic response that is necessary for operating coupled multiple units at higher speeds. These pantographs therefore had design features and behaviours that did not exist when the legacy infrastructure was established and were therefore difficult to assess and demonstrate compatibility.***

New Trains project teams are advised to engage with the Network Rail Routes at the earliest opportunity, not just by formal channels but by contact with the infrastructure asset managers that are familiar with the condition and constraints of the local infrastructure.

Learning Point:	***A recent design of New Train experienced significant problems with train detection in areas with low voltage dc track circuits. The problem only became apparent as autumn conditions begun to bite in late October, despite them operating without problem since June of that year. Despite the trains being fitted with Track Circuit Assistors they still failed to operate this design of track circuit. The New Trains had disk brakes installed whereas the stock that they replaced had tread brakes or scrubber blocks. It is this key difference that is believed to be contributory to the problem - since this allowed leaf contamination to build up on the surface of the wheel therefore affecting the ability of the New Train to operate the track circuit.***
Good Practice Example	***Train manufacturer CAF formed groups to provide the focus to deliver compatibility and approvals – i.e. to deliver the Statements of Compatibility. They held monthly meetings with the Operator and the***

	Network Rail Compatibility Team. CAF also published a Statement of Compatibility Plan weekly which kept the Operator and NR fully informed.
Good Practice Example:	***Northern's New Train Project identified gauging as a high risk item. As a result a joint working group was established that was attended by the manufacturer, NR and the Operator which met weekly. The plan was met and delivered to budget and working directly with NR worked well to secure the necessary possessions etc.***

5.4 Compatibility with existing trains on the route

In addition to ensuring compatibility with existing legacy infrastructure it is also necessary to demonstrate compatibility with existing trains already in operation on the route.

Unfortunately, it is often the case that it is unclear who owns the relevant data (and therefore responsible for keeping it accurate) and as a consequence information with respect to existing trains is often out of date.

Learning Point:	***One Operator reported that information on other trains is almost never available. Operators should be working towards having Compatibility Files and Statements for all their rolling stock – to facilitate the sharing of information on request. It is accepted that this situation should get better as more and more rolling stock is progressively replaced.***
Good Practice Example:	***The R2 industry computer system could be used to manage and therefore share the necessary train data with the wider industry.***

5.5 Compatibility with 'Neighbouring Systems'

In addition to the railway system there is also a need to ensure that the introduction of a New Train will not affect the operation of any of the railway system 'neighbours.' Neighbours include other transport system operators e.g. London Underground; Light Rail / Tram systems etc.

There is therefore the need for a consultation exercise to be undertaken to ensure that any 'affected parties' are alerted and have the opportunity to discuss any concerns that they may have.

Experience has demonstrated that this can be a time-consuming process and should not be left until the last minute. One of the key problems is that it is not immediately clear who the point of contact should be with respect to the consultation and how it is best to contact them.

Learning Point:	***One Operator reported that some neighbouring systems aren't clear about who is managing what part of the risk. They were asked by a Tram Operator how do they stop my train crashing onto their network. Other than ensuring the dynamic performance of the vehicle is to specification, the rest of this risk is controlled by NR's Infrastructure Risk Assessment. This took a bit of effort to explain and to clarify this with them.***

5.6 Operation of 'Multi-Mode' Trains

In recent years there has been a proliferation of new trains introduced that are able to operate in a variety of power sources, be that external electrification, diesel or battery. At the time these trains were introduced, there was little industry experience in relation to the management of system changeovers, nor any readily available good practice and therefore their modes of operation have varied.

In order to address this gap and facilitate industry learning from these projects – and in an attempt to align future industry requirements, experience to date has been captured in RSSB Rail Industry Standards - RIS-2713-RST: Issue 1- System Requirements for the Introduction and Operation of Multi-Mode Rolling Stock[12] and RIS-3784-TOM: Issue 1 - Provision of Signage at Power Changeover Locations[13].

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[12] https://www.rssb.co.uk/-/media/Project/RSSB/RssbWebsite/Documents/Registered/Standards/2021/05/24/07/51/RIS-2713-RST-Iss-1.pdf
[13] https://www.rssb.co.uk/standards-catalogue/CatalogueItem/ris-3784-tom-iss-1

6 Authorisation

6.1 Overview

The ORR authorises new vehicles and aims to engage with the applicant at an early stage to ensure that the eventual application will meet the requirements for authorisation. While the interoperability processes do not of themselves ensure that hazards are being managed, the engagement also considers legal duties relating to the management of safety, for which ORR is the regulator, and will consider other roles such as that of the operator.

However, their involvement has no legal basis until an application for authorisation is made, which is typically at the end of the manufacturing process. This can represent a very small window of opportunity and is effectively too late in the process if there are issues identified.

It is therefore recommended that New Train projects engage with the ORR much earlier.

