Rail Delivery Group

National Rail

KTR v6

Key Train Requirements

Version 6

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On behalf of: V/V SIC

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AMENDMENT RECORD

KTR Version	Dated	Notes
One (1)	January 2011	First Issue
Two (2)	February 2013	Updated issue incorporating industry feedback following publication of Issue One
Three (3)	September 2014	Addition of Operational aspects, new suggestions and comments. Title changed from Key Technical Requirements for Rolling Stock to Key Train Requirements
Four (4)	June 2016	Additional and new items added. New appendices included.
Five (5)	Nov 2018	Complete review and reformat. Additional and new items added. New appendices included..
Five.One (5.1)	May 2019	Minor clause numbering errors corrected. GSM-R clause 5.13 improved, new 5.14 added. Old 5.14 renumbered to 5.15. Spreadsheet version published.
Six (6)	November 2020	New items added. Spreadsheets updates.

Note: Where a requirement has been reworded to suit the new format, but not materially changed, this change has not been indicated. Vertical dotted lines to the right of text and titles indicate changes and additions from the previous version.

Have you got some suggestions for new or revised requirements or want more information?

Send your idea, request and your details by email to ktr@raildeliverygroup.com.

Contents

Introduction to Key Train Requirements (KTR)

Why Use This Document?

This document is intended to assist rolling stock procurers, specifiers, manufacturers and system suppliers to compile procurement specifications by:

- Drawing attention to experience that has emerged from historic rolling stock projects,
- Drawing on railway research projects,
- Capturing aspects of train design that are recognised as industry good practice but cannot, due to the clearly defined scope for mandatory Standards, be covered by the usual contractual requirement to 'comply to all applicable Standards',
- Listing clear recommendations that have emerged from industry research, but have not yet been incorporated into Standards,
- Highlighting areas where new developments are taking place that will potentially need to be considered when requirements are being specified and trains being designed to operate in the UK,
- Including recommendations from Rail Accident Investigation Branch (RAIB) reports or National Incident Reports (NIRs), to ensure that safety is enhanced at the earliest opportunity.

In addition to the contents of this document there are other standards which should be included as contractual requirements unless there is a compelling reason for not doing so. In particular, existing Railway Group Standards that have not been identified as National Technical Rules (NTRs) and have and are being reissued as Railway Industry Standards (RISs). The status of RISs has been changed such that relevant Statement of National Regulatory Provisions (SNRP) and licences under the Railway Act 1993 (as amended), require compliance with applicable Rail Industry Standards (RISs) unless SNRP or licence holders (which are typically Infrastructure Managers and Railway Undertakings) have identified an equally effective alternative to achieve the purpose of the RIS after consultation with those who are likely to be affected.

Specifiers should ensure that Train Technical Specifications specifically refer to all RISs that are deemed applicable by the Operator / Railway Undertaking.

Guidance on the use of RGSs, RISs etc can be found on the RSSB website.

One area of importance for consideration early in the design is the compatibility with the infrastructure, this is supported by *RIS-8270-RST 'Route Level Assessment of Technical Compatibility between Vehicles and Infrastructure'*, which sets our requirements and gives guidance on areas of significance and is referenced in ORR guidance which shows its importance.

Generally, European Standards (ENs), International Standards (ISOs and IECs) and British Standards (BSs) have been called up, but there may be instances where other national standards are equally acceptable.

Although mainly applicable to the procurement of new rolling stock, some of the requirements in the KTR are equally relevant to vehicle refurbishment or continued service

operation (life extension) projects. The requirements of relevance will be confined to the scope of work content in this case.

Refurbishments provide an opportunity to incorporate / improve systems, due to technology advances, where cost permits. An example of this is changing to LED head, tail and marker lamps, which are brighter, more efficient, more reliable, require less maintenance and result in a reduced whole life cost.

How To Use This Document

This document is intended to be used as an aid in preparing a train specification, and contains broad content, not all of which will be applicable to every train procurement process.

Specifiers should familiarise themselves with the KTR document and understand the requirements of the train operator's service before commencing a procurement process.

Train builders should review their product platforms against the KTR document and prepare a commentary that can be provided to potential customers. They should also use these industry-wide benchmarked requirements in the development of new rolling stock products. The KTR document contains both established and emerging requirements that are indicative of both current and future market drivers.

For many of the items covered in this document, a decision will need to be made by those specifying and designing trains as to whether there is a business case for incorporating the requirement. In these cases, it is recommended that this document should be used to complement a high-level business specification which defines the nature of the service to be provided (e.g. route capacity and journey times) whilst leaving some flexibility for future redeployment. It must therefore be stressed that each individual project will need to consider carefully the applicability of each of these requirements and their impact on whole system, whole life costs in order to identify solutions that represent best value for money to the industry. It is recommended that, as an absolute minimum, the following factors should be taken into account when evaluating whole life, whole system costs:

- Initial train procurement cost,
- Cost of in-service failures (e.g. proven reliability of sub-systems, systems redundancy),
- Cost of non-availability due to planned or unplanned maintenance (e.g. ease of changing key components, systems diagnostics, condition based maintenance approach),
- Cost of maintenance and overhaul (e.g. modular sub-systems, corrosion resistance),
- Energy costs (e.g. vehicle mass, traction drive efficiency, energy recovery, energy efficient auxiliary systems),
- Track wear and tear (e.g. unsprung mass, bogie rotational stiffness).

Sources used in this document's creation

NIRs, RAIB and RSSB research reports have been reviewed for useful requirements, and where valid have been included. They should still be checked for other background information and learning. Recommendations from RAIB reports or NIRs, should be considered during a train refurbishment or upgrade programme too.

Other incidents are assessed for usefulness and included where applicable.

Additional sources of information are operational RISs and the Rule Book.

Note that at the time of publication the hyperlinks were correct to RSSB research projects on SPARK. Should this not be the case, search for the given document title on Sparkrail.org. In some cases, a login to RSSB's SPARK may be required in order to see the information. In other cases a full membership of RSSB may be required. Contact RSSB through the RSSB Customer Self-Service Portal: https://customer-portal.rssb.co.uk/ as necessary.

Copies of Railway Group Standards (RGS) and Railway Industry Standards (RIS) are available from RSSB.

Copies of Network Rail standards listed can be obtained from: https://ihsmarkit.com/products/uk-network-rail-standards.html.

Copies of International, European and British Standards can be obtained from BSI.

Additional references to, for example, standards or RSSB Research Projects which are in progress or due to start, have been included in this document for information, sometimes with the information in a supporting appendix. Suitable outputs from the completed work will be included in future KTR updates.

In addition the DfT's '*National Railways Security Programme'* NRSP document includes clauses specific to rolling stock. This document is restricted, however the relevant clauses have been incorporated into the corresponding sections of KTR.

Document 'Valuations of Rolling Stock Improvements' provides useful guidance during a procurement process. It is recommended that this is reviewed as part of the specification development.
The document (*file name: 20161018SYSTRARollingStockStudyFinalReportv2.pdf*) was published by the Passenger Demand Forecasting Council.

Note: the paper is freely available to all PDFC members (including all passenger TOCs, RSSB, DfT, NR and a range of academics and transport consultancies) – http://www.raildeliverygroup.com/pdfc/pdfc-fa-members.html - it is not available to non-PDFC members, as PDFC membership benefits are underpinned by subscription charges.

Document Structure

Whilst acknowledging the comments above regarding the business case, many of the requirements listed simply represent industry good practice and should be seen as necessary requirements for any train.

In this case the structure of each clause is:

A Requirement, categorised by:

(E) = Essential. 'Shall' is used for any design of train and that there is NO valid business justification for non-inclusion.

(D) = Desirable and 'should' is used, where there may be a choice.

(B) = Depends on a Business Case decision. A business case is used to decide if a requirement is necessary. Should it be required, the requirement is considered essential.

(I) = Information or introductions to add detail as necessary.

A Rationale, in *italics,* is provided after most requirements.

A box around a statement giving additional information and links to supporting documents.

The document is sub-divided into five sections of key requirements for rolling stock as follows:

Section 1: Key Requirements - Technical

Section 2: Key Requirements - Performance

Section 3: Key Requirements - Passenger Facing

Section 4: Key Requirements - Operational

Section 5: Key Requirements - Communications and Diagnostics

A request for tracking of the type of changes from the v5.1 version has been made. Coloured text has been used to show this, as follows:

Purple text with line at right – New

Red text with line at right – Amended

Blue text with line at right – Renumbered, moved and possibly amended.

Background to KTR

In 2009 the Technical Strategy Advisory Group (TSAG) remitted the Vehicle / Vehicle System Interface Committee (V/V SIC) to develop guidance on key technical requirements for new trains. These requirements represented best practice that experience has demonstrated not to be adequately covered by mandatory standards. The initial version of the document (KTR v1) was published in January 2011, with a second version in February 2013 and a third version in September 2014. Version 4 was renamed Key Train Requirements (KTR v4), and was issued under the auspices of the Technical Strategy Leadership Group (TSLG) and included an expanded coverage of operational aspects.

Following industry feedback on the content, suggestions were received that it would benefit from a full review and reformatting to facilitate easier incorporation into procurement specifications. This became v5 and had an interim update to 5.1. Additionally the requirements were published as Excel spreadsheets.

In KTR v2, an appendix A (*Items Intentionally Excluded from KTR*) was added. This appendix has been updated in subsequent versions.

Appendix B was added at v4, with useful links to current research and innovation programmes, this has been updated.

Appendix C was added at v4, to cover requirements relating to toilet design. This incorporated input from train operators, owners and manufacturers; as well as from Transport Focus. This has been updated.

Appendix D was also added at v4, to cover software and cyber security. Its scope is broader than design, as it helps with updating or actions following cyber-attack. This has not been updated.

New appendices were added to v5 as follows:

Appendix E, to cover the choice of fasteners.

Appendix F, for guidance on monitoring infrastructure from the train.

Appendix G, contains useful supporting information that helps explain some of the requirements.

Appendix H, has suggestions for automating Train Preparation.

Appendix I, had additional information on ERTMS / ETCS fitment was removed at v6 as it was no longer valid.

At v6 a new appendix J on catering equipment and an appendix K on T1140 seat comfort parameters were added.

And a Glossary was first included at v5 and added to in v6.

The drafting group consists of representatives from manufacturers, leasing companies, TOCs, Network Rail and technical specialists and is led by RDG.

0. Transmission of Infectious Diseases

It is too early to make any recommendations on train design to minimise transmission of infectious diseases, such as COVID-19, but readers should give some consideration to research that has been done to include in train specifications. Items to consider are surfaces, including touch-points (handles, push buttons etc), upholstery and HVAC.

There is an Industry Working Group under Technical Leadership Group (TLG), known as *TLG C-19 Working Group* which has the following scope:

Principle Objective

Coordinate and steer across industry the development of new knowledge and solutions to restore public confidence in rail, and ensure the safety of passengers and staff, in the short-term immediate response from the coronavirus crisis, in the medium-term while the virus is still circulating, and in the long-term to be prepared for future pandemics which may have different characteristics to Covid 19 or influenza.

Remit

- Identify current best-practice and ensure that this is widely disseminated,
- Coordinate industry response when the development of new knowledge and solutions is needed,
- Provide industry advice on best-practice and the emerging science, based on scanning work being undertaken by RSSB. Guide this RSSB work by suggesting areas of focus and responding to outcomes,
- Identify critical relevant potential workstreams or R&D where gaps in knowledge exist, including seeking funding where necessary.

Subject Areas

Transmission: *measures to reduce [Trains, Stations, Buildings, Depots and Operational Areas]*

Surface: Sanitisation, Cleaning and Anti-Viral Coatings

Airborne: Air Management, HVAC

Human to human contact: Social Distancing

Science: *to understand and monitor transmission mechanisms and rates in the railway environment*

Transmission models

Mechanisms of infection in the rail environment

Efficacy of measures

Cost-effectiveness and Business Cases

Recovery: *the imperative to restore confidence*

Providing those undertaking market research with understanding of the critical technical issues

Providing those undertaking industry communications with 'one version of the truth' so that industry messaging is clear, accurate and factually-based

For each of these subject areas the TLG C-19 Working Group will:

- Generate a register of existing R&D activities and initiatives,
- Identify gaps and opportunities,
- Steer the delivery of short-term activities based on the identified gaps and opportunities.

For more information, contact RSSB through the RSSB Customer Self-Service Portal: https://customer-portal.rssb.co.uk/.

Any findings or recommendation will be included in the next version of the KTR.

1. Key Requirements - Technical

1.1 Vehicle Mass

1.1.1 The mass of the rolling stock shall be optimised to deliver the lowest whole life cost to the 'railway system' (E).

Reduction in vehicle mass provides benefits to the whole railway 'system' by reducing the impact of the vehicle on the track.
A reduction in vehicle mass can result in a lower Variable Usage Charge (VUC).

It is recommended that the outputs of Railway Safety and Standards Board (RSSB) Project *'T712: Research into Trains with Lower Mass in Britain'* are used to inform any decisions as to the target mass for new builds of rolling stock. Available here: https://www.sparkrail.org/pages/libraryresults.aspx?k=t712

1.1.2 The unsprung mass of the rolling stock should be minimised (D).

Small changes in unsprung mass can have a significant impact on track deterioration caused by the vehicle, particularly at higher speeds and can result in a lower VUC.

The VUC calculator can be used to determine the effect of reducing vehicle and unsprung mass on the VUC. The VUC calculator is available from the Network Rail website here: https://cdn.networkrail.co.uk/wp-content/uploads/2020/04/Unofficial-CP6-VUC-calculator-April-2020.xlsm.

1.2 Track / Train Interface

1.2.1 Rolling stock shall be assessed using an industry-recognised whole-life, whole-system vehicle / track interaction model so that the vehicle / track interface is optimised (E).

To ensure the system is considered as a whole, rather than the vehicle or the infrastructure in isolation.

Key elements to consider are:

- Reducing primary yaw stiffness (PYS) can lower the amount of wear and rolling contact fatigue damage experienced by both the wheel and rail, extending their life.
- The use of variable stiffness bushes in the primary suspension components can result in lower curving forces, whilst maintaining the benefits associated with stiffer suspensions at higher speeds.
- The choice of wheel profile can help to reduce damage and wear, extending wheel life, for example the use of the P12 profile as an

alternative to the P8 profile may reduce rolling contact fatigue.

The effect that different vehicle types, suspension characteristics and wheel profiles have on the whole life cost and the infrastructure can be assessed by using modelling tools; such as the Vehicle / Track Interaction Strategic Model (VTISM) or the Network Rail Variable Usage Charge (VUC) calculator.

Details of the RSSB Vehicle / Track Interaction Strategic Model (VTISM) project can be found under research project *'T792 Stage 2 development of the Vehicle Track Interaction Strategic Model', here:*

https://www.sparkrail.org/Lists/Records/DispForm.aspx?ID=9856

Note: VTISM can be used to compare the effects of different wheel profiles on wheel wear and damage

The access charges for CP6 and the Network Rail VUC calculator can be found at:

https://www.networkrail.co.uk/industry-and-commercial/information-for-operators/cp6-access-charges-2/.

Note: The VUC calculator can be used to compare the track usage charges for different vehicle types.

1.2.2 Adoption of active suspensions (mechatronics) should be considered to improve ride and curving performance (D).

However, given the rapid development of mechatronics, this technology should be considered subject to an assessment of its maturity and the robustness of the supporting business case.

It is recommended that the work being led by V/T SIC on behalf of the Technology Leadership Group (TLG) is used to inform any decisions as to the appropriateness of mechatronics.