Learning Point:	***According to ORR:*** ***Some New Train fleets are reaching too late a stage in their development before safety problems are identified. This means that resolving issues is unduly challenging. The associated risks are (i) delaying introduction to service, or (ii) the need for additional operational control measures that could have been avoided with better application of the principles of health and safety by design.***
Learning Point:	***ORR has identified the following safety issues with recent New Train designs:*** ***Large stepping distances from platform to train*** ***Cables between carriages which make it possible for trespassers to climb onto the roof and coming into contact with 25,000V a.c. overhead wires*** ***Curved windscreens causing reflections which limit the driver's vision*** ***Software inhibiting application of the service brake.***

In order to assist Train Operators to understand and navigate the Authorisation process in 2014 ATOC produced RDG-ENG-GN-002: Guidance Note – The ATOC Guide to Vehicle Change [14]which set out the vehicle change related requirements of the Railways (Interoperability) Regulations (2011) and the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS) as they applied at the time to mainline Railway Undertakings. It also took account of the EC guidance for Member States on interpretation of the Directives that lay behind these regulations.

[14] Whilst this document is now out of date in parts - it does remain a useful reference source.

7 Operational Readiness

7.1 Overview

New Trains are often used by Operators as a mechanism for business transformation e.g. new methods of operation and the implementation of new business processes. Therefore the New Train itself, whilst very important, is only one key aspect of this business change. However, New Train projects such as these are a perfect example of how a railway is a system of systems. Changing just one aspect of this can be risky if you do not understand the implications, but changing the trains and the maintenance arrangements wholesale brings a very different risk profile which is very wide ranging and one that is very easy to make mistakes within the confines thereof.

7.2 People

It is a truism that New trains do not put themselves into service – people do!

It is therefore fundamental that everyone involved in supporting the operation of the New Train needs to be trained on the aspects relevant to their role, be it drivers, controllers, maintainers, despatch staff, on board traincrew etc.

New train introduction has an impact on all aspects of an Operator's business – and this is readily illustrated in the diagram below:

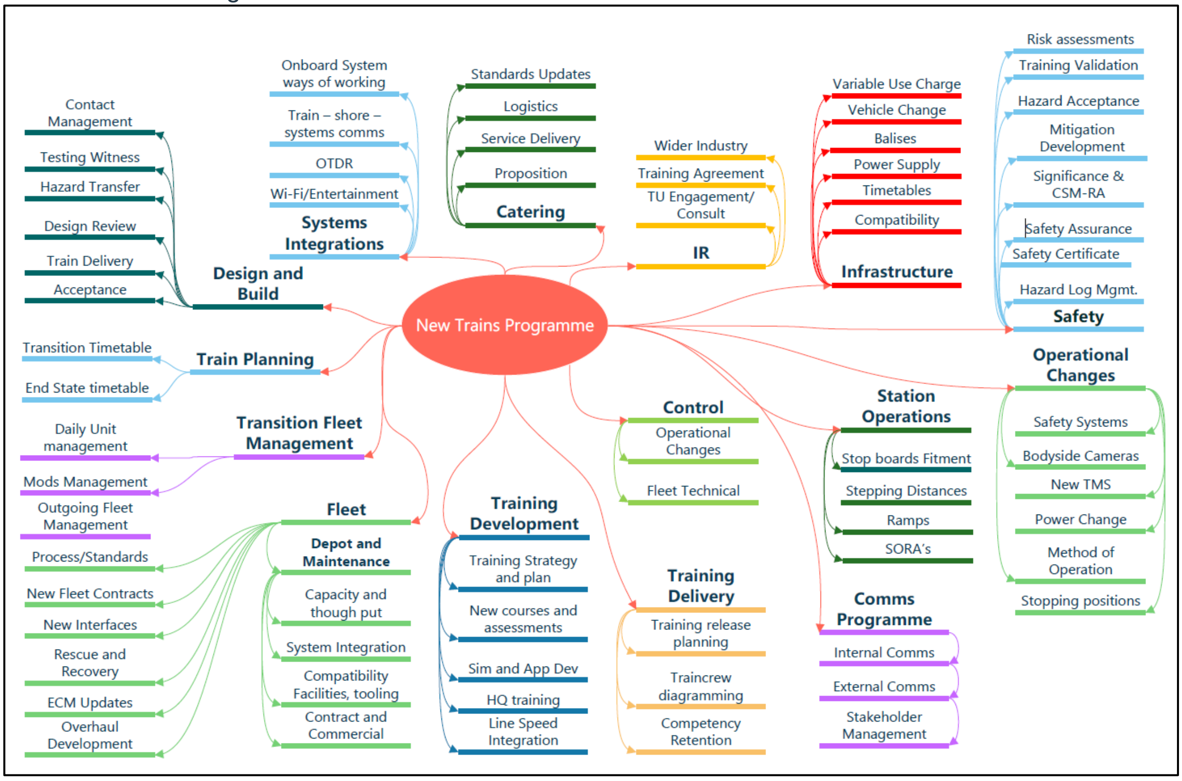

Diagram Courtesy of Avanti West Coast

Learning Point:	***It has been commented by TOCs on more than one occasion that the Operational aspects are often more difficult to get to grips with than the Engineering.***

It is therefore very important that TOCs develop a robust plan for all these 'business transformation' activities. In addition, it might be the case that the TOC will be changing the maintenance arrangements from 'in-house', to a Third-Party Train Supply or Technical Support and Spares Supply Agreement (TSA and TSSSA respectively). This will potentially involve the Transfer of Undertakings Protection of Employment (TUPE) rights of affected staff and this therefore needs to be carefully planned.