1.3 Coupler Systems

1.3.1 Couplers

1.3.1.1 Dependent upon the maximum train operating speed and usage the following end coupler shall be chosen at a respective height above rail level (ARL) (E):

≥ 250 kph - refer to the Loc & Pas TSI,

< 250 kph - Loc & Pas TSI compliant Dellner 12 / Voith 136 / Faiveley 130 or equivalent, at a nominal 925 mm ARL of its coupling centre line.

The use of cross-compatible couplers supports the removal of barriers to the interworking of rolling stock supplied by different manufacturers and facilitates emergency rescue.

The output from RSSB Project '*T1003: Standardisation of Coupling Arrangements'* presents a business case for mechanical compatibility in couplers.

As part of the project a specification for a Type 12 coupler was created in document '*Standardisation of coupling arrangements - Phase 2 (T1003 Report)*'. Available here for RSSB members:

https://www.sparkrail.org/Lists/Records_StaffMembers/DispForm.aspx?ID=846

If you are not an RSSB member a request for a copy of the relevant report needs to be made to RSSB, see reference on page 10.

Additional guidance on coupler design can be found in section 2.3 of *'RIS-2780-RST Rail Vehicle Structures'* and in *'RIS-2790-RST Compatibility of Rail Vehicle Couplings and Interconnectors'.*

1.3.1.2 The ability for interworking with subsets of existing design / product / platform of rolling stock from a supplier should be demonstrated, recognising the aspirations for the long-term use of the rolling stock (D).

Where a supplier is providing more of the same vehicle platform or class, these should be as interoperable as possible, without stifling future innovation. This permits easier cascade of the rolling stock.

1.3.1.3 To facilitate rescue / recovery of stranded trains an 'emergency - limited functionality' mode of communication between the stranded and rescue train should be provided (D).

This enables the failed train to remain suitable for passenger-use, including welfare facilities, with limited operational restrictions, until reaching a suitable location to be taken out of service, taking into account the passenger environment.

To permit more extensive use of the rescue train / locomotive the following would need to be provided:

- Full service brake application,
- Traction Control,
- Crew to Crew Communication,
- Door Control and Interlock,
- Public Address,
- Passenger Communication Emergency Alarm,
- Electric Train Supply (hotel power),
- Passenger Information System.

1.3.1.4 The end coupler shall function reliably in difficult environmental conditions (e.g. snow and ice; dead flies, dust or other contamination), taking into account the anticipated frequency of coupling operations (E).

Design features that may be appropriate include:

- Protection of the coupler when not in use,
- Automatic heating of the electrical head to prevent the build-up of ice,
- Protection of the electrical connections by a tight cover when not coupled,
- Protection of the pneumatic connection by a valve with an airtight seal of proven design,
- Features to ensure that the coupler pocket remains free from the build-up of snow and ice,
- Locating electrical heads to prevent ingress of de-icing fluids, melting snow and ice draining from the mechanical head.

This ensures that infrequently used couplers are available when needed and frequently used ones are serviceable.

It is recommended that the outputs of RSSB Project *'T958: Ensuring Automatic Coupler Reliability During Ice and Snow'* are used to inform any decisions with respect to the design of new builds of rolling stock. Available here: https://www.sparkrail.org/Lists/Records/DispForm.aspx?ID=727

1.3.1.5 To aid rescue using just the mechanical coupler, the electrical head should be retractable, and remain in the back position with the cover closed (D).

1.3.1.6 The location of the electrical connector should be positioned to reduce dirt accumulation within it (D).

The better location is on top or at the side of the coupler rather than underneath, but this is not always feasible due to gangways or space.

1.3.1.7 An air pipe connection should be provided to allow a locomotive to charge the brake pipe and control air via its brake pipe (D).

1.3.1.8 Air pipe connections should be provided to allow a locomotive to charge the Main Reservoir (MR) pipe and control the brake application and release, via the Brake Pipe (BP) (D).

1.3.1.9 The coupling should permit locomotive haulage / rescue using a compatible mechanical adaptor coupling (D).

1.3.1.10 The adaptor/rescue coupling should include the means to charge the air supply for the brake system from the locomotive brake pipe (D).

1.3.1.11 To aid locomotive rescue moves the brake system should be capable of being controlled using brake pipe pressure commands (D).

More information on brake systems to enable rescuing by a locomotive is given in section 2.5 of *'GMRT2045 issue 4 Compatibility Requirements for Braking Systems of Rail Vehicles'*.

1.3.1.12 A coupler that self-tests and proves coupling should be provided (D).

When two trains are coupled a pull test is performed to ensure the mechanical connection is made, this requirement is a request for a pull test to be carried out automatically.

1.3.2 Retractable 'Nose Cone' Covers

1.3.2.1 Coupler systems with retractable 'nose cone' covers should ensure that trains can only be coupled once the covers have been opened (D).

Frequent attempted coupling activities have occurred with the covers not being retracted or opened causing damage, consequent delays and subsequent loss of availability.

1.3.2.2 An interlock / error message should be relayed to the driver following a request to open the nose cone covers during a coupling operation (D).

This could be incorporated with a 'coupling mode' whereby a prevention of drawing forward exists to ensure damage does not occur to the nose.

1.3.2.3 An 'open rear coupler covers' functionality should be provided for coupler systems with retractable 'nose cone' covers (D).

This is to aid speedier coupling as the covers are already open for the second unit arriving to couple at the rear.

1.3.2.4 An 'open rear coupler covers' indication to the cab where the request has been made should be given (D).

1.4 Brake System

1.4.1 Dynamic braking systems shall deliver optimal whole life / whole system costs (E).

Recovering energy during braking, reduces energy usage, maintenance costs and use of friction brake consumables and eliminates the release of wear products when braking.

1.4.2 For rolling stock with electric traction the ability to brake regeneratively shall be provided (E).

The strategy for all parts of the electrified GB rail network is to accept regeneration. If the infrastructure is not regen-enabled at service introduction, a facility is to be provided on the train to disable it.

1.4.3 The maximum jerk rate for changes to brake demand (including initial application) and during blending of the brake system are given in '*GMRT2045 issue 4 Compatibility Requirements for Braking Systems of Rail Vehicles'* clause F.2.5.2 and the referenced European Standards therein. The value chosen depends on the type of service and many GB projects have successfully used 0.5 m/s^3 for passenger comfort (I).

A suitable value of jerk rate ensures a comfortable ride and the safety of standing passengers.

The clause of jerk rate in v5 of KTR has been removed and replaced with the one above.

1.4.4 The train consist shall provide a true train speed signal under all operating conditions (E).

This level of redundancy ensures the train can maintain performance and therefore makes the train fault tolerant.

Subject to achieving compliance with mandatory standards to ensure sufficient braking capacity under all circumstances, this could be achieved by leaving an axle(s) unbraked to deliver unambiguous speed signals.

An unbraked axle is acceptable on a long train formation but can be a problem on short formations.

1.4.5 The train consist should be capable of re-distributing the braking demand throughout the remainder of the train in the event that the brakes on a bogie(s) or wheelset(s) are isolated (D).

1.4.6 Options should be provided for the provision of additional braking systems (D).

The ability of trains to provide predictable braking performance under all conditions (e.g. using distributed variable rate sanding or track brakes) offers the potential to reduce service disruption (e.g. leaf-fall), reduce wheel damage and has been recognised as a significant factor in enabling reductions in headways and hence maximising route capacity.

See section 1.6 of this KTR for information on distributed variable rate sanders.

'*RIS-2710-RST Magnetic Track Brakes*', which advises on the integration and compatibility management of Magnetic Track Brakes (MTBs) on rolling stock for use on the Great Britain (GB) mainline railway has been published. Magnetic Track Brakes are in use on heavy rail in Continental Europe at speeds up to 200kph. The RSSB research project '*T1099: Enabling Magnetic Track Brakes on Network Rail managed infrastructure'* gives guidance on understanding and demonstrating compatibility of magnetic track brakes with existing Network Rail infrastructure and provides information for the development of GB compatible infrastructure. Available here:

https://www.sparkrail.org/pages/libraryresults.aspx?k=T1099

1.4.7 The 'effective' brake force applied shall reflect that requested by the driver throughout the complete brake blending process at all speeds (E).

Experience has demonstrated that the blending of the respective braking systems has often proven difficult to achieve under all circumstances.

1.4.8 Whilst the train is undergoing testing / commissioning, tests should be conducted to confirm the brake blending transfer from dynamic to friction brake is seamless and that correct "handover" verification without delay from one system to the other is confirmed (E).

This is regarding the transfer from Dynamic to Friction brake and the importance of the low speed "handover". The jerk rate can be affected but it is the fact operationally, there could be a point in time (seconds) where there is no dynamic or friction brake at the low speeds (falling speeds between the range 13-9 mph for example) where this occurs.

1.4.9 All valves and isolation cocks used in the brake system of rolling stock shall comply with the appropriate European Standard for use in railway applications (E).

Components that do not comply with standards for use in railway applications may not be suitable for the reliable operation in the railway environment.

The RAIB report *'Report 05/2020: Loss of brake control on a sleeper train approaching Edinburgh'* into the loss of brake control of a sleeper train approaching Edinburgh identified that the Brake Pipe Isolation Cock involved in that incident did not meet the requirements of *BS EN 14601:2005+A1:2010 Railway Applications – Straight and angled end cocks for brake pipe and main*

reservoir pipe, as that standard was not explicitly called up by the TSI for the coupler configuration used.

The RAIB report can be found here:

https://assets.publishing.service.gov.uk/media/5ece325b86650c76a551df1a/R052020_200528_Edinburgh.pdf

1.4.10 All isolation cocks used in the brake system of rolling stock shall be orientated so that if they come loose, they will fail to a safe position (E).

Isolation cock handles could come loose in service, for example due to vibration and / or gravity, even if equipped with a latch. The intent of this requirement is to ensure that if this happens, it does not lead to any loss of performance of the brake system.

The RAIB report *'Report 05/2020: Loss of brake control on a sleeper train approaching Edinburgh'* into the loss of brake control of a sleeper train approaching Edinburgh identified that the Brake Pipe Isolation Cock involved in that incident was orientated so that if it came loose in service, it would fall down into a position that isolated the brakes on the following vehicles. This orientation has been modified so that the cock handle is at its lowest position when the brakes are not isolated, so it will not move under gravity or vibration, and is at its highest position when the brakes are isolated, so that movement under gravity or vibration would cause the handle to fall to a position that would de-isolate the brakes.

1.5 Brake Application on Door Release or Loss of Door Interlock

1.5.1 The train shall not be able to move, relative to the platform, once it has come to a stop and doors are enabled and shall only be able to move again once door interlock is achieved (E).

This is to ensure safety at the Platform-Train Interface by preventing train movement whilst the train doors are enabled. A suitable over-ride would need to be provided.

The Loc & Pas TSI covers interlocks as does '*RIS-2747-RST Functioning and Control of Exterior Passenger Doors on Vehicles'*.

The Loc & Pas TSI says power cannot be taken until interlock is achieved. It does not say the train cannot roll, which is the intent of the KTR clause.

1.5.2 Reaction to a loss of door interlock shall be in accordance with clause 2.5.4.1 of *RIS-2747-RST Functioning and Control of Exterior Passenger Doors on Vehicles* (E).

The Loc & Pas TSI clause 4.2.5.5.7 has no commentary around how the train should react to a loss of door interlock. '*RIS-2747-RST Functioning and Control of Exterior Passenger Doors on Vehicles'* clause 2.5.4.1 does, where it specifically requires an emergency brake to operate that can be overridden by the driver should they decide to.

1.6 Wheel-Rail Treatments

1.6.1 Sanding Systems

1.6.1.1 For new or retrofit of multiple units, variable discharge rate sanders shall be designed and fitted in accordance with the good practice guidance detailed in Section 2.4, Appendix A and Appendix B of '*GMRT2461 iss 3 Sanding Equipment'* (E).

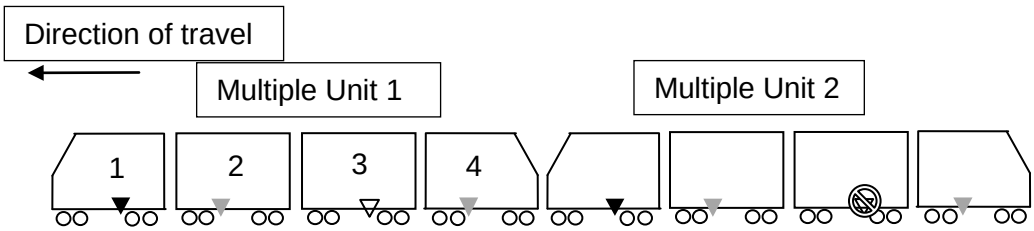
RSSB research project '*T1107 Trials of sanders and sand laying rates'* has demonstrated the significant improvement in adhesion levels and braking performance (both reduction in and variability of stopping distance)that can be achieved both by increasing the number of sanding positions on a train and by using variable rate sanders to control sand-laying density. Section 2.4, Appendix A and Appendix B of '*GMRT2461 iss 3 Sanding Equipment'* set out good practice for the design and configuration of sanding equipment to optimise braking performance.

'T1107' project is available here:
https://www.sparkrail.org/pages/libraryresults.aspx?k=t1107

'T1181 ADHERE: In-service assessment of adhesion mitigation measures', analysed the data from RSSB research project *'IMP-T1107'* on the use of single or double variable rate sanders (SVRS or DVRS) on an existing fleet. A link to T1181 can be found here:

https://www.sparkrail.org/Lists/Records/DispForm.aspx?ID=26237.

1.6.1.2 Sanders shall be configured so that when units are coupled and operating in multiple formation the following applicable sanders are operational; First (leading) unit - leading vehicle and if fitted second pair of sanders; second unit - leading vehicle; third unit - leading vehicle. An example layout is shown in Figure 1.6.1.2 (E).



Notes / key

a. Arrangement to be replicated for each direction.
b. Sander arrangement on coaches 2 and 3 is interchangeable.
c. ▼ Leading (first) active sander on unit in direction indicated.
d. ▼ Second active sander on unit in direction indicated.
e. ▽ Sanders active in other direction.
f. Sander in trailing unit suppressed.
g. For 3 connected multiple units, multiple unit 3 to be configured as multiple unit 2.

Figure 1.6.1.2 – Example of arrangement of sanders on multiple formations

RSSB research project *'T1046 Optimising the ability of industry to deal with low wheel-rail adhesion and the use of sanders on train'* demonstrated the benefits in low adhesion risk reduction through using multiple sanders. The project reports can be found here:

https://www.sparkrail.org/pages/libraryresults.aspx?k=T1046

1.6.1.3 When designing and locating the sand hopper the height / size / shape / location of its filling orifice for replenishing sand shall be considered for maintenance accessibility and need for dry, clean sand (E).

This is to ease filling, reduce manual handling, minimise spillage and ensure sand remains dry and usable. An internal filler could be considered for third rail conductor rail areas.

The Adhesion Working Group has produced a guide to improving adhesion which includes sanders in Sections 5 and A2.

A link to the document is here:

https://www.raildeliverygroup.com/component/arkhive/?task=file.download&id=469773735

Note: This KTR clause is not covered in GMRT2461 issue 3.

1.6.2 Flange Lubrication Systems

1.6.2.1 On-board flange lubrication systems should be provided (D).

Having lubrication systems on board the train provides additional protection to reduce wheel wear and extend wheelset life.