Learning Point:	***In one case the TUPE transfer was linked to the delivery of new trains – but the Contract envisaged a 'drip feed' of TUPE transfers as the trains arrived, but this was not practical. What eventually happened was four / five years for the TUPE to take place from contract signature – since the trains were delivered late.***
Good Practice Example:	***Greater Anglia seconded their Head of Production (who was very much a people person) to work with one of their best HR people to lead on TUPE. They spent their time getting the Comms right, by walking onto the shopfloor and spending time in messrooms to explain the current status to the affected people. In parallel a Voluntary Severance scheme was run together with having clear governance around recruitment to ensure that people were not recruited that did not have a long-term role in the future organisation.***

It is also absolutely key that this plan is reviewed regularly in line with any changes to the delivery profile of the New Trains or any delays to the delivery of necessary infrastructure upgrades.

This plan also needs to be supported by a robust communications and engagement plan. Often the biggest 'people' related issue is the 'not knowing / being in limbo' aspects of business change – as opposed to understanding the reality – since it is a fact that should an organisation not be on top of this – rumours will circulate. To be effective, this takes time and effort to ensure that the message is effectively conveyed to staff and that any rumours are spiked. This is not just about posters, billboards or the intranet – it's about taking the time to talk directly to the people affected in messrooms and on the shopfloor.

There is also the possibility that new skills will be required in the light of the new technology that the New Trains bring. This is especially the case with respect to computer software control of on-train systems (See Part 8).

This needs to be factored into Operator's plans in terms of the need to develop existing staff or where that is not possible to actively recruit new staff with the necessary skills.

7.3 Training Requirements

The training requirements for staff will be dictated by the type of New Train e.g. is the train a 'follow on build' from an existing design that the Operator is already familiar with – or is the design completely novel to the organisation?

Good Practice Example:	***Avanti West Coast summarised the considerations needed when developing company-wide training plans in support of New Train introduction as follows:***
	• ***Is the train new or a follow on-build?***
	• ***How will the train be operated?***
	• ***Who are the training courses designed for? New or Existing staff?***
	• ***Needs to consider all traincrew grades and trainers***
	• ***Will the course involve simulators, Apps, VR?***
	• ***How long will the course last?***
	• ***How will the first trainers be trained and who will deem them competent?***
	• ***Have you got enough trainers to deliver the training plan?***
	• ***Have you got enough drivers to be trained and maintain the service?***
	• ***How many drivers can the driver depots afford to release?***
	    ○ ***The need to release staff from their day-to-day roles for training is a significant constraint***
	    ○ ***Each depot will also typically have their own requirements***
	• ***Are there new ways of working to develop and implement?***
	• ***How will Union and Staff engagement and agreement be approached?***
	• ***The training plan development process is typically a highly***

	iterative process • ***There needs to be continued Business Engagement to ensure best fit with maintaining timetable delivery.***

It cannot be stressed how important the training plan is in support of a New Train programme – since this is nearly always determines the entry into service date of the New Train and therefore the commencement of the Fleet Cascade.

Learning Point:	***Having developed a 'Training Roll-Out' Resource Plan one TOC realised that they needed to recruit additional resource to provide the 'headroom' needed to facilitate the company-wide training that was required.***
Learning Point:	***One Operator commented that the Training Plan 'falls apart' during holiday periods. The Training Plan therefore needs to acknowledge these periods and robustly factor these in.***

7.3 Engagement with Trades Unions

It also cannot be stressed how important it is for the Trades Unions to be consulted with respect to proposed changes to operation e.g. a move to Driver Controlled Operation.

As a result of the following good practice employed by one Operator there were no driver IR issues when it came to put the new trains into service:

Good Practice Example:	***Greater Anglia appointed a nominated lead for the new train introduction who came from the driver management fraternity, but had very good relationships with the drivers.***
Good Practice Example:	***Greater Anglia spent a lot of time working with their drivers and had a major engagement programme with their representatives. This was not just with the formal reps, but also involved the 'movers and shakers' in relation to influencing opinion who were not necessarily formal representatives – i.e. those that were most respected in the driver community.***
Good Practice Example:	***Greater Anglia undertook 'mass release' of drivers to ensure they were as involved in the process as possible in order to ensure they felt that they were getting what they wanted from the new trains.***

7.4 Depot Readiness

A very common pitfall that Operators fall into is related to the fact that the depots are not ready to maintain the new trains when they arrive. The more common reasons for this are listed below:

- Operators find themselves trying to maintain their existing fleets and also introduce a new fleet at existing facilities
- Compared to specifying the train requirements, there is considerably less focus on specifying the detailed depot modifications required to maintain the new fleet of trains.

Sufficient effort therefore needs to be spent to produce a list of detailed depot modifications required to maintain the new fleet of trains.