Useful information is given in *BS EN 15427: Railway applications. Wheel/rail friction management. Flange lubrication*. This is due to replaced by the following updated documents in due course:

- *EN 15427 – 1-1 – Wheel/Rail Friction management – Flange lubrication – equipment and application,*
- *EN 15427 – 2-1 – Wheel/Rail Friction management – Flange lubrication – Properties and characteristics.*

1.6.2.2 The on-board flange lubrication system should be designed such that an adaptation of lubrication frequency / parameters can be easily changed in the depot without requiring software updates, where applicable (D).

1.6.3 Top of Rail Management

1.6.3.1 On-board top of rail management should be provided (D).

Having systems on board the train provides additional assistance to train wheels.

Useful information can be found in the following documents, due to be published soon:

- *EN 15427 – 1-2 – Wheel/Rail Friction management – Top of rail materials– equipment and application,*
- *EN 15427 – 2-2 – Wheel/Rail Friction management – Top of rail materials – Properties and characteristics.*

1.7 Consumable Tank Capacities and Servicing Requirements

1.7.1 The following European Standards give some useful information on tank designs and equipment (I):

- *BS EN 16362, Railway applications — Ground based services — Water restocking equipment,*
- *BS EN 16922, Railway applications – Ground based services – Vehicle waste water discharge equipment.*

1.7.2 Sufficient capacity shall be provided for all tank systems to avoid the need for ad-hoc intermediate replenishment between planned visits to depots or servicing points (E).

Proposed rolling stock maintenance cycles should be used to determine the required capacities of fuel tanks; fresh water tanks (including buffets); Controlled Emission Toilet (CET) tanks; windscreen washer tanks, flange lubrication systems, sand hoppers (see 'GMRT2461 Sanding Systems' also) and AdBlue diesel engine additives. This means that sufficient capacity shall be provided for all such systems to avoid the need for ad-hoc replenishment between planned visits to depots or servicing points. Whilst providing larger water and waste tanks for toilets clearly takes up valuable space and increases vehicle mass, recent experience from new trains' procurement is that underestimating tank capacity requirements leads to problems in service. (See section 3.13 and Appendix C for further requirements related to toilet provision).

1.7.3 Consumables / waste shall be easy to replenish / discharge without the need to position the rolling stock over a depot pitted road and it shall be possible to completely replenish / discharge such systems from either side of the vehicle (E).

Not all depots have pits. Sometimes replenishment at stations or in sidings is required.

1.7.4 Protective caps on consumable replenishment connectors shall be fitted with secondary retention devices, the design of which shall be of sufficient strength to withstand the dynamic forces should the cap become loose in service (E).

There have been instances of caps being left off Controlled Emission Toilet (CET) connectors and breaking away, causing damage, jamming in pointwork or creating a risk of injury.

1.7.5 Critical consumables (e.g. fuel, washer fluid etc.) that would prevent normal operation of the train shall be flagged to the driver and advised to the Control room when they reach an agreed minimum level (E).

This permits replenishment to be planned and reduces the risk of train delay or cancellation.

1.7.6 Consumables such as toilet tanks that are not service critical should send a message to the Control room so that action can be planned to mitigate the effect of the low level (D).

This permits replenishment to be planned and reduces the risk of train delay or cancellation.

Where relevant this message could also be provided to train crew (other than the driver), so that appropriate action can be taken, e.g. relocation of wheelchair users.

1.7.7 It should be possible to connect shore supplies from both platform and track level (D).

Some operators currently struggle to access such connections for example, electrical, mechanical and pneumatic, when vehicles are stabled adjacent to platforms.

This is equally applicab le to equipment isolation switches e.g. Battery Isolators; and level indicators; e.g. coolant and fuel. The Loc & Pas TSI clause 4.2.11.6 (stabling RST) refers to '*EN 60309-2:1998. Plugs, socket-outlets and couplers for industrial purposes. Dimensional interchangeability requirements for pin and contact-tube accessories'*, but its position is not included. Other information may be found in '*BS EN 50546. Railway applications. Rolling Stock. Three phase shore (external) supply system and connectors for rail vehicles',* which is due to be published soon.

1.7.8 Where possible the replenishment points of different fluids should be designed to reduce the risk of cross-contamination (D).

This may mean having them in different locations along the vehicle.

1.7.9 Interfaces for replenishing consumables should be in accordance with a recognised standard (D).

Standardised connections ensure interoperability. Standard connectors for fuel and water exist.

RSSB has carried out a survey of the current AdBlue refilling facilities at depots in GB and the findings will be used by the CEN TC256 WG43 GB representative to help develop a new European Standard '*WI00256950 Railway applications — Ground based service — AdBlue refilling equipment.*'The report is on SPARK as '*AdBlue Connections (S332)*'and available here: https://www.sparkrail.org/Lists/Records/DispForm.aspx?ID=25967 In addition CEN TC 256 WG 43 is working on the following standard:

- *WI00256957 Railway applications — Ground based service — Hydrogen refuelling equipment.*

(Note: The WI is a working code for standard writing, it will not receive a number until it is ready for Enquiry).

1.7.10 Consideration should be given to avoiding the use of cosmetic access covers over external filling and emptying points (D).

There have been instances of cosmetic covers not being closed and falling- or being knocked off, and where a self-closing mechanism has failed.

One example was NIR 3558 – CET Flaps found missing / loose.

1.7.11 The current operational status of the toilets and the level of water and CET tanks should be updated on a frequent basis to an off-the-train location for use by the maintenance depot (D).

1.8 Windscreen Wiper Systems

1.8.1 Windscreen wipers on non-active cabs shall not be damaged as a result of aerodynamic effects experienced throughout the design speed range of the rolling stock (E).

Historically, with certain designs of rolling stock, there have been instances of intermediate windscreen wipers becoming damaged as a result of aerodynamic effects lifting wipers away from the windscreen when running at speed.

1.8.2 Consideration should be given to protecting the wipers from impact damage when not in use (D).

1.8.3 The use of variable speed windscreen wipers should be considered, including an intermittent setting (D).

This will reduce the need for drivers to operate the wiper control when continuous operation is not required.

1.8.4 The windscreen wiper system should be effective at removing all typical contaminants likely to be encountered during operation (D).

Typical contaminants are listed in '*EN 50125-1 2014 Railway applications - Environmental conditions for equipment - Part 1: Rolling stock and on-board equipment*' clause 4.11.

1.9 Electrical Connectors, Jumpers and Cable Idents

1.9.1 Electrical connectors (plugs and sockets including jumper plugs and cables) shall be designed to operate reliably for the life of the rolling stock (E).

Electrical faults on existing rolling stock are frequently associated with poor connections or water ingress into plugs and sockets.

Note 1:	This includes ensuring they are positioned remotely from potential sources of water ingress and oriented to avoid water traps and also ensuring the sealing arrangements will not degrade over time.
Note 2:	The orientation of non-horizontal plugs and sockets should be such that water will not collect in the lower part.
Note 3:	Sometimes condensation can run down a cable into a connector and a loop prior to entry can prevent this.

BS EN 50467:2011. Railway applications. Rolling stock. Electrical connectors, requirements and test methods, gives some useful information.

1.9.2 Electrical wiring identification labels (idents) shall withstand normal wear and tear without significant physical degradation in order to remain legible for the life of the rolling stock (E).

Faded or lost idents cause delays in fault finding while cables are traced and increase the risk of maintenance errors.

An example of good practice in this area is colour coding of wiring idents.

1.9.3 Cabling shall be in accordance with '*BS EN 50343:2014 Railway applications - Rolling stock - Rules for installation of cabling'* (E).

1.9.4 Junction box, socket or plug arrangements shall ensure that an unintentional ingress of water does not lead to a water build-up causing corrosion or failure (E).

Most boxes are designed to an IP rating, but during maintenance a seal or gasket may be incorrectly fitted leading to water ingress.

One instance was NIR 3548 – Class 395 Wrong-Side Service Brake Failure.

1.10 Adhesive Bonded Components

1.10.1 The train design philosophy should be that no in-situ adhesive bonding is required to maintain or repair the rolling stock, with all Line Replaceable Units (LRUs) being mechanically attached to the rolling stock (D).

There have been instances where depot-replaced items e.g. windows, have subsequently become detached in-service. Additionally, this process can mean trains remaining out of service as a result of the time required for bonding which may be extended by uncontrolled depot conditions.

Designs where windows are bonded directly to the rolling stock structure are not compliant with this requirement since it cannot be guaranteed that depot temperature or humidity will be within the specified ranges to ensure a satisfactory bond. Glazing units are preferred supplied bonded to a frame which is then mechanically fastened to the rolling stock structure.

It is not recommended that any components are secured to the vehicle exterior solely by the means of bonding. A form of secondary retention should be considered.

1.11 Reliability, Availability, Maintainability and Safety (RAMS)

1.11.1 Reliability

1.11.1.1 Targets for the frequency and impact of failures shall be agreed (E).

Reliability targets (frequency and impact of failure) need to take into account the benefits to the operation and the costs (technical and commercial) of providing a particular level of performance.

It is recommended that RSSB Project 'T782: Maximising Future Rolling Stock Reliability' is used to inform any decisions taken with respect to setting contractual reliability targets, available here:

https://www.sparkrail.org/pages/libraryresults.aspx?k=t782

1.11.1.2 Rolling stock, where practicable, shall include the necessary functionality to recover from or mitigate for technical failures and to assist train crew in minimising the consequences of a failure (i.e. delay) with minimal intervention (E).

1.11.1.3 Reliability targets shall be specified and measured in terms of the agreed current industry key performance indicators (KPIs) (E).

The current KPIs are MTIn (Miles per Trust Incident number) and DPI (Delay Per Incident).

1.11.1.4 When operating in 'degraded mode' the control systems shall be reconfigurable, preferably automatically, so that the impact on critical systems is managed to enable rolling stock to remain in-service (E).

'Degraded mode' could be a failure of a key system (e.g. auxiliary converter).

1.11.1.5 The interaction of the individual train systems shall be taken into account in the design and testing phases and incorporated prior to introducing into service in order to improve the performance of new trains (E).

Techniques like 'Break the train', 'trial train crew and passenger experience' and driver feedback, are also good means to identify issues.

1.11.1.6 During the design process consideration should be given to the following principles "Design for Safety, Reliability and Maintainability' (D).

1.11.2 Availability

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

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.

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

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.

Examples of good practice to optimise availability (primarily for multiple units) are:

- Ensuring the end vehicles are identical to facilitate unit reforming in the event of collision damage,
- Avoiding providing wheelchair facilities in vulnerable vehicles, e.g. leading vehicles,
- The provision of 'shunt' controls where long fixed formation sets can be split to facilitate subsequent unit reforms,
- The provision of a jumper with plugs / sockets in the centre of longer formations to enable units to be split and reformed as required.

1.11.3 Maintenance and maintainability

1.11.3.1 Maintenance, overhaul and renewal requirements are set out in Loc & Pas TSI section 4.2.12.3 (I).

1.11.3.2 Systems and sub-systems shall be designed to minimise the amount of maintenance required and vehicle downtime during these activities. (E).

Not only do high levels of maintenance requirements lead to loss of availability but interventions are a potential source of unreliability.

Examples of good practice in this area are that:

- Rolling stock should be designed to facilitate the use of infrastructure based remote condition monitoring equipment to undertake automatic vehicle inspection; e.g. measuring brake pad thickness, wheel tread wear and pantograph carbon thickness, avoiding the need to access depot facilities that are limited, such as underframe pits / safe roof access. Additionally, it reduces time and occurrences of 'working at height' and 'electrical isolation',
- On-board condition monitoring systems capable of downloading data to intelligent analytical tools that are able to recommend maintenance interventions in order to prevent in-service failures from occurring,
- Electronic modules are specified with 'plug and play' connectivity (to remove the need for manual configuration upon component replacement).
- Application of MSG-3 methods from the aerospace industry.

1.11.3.3 It shall be possible for typical repair activities to be completed during an agreed specified timeframe allocated for maintenance (E).

Examples of good practice are to create a list of predictable repair activities, including items such as typical vandalism / minor accident repairs, with agreed vehicle downtimes that are demonstrated as a part of the train acceptance process. e.g. parts of rolling stock that are vulnerable to impact damage (e.g. front fairings) are easy to replace. This excludes bodyshell penetration or structural damage.

1.11.3.4 All primary retention devices on exterior equipment covers and access panels shall be visually obvious when they are not engaged, with their orientation to show open or locked being consistent throughout the train (E).

1.11.3.5 Exterior equipment covers, and access panels shall be designed to ensure they do not become open in-service (E).

Serious accidents have occurred as a result of access covers and panels opening in service, striking lineside infrastructure resulting, in the most extreme cases, in train derailment.

This may be achieved by provision of a two stage retention system, which is detachable for maintenance purposes.

Further guidance is given in '*RIS-2780-RST Rail Vehicle Structures'.*

1.11.3.6 Roof mounted equipment requiring frequent maintenance activity, for example, filters, shall be quick and safe to access (E).

1.11.3.7 The installation and position of mechanical fixings used to secure equipment shall be designed to enable easy checking for security during maintenance (E).

Some equipment fasteners have been known to be visible between other equipment but not possible to access without removing other equipment. This can lead to extra work and the possibility of failure.

1.11.4 Spares

1.11.4.1 Spare items, sufficient for the expected design life of the train and for maintenance e.g. bogies, wheelsets, pantographs, engine rafts, air-conditioning modules etc should be procured during build, suitably stored and included in the lease to optimise availability (D).

Once a train build has been completed it is likely that tooling will be dismantled and the manufacture of replacements then becomes difficult and costly.

1.11.4.2 Non-consumable items and those unique for that train, for example, bogie frames, crashworthy cab structures should be purchased at the same time (D).

1.11.4.3 A list of 'strategic spares' shall be provided by the train builder and agreed (E).

For example, components that do not form part of the maintenance and overhaul plan requirements but would be expensive or time-consuming to manufacture after the train-build is complete.

1.11.5 Obsolescence Management

1.11.5.1 An obsolescence management plan to cover the design life of the train shall be provided (E).

This is especially the case for electronic equipment and includes all rolling stock related software, operating systems, IT hardware, diagnostic and back-office software.

Note: Good practice in obsolescence management can be found in *'BS EN IEC 62402 Obsolescence Management'*.

1.11.6 Maintenance Manuals and Materials

1.11.6.1 Maintenance manuals detailing essential and supporting information shall be provided (E).

The following suite of standards gives information on maintenance plans and records:

- *BS EN 17023, Railway applications - Rolling stock maintenance - Creation and modification of maintenance plan,*
- *BS EN 17018 Railway applications - Rolling Stock Maintenance - Terms and definitions,*
- *BS EN 17095, Railway applications - Rolling stock maintenance - Maintenance records.*

1.11.6.2 Comprehensive and accurate drawings, maintenance manuals and spares lists shall be provided in a searchable electronic format (E).

1.11.6.3 Comprehensive fault finding information including training shall be provided (E).

This includes digital interactive and computer-based methods including virtual reality.

1.11.6 4 A Design Authority shall be identified and agreed at the time of train procurement, with specific responsibilities for ensuring that all documentation listed in 1.11.6 is maintained and updated to reflect subsequent engineering changes (E).

To ensure that, irrespective of the contractual structure agreed for train maintenance, future train maintenance can be undertaken in an efficient and safe manner it is essential that all documentation relating to the train is regularly updated to reflect changes in configuration. A Design Authority ensures there is no ambiguity as to roles and responsibilities in this regard.

1.11.7 Maintenance Training Manuals and Materials

1.11.7.1 Maintenance training materials that consist of essential and supporting information shall be provided (E).

1.11.7.2 All maintenance training manuals and materials shall be provided in a format that is accessible to maintenance staff and trainers (E).

1.11.7.3 Maintenance training support tools or apps shall be provided (E).

The manuals and materials need to be in a standard format, which will help to keep high training standards and provide consistency.

Manuals need to be in an electronic format, indexed and searchable, so they can be used with tablets and smart phones.

1.11.7.4 Consideration should be given to licensing of training support tools or apps including, (D):

- The number of licences available,
- The type of licence,
- Future support.

1.11.8 Fasteners

1.11.8.1 The choice of fasteners shall be demonstrated, by confirmation that the guidance in Appendix E has been followed (E).

One of the most significant sources of risk for accidents caused by train defects is failure of fasteners resulting in detachment of components whilst in service. The detachment of large and heavy items carries a high likelihood of train derailment. Whilst many incidents may be directly attributed to maintenance errors, it is essential that trains are designed, as far as is reasonably practicable, to minimise the consequences of such errors.

1.11.8.2 There shall be a defined strategy for the management of torque-tightening of fasteners (E).

This may include marking, automation of torque application or other means.

1.11.8.3 The torque tightening strategy shall consider the management of the torque associated with maintenance activities (E).

1.11.9 Sight Glasses

1.11.9.1 Sight glasses for checking fluid levels, where fitted, shall be positioned to enable easy viewing and be protected from flying ballast or other debris (E).

This will reduce the risk of damage and the resultant loss of fluid. Sensors may be used instead.

1.12 (in v5.1) Meteorological effects now included in chapter 2 section 2.8.

1.12 Traction and Power Capacitors

1.12.1 General

1.12.1.1 *'IEC 61071: Capacitors for power electronics'* contains some useful guidance (I).

1.12.2 Location of Traction and Power Capacitors

1.12.2.1 Traction & power capacitors shall be located on underframes or in a segregated technical area with protective barriers in which case a risk assessment covering location and protection mitigations shall be provided (E).

It is preferred that traction & power capacitors are not within the body shell where passenger or staff may be.

1.12.2.2 Traction & power capacitors shall be fitted with protection mitigations for example pressure, temperature (E).

1.12.2.3 Traction and power capacitors shall include comprehensive protection systems regardless of their location (E).

Built-in capacitor protection measures can be temperature cut-off, over-pressure detection, segmented film construction.

1.12.3 Management of Traction and Power Capacitor Maintenance

1.12.3.1 A method of managing the life of traction and power capacitors shall be included in the maintenance plan (E).

Capacitors of this type are a component with a finite service life and so the principal mitigation is to ensure they are replaced at the appropriate periodicity. This should include the keeping of records to effect the timely change out of components and may also include routine visual inspections to identify evidence of degradation.

The risk of a chemical reaction within the electrolyte possibly (resulting in the evolution of flammable gas) increases with age. One possible cause might be the integrity of the casing degrading through environmental conditions, allowing possible ingress of contaminants. Similarly, electrical stress conditions such as a

high voltage surge may result in a pressure increase within the casing, possibly leading to rupturing.

The risk of a failure of power capacitors (possibly resulting in the evolution of flammable gas) increases with age. Failure can occur for a number of reasons which might include electrical stress conditions such as a high voltage surge or transients and excessive temperatures.

These conditions also act to reduce the components service life through accelerated ageing.

There have been several instances of capacitors exploding (*NIR 3610 – 'Class 221 - Combustion Event Caused by Capacitor Gassing', [also see RAIB Safety Digest 01/2020], NIR 3585 – 'Class 710 - Capacitor gassing & risk of explosion'* and RAIB *Report 05/2018: 'Explosion inside an underframe equipment case at Guildford [on Class 455]')*, which have so far not caused injury but plenty of damage.

1.12.3.2 A statement for the safe maintenance of traction and power capacitors shall be provided as part of the maintenance plan (E).

1.13 Equipment Redundancy

1.13.1 An equipment redundancy strategy shall be prepared taking note of the train operator's plan (E).

Some operators deal with failed equipment on trains in service in different ways and this may influence the design approach.

Train operators follow '*RIS-3437-TOM Defective On-Train Equipment'* (DOTE) in preparing their approach to dealing with failed equipment.

1.14 Ingress of Water1.14.1 The watertightness of completed vehicles shall be tested prior to delivery (E).

Water unintentionally entering vehicles or standing can cause failure and corrosion.

Eurospec has produced a document '*Watertightness test specification for rolling stock'*, which can be used to give guidance on the risk assessment and tests to be performed, and can be found here:

https://eurospec.eu/watertightness/

1.14.2 Areas that may retain water shall be avoided (E).

The presence of water traps introduces a risk of water ingress into passenger / staff areas, electrical faults and accelerated corrosion requiring costly repairs in the future.

This applies to corrugations on the roofs, flat areas e.g. for jumpers or pantograph wells, where a fall and drains should be included, to allow the water to flow away.

Similarly for the management of condensation inside the vehicle.

1.14.3 Sealants should not be used in a horizontal plane where their failure will result in water ingress (D).

Sealants should be avoided where water can pool (see NIR3346).

1.14.4 Electrical equipment, within the bodyshell, should be suitably protected from the unintended ingress of water (D).

The failure of a sealant-joint allowed water to fall on the electrical equipment below (see NIR3346).

1.15 Train Security

1.15.1 Appropriate locking mechanisms for all doors to ensure security of the train shall be provided (E).

1.15.2 Alarms shall be installed to sound in the event that any external doors are forced (E).

The NRSP document section 8.44 – 8.48 defines the requirements for protecting trains against unauthorised access e.g. when stabled or empty at station platforms.

1.15.3 Access to non-passenger areas shall be controlled and secured by appropriate means (E).

1.16 Locks and Keys

1.16.1 A strategy for access to non-passenger areas and to equipment cabinets in passenger areas shall be agreed between the operator and supplier (E).

1.17 Vehicle Gauging Information

1.17.1 Vehicle gauging data in accordance with *'RIS-2773-RST: Format for Vehicle Gauging Data'* shall be provided (E).

Rolling stock manufacturers may be reluctant to state their actual vehicle profiles (claiming it is their Intellectual Property). As a result they only declare their vehicle profiles in accordance with standard vehicle gauges, although in many areas the actual vehicles are smaller. When the stock is cascaded a route compatibility assessment will potentially identify more 'foul structures' than would be the case if the actual vehicle profile was known. Indeed, there is the potential for infrastructure works being identified that are not actually required. This practice imports avoidable cost to the industry and places unnecessary restrictions on route availability in the event of emergency diversionary routes being required.

A copy of '*RIS-2773-RST: Format for Vehicle Gauging Data'*, a data spreadsheet and a data example are available from the RSSB website.

1.17.2 Part 3 of '*GERT8073 Requirements for the Application of Standard Vehicle Gauges'* sets out the process and conditions for declaring vehicles compliant to a standard vehicle gauge (I).

1.17.3 The gauging model should be made available to the vehicle owner, so that when cascading is needed, the vehicle can be cleared for the new route (D).

1.18 Electrical Collector Systems

1.18.1 Third Rail (750 V DC) Rolling Stock

1.18.1.1 DC collection systems are to comply with *'GMRT2113 Rolling Stock Subsystem and Interfaces to DC Conductor Rail Energy Subsystem'* (I).

1.18.1.2 New DC third rail rolling stock should include provision for the inexpensive retrofit of 25kV equipment (D).

It has been suggested that the long-term aim of the industry should be the replacement of the 750 V DC third rail system with the 25 kV overhead line system.

Note 1: In this context 'inexpensive' means that the design has made the provision for the fitment of equipment by the designer purposely allocating free space; power supply and consideration of cabling to the relevant location(s).

Note 2: The case for the replacement of the 750 V DC system with 25 kV overhead was the subject of RSSB Project '*T950: Investigating the economics of the 3rd rail DC system compared to other electrification systems*'.

The project reports are available here:

https://www.sparkrail.org/pages/libraryresults.aspx?k=t950

Note 3: Any such Project should consider and adopt a clear position on whether the AC conversion capability is to be proven by build, approval, and acceptance of a small number of units on a dual-voltage class basis, such that an approved classification exists for subsequent fleet conversion or accepted on a 'capable of' basis leaving approvals risk for the conversion project. The Rolling Stock Owner will be critical to this decision.

1.18.1.3 The design of 750 V DC shoegear shall ensure that, in icy conditions, an appropriate minimum current can be drawn to maintain the best possible shoe contact to the rail (E).

The objective is to generate sufficient heat to prevent shoegear from becoming frozen to the conductor rail when trains are stationary and therefore not drawing traction power.

This can be achieved by a selectable 'ice mode' which may also encompass changes to permissible electrical interference levels subject to an agreed safety case.

1.18.1.4 Collection shoes and arms of 750 V DC collector rail systems on multi-mode powered trains shall be retractable (E).

With multi-mode powered trains, the retraction of the shoe gear when off DC systems can reduce the likely loss of shoes by, for example, high ballast.

1.18.2 Pantograph System Design

1.18.2.1 25kV AC pantograph collection systems are to comply with *'GMRT2111 Rolling Stock Subsystem and Interfaces to AC Energy Subsystem'* (I).

This now includes a facility for the driver to isolate the pantograph automatic dropping device (ADD). Was clause 1.18.2.2 in v5.1.

1.18.2.2 The pantograph installation design should consider the use of polymeric insulators, or other non-ceramic insulators (D).

The RAIB report R062013 (i.e. the Littleport incident when a Class 365 Pantograph detached following the fracture of the ceramic insulators) recommends their fitment as they are considered to better absorb energy in the event of a pantograph incident.

The ceramic insulators were a fusible point in a dewirement. Polymer ones are less likely to break so the weak point has now moved into the OLE. RSSB research project '*T1060: Understanding the forces and energy in the electrification system during de-wirements*' found that the risks of using these insulators was minor, but that a risk assessment should be carried out.. Useful information on assessing the risks of using the polymer insulators is included in the report, which can be found here:

https://www.sparkrail.org/pages/libraryresults.aspx?k=t1060

1.18.2.3 Passenger facing equipment shall not suffer adverse effects as a consequence of passing through neutral sections (E).

The aim of this requirement is that the equipment continues in the mode it was in when the supply was removed without the need for on-train staff intervention. Sometimes, once a supply is removed, the equipment returns to a start mode (e.g. HVAC) or needs resetting.

1.18.2.4 Facilities for securing safety harnesses for staff working at height in emergency situations shall be provided around the pantograph well (E).

For example when dealing with damaged pantographs / dewirements.

1.18.2.5 A method to prevent flash-overs from the pantograph to the vehicle body causing damage or even holing the body should be considered (D).

There are regular instances and in one case *NIR 3572 – 'Class 345 molten metallic spray entered saloon area following birdstrike',* where the damage could have injured a passenger.

Insulating materials could be placed under the pantograph frame.

1.18.3 Supply System Changeovers

Note in v5.1 this was clause 4.6, from where it has been moved.

1.18.3.1 Dual voltage rolling stock should be designed so that supply changeover from 25 kV AC overhead electrification to 750 V DC third rail (and vice versa) is achieved as quickly as possible on the move (D).

Much time can be wasted, when stationary, during these changeovers. Doing it in on the move saves time and the reconfiguration of systems needs to be as simple as possible.

Ideally system changeovers should be completed within one minute for all on-board systems and possible formations of multiple units.

1.18.3.2 For trains that are multi-mode the capability for static and / or dynamic power changeover between modes shall be as defined by the specifier (B).

1.18.3.3 Where specified, dynamic changeover shall be achieved at all speeds up to maximum design speed (E).

With increasing introduction of discontinuous electrification schemes any requirement for a train to stop in order to change between electric and self-power modes has an impact on performance.

Dynamic changeover between modes includes pantograph / shoegear raising / lowering.

RSSB are drafting a new Railway Industry Standard 'RIS-2713-RST Multimode Vehicles' which will be published in 2021.

1.19 Systems Architecture & Train Software

1.19.1 Systems Architecture

1.19.1.1 Electrical equipment (at the Line Replaceable Unit level) shall have a modular, open architecture (based on the application of Internet Protocol (IP) communications functionality) (E).

1.19.1.2 The architecture for train safety systems / information systems shall be designed to prevent unauthorised access from, for example, passenger WiFi connections (E).

There is an increased risk of cyber-attacks if passengers are able to gain access to a network used for train systems.

Separate Ethernet backbones for train safety systems / information systems and those intended for passenger access may be based on virtual LAN (VLAN) or physical separation.

1.19.1.3 Cables for communication between vehicles shall be durable, maximise data transfer and band-width potential, suitable for future upgrading, and suitable for a railway environment by being in accordance with the following European Standards: (E).

- *BS EN 50155 Railway applications - Rolling stock - Electronic equipment,*
- *BS EN 61373 Railway applications. Rolling stock equipment. Shock and vibration tests.*

Cat 7 cables, rather than Cat 5 maximise data transfer. Some versions of Cat 7 cables may not be suitable for use in jumper cables between vehicles as they are relatively brittle and susceptible to failure with repeated flexing.

Where Cat 7 jumpers are not available multiple Cat 5 cables in a jumper have proven appropriate to maintain Cat 7 performance.

Noting that the supply chain is moving forward and this situation with Cat 7 may be superseded – specifiers should check with suppliers for the latest options on cables for rail application.

1.19.1.4 Switch configuration shall be set, to only accept the expected connected device or format, to ensure that accidental or malicious inputs cannot be accepted (E).

1.19.1.5 Switches and access points shall be in locked cupboards, to ensure malicious physical connections cannot be easily made (E).

A requirement for a lock strategy is given in 1.16.

1.19.1.6 Choice of connectors shall be carefully considered to ensure system components cannot be incorrectly connected either accidentally, or maliciously (E).

1.19.2 Train Software

1.19.2.1 Useful background guidance on procuring trainborne software on trains can be found in RSSB research project '*T1047 Industry guidance on the use of software-based systems for railway applications'*, Some output from this research is given in the following guidance note *'GEGN8650 Guidance on High Integrity Software-Based Systems for Railway Applications'* and should be reviewed (I).

1.19.2.2 There are various European Standards on software including (I):

- *BS EN 50657 Railways Applications. Rolling stock applications. Software on Board Rolling Stock,*
- *BS EN 50126 series: Railway Applications. The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS),*
- *BS EN 50128: Railway Applications. Communications, signalling and processing systems. Software for railway control and protection systems,*
- *BS EN 50129: Railway Applications. Communication, signalling and processing systems. Safety related electronic systems for signalling.*

1.19.3 Cyber Security

1.19.3.1 The application of system architecture security shall be demonstrated, by provision of a clause by clause response, that the guidance in Appendix D has been followed (E).

Cyber security on rail is still young. Until standards are produced this appendix provides some good guidance.

1.19.4 Software Deployment Strategy

1.19.4.1 A software deployment strategy shall be agreed between the relevant parties and should include how to manage the upload of software on the train through an Engineering Change process (E).

The management of updating software needs to consider the following:

- Acceptance criteria for software upgrades (lab testing, regression tests, risks and implications of incorrect function, impact assessments on driver, train crew, maintenance staff etc),
- Perform specific tests or type tests on the train, where necessary,
- Agree on an uploading regime (e.g. staged upload on X out of Y trains, then more later for in-service verification),
- Agree on the uploading methods, (either individual manual upload, remotely for lower-risk systems or by coupling two trains of different version levels together,
- The compatibility between previous and updated versions (i.e. backward compatible) on a unit / vehicle level needs to be considered and checked,

- Agree a concept for use of trains in multiple operation with different software versions,
- A concept to return to a previous software version in the event of unintended behaviour of the new software version,
- Configuration management of whole train software (the different versions of train systems software as a whole should be known, recorded, and behaviour working together understood).