Depot Stabling capacity has also proved to be a thorny issue in the past – especially if the new trains are of different lengths than the trains they are replacing.

Good Practice Example / Learning Point:	***In order to create the necessary capacity to upgrade a depot, Greater Anglia outsourced a lot of the existing fleet maintenance. However on reflection they reported that this should have been more – since everything needed to have worked perfectly for the plans to have worked – i.e. there was not enough contingency to generate some headroom for the depot to still be able to function and deal with the unexpected.***

Learning Point:	***One Operator reported that whilst the live depot was being rebuilt and maintenance outsourced, TOC performance 'drained away' as a result of the problems maintaining the existing fleet gradually building up as a consequence of the pressures on availability increasing – to the detriment of fleet reliability.***
Good Practice Example:	***In the light of the number of contractors on site undertaking simultaneous depot upgrades Northern appointed a 'Contractor Coordinator' to manage all of the works and to ensure the depot teams (and the other contractors) knew exactly what should be happening at the depot. This proved very helpful when the works were planned and conflicts were readily identified.***
Learning Point:	***As a result of an original Franchise Commitment for the construction of a new depot not being realised, one Operator found that they had to completely revise their fleet maintenance plans from scratch – despite the new trains already having been procured. In the light of the pressure to quickly let Contracts related to the depot upgrades they believed to be required, experience showed that it would have been better for them to spend much more time writing the specification for the depot works – prior to letting these Contracts.***
Learning Point:	***One Operator discovered and therefore had to acknowledge that what they needed in relation to depot modifications was not in accordance with what was specified in the Contract. This led to an uncomfortable clash between what they termed as 'Reality' and the 'Contract' which created real challenges.***
Learning Point:	***Typically Operators do not readily understand what they have in terms of stabling capacity. One operator commented that it is not easy to translate 4-Cars @20m with 5-Cars@23m which equates to a new train being 1.5 times the length of an old train and existing sidings are based on 4, 8 and 12 Car lengths – with most sidings being 8 or 12 Cars. This created 'different currencies' which were often difficult to understand.***
Learning Point:	***New trains that are of differing lengths to those that they are replacing can lead to inefficient use of sidings e.g. 8-Car roads can only accommodate one new 5-Car train etc. One TOC deployed people with trundlemeters in order to measure exactly what their actual siding lengths were.***

7.5 Resourcing

Adequate resourcing of projects teams is also essential for a successful outcome.

Learning Point:	***Some suppliers and project teams have openly expressed the need for 'more boots on the ground.' This has stretched resources down the line and has sometimes resulted in basic issues becoming 'last minute panics' that have threatened deadlines.***

7.6 Fleet Transition / Cascade

As identified in 7.4, the arrival of the new train fleet whilst continuing to operate the existing fleet places additional stress on the Train Operator.

It is therefore imperative that a detailed fleet transition plan is documented that contains all of the working assumptions – especially should the new train deliveries be late and there is sufficient flexibility / contingency built into the leasing arrangements for the existing fleet. It is equally important that this document is regularly reviewed and updated in the light of emerging information in relation to delivery dates of the new fleet etc.

Good Practice Example:	***Greater Anglia produced a Cascade Plan / Capacity Model which included details of which old trains were going out / which new trains were coming in on which weeks etc. and identified where the capacity challenges would be as time progressed. The cascade plan contained details of all the underpinning assumptions e.g. driver training; progress with infrastructure upgrades; number of diagrams; which***

	depot roads were being taken out of use for upgrades; which parts of the routes etc. and was updated every period (or more frequently if required).
Good Practice Example:	***Greater Anglia commented that the Cascade Plan facilitated the TOC to build Cascade Planning into their business processes by setting up a weekly cascade planning call (of over 30 participants from across the business) where not only was it was communicated to all involved 'where things were at' but the meeting also facilitated a 'corralling of the minds' and allowed the participants to 'kick things around.'***
Good Practice Example:	***Greater Anglia reported that there were ultimately 46 versions of the Cascade Plan it was an incredible amount of effort to keep this plan updated, but considering the complexity of the fleet cascade undertaken the level of detail necessary to get things right it was definitely an absolute necessity and it ensured that the correct business decisions were taken. This allowed management action to be taken once a problem was highlighted at a location with sufficient time to be able to do something about it e.g. outstabling of rolling stock.***
Learning Point:	***One TOC had planned a three month overlap period between the lease expiry of their legacy fleet of trains and the planned deliveries of their new train fleets. Unfortunately the delivery of the new train fleet was six-months late and therefore the TOC found themselves having to hand over legacy trains back to the RoSCos (who had quite rightly found a new Operator for the vehicles) without having any replacement rolling stock readily available to them to run their service.***
Learning Point:	***One TOC reported that a successful fleet transition is only possible if all the factors at play are fully understood and that getting people to be comfortable to discuss the reality was sometimes difficult, but it was important to get to this maturity stage - since when people were reviewing the 'real plan' it really did make decision making easier.***
Learning Point:	***One TOC had planned to simultaneously introduce into service two fleets of new trains from different manufacturers. As it transpired one fleet was late and the other fleet was very late – which provided a unique opportunity to apply the lessons learned from the initial fleet introduction to the second fleet introduction. The TOC subsequently reflected that had the trains been delivered as planned it would have been an 'absolute nightmare' for them to try to manage.***
Good Practice Example:	***Northern used another TOC's site for commissioning their new fleet during the day when the site was underutilised by the 'owning TOC'. This provided a real opportunity to support the fleet since the site was fully equipped with a large stabling area and there were also two drivers available for train moves during the day.***
Good Practice Example:	***CAF discovered that they were unable to meet the contracted delivery timescales and therefore had to make changes to work out how to get the deliveries back on track.*** ***In order to do this they:*** • ***Undertook a review of the Train Service Agreement and Applied Lean processes*** • ***Set a 20 Day timeframe*** • ***Defined seven stages – with visualisation boards*** • ***Made changes with the customer involved*** • ***Requested that the Operator provided additional drivers paths*** ***This got the programme back on track with better than expected timeframes.***
Learning Point:	***As a consequence of a fleet cascade of Turbostars from four different TOCs, one TOC found that each Turbostar fleet was different in terms of configuration, onboard equipment and position in their respective maintenance plans. The affected TOC commented at the time that they did not envisage the sheer amount of work that was required to be undertaken in order to produce the necessary homogenous fleet – suitable for their operation.***
Learning Point	***One TOC discovered that the layout of the door controls of a cascaded fleet of trains was different to those that it already had in operation***

	since it had Guard Control Operating Panels (GOPs). This caused operational problems when the trains were initially introduced to service.

7.7 Operational Impact

There are numerous potential impacts to the 'day to day' operation of the railway as a consequence of New Train introduction.

Operators should therefore consider the following when developing their 'Operational Readiness' plans:

- Is there a need to marshal the New Trains in a different way due to changes in unit and train length? e.g. 1x 5-car berthed in an 8-car siding needing to be coupled prior to departure to another 1x 5-car similarly berthed
- Is there a need for increased shunting and fleet moves to get sets to e.g. CET roads where new units with toilets are introduced vice non-toilet fitted trains impacting on depot operations and mainline ECS moves with consequences for infrastructure maintenance times?
- Is there any need to increase in on-network berthing and its acceptability to the NR infrastructure manager?
- Do the New Trains need an increased duration for train preparation requiring shorter isolations to protect times of first movements with an impact on infrastructure maintenance durations?
- Are there any implications with respect to necessary changes to the level and location of "bolt holes" which are not used in the Working Time Table berthing plan but provide the flexibility to enable Short Term Planning and Very Short Term Planning maintenance possessions to be taken?
- Are there any changes needed in early/late Empty Coaching Stock (ECS) movements due to new depot locations impacting on infrastructure maintenance?
- Is there an impact on other operators who use shared berthing locations where the host's aspirations make previously provided accommodation to such third parties no longer on offer?
- Is there an impact on route knowledge requirements and retention opportunities from revised ECS requirements to/from berthing locations?
- What are the arrangements for rescue and recovery of failed New Trains? How will the recovery be undertaken and with what? Whose responsibility will it be to recover the failed New Train? Who will attend failed New Trains?
- Is there a need for a 'full shutdown / switch off / reboot' of the train every day to keep the onboard digital systems functioning correctly? If so, whose responsibility will it be at all stabling points? Has this been incorporated into the driver's train preparation and has sufficient time been allocated to undertake the task?

Learning Point:	***One TOC prioritised the delivery of service trains over commissioning runs. This resulted in thousands of hours of manufacturers time being wasted – and delayed the introduction of the new train fleet to service.***
Learning Point:	***On two recent builds of New Trains there is a requirement to undertake a 'full shutdown' of the train every 24 hours in order to keep the on board digital systems functioning correctly. Whilst the affected TOCs were aware of this requirement and had planned accordingly, when there was a change of plan – e.g. as a result of Industrial Action or other disruption, this requirement created problems for trains that had been 'outberthed' as a result – since no arrangements had been put in place to undertake the train shutdowns – and trains subsequently failed as a result of this oversight.***

7.8 Infrastructure Readiness

Some New Train Projects have been delayed by new infrastructure not being ready for the new fleet service introduction.

Projects also therefore need to maintain a watching brief with respect to any such infrastructure projects and revise their implementation plans as required.

Leaning Point:	***One new electric train fleet was dependent upon the Infrastructure Manager completing an electrification project. The electrification ran late but was completed just in time for the new timetable. The problem was that due to the delays there was insufficient time available for route proving and driver familiarisation which resulted in insufficient drivers trained over the new route and therefore the proposed timetable could not be operated.***

7.9 Collaboration

On occasion it is discovered that the Contract does not specify practical solutions.