1.19.5 Protective Shut-Down Parameters

1.19.5.1 Parameters leading to a protective shut-down of a train that cannot be locally reset by the driver shall be identified by the train builder and agreed as part of the design review with the operator (E).

It should be possible to reset the train either automatically or by the driver following a protective shut-down event.

On 9th August 2019 the frequency on the UK national grid dropped to below 49 Hz. This caused disruption on the Thameslink fleet. All Class 700 units operating on AC at the time of the incident permanently shut-down in response to the frequency dropping below 49 Hz. A permanent shut-down required a technician with a laptop to physically connect to the train and reset the train following the event.

1.20 Global Navigation and Satellite System (GNSS) On-Board

1.20.1 A Global Navigation and Satellite System (GNSS) shall be provided (E).

The selection of GNSS and any augmentations will depend on its intended purpose and this may determine the necessary accuracy required for different systems. RSSB research project *'T892: Data and Analysis for a cost-effective GPS-based locator with simple augmentations'* provides some good practice. Available here:
https://www.sparkrail.org/pages/libraryresults.aspx?k=t892

1.20.2 The location, date and time stamp information derived by GNSS should then be fed to all the on-board train systems that require position information, such as PIS (Passenger Information Systems), on-board data recording etc (D).

This will give consistency to the information processed and used by the different train systems.

1.20.3 Where GNSS is deployed, consideration should be given to a secondary / backup source that is both technically different to GNSS and not reliant on GNSS (D).

This is to avoid common mode issues and provide a secondary source of positional information.

1.21 Management of Speed

1.21.1 Speed limiting (to stop a chosen set speed being exceeded) and speed set (like cruise control) systems are available and specifiers should consider their operational requirements and risks for mainline and depot use before specifying (I).

1.21.2 A speed limiting system should be fitted (D).

This can be used by the driver to restrict to the line speed, control speed when descending gradients and for passing through wash plants.

1.21.3 Where fitted, such systems shall have an appropriate tolerance around the chosen speed (E).

This will prevent the vehicle overspeeding when descending a gradient for example.

1.22 intentionally left blank

1.23 Critical and Non-Critical Systems and Supplies

1.23.1 Critical and non-critical systems shall have separately switched supplies (E).

This is in order to ensure that spurious faults in a non-critical system cannot cause the critical system to fail in an unsafe manner.

An example of this is a passenger information system and a door system sharing the same power supply, leading to a cross-feed.

1.24 Load Shedding Strategy

1.24.1 A load shedding strategy in the event of perturbation and loss of main electrical supply shall be proposed and agreed (E).

This should consider for how long systems such as lighting, HVAC, toilets, internal emergency signposting, announcement system, Wi-Fi and train radio and other communication systems are kept available from auxiliary supplies (e.g. batteries) in order to maximise the essential services.

1.25 intentionally left blank

Note v5.1 clause 1.25 Pressure Limits – moved to section 2.9.

1.26 Multi-Mode (Bi-Mode, Tri-Mode etc,) Powered Trains

1.26.1 Multi-mode solutions shall demonstrate that the following factors have been taken into account (E):

- Proportion and range of the planned duty cycle under each type of traction,
- The train performance under each type of traction (i.e. reduced performance may be acceptable in certain circumstances),
- Performance in normal operation versus performance where a secondary power source is provided for a 'get home' or 'last mile' mode,
- Whether a static or dynamic changeover is required between modes. Dynamic changeover reduces journey time,
- Whether changeover between modes is initiated by the train automatically, or manually by the driver, and any infrastructure required to support this process is available,
- Infrastructure changes to support in-service charging / refuelling facilities, e.g. at stations, if electrical energy or for example, hydrogen storage is used,
- The electrical safety of any current collector equipment (e.g. pantographs, shoegear) and associated cabling and equipment when operating in other than electric mode.

Additional information can be found in the following IEC standard, '*IEC 62864 part 1: Railway applications - Rolling stock - Power supply with onboard energy storage system - Part 1: Series hybrid system*.'

For the use of hydrogen see the HyTunnel project output and RSSB research project *'T1172 Hydrogen Powered Trains Project Route to Enter into Service'*.

RSSB are producing a RIS on multi-mode trains, numbered '*RIS-2713-RST'*. Publication expected in mid-2021.

RSSB are preparing guidance on risk assessment under the '*Electricity at Work Regulations'* on electrified networks as project 17-036 as *'GEGN8575 Guidance Note on the Management of Electrical Risk Related to Operational Tasks on Electrified Lines'.*

Work is ongoing by the industry 'Multi-mode System Review Panel' to help with multi-mode operations which covers supply changeover and track based balises etc.

1.26.2 Consideration should be given for EMUs that are not multi-mode, to have a limited capability to move themselves on batteries (D).

This would enable units to operate for short distances without external power and dependency on energy infrastructure, e.g. within depot and station limits and for self-recovery.

1.27 Train Control & Management System (TCMS) – Design

1.27.1 The TCMS network shall be designed to ensure high reliability (E). *High reliability can be ensured by having redundancy in the system.*

1.27.2 The driver's TCMS display shall show relevant information under normal and train fault conditions, using easily understood terminology (E).

Information for the driver is important, but it is essential that it is only relevant to the situation. It is expected that more in-depth information will be provided for depot maintenance staff or control as necessary.

1.27.3 Provision should be made for drivers, and other members of train crew, to isolate / reset defective essential equipment through the TCMS, where this cannot otherwise be done locally to the driving position (D).

Any requirement for the driver or train crew to pass through a train, or exit the train to walk on the track, to isolate equipment introduces significant safety risk and delay.

Information on Call for aid and Passenger Alarm devices can be found in the following European Standards:

- Harmonised standard *'EN 16683:2015 Railway applications. Call for aid and communication device. Requirements'* sets out specific requirements for PRM TSI compliant Call for Aids and addresses the conditions for a reset including remote reset within section 4.9 of EN 16683:2015.
- Harmonised standard *'EN 16334:2014 Railway applications. Passenger Alarm System. System requirements'* sets out specific requirements for LocPas TSI compliant Passenger Alarms and Communication devices for passengers and addresses the conditions for a reset including remote reset within section 6.12 of EN 16334:2014."

1.27.4 A TCMS carrying vital / critical data shall have these functions protected by being separated from other train-borne systems and have a secure architecture (E).

1.27.5 An indication of the status of headlights, marker and tail lights being displayed at front and rear shall be provided in the cab (E).

This may be used during train preparation to support the idea of automation of train preparation, see Appendix H, by using a TCMS screen or 'mimic panel', and in service to confirm the correct status of the lamps and indicate any failures.

1.27.6 The status of air in secondary suspensions e.g. isolated, inflated or deflated shall be available in the cab (E).

This may be used during train preparation to support the idea of automation of train preparation, see Appendix H, by using a TCMS screen for example to check air bag status.

1.27.7 The status of DSD / Vigilance e.g. fault or isolated shall be available in the cab for use during train preparation (E).

This clause is to support the idea of automation of train preparation, see Appendix H, by using a TCMS screen for example to check DSD / Vigilance status.

1.27.8 The status of Emergency Bypass Switch (EBS) e.g. operated shall be available in the cab for use during train preparation (E).

This clause is to support the idea of automation of train preparation, see Appendix H, by using a TCMS screen for example to check EBS status.

1.27.9 The status of the safety system, e.g. TIS, has been operated or isolated shall be available in the cab for use during train preparation (E).

This clause is to support the idea of automation of train preparation, see Appendix H, by using a TCMS screen for example to check safety system status.

1.27.10 The status of the fire and smoke detection and suppression systems, e.g. cylinder pressure or fault etc shall be available in the cab for use during train preparation (E).

This clause is to support the idea of automation of train preparation, see Appendix H, by using a TCMS screen for example to check Fire and smoke detection systems status.

1.28 intentionally left blank

Note clause 1.28 Torque-tightening in v5.1, now moved to RAMS section 1.11.

1.29 Train Location Reporting

1.29.1 As part of the Customer Information Strategy programme of projects a standardised way of receiving train location data through the Global Navigation Satellite System (GNSS). It was developed and established as an industry service to support better train location reporting (I).

1.29.2 The purpose of this service is to significantly improve the quality of data customers receive on their train's location and expected arrival times at stations along the route. The data will also be used to analyse and model performance so improvements in performance can be made. To do all this, the collection of location data from all trains in a standard format is needed (I).

1.29.3 There will be a requirement for train manufacturers and integrators to fit location sensors and communication equipment to their vehicles. GNSS equipment such as GPS, GLONASS, Galileo, etc are proven options, but train integrators may wish to use other innovative solutions provided the data output can meet the requirements of *RDG/EC/GN/005 Guidance Note – On Train Satellite Navigation Equipment/Darwin Interface*', see below (I).

1.29.4 Where use of a supplier's back office intermediary exists, the on-train location sensing equipment shall collect data, store it and buffer it for transmission to shore. The supplier's back office system will then manage the onward communication to the Industry Train Location Gateway (E).

1.29.5 Where direct communication from the train to the Industry Train Location Gateway is used, the on-train location sensing equipment shall collect data, store it and buffer it for transmission to the Industry Location gateway (E).

1.29.6 This Communication with the Gateway shall be in accordance with the appendix of '*RDG/EC/GN/005 Guidance Note – On Train Satellite Navigation Equipment/Darwin Interface*' (E).

To achieve the quickest rollout and provision of a useable customer information service the project seeks to reuse where possible existing equipment especially on-train GPS and to bring the service up to a preferred standard over time using an established gateway.

The specification '*RDG/EC/GN/005 Guidance Note – On Train Satellite Navigation Equipment/Darwin Interface*' is available on the RDG website.

1.30 now deleted

Note clause 1.30 Automating Train Preparation in v5.1, now added to the relevant sections and summarised in Appendix H.

2. Key Requirements – Performance & Environmental

2.1 Aerodynamics

2.1.1 Aerodynamic efficiency optimisation in terms of whole life cost shall be demonstrated (E).

Increased drag can affect the traction power requirements and reduces energy efficiency.

2.1.2 The dynamic effects of air turbulence on underframe hoses, cables and retention devices shall be demonstrated to not cause movement outside of the kinematic envelope or standard vehicle gauge (E).

Failure to consider the impact of aerodynamics in the risk assessments for a flexible hose that came loose at speed and impacted ballast which struck a trackworker (RAIB Chathill report).

A copy of the RAIB report 'Safety digest 07/2017: Chathill' can be found on www.gov.uk website here:

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/612294/D072017_170508_Chathill.pdf

2.1.3 Vehicle bodies and vehicle interface designs shall minimise air disturbance on station platforms (E).

Passing vehicles can cause disturbance on platforms and to adjoining structures, which can affect wheelchairs, child buggies and other inanimate but loose objects, e.g. luggage.

RSSB research report *'T248: Review of train slipstream effects on platforms'* provides some background. A copy can be found on SPARK here:

https://www.sparkrail.org/pages/libraryresults.aspx?k=t248.

Also research project *'T1098: Identifying mitigations for the risk of unplanned movement of wheelchairs and pushchairs on station platforms'* highlights some risks to be considered. It can be found here:

https://www.sparkrail.org/pages/libraryresults.aspx?k=t1098

'RIS-7016-INS Interface between Station Platforms, Track, Trains and Buffer Stops' also has some information.

The LOC & PAS TSI covers slipstream and pressure pulses and *'GMRT2100 Rail Vehicle Structures and Passive Safety'* covers pressure pulses.

2.2 Propulsion

2.2.1 The amount of redundancy provided by the propulsion system shall take account of the demonstrated service reliability of existing equivalent systems (E).

As the network becomes increasingly congested, it is increasingly important to ensure system resilience. It is therefore essential that a failure of an individual sub-system on a train causes as little service disruption as possible.

Some examples of redundancy are traction convertors being split per bogie, the ability to isolate motors per bogie, auxiliary convertors able to compensate for failures and cross feeds of auxiliary circuits from an adjacent vehicle for continuity of supply.

2.2.2 clause in v5.1 now deleted.

2.2.3 Propulsion systems shall be designed such that that when one system fails, the remaining systems minimise the degradation to train performance, with this change of status being reported via the TCMS (E).

Automatic enhancement of the performance of remaining functional propulsion packages minimises the performance impact of a propulsion package failure for the train concerned and so reduces the resulting impact on service punctuality.

2.2.4 Propulsion systems shall be designed to be capable of meeting the operator requirements to rescue a completely failed train of similar operational compatibility (E).

Additional clarification of operator requirements will be required, for example: gradient, speed, distance to travel to detrain, loading condition, etc.

2.3 Sustainability

2.3.1 An environmental impact assessment for the rolling stock's entire life, in accordance with '*ISO 14040: Environmental management - Life cycle assessment - Principles and framework*', shall be undertaken (E).

Rail is an environmentally sustainable means of transport, and has a major role to play in encouraging modal shift from less sustainable modes. However, it does have environmental impacts which need to be considered at the design stage for the entire life of the rolling stock.

This assessment should cover rolling stock construction, manufacture, delivery, operation, maintenance / overhaul, and end-of-life. Environmental impacts to be considered include energy usage, emissions, water usage, materials usage, waste, pollution, and noise and vibration.

The industry has developed 10 Sustainable Rail Principles including two related to the environment which are 'reducing our environmental impact' and 'carbon smart'. See '*Rail Sustainable Development Principles (2016)*' on the RSSB website

The RSSB website also has some useful information, of which the document above is a part, at:

https://www.rssb.co.uk/Research-and-Technology/Sustainability

2.3.2 A description of how 'design-for-disassembly principles' are used, including issues such as the marking of plastics and avoiding the blending of materials, shall be provided (E).

The blending of materials can make recycling of components costly and complex, or even impossible.

BS 8887 series: - Design for manufacture, assembly, disassembly and end-of-life processing (MADE) is an example of how this can be achieved.

2.3.3 Confirmation shall be provided that rolling stock and spare parts do not incorporate any materials which are restricted in the UK (E).

2.3.4 An inventory of all materials by type, including their weights, shall be provided (E).

This shall cover all parts in the rolling stock, together with spare parts.

2.3.5 Hazardous materials shall be listed by part number, quantity, location, etc and a risk assessment provided to justify their use (E).

This information is required to enable future operators and maintainers of the vehicles concerned to meet their legal obligations in managing the risks associated with any hazardous materials.

2.3.6 The percentage weight of the rolling stock comprising recycled content shall be provided (E).

The following page on the UNIFE website has some useful links and includes a template for the provision of this information in a common format at:

http://unife.org/banners/81-material-declaration-template.html

2.3.7 End of life recyclability and recovery targets, based on the terms defined in '*BS ISO 21106: Railway applications — Recyclability and recoverability calculation method for rolling stock'*, shall be provided (E).

The aspiration is that the fleet should achieve 85% re-use and recyclability, and 95% re-use and recoverability, by mass.

2.3.8 An 'End of Life Disposal Plan', to support the future detailing of disassembly, identification, segregation and disposal methods for each component shall be provided. (E).

This information is required to demonstrate the whole life environmental impact for the train design.

UNIFE has developed this further for the rail industry with their *'Recyclability and Recoverability Calculation Method for Railway Rolling Stock'* here:

http://www.unife.org/news/72.html

and see their calculation method document:

http://unife.org/component/attachments/?task=download&id=326

and a Recycling Calculation template:

http://www.unife.org/component/attachments/?task=download&id=346

2.3.9 An 'Environmental Product Declaration' in line with '*UNIFE 495 Product Category Rules for Rail Vehicles'* or other externally verified certification shall be provided (E).

More information can be found at:

http://www.environdec.com/en/PCR/Detail/pcr2009-05

2.3.10 If an 'Environmental Product Declaration' cannot be provided, the supplier shall describe their policy in this area (E).

2.4 Energy Efficiency & Traffic Management

2.4.1 Calculations to demonstrate the rolling stock systems have been optimised, for specified routes, for energy efficiency for the whole life of the train shall be provided (E).

Whilst trains that are not designed to deliver energy efficiency may offer lower initial cost, the whole life implications can be considerable; not only in terms of increased energy costs, but also the potential requirements to strengthen infrastructure power supplies.

2.4.2 Energy usage data systems are to be fitted in accordance with the relevant TSI (I).

'BS EN 50463 series 'Energy measurement on board trains' describes rail metering equipment', however RGS '*GMRT2132 On-board Energy Metering for Billing Purposes*' describes the GB charging regime and is supported by some Network Rail documents which can be found here:

https://www.networkrail.co.uk/industry-commercial-partners/information-operating-companies/on-train-metering/

2.4.3 The train should indicate to Network Rail when it is using on-board systems, e.g.: diesel or battery power, when operating on OLE or third rail routes (D).

This is so a charge for electricity-usage will not be made when the train is running on diesel or battery under the 'wires'.

Currently the charging system does not automatically know when a different mode is being used on a multi-mode train. Therefore, it is important to advise when it is not using OLE or third rails.

2.4.4 A Connected Driver Advisory System (C-DAS) shall be provided (E).

Provision of C-DAS not only provides the capability to provide the train driver with driving advice to minimise energy consumption taking account of the real-time position in terms of the locations of other trains and any short-term infrastructure constraints, but also enables the advice provided to optimise traffic flows through critical junctions and hence improve punctuality and route capacity. Although some of these benefits will only be realised where Network Rail provides Traffic Management Systems, compliant C-DAS products will also give operational benefits where no Traffic Management System (TMS) is present.

A website where useful documents will be available is being produced currently. In the mean-time these can be obtained from vish.kalsapura@networkrail.co.uk.

'RIS-0711-CCS Interface Requirements for Connected Driver Advisory System' specifies interfaces to ensure that they are compatible with other current protocols and systems,

Another related document for C-DAS from Digital Railway is:

http://digitalrailway.co.uk/wp-content/uploads/2019/04/153821-NWR-SPE-ESE-000009-C-DAS-System-Definition-v3.0.pdf

2.4.5 An intelligent power management system shall be provided, such that engines run only when necessary and on-board systems are only energised as required (E).

This approach not only minimises energy consumption, but also ensures that noise and emissions are minimised and the service life of sub-systems extended.

An example of good practice in this area is the intelligent control of diesel engines that shut-down when not required to provide useful power to the train, and also the use of batteries to boost energy for acceleration.

2.4.6 Rolling stock should revert to 'stabling-mode' after an agreed time delay, following a driver de-energising the driving cab (D)

Typically, such a 'stabling mode' would switch off selected loads such as the heating, ventilation and air conditioning (HVAC), with lighting systems reverting to emergency lighting levels only or switching off. Frost protection systems should remain active and lighting circuits should be designed to facilitate local switch-on (for cleaning purposes). Similarly, a temperature detection device should be considered so that the passenger and traincrew accommodation enters service at an appropriate temperature.

2.4.7 Where ECS moves are frequently carried out a facility ('ECS-mode') to reduce the active systems to a minimum should be provided (D).

Typically, such a mode would switch off selected loads such as the heating, ventilation and air conditioning (HVAC), with lighting systems reverting to emergency lighting levels only or switching off. Frost protection systems should remain active and lighting circuits should be designed to facilitate local switch-on. Similarly, a temperature detection device should be considered so that the passenger and traincrew accommodation enters service at an appropriate temperature.

2.4.8 A facility to remotely switch on HVAC (both cab and saloon independently) and lighting (saloon only) should be provided (D).

This would ensure the train enters service within an agreed temperature range for cab and passenger environments.

As an enhancement to the above functionality, this remote switch-on could be initiated by the process of allocating trains to diagrams, with a sufficient 'warm up / cool down time' incorporated to ensure the train enters service at the correct on-board temperature.

2.4.9 A separate method of heating, to supplement that provided by waste heat from the diesel engine, shall be provided (E).

This would enable an acceptable on-board temperature to be achieved more quickly. This is particularly important for driving cabs where departure may be delayed until an acceptable temperature is achieved.

2.4.10 Low energy consumption lighting shall be provided (E).

Low energy technology offers energy savings, longer life and whole life cost.

2.4.11 clause in v5.1 now deleted.

2.4.12 Provision for the adoption of alternative power generation and energy storage should be made (D).

This would help with provision of new technology to give more rolling stock flexibility in the future.

2.4.13 Energy consumption data for a specified train diagram with agreed input parameters shall be provided by the train manufacturer (E).

This enables like-for-like comparisons of energy consumption to be made between trains in the financial evaluation model.

2.4.14 Consumption rates of onboard energy generation systems, e.g. diesel, liquified petroleum gas (LPG) or other alternative fuels shall be reported (E).

This can be used to identify, for example, engine issues, to improve reliability and availability.

2.5 Auxiliary Power

2.5.1 Auxiliary power supplies shall provide sufficient spare capacity for the life of the rolling stock (E).

This permits flexibility for the future installation of, for example, ERTMS and other additional equipment that may be required to support future business needs.

Historically a figure of 10% spare capacity has been used and is viewed as appropriate.

2.6 Pneumatic Air Supply

2.6.1 Air supplied by the train shall be clean, dry and free of oil (E).

This will slow the deterioration of components and limit the likelihood of freezing in cold weather.

2.6.2 Air reservoirs constructed from stainless steel should be considered (D).

This reduces the likelihood of internal corrosion.

2.7 Track Circuit Assisters (TCA)

2.7.1 Track circuit assisters are required to be fitted in accordance with Railway Group Standard '*GMRT2477 Compatibility Requirements for Track Circuit Assisters (TCAs) on Rail Vehicles',* which is supported by a Railway Industry Standard *'RIS-2777-RST Functionality and Management of Track Circuit Assisters (TCAs) on Rail Vehicles'* (I).

2.7.2 Anyone planning to introduce new self-powered trains should refer to the '*Risk Advisor Tool'* in order to determine whether there is a requirement to fit TCA. A copy of the '*TCA Risk Advisor Tool and User Guide'* can be provided to RSSB members on request through the RSSB Customer Self-Service Portal https://customer-portal.rssb.co.uk/ (I).

2.7.3 The status of Track Circuit Assisters (TCA), where fitted, e.g. faulty or isolated shall be available in the cab for use during train preparation (E).

This clause is to support the idea of automation of train preparation, see Appendix H, by using a TCMS screen for example to check TCA status.

2.8 Meteorological Effects

Note that this section was clause 1.12 in v5.1.

2.8.1 Rolling stock systems shall be designed to operate reliably under predicted environmental conditions to be experienced in the UK during the design life of the rolling stock (E).

Rolling stock needs to be designed considering foreseeable future extremes of heat, rainfall and cold with respect to the impact of climate change and the associated predictions of more frequent instances of extreme weather conditions.

The predicted environmental conditions, which may exceed those legally required, need to be specified in the tender, taking due cognisance of the potential impact on mass, cost, performance, space, energy consumption etc of the values chosen.

Network Rail has a Climate Change and Weather Resilience team who have developed a risk assessment document and a guidance note that predicts changes in weather for the next 60 years. It is mainly aimed at infrastructure, but indicates possible parameters for rolling stock. These documents are available from Network Rail and are titled and can be found here:

'Weather-resilience-climate-change-impact-assessment-Guidance-Note'

https://safety.networkrail.co.uk/wp-content/uploads/2018/06/Weather-resilience-climate-change-impact-assessment-Guidance-Note.pdf

'Climate-change-projections-Guidance-Note'

https://safety.networkrail.co.uk/wp-content/uploads/2019/09/Climate-change-projections-Guidance-Note.pdf

RSSB also has a Climate Change Adaption Group which may also provide guidance.

Note: This clause is additional to the Loc & Pas TSI clause 4.2.6.1 etc environmental conditions.

2.8.2 Suitable protection shall be provided for vulnerable equipment to prevent the ingress and build-up of dirt, moisture, snow or the effects of sea-water on electrical equipment (E).

The drawing of contaminated air through cabinets can lead to clogging and flashovers. A deluge of sea-water passing over electrical equipment can cause shorting out.

An example of good practice in this area is sealed equipment cases reliant on external heatsinks. These heatsinks should be designed not to clog, or should be easy to clean without lots of equipment having to be removed to gain access.

2.8.3 Equipment ventilation louvres should be designed so that airflow is not adversely reduced by the dynamic effects of snow (D).

Snow can be drawn into cooling systems via the louvres causing clogging, overheating and equipment failure.

Practice in countries where snow is frequent is to have these louvres at cant rail height.

2.8.4 Equipment ventilation louvres, radiators or their filters should be designed so that airflow is not adversely reduced by the accumulation of debris and dust (D).

Dust, pollen and seed heads can be drawn into cooling systems via the louvers or radiators causing clogging of them or their filters leading to overheating and equipment shut-down.

One possible solution is to intermittently reverse blowers to clear any accumulation of debris or seed heads from the radiators.

2.8.5 Critical systems (e.g. warning horns, cab and passenger doors, windscreen wipers, DCO cameras, couplers [see also 1.3.4] and head, tail and marker lights) shall be protected from the effects of the build-up of snow and ice (E).

This may include heating them and preventing snow ingress.

2.8.6 The below-solebar area of the rolling stock should be as smooth and continuous as possible (D).

This helps to reduce the under-pressure below the train, and so reduces the vulnerability to a build-up of snow and ice. Snow and ice build-up not only affects performance but also acts as a significant obstacle to undertaking maintenance inspections. It also creates problems when trains encounter warmer conditions in the course of their journey, resulting in ice falling from the train at speed, with the associated risk of damage and injury.

2.8.7 Axles should be protected to prevent damage as a result of ballast thrown up caused by ice falling from trains (D).

Ice falling from a train can cause ballast to be thrown up damaging axles and wheels. Similarly, frozen ballast can also be picked-up and snowballed causing damage to axles and underframe equipment.

2.8.8 Hoses and underframe cabling should be designed and routed to reduce their susceptibility to damage caused by the build-up of snow and ice, any resultant increase in mass and from snow and ice falling elsewhere from the train (D).

Ice can be picked up and cause damage and the mass of snow and ice can fatigue or break hoses and cabling.

2.8.9 The availability and effectiveness of the friction brake shall be maintained during snow or ice conditions (E).

Railway Group Standard *'GMRT2045 issue 4 Compatibility Requirements for Braking Systems of Rail Vehicles'* gives some guidance on braking in adverse weather in clause G 2.6.1.5 and F 10.1.5. It also refers to the Guidance Note *'GEGN8628 issue 2 Preparation for and Operation during Winter'* appendix C on braking in winter conditions.

2.8.10 Trains should be designed such that it is possible to operate them through flood water up to the limitations of the infrastructure as described in RSSB Project '*T1052 Review of the Rules for the Operation of Trains Through Flood Water'* (D).

Climate change is expected to result in more frequent extremes of weather, including heavy rainfall. Restrictions having to be applied to the operation of trains through flood water can have a serious impact on service delivery.

RSSB research project to look at the effects of trains operating through flood water '*T1052: Review of the Rules for the Operation of Trains Through Flood Water'* provides information. The project reports are available here:

https://www.sparkrail.org/pages/libraryresults.aspx?k=t1052

2.8.11 Trains should be designed such that it is possible to operate them through snow up to the limitations of the infrastructure (D).

Climate change is expected to result in more frequent extremes of weather, including heavy snowfall. Restrictions having to be applied to the operation of trains through fallen and falling snow can have a serious impact on service delivery.

2.8.12 The heating / air conditioning system should remain operational in inactive cabs where trains are required to reverse or divide (D).

If extremes of temperature exist in the cab, the driver has the right to refuse to take the train until it is at a safe level, this causes delay and annoyance to passengers.

2.8.13 The design of the vehicle should prevent the accumulation of snow between vehicles and on hoses and jumpers (D).

Snow and ice which falls from vehicles causes damage to underframe equipment, lineside equipment and could injure passengers and staff.

2.9 Pressure Limits

Note that this section was section 1.25 in v5.1.

2.9.1 In tunnels the change of pressure should be in accordance with appendix A.2 of '*UIC 779-11: Ed 2 (2005) Determination Of Railway Tunnel Cross-Sectional Areas On The Basis Of Aerodynamic Considerations*', to suit the type of train proposed and the route it will use (D).

Changes in pressure can affect a person's health and a value of 10 kPa is quoted in standards as a maximum pressure change over the whole tunnel transit. However, for comfort purposes the lower levels specified should be applied.

For the UK national rail network, the following aural comfort limits have been applied for unsealed trains running in tunnels.

Table 2.9: Aural comfort limits

Routes	Pressure Change Limits
UK national network except HS1 and Crossrail (Elizabeth Line) Central London Tunnels (Classified as Type A operation in UIC 779-11)	Extreme Case Limit: 4.0 kPa in 4s Normal Case Limit: 2.5 kPa in 4s
HS1 (Channel Tunnel Rail-Link)	Extreme Case Limit: 3.5 kPa in 4s Normal Case Limit: 2.0 kPa in 4s

Cross Rail (Elizabeth Line) Central London Tunnels	Maximum pressure pulse not to exceed 3.0 kPa within 4s period. Maximum repeated pressure pulse not to exceed 0.7kPa within a 1.7s period (Ref 1)

Ref 1 C W Pope, A West and W G Gray, 'Aerodynamics, Ventilation and Cooling of the CrossRail Tunnel System', 8th International Conference on Aerodynamics and Ventilation of Vehicle Tunnels', Organised and sponsored by BHR Group Limited and held in Liverpool, UK, 6 – 8 July 1994.

Notes:

1) Extreme Case: rare case of two trains passing in a tunnel at a critical point resulting in the most severe pressure change.
2) Normal Case: single train transit through a single-track tunnel.

For sealed trains, base-line pressure comfort criteria are given in Appendix F (Section F4) of UIC 779-11. Where there are operations with both sealed and unsealed trains, it is necessary to ensure that the 'extreme case' pressure change limit is not exceeded in unsealed trains passing in double track tunnels.

Further explanation on pressure limits, including relevant extracts from UIC 779-11 and a description of background and early work performed on this subject can be found in the report '*Aural pressure comfort limits in tunnels'* here on SPARK:

https://www.sparkrail.org/Lists/Records_StaffMembers/DispForm.aspx?ID=751

(RSSB Membership is required to see it, see information on page 10).

Note: UIC 779-11 is based on the work of ERRI C218 and values are also included in Annex B of *'EN14067-5 Railway applications - Aerodynamics - Part 5: Requirements and test procedures for aerodynamics in tunnels'.*

3. Key Requirements - Passenger Facing

3.0 Introduction

3.0.1 Since each service operated will have specific requirements, e.g. extra luggage provision on airport services, higher density seating on commuter services, etc. there can never be a 'one solution fits all' to this aspect of train design. Because of this, what follows is a list of passenger-facing features, with associated guidance, that should be considered when specifying vehicle interiors. In all cases full account should be taken of the principles, requirements and guidance relating to interior passive safety (I).