Leaning Point:	***An Operator found that they ended up falling into the trap of 'but the Contract says' and had therefore to find ways around it. e.g. The Contract was written in a way that there was no mechanism for the TOC to place a limit on how many new trains could be delivered – pre acceptance. It was only once the depot became completely 'Chock A Block' with trains that alternative agreements were made with the manufacturer. After this had happened the TOC reflected 'how on earth did we let that happen?' and whilst the 'Contract said' on reflection the TOC accepted that they were not sufficiently challenging about the practicality of this at the time.***
Learning Point:	***Contracts should be used to get the right outcomes. If they are not right don't follow them – and acknowledge this fact. Don't just accept the words of the Contract as 'gospel' and take the time to work out how you are going to change it. Organisations should not deal with such issues by 'putting the Contract in the bottom drawer' – since it is the only thing that can drive the necessary changes to improve how people work together – a way needs to be found to make it work for you.***

If an Operator is too Commercially led at the outset this can create difficulties.

Leaning Point:	***One Operator reflected that their initial approach allowed the creation of walls both metaphorically via the contract and physical walls on the depot e.g. Individual allocated spaces for manufacturers – which was a big mistake. Following a lot of subsequent effort this has been recovered through joint initiatives which are now the norm – to recover the team spirit / dynamic at the depot, the 'one team approach' and this has been key to the improvement witnessed..***
Good Practice Example:	***From the early 2020s Greater Anglia's Norwich Crown Point was no longer branded by organisation – it is the branding for everyone as a joint team. It was found that people had very little brand loyalty (in the light of a succession of franchising changes and TUPE, but nevertheless they remained proud to work for 'Crown Point Depot.' Everyone (GA/Stadler/Alstom/NR) is issued with Crown Point polo shirts and lanyards (and they may choose or choose not wear them!) in an attempt to create the 'One Team' ethos.***

Photo Courtesy of Greater Anglia

Learning Point:	***Success will only be achieved by TOCs and Third-Party maintainer organisations taking the time to build the relationships necessary for trust to develop. There needs to be a will to make it work, since you cannot 'collaborate at' someone! Working on joint initiatives pull the organisations together.***

ISO 44001: Collaborative business relationship management systems specifies requirements for the effective identification, development and management of collaborative business relationships within or between organizations.

<table>
<tr><td>Good Practice Example:</td><td>Arriva Rail London has employed ISO 44001 in relation to their relationships with their third-party maintainer and also Network Rail.</td></tr>
<tr><td>Good Practice Example:</td><td>One New Train Introduction programme was successful because a collaborative working ethos was in place at the very start of the project between the RoSCo, TOC and Train Supplier.

The collaborative principles used in this approach is outlined below:

A shared sense of success
A shared fear of failure
A need to rely on each other
Hold each other to account

This can also be summarised by the following phrase:
'If we all perform we will succeed…. but if one fails we all fail'

Further insight into this is provided below:

All parties have their own processes
Not 3 organisational mini-teams
People took the time to get introduced and get to know each other
All parties travelled together e.g. to site visits
Time and effort was expended to get people to work together – there is a need to take the time to spend time together
It's not about blind trust – it's about holding people to account
Don't bury the Contract in a drawer – give it a voice.
Move to a preventative mindset
</td></tr>
</table>

	• *Planning Phase: A willingness to share the detailed programme e.g. Worked with the train supplier to understand the assumptions and contingency in the plan (this came in very helpful once the delivery programme became delayed)* • *Respectful challenge* • *Manufacturing Phase: A freedom to roam that built trust* • *The Quality Assurance teams supported each other* • *Managing Risk and Problem Solving: Joint Risk Register* • *Who is best placed to manage? e.g. Gauging and training – TOC responsibility* • *Work together when things go wrong (it was also important how people work together)* • *Interfaces not divides.*
Learning Point:	***Manufacturers are naturally wary of the customer representative on site. However, the collaborative 'one team' philosophy managed to break this down since they successfully demonstrated 'active support' even when things got difficult.***
Learning Point:	***One TOC commented that it is really important to take the time to fully understand the Contract and also understand how it is supposed to work.***
Learning Point:	***Another TOC commented that effective collaboration is hard work to implement and then once this is established it is really fragile and needs to be tended with care.***
Learning Point:	***It has been suggested that there are three 'C's to collaboration:*** • ***Coordination*** • ***Cooperation*** • ***Communication*** ***It is also important that this encompasses all stages of the new train project.***
Learning Point:	***Where new trains are being procured from manufacturers that are not familiar with the UK market and some of our idiosyncrasies this will create a need for careful liaison with the manufacturer as a result of unfamiliarity with the UK landscape and also cultural differences.***
Learning Point:	***In order to foster the collaborative approach, it is important that teams take the time to celebrate the successful achievement of key milestones.***

7.10 Processes and Systems

The procurement of a new train can sometimes import a radical change of systems and processes – especially if there is a change of the maintenance requirements for the new fleet of trains e.g. from TOC maintained to a Third-Party maintenance arrangement.

There is therefore a need to fully understand 'how things will work' in the future and who it is anticipated will be doing what. This clearly demonstrates the importance of Human Factors Integration.

Leaning Point:	***One Operator commented that they were initially focussed too much on compliance i.e. were they compliant with all of their standards and Safety Management System (SMS) Requirements – and therefore there was nowhere near enough focus on useability of the processes and whether the end user could actually use the new systems and processes that were in place as the transition to Third-Party maintenance was made. This loss of focus generated lots of 'workarounds' that were hidden from TOC management and therefore were never highlighted for resolution – had this been the case systems that were more useable for the teams would have been produced.***
Learning Point	***A TOC reported that simply trying to create a single version of the truth was a real challenge as a result of attempting to mesh together independent systems from two fleet maintainers with the TOC systems to make sure each party has access to fleet availability and open defects information etc. This was described as a 'Clash of the Systems.'***

Good Practice Example:	***CAF adopted the reporting formats of Northern to improve the interaction of their staff at the working level.***

Whatever processes are in place should maintain a focus on the passenger that the Operator should deploy to holding third-party maintainers and train suppliers to account.

Good Practice Example:	***Greater Anglia developed Rules of the Depot and Rules of the Train Plan for both of their new train fleets. These are designed to ensure that when Train Planners are developing new Timetables they are following the Rules of the Depot which will produce a Timetable that produces diagrams that accommodates the needs of the depot by facilitating the fleet to be maintained in the best way possible and is therefore achievable.***

Further guidance in relation to how the performance of depots can be improved can be found here: RDG-ENG-GN-009: Depot Performance Handbook – A Good Practice Guide[15]

Good Practice Example:	***Greater Anglia reflected on their performance towards the end of their new train introduction programme as follows:*** ***"Having turned back the clock two years, when we were experiencing 74 cancellations per week – and at the moment whilst the MAA is 21, over the last 4 weeks we have been at 6. Correspondingly, the minutes were at 1800 2 years ago which has dropped to 800 mins MAA now, and over the last four weeks this has been at 520 mins. The new trains have therefore been a massive driving force in improving performance of the business – despite the grumbles on the way!"***

The Engineering Change process is a process that needs to be carefully managed – as does the involvement of drivers in relation to functionality/operability changes related to software development. (See 3.19).

Learning Point:	***One manufacturer reported that due to the protracted Engineering Change Process in place that involved TOC and RoSCo, some Engineering Changes took in excess of six months to obtain the necessary approval.***
Good Practice Example:	***A good collaborative approach to Engineering Changes on Northern's New Trains project facilitated the rapid progression of key modifications that were found to be necessary to allow the project to remain on track.***

7.11 Reliability Growth

It is a truism that you will not fully understand the inherent reliability of your new train until the fleet is in full public service.

The traincrew and maintenance teams need time to get to understand how their new trains operate and unexpected faults and failures are inevitable.

Good Practice Example:	***Greater Anglia made an early decision to invest in a 'knowledge bank' for 'in-service support' and decided to build a 'Decision Support Tool' to assist the team in Control. The way the system was structured was that it allowed staff to capture the learning from each and every incident. The idea of the Decision Support Tool (DST) is that it will ultimately be able to advise for every incident what needs to be done – since someone else has already embedded the previous learning of what needs to be done to get a train moving as quickly as possible. If the solution to the problem is not captured, then Control staff will jot down their experiences i.e. what they did and whether or not it worked which is updated in the DST – for the next occasion – thereby increasing the***

[15] https://www.raildeliverygroup.com/our-services/cop-guidance.html

	competence and knowledge across the TOC's Controllers. This positive feedback loop ensures that the same mistakes are not made twice.
Good Practice Example:	***CAF shared fault logs with the TOC at their technical reliability meetings in order to understand more about faults and failures.***

7.12 Catering

There are numerous aspects that need to be covered in support of on-board catering.

Learning Point:	***One Operator found that it had not been made clear with their Train Maintainer who is responsible for cleaning the coffee machine?***
Learning Point:	***Another Operator found that it had not been made clear with their Train Maintainer who is responsible for the removal of catering equipment to allow heavy cleaning around and behind.***

8 Software Management

8.1 Background

Train control architecture is getting ever more complex. Recent designs of trains are 'fly by wire' control and when compared to historical designs of train control e.g. relay logic, software control would appear to be emerging as the default situation and it is for this reason that this small chapter has been included in this document.

Software presents the industry with a real challenge in terms of 'upskilling' since there remains a dearth of industry knowledge in this area, but it is promising that some improvement has been made in recent years.

Control systems are becoming ever more integrated and engineers will therefore need to have a systems engineering approach to the integration and functional understanding of these systems and software.

This is further compounded by train designers integrating software from multiple sub-suppliers' equipment that do not interact in the way that was intended. It can therefore be very difficult to identify the 'root cause' of problems.

An added complication is that sub-suppliers often sub-contract the 'coding' of the software to specialist software companies and therefore even the train manufacturer's detailed knowledge of the software design is also very limited.

Learning Point:	***One GB train manufacturer subcontracted the coding of their train control software to a company based in China. The Chinese company subsequently further subcontracted the software development to a company back in Europe.***

8.2 Cyber Security

Cyber Security presents the industry with a huge challenge in relation to ensuring New Trains are designed to be able to remain secure to all of the threats posed as a result of Cyber Security Risk – not only as they are rolling off the production line, but also throughout their useful life.