3.0.2 There are some useful considerations on passenger Health & Safety and Well-being (HSW) given in RSSB Research project '*T1147 Crowding on trains and in stations'* in sections 5.2.4, 5.4 and 5.5 of report *'The Health, Safety and Wellbeing Effects of Crowding on Trains and in Stations (T1147 Report)'* (I).

The project is available here:

https://www.sparkrail.org/pages/libraryresults.aspx?k=t1147

The report is available here:

https://www.sparkrail.org/_layouts/15/Rssb.Spark/Attachments.ashx?Id=75NEMTS3ZVHP-8-13710

3.1 Heating, Ventilation and Air Conditioning (HVAC)

3.1.1 Temperature Control (Normal Service)

3.1.1.1 The HVAC shall be capable of maintaining the passenger saloon at the envelope temperatures, with allowed variations, as specified in '*EN 13129: Railway applications. Air conditioning for main line rolling stock - Comfort parameters and type tests' or 'EN 14750-1 Air conditioning for urban and suburban rolling stock - Part 1: Comfort parameters'* (E).

HVAC system issues cause real problems to train operators the world over. To make inroads into improving this, European Operators have jointly developed some common requirements for HVAC that should encourage suppliers to improve their products across Europe. These requirements have been captured in a '*EuroSpec Specification for air conditioning of Railway Vehicles'.*

Rail Delivery Group (RDG) is a partner in the EuroSpec consortium. Copies of the EuroSpec can be obtained via the EuroSpec website at www.eurospec.eu.

3.1.1.2 The HVAC system shall be designed in such a way that the balance between heating and cold airflow do not create passenger discomfort (E).

3.1.1.3 The heating and air-conditioning systems shall complement each other so that if both are functioning at the same time they work together to achieve the required temperature and one does not dominate the other (E).

This is intended to control the effect of the flow of air from the air-conditioning system when the heating system is also in use and effectively 'blowing away' the warmth in winter.

In some existing fleets of trains, the air-conditioning system runs continuously regardless of the external weather conditions. As a result, when the heating system is used during the winter months the air conditioning tends to dominate and overpowers the heated air, effectively blowing away the warmth, therefore no benefit is felt from the heating and the carriage remains cold and uncomfortable. The air flows associated with this arrangement also contribute to passenger discomfort.

3.1.1.4 The heating set point shall be independently adjustable by maintenance staff between 21 and 23 ^{o}C (E).

3.1.1.5 Functionality to allow traincrew to alter the setting of saloon HVAC may be provided; where it is, a variation of $\pm$ 2 ^{o}C should be provided, but is reset once the system powers down (D).

This is so that train crew do not try to adjust the temperature following requests from passengers and upset the system or even cause it to fail. But where it is provided the variation is limited.

3.1.1.6 On particularly hot days, the HVAC system should maintain a temperature differential to ambient rather than trying to attain a 'set point temperature.' Suggested limits are given in *EN 13129: Railway applications. Air conditioning for main line rolling stock - Comfort parameters and type tests' or 'EN 14750-1 Air conditioning for urban and suburban rolling stock - Part 1: Comfort parameters'* (D).

This reduces the system load and the 'thermal shock' effect for passengers boarding and alighting and passengers having to wear coats in summer. The European Standards give a curve to be followed comparing internal and external temperatures,

It is considered that the way that existing HVAC systems are designed, with a targeted set point temperature that the system endeavours to maintain (irrespective of system rating) is a key contributory factor to HVAC failures on days when high ambient temperatures are experienced. It is believed that the systems are trying to deliver an unrealistic set point and therefore become overloaded. Altering the control algorithms in this manner should go a long way to alleviating this problem.

3.1.2 Fresh Air Intake

3.1.2.1 The HVAC system should control the fresh air intake quantity proportional to the passenger loading (D).

This ensures that CO_2 levels are effectively managed at a safe and comfortable level, whilst avoiding the use of energy to unnecessarily heat or cool excessive amounts of fresh air.

The Loc & Pas TSI clause 4.2.5.8 covers Internal air quality but this requirement is more about energy saving.

3.1.2.2 The HVAC fresh air intake should be designed to prevent the ingress of dust and smells during friction braking and of diesel engine fumes (D).

Good separation of the HVAC fresh air intake and the engine exhaust will prevent diesel fumes from being drawn into the vehicle. Closing of fresh air vents during braking will reduce filter clogging and stop smells entering the vehicle interior.

3.1.3 Emergency / Degraded Mode

3.1.3.1 HVAC systems should be designed to provide a level of emergency ventilation in the event of a loss of traction supply, powered by the vehicle batteries, for 90 minutes (E).

The Loc & Pas TSI in clause 4.2.5.8 requires a minimum of 30 minutes.

3.1.3.2 Whilst in ‘stabling-mode’, or ‘ECS-mode’ (see 2.4.6 and 2.4.7) in the event of low ambient temperatures, frost protection shall remain available when needed (E).

This is to reduce the likelihood of cold weather causing frozen water pipes or affecting the brake systems.

3.1.4 Refrigerant

3.1.4.1 The selection process for the HVAC system and associated refrigerant fluid in terms of whole life cost shall be demonstrated. (E)

Whilst typical systems utilising higher Global Warming Potential (GWP) fluorinated greenhouse gases (F-Gases) as refrigerant are well tested and understood, the price of these fluids are likely to increase following the latest update to the F-Gas regulations. It is therefore recommended that a comparative lifecycle cost assessment is undertaken. This should include sufficient contingency for increasing prices of the various refrigerant fluids assessed. It should also consider the likelihood of leaks occurring and the impact of the subsequent refrigerant replenishment and associated repairs. Any reliability assumptions should be based on test data or evidence collated from similar systems currently in service.

The revised F-Gas regulation, (EU No 517/2014) came into effect from the 1st January 2015 and applies to all EU member states. The regulation introduces a phase-down mechanism involving a gradually declining cap on the total placement of bulk HFCs (in tonnes of CO_2 equivalent) on the market in the EU. The broad intention is to encourage manufacturers and suppliers to transition towards the use of lower GWP refrigerants by developing new systems that could be more cost effective in the long term.

RSSB Project *'T1164 The Future of Refrigerants in Rail Vehicle HVAC Systems'* undertook a high-level overview of alternative systems available to the rail industry. The associated reports are available on SPARK here:

https://www.sparkrail.org/pages/libraryresults.aspx?k=t1164

Note clause 3.1.5.

3.2 On-Train Security

3.2.1 Passenger Security

3.2.1.1 RSSB commissioned a research project to look at many aspects of personal safety *'T1012: Developing a good practice guide for managing personal security on-board trains',* some items are already included in the KTR, but there may be others in the Technical section of the T1012 report that suit a particular service (I).

The report is available on SPARK here:

https://www.sparkrail.org/Lists/Records/DispForm.aspx?ID=17895

3.2.1.2 Other terms for CCTV include "Network video surveillance system (NVSS)" and "Digital video recording system (DVRS)", but the former is more widely understood and will be used in this section (I).

3.2.2 Closed Circuit Television (CCTV)

3.2.2.1 CCTV shall be fitted in saloon areas in accordance with '*RIS-2712-RST On-Train Camera Monitoring Systems'* clause 3.4 and Parts 2 and 4 (E).

3.2.2.2 CCTV that provides maximum coverage of passenger accessible areas, including vestibules, interior of the bodyside doors and areas used for storage of luggage, cycles etc, but excluding the interior of the toilet cubicle, shall be provided (E).

CCTV can be used to deter anti-social behaviour and be submitted as evidence following incidents. If luggage storage areas are also covered, passengers are more likely to use them.

The items in this clause are in addition to what is covered in *RIS-2712-RST On-Train Camera Monitoring Systems'.*

3.2.2.3 CCTV should include the functionality to monitor live footage by control room personnel (D).

It is important for both security and for operational / performance reasons.

3.2.3 Personal Security

3.2.3.1 Where the seating layout is uni-directional the seat design should reduce the risk of theft from behind (D).

An example of good practice is the installation of a physical barrier between seats, provided there is no conflict with dynamic seat performance requirements for interior passive safety.

3.2.4 Security Announcements

3.2.4.1 A location for prominent display of security posters shall be provided (E).

3.2.4.2 A means for security announcements to be made through the train PA should be included (D).

There is a requirement under the DfT 'National Railways Security Programme Regulations' Section 8.15 to conduct Security messaging as per NRSP section 12. This means provision of places to display regulated security posters e.g. 'See it, Say it, Sorted' and to issue regular pre-recorded security announcements over the train PA.

3.2.4.3 It shall be possible to update pre-recorded security messages and the trigger points / frequency easily and quickly with minimal cost (E).

3.2.5 Design for Security

3.2.5.1 Previous work has found that designing trains to GMRT2100 gives good protection to bomb blasts, however, there is further research available which could be used, should a higher level be required. SecureMetro is one of the better and more relevant examples of research conducted on bomb blast mitigation with reports available on SPARK (I).

The reports on Spark can be found here:

https://www.sparkrail.org/Lists/Records/DispForm.aspx?ID=12399

3.2.5.2 The design of the train interior shall be such that hiding places are few, theft from luggage stacks and racks is reduced and there is good visibility to deter assaults (E).

3.3 Passenger Ergonomics & Seats

3.3.1 Introduction

3.3.1.1 Passenger comfort is an important issue for rolling stock, but is also very complex to address, especially when producing procurement specifications. Recent work by RSSB on '*T1140 Defining requirements for seat comfort'* has added some scientific evaluation to seat comfort and has requested that these be incorporated into the KTR (I).

3.3.1.2 The content of *T1140* is a step forward, but follow-on work is required as railway seats are used in a dynamic environment and therefore static assessment can only ever be part of seat evaluation. Ideally the follow-on work should develop an assessment method based on seats tested in a dynamic situation (e.g. dynamic rig) to a defined route profile (I).

3.3.1.3 Additional factors need to be taken into account which may adversely affect comfort, such as (I):

- Limits of GB loading gauge,
- Demand for seating capacity in relation to the maximum achievable vehicle and saloon length,
- Requirements in legal standards like TSIs and NNTRs.

3.3.1.4 The comfort expectation of passengers depends upon the type of service and anticipated average journey time on a train as well as the type of seating class chosen. Passengers travelling First Class expect better levels of seat comfort, whilst passengers travelling Standard Class accept a lower level of comfort (I).

The EuroSpec document '*Seat Comfort Appendices',* see later for a link, includes an example questionnaire for the train operator to use to decide the parameters to provide to the seat supplier on journey times, postures, etc.

3.3.1.5 T1140 expressed the following journey types when evaluating passenger comfort. See Figure 3.3. Note this figure has been modified slightly to include seating class criteria (I):

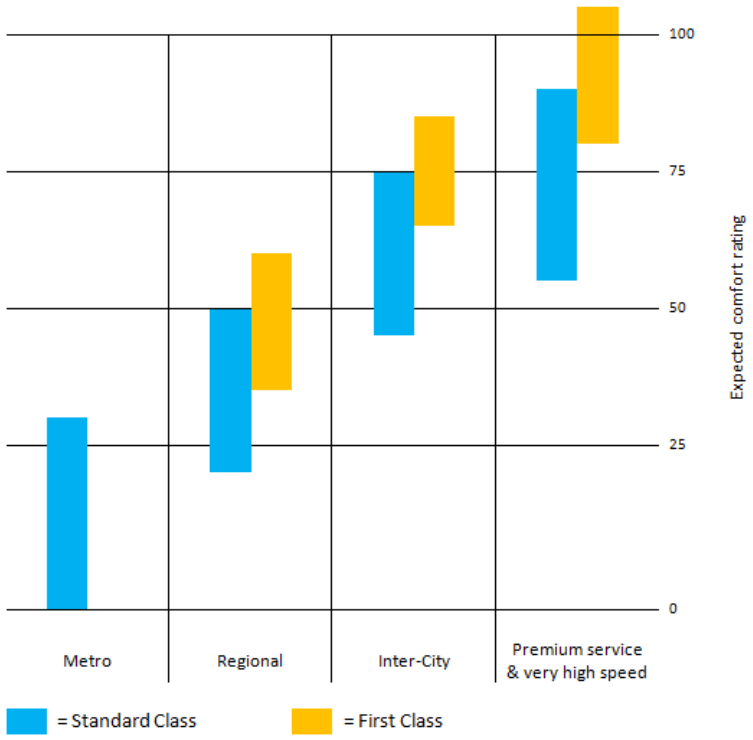


Figure 3.3 Expected seat comfort scoring range

3.3.2 Seats

3.3.2.1 Passenger seats shall be procured and assessed, using either the seat comfort score-based system of RSSB report *T1140 Defining requirements for seat comfort* or the criteria-based *EuroSpec Seat comfort system* (E).

The procurement and assessment of seat comfort needs to take into account the journey type and typical anticipated periods of seat occupancy of the journey type. Also there might be a need to distinguish between the seat class types.

It is recommended that new seats and / or seating layouts are verified as a mock-up-based evaluation exercise as outlined in the above mentioned documents.

The RSSB T1140 project reports can be found here:

https://www.sparkrail.org/pages/libraryresults.aspx?k=t1140

The EuroSpec Seat Comfort specification and appendices can be found here:

https://eurospec.eu/seat-comfort/

3.3.2.2 The passenger seats shall attain a level of comfort appropriate for the journey type and seating class as shown in Figure 3.3 (E).

In addition to the comfort requirements the seats need to comply with legal requirements (PRM TSI, fire safety, interior passive safety etc.) and other limiting factors (GB loading gauge, demand on overall seating capacity etc.).

3.3.2.3 If using the *EuroSpec Seat comfort system* document the anthropometric data shall be appropriate for GB (E).

Appropriate datasets for GB are PeopleSize 2020 or the German data in *ISO 7250-3 Basic human body measurements for technological design − Part 3: Worldwide and regional design ranges for use in product standards*.

3.3.2.4 Table 1 in *'T1140 Defining the requirements of a seat comfort selection process – Revised August 2019'* report, provides the optimum parameters to achieve a good comfort rating score, however alternative values may be required in order to achieve the required seating capacity, comfort and layout. An explanation of the T1140 parameters can be found in Appendix K (I).

The T1140 report and appendices can be found on Spark here:

Defining the requirements of a seat comfort selection process (T1140 Report)

Defining the requirements of a seat comfort selection process: appendices (T1140 Report)

3.3.2.5 Seat accessories according to RSSB report '*T1140 Defining requirements for seat comfort'* are considered to provide an increased level of comfort. Individual seat accessories are shown in the list below in descending order that may influence the overall comfort rating (I).

- Arm rests,
- Seat spacers between seats,
- Flip down tablet / surface,
- Individual USB / power socket (see 3.20.2),
- Foot rest,
- Rear seat storage pocket,
- Cup holder.

3.3.2.6 The arrangement of 3+2 seating shall be avoided (B).

Due to gauging limitations, 3+2 seating arrangements only permit narrow seats and restricted aisle widths, reducing comfort and standing space, as well as leading to extended dwell times. Having 3+2 seats means that many of the accessories within 3.3.2.5 cannot be provided and the requirements in this section on seat comfort may not be achieved.

3.4 Ride Quality

3.4.1 A Mean Comfort Index (MCI) shall be defined and agreed with the customer. The measurements shall be conducted in accordance with '*BS EN 12299:2009 Railway Applications – Ride Comfort for Passengers – Measurement and Evaluation'* when running on a track according to Track Quality Class C as defined in '*BS EN 13848-6:2014 Railway applications – Track - Track geometry quality - Characterisation of track geometry quality'* (E).

Examples of MCI value on route-defined reference track are for intercity routes 1.5 and for suburban 2.

However, experience has shown that current track quality in GB is improving but may not all be at the level defined in Europe or in standards.

An approach currently being carried out is that virtual test track data is provided to the train builder who analyses it, assigns Cat A, B and C values to it and calculates their ride comfort index based on the right mixture of track quality types in the ratios required by the standards. When the actual ride testing is conducted, it is done over the actual running route, at the range of speeds that the train will operate. When the values are recorded, they are filtered into categories for track quality levels A, B and C before being applied.

3.5 Sound, Noise and Vibration Levels

3.5.1 RSSB are considering a proposal to compile a library of sound, noise and vibration values for current trains. This can then be used by train buyers and train builders to have typical values to request and build to. It will also provide an aspiration to improve the levels within a vehicle. This will be '*T1226 Noise levels in passenger carriages*' (I).

3.5.2 Note for readers and users with reference to the following clause (I).

ISO 3381 is being revised. A complete draft that should replace both *ISO 3381:2005* and *EN ISO 3381: 2011* is awaiting Final Vote once comment resolution is complete, taking account of European, US and Japanese comments. It was hoped it would be published by the time this version of KTR was ready, however, it is understood that the new version will be published in summer 2021.

Some areas of revision in the standard are:

1. Types of area within the vehicle are more flexibly defined allowing the approach of this document to specify 'saloons' and 'vestibules' to be better defined between rolling stock buyers and suppliers.
2. The control of acoustic track quality (acoustic roughness and decay rates) during the test has simplified and made less costly by the use of a short measured reference section of track and an external monitoring microphone. This would allow meaningful testing in the UK to be more cost effective.

Although the reference to the draft (*prBS EN ISO 3381: 2019*) standard is still mentioned in the following clauses, it is suggested that this is used where possible, because of the improvements mentioned above, but checks are made to see if the 2021 version of the standard has been published.

3.5.3 For all vehicle types when stationary, with traction supply available, auxiliary systems (including air conditioning) running and all doors closed, the A-weighted sound level measured inside the seating area of passenger vehicles shall not exceed $L_{pAeq,T}$ = 62 dB measured according to *prBS EN ISO 3381: 2019, 'Railway applications. Acoustics. Measurement of noise inside railbound vehicles'* (E).

All measurements are to be carried out in accordance with *prBS EN ISO 3381: 2019, 'Railway applications. Acoustics. Measurement of noise inside railbound vehicles',* which defines measurement positions, operating conditions and environmental conditions.

3.5.4 For all vehicle types, the emission of prominent harmonics or discrete tones in all operating modes or conditions shall be minimised and be assessed on the basis of the one-third octave spectrum analysis outlined in Annex K of '*ISO 1996-2: 2017, 'Acoustics -- Description, measurement and assessment of environmental noise -- Part 2: Determination of environmental noise levels'.* Where this method identifies a one-third octave band containing a tone it shall be reported. It shall also be reported whether the difference in A-weighted level between this one-third octave band and the overall noise level, $L_{pAeq,T}$, is less than 6 dB. In this case it indicates that this one-third octave band is prominent and affects the A-weighted overall level of the noise (E).

The criterion for labelling a tone as 'prominent' if its one-third octave band has a level within 6 dB of the overall level focuses attention only on tonal sounds that passengers would find to be annoying to a significant extent.

Refer to Annex K of *'ISO 1996-2:2017 Acoustics -- Description, measurement and assessment of environmental noise -- Part 2: Determination of environmental noise levels' and 'prBS EN ISO 3381:2019, Railway applications. Acoustics. Measurement of noise inside railbound vehicles'*.

3.5.5 The spectrum of noise shall be measured inside the vehicles under the tested operating speeds and conditions shall be measured and reported according to 'pr*BS EN ISO 3381:2019, 'Railway applications. Acoustics. Measurement of noise inside railbound vehicles'* for all vehicle types (E).

3.5.6 From this the Preferred Speech Interference Level (PSIL) shall also be calculated and reported (E).

The purpose of this requirement is to ensure that passengers within a distance of up to 2 metres are able to speak to each other normally. Similarly if the PSIL level is too low, passengers are concerned about being overheard.

PSIL is defined as the arithmetic mean of 500 Hz, 1 kHz and 2 kHz octave bands; i.e.: PSIL = (L_{P500} + L_{P1000} + L_{P2000}) /3 dB.

Note: All measurements are to be carried out in accordance with *'pr BS EN ISO 3381:2019, Railway applications. Acoustics. Measurement of noise inside railbound vehicles'* which defines measurement positions, operating conditions and environmental conditions.

3.5.7 The A-weighted equivalent continuous sound pressure level ($L_{pAeq,T}$), measured in accordance with '*prBS EN ISO 3381: 2019, Railway applications. Acoustics. Measurement of noise inside railbound vehicles'*, measured while the vehicle is operating in the open, at maximum speed, on reference track as defined in *prBS EN ISO 3381: 2019*, shall not exceed the following (E):

- New Intercity, long-distance train equipped with pressure sealing and designed for maximum speeds up to 140mph (225kph):
  - Seating Areas – 72 dB (measured according to pr BS EN ISO 3381: 2019, section 5.3.1),
  - Vestibules – 77 dB (measured according to pr BS EN ISO 3381: 2019, section 5.3.2).
- New Intercity, long-distance train without pressure sealing and designed for maximum speeds up to 125mph (200kph):
  - Seating Areas – 74 dB (measured according to pr BS EN ISO 3381: 2019, section 5.3.1),
  - Vestibules – 78 dB (measured according to pr BS EN ISO 3381: 2019, section 5.3.2).
- New suburban and commuter trains designed for maximum speeds up to 100mph (160kph):
  - Seating Areas – 74 dB (measured according to pr BS EN ISO 3381: 2019, section 5.3.1),
  - Vestibules – 76 dB (measured according to pr BS EN ISO 3381: 2019, section 5.3.2).

The intention is that the passenger experience, in terms of noise levels, should be broadly comparable to, and preferably better than, existing standards in similarly operated types of current rolling stock and compete with the experience offered by other forms of surface transportation such as road coaches and private cars.

These limits, based on minimum general standards found in existing stock, may be adjusted for the procurement of specific stock since requirements vary according to the speed of operation and the design purpose of the stock. The sound level is also influenced by many engineering factors varying between types of rolling stock such as, but not limited to:

- Vehicle construction,
- Allowable vehicle mass,
- Power source (or not) in the vehicle,
- Type of passenger doors,
- Type of interior,
- Pressure sealing.

3.5.8 The vehicle design shall ensure an absence of irritating noises, under all operating conditions and this shall be observed during routine testing of the whole fleet (E).

Examples of irritating noises are rattles, squeaks, whistles and hums from interior fixtures and fittings (panels, blinds etc).

3.5.9 As far as reasonably practical, design features that will prevent the development of irritating noises during the life of the rolling stock shall be applied (E).

A particular source of annoyance for passengers comes from irritating noises, such as rattles, squeaks, whistles and hums from interior fixtures and fittings (panels, blinds etc).

This may require certain items to be replaced as part of maintenance, e.g., seals, felt, etc.

3.5.10 The rolling stock design shall ensure that vibrations generated by vehicle-mounted equipment are isolated from the vehicle bodyshell (E).

Vibrations generated from equipment such as diesel engines and air compressors are a frequent source of complaint.

3.6 Bodyshell Design and Windows

Note: This section was split in v5.1 as clauses 3.3.2, 3.6 and 3.7.

3.6.1 The vehicle bodyshell structure should use a common arrangement of window apertures (D).

This allows future flexibility for interior layouts, with window apertures not required, being blanked and a fixed size of bodyside light.

3.6.2 The number of variant sizes of bodyside windows should be kept to a minimum (D).

Standardisation of bodyside windows will enable the stock holding of spare windows to be minimised.

3.6.3 Deadlights (the vehicle structure between window apertures) shall be as narrow as practicable(E).

Minimising the size of deadlights increases flexibility with seating position and improves comfort.

3.6.4 The rolling stock design should endeavour to align passenger seats with bodyside windows (D).

There is much comment about seats not aligning well or at all with windows. Many passengers do like to look out of the window.

Where there are no windows as a result of the vehicle structure, other passenger amenities such as luggage stacks and toilet modules should make use of this space.

3.7 Catering

3.7.1 Catering Equipment

3.7.1.1 The provision or not of a catering service shall be considered (B).

The type of catering service needs to be defined in order to determine the catering equipment required.

The choice of catering service equipment will affect various aspects of the train design, eg electrical load, space provision, retention tanks, etc. required.

Is this a full meal provision, snacks and drinks from a bar or just a trolley service?

3.7.1.2 A list of possible catering equipment to suit the chosen catering service is given in Appendix J (I).

3.7.1.3 The train user population is specified train crew and maintenance staff who range from 5th percentile female to 95th percentile male in accordance with '*PeopleSize 2020'* or '*ISO 7250-3 Basic human body measurements for technological design — Part 3: Worldwide and regional design ranges for use in product standards'* (I).

A consideration for very tall or very small staff members is the danger that if the operator wants a lot of appliances, and to keep everything within a defined height means it makes the catering space much larger (longer) and reduces seating available in that vehicle.

3.7.1.4 It shall be possible to clean the catering equipment and its surrounding area effectively and safely (E).

The equipment and surfaces are to be durable, stain resistant and made of approved materials that are easily cleaned and maintained to food hygiene standards.

Having rounded corners and edges, no holes, and no sharp intersections will reduce dirt traps and facilitate easy and safe cleaning. Typically appliances and food preparation surfaces are manufactured using catering grade stainless steel.

3.7.1.5 The catering equipment shall be designed / packaged for the railway environment. (E).

Most 'off the shelf' equipment is not designed for railway applications and needs to be modified / installed to take account of the dynamic environment.

An example of this is the microwave ovens. To enable these industrial microwave ovens to operate through neutral sections requires a large power / battery inverter to be provided. Additionally a timer that "remembers the setting" may be required, but these are not in the core design.

Vibration testing of the equipment needs to be demonstrated for both electrical and mechanical devices.

3.7.1.6 The catering equipment shall be designed / packaged to reduce the risk of spills as far as possible (E).

Most 'off the shelf' equipment is not designed for the railway environment and needs to be modified / installed to take account of the dynamic environment.

An example is that coffee pots need to be restrained to the equipment while heating / stored, but they need to be lifted off and so a mechanical 'self-locking / easy-release' fitting is required.

3.7.1.7 Ideally, a mock-up as part of the design process should be provided (D).

This should engage the operator's staff and be used to undertake initial safety risk assessments, to look for holes, sharp edges, handholds etc and to assess lighting levels.

3.7.1.8 Risk assessments and trials of the design to confirm safe working from an operational and process perspective shall be carried out (E).

Scalds and burns are the most likely accidents onboard for catering staff and the above processes are to go as far as practicable to reduce the risk of these.

3.7.1.9 Ergonomic assessments, see next section, prior to service, shall be performed to ensure the intended range of staff or passengers using the catering areas can reach and move around safely as follows (E):

- Catering area and galley by train staff,
- Serving counter by train staff and adult passengers,
- Setting, serving and clearing of tables where at-seat service is offered by train staff,
- Loading and unloading of catering supplies by train staff.

Ergonomic assessments, prior to service, can be performed to ensure the intended range of staff and passengers using the areas can reach and move around safely.

This should be part of the Human Factors and CSM requirements using the operator's catering staff.

The assessments can take the form as follows:

Static

Safety risk assessments, utilising participants fitting the extremes of the ergonomic range, are asked to use each piece of catering equipment and storage facility, and assess it for reach and visibility, whilst being observed.

Task assessments, utilising participants fitting the extremes of the ergonomic range, are asked to assess the suitability of the catering area. Before commencing, it is important to determine the kind of activity that will be conducted. The main activities to be conducted by staff members are assumed to be as follows:

- Loading & unloading of trolleys,
- Delivery receipt (e.g. trolley management),
- Preparation for service (e.g. switching on equipment),
- Food preparation,
- Beverage preparation,
- Stock management (e.g. replenishing stock, stock rotation),
- Equipment service (e.g. preparing coffee machine, empty grounds),
- Cleaning and tidying.

Dynamic

Safety risk assessments, utilising participants fitting the extremes of the ergonomic range, are asked to use each piece of catering equipment and storage facility, and assess it for reach and visibility, whilst being observed.

Task assessments, utilising participants fitting the extremes of the ergonomic range, are asked to assess the suitability of the catering area. Before commencing, it is important to determine the kind of activity that will be conducted. The main activities to be conducted by staff members are assumed to be as follows:

- Preparation for service (e.g. switching on equipment),
- Food preparation,
- Beverage preparation,
- Stock check,
- Equipment service (e.g. preparing coffee machine, empty grounds),
- Cleaning and tidying.

3.7.1.10 All doors in catering areas shall incorporate a means of viewing to allow staff within the compartment to view the area immediately outside the door without having to open it (E).

The means of viewing could be a 'spy hole' so staff could check outside whilst stocktaking or to allow them to check for a fire if using it as an escape route.

Note: Special considerations may be needed to provide an escape route from the galley for staff and through it for passengers.

3.7.1.11 A viewing window in the door for use when entering and leaving the kitchen shall be provided (E).

This allows staff to check there is no one immediately adjacent.

3.7.1.12 Secure storage for the personal belongings and operational equipment of catering staff shall be provided outside of the catering area away from the passenger area (E):

- Clothing, including jackets, coats, hats,
- Small bags,
- Chef's equipment,
- Small luggage.

These need to be outside of the catering area for hygienic reasons and away from the passenger area for security reasons.

3.7.2 Catering Equipment Maintenance

3.7.2.1 The catering equipment used shall be designed to support easy maintenance (E).

3.7.2.2 The time required to change line replaceable units of catering equipment should be as short as possible and shall be agreed with the operator (E).

To maintain service it is essential that certain catering equipment in the event of failure can be replaced in a short timeframe.

It is feasible that toasters and panini grills can be exchanged within 30 minutes, microwave ovens and radiant grills can be exchanged within 60 minutes and it is envisaged that other single pieces of equipment can be exchanged overnight.

3.7.3 Loading and Unloading of Catering Supplies On to the Vehicle

3.7.3.1 The train design shall support the agreed process for loading and unloading of catering supplies (E).

It is assumed that the trolleys and other goods are pre-cooled and are taken to the train in insulated transport carriages via the station platform. It is also assumed that used trolleys and other material are taken away with the same transport carriages.

Food, fresh water and trolleys may require to be loaded onto the train via a ramp securely attached to the vehicle.

A nearby exterior door could serve as a loading door.

3.8 Interior Interface Rails

3.8.1 The use of continuous interface rails in the saloon area for attachment of furniture should be provided (D).

For attaching seats, tables, partitions etc. to the vehicle structure and permits a more flexible interior which could be changed to suit service requirements, and to permit bodyside cantilever, floor rail, and combined floor / side mounting arrangements to be feasible for refurbishment flexibility.

Entry points along the interface rail, as well as the ends, permit fixings to be easily positioned or changed.

3.9 Passenger Counting

3.9.1 A means of obtaining real-time passenger loading information for each vehicle shall be provided (E).

Provision of accurate passenger