Thankfully industry guidance documents have been developed to assist the industry with the specification, assessment and ongoing management of this area. A selection of documents considered useful is presented below:

- RSSB Technical Note – TN2312 Iss 1: *Rolling stock – cyber security essentials*
- Rail Partners Guidance Note – RP-GN-06: *Cyber Security Working Practices for Rolling Stock*[16]

8.3 Skills

As previously identified, there is a need to 'upskill' our workforce and the industry therefore should prioritise the improvement of software skills throughout the industry.

As a minimum these skills need to encompass knowledge of:

- Software development processes
- Software validation and integration processes.
- Software upload (and download)
- Configuration control processes.
- Cyber-security awareness and mitigation
- Software lifecycle management

[16] This document is only freely available to Rail Partners member organisations.

8.4 Stability and Reliability

There must be appropriate staging environments to support adequate testing before software goes onto a train. Software should only be rolled out across the fleet of trains once it is proven.

All too often, typically as a result of commercial pressures, or as a result of changes that are made to fix known deficiencies, manufacturers produce and install updated software that contains ‘bugs’ which generate unexpected faults in service.

There have been instances in the past where trains have needed to be ‘reverted’ to a previous software version – provided that this is even possible.

Learning Point:	***Testing of software on a real train is an important step – since laboratory testing does not replicate the ‘real life’ environment and there are numerous examples where potential problems have not been identified prior to installation on service trains.***
Learning Point:	***A TOC commented that their experience with one Train Supplier is that during their software ‘validation and verification,’ their ‘verification’ was ‘demonstrably awful’. The TOC found that the Train Supplier was too keen to get trains out on test on the mainline with only the most minimal verification – which in the majority of cases the TOC managed to spot beforehand, but admitted did on occasion caught out the TOC quite badly.***

It cannot therefore be stressed enough that the roll-out of new versions of software should not be rushed.

Good Practice Example:	***The provision of Operator test benches helps to prevent software with ‘bugs’ from being uploaded to service trains.***
Good Practice Example:	***A new software version should initially be installed on one train, that is closely monitored for a period. Subject to this trial not identifying any concerns, the new software version should then be rolled out across a sub-set of the fleet, again closely monitored. Subject to this wider trial not identifying any problems, gradual roll-out to the full fleet can commence with a level of confidence.***
Learning Point:	***One Operator discovered that the manufacturer did not have a ‘roll-back’ plan following a train software update that was found to be defective. As a result, the software could not be restored to the previous version – and the trains with the updated version had to remain out of traffic until the necessary software ‘patches’ could be developed.***

It is likely that there is a need to inform traincrew of significant differences in terms of software functionality e.g. as a result of different functionality on the Train Control Management System.

Good Practice Example:	***A prominent sticker displayed in the cab in relation to the software version installed provides an immediate alert to any traincrew.***

8.5 Configuration

Due to its nature, software configuration control is far from straightforward.

Electronic hardware is typically loaded with both ‘firmware’ and ‘software’. Therefore, the following need to be accurately recorded in order to maintain effective configuration control across fleets

- vehicle number
- hardware position (if more than one position on the train is possible)
- hardware version
- hardware serial number
- firmware version
- software version

There are further complexities to manage where rolling stock variants have different installed versions of hardware, firmware and software – especially if these versions are not compatible with each other and need to be kept separated in service.

Good Practice Example:	***Ideally software should be compatible with old and new hardware and firmware.***
Good Practice Example:	***One fleet of trains automatically reports the configuration of all of the software installed on the trains. This provides confidence to the Operator and Maintainer that the configuration of the software installed across the fleet is in accordance with the associated certification.***
Good Practice Example:	***In order to assist the rail industry with the management of Engineering Change related to software modifications RSSB have published TN104, Technical Note: Engineering change (software and firmware)[17] which provides additional guidance regarding changes to software and firmware on rail vehicles and provides additional guidance on the potential effects of vehicle software and firmware changes on vehicle compatibility with infrastructure.***
Good Practice Example:	***In order to assist the rail industry procure high integrity software control systems, RSSB have published Rail Industry Standard (RIS) RIS-0745-CCS: Client Safety Assurance of High Integrity Software-Based Systems for Railway Applications[18]. This RIS includes a set of principal requirements, rationale and guidance on the specification, use and management of software-related systems.***

8.6 Data Management

Operators need to be prepared for the additional data management requirements that additional software-controlled systems generate. Such systems include:

- Passenger Information (content management)
- Passenger Counting (processing)
- Seat Reservation Systems (SRS) (integration)
- Remote Condition Monitoring (data exploitation)

[17] https://www.rssb.co.uk/-/media/Project/RSSB/RssbWebsite/Documents/Registered/Technical-Notes/2023/05/31/14/32/TN104-Eng-change-softwarefirmware--final.pdf
[18] https://www.rssb.co.uk/standards-catalogue/CatalogueItem/ris-0745-ccs-iss-1

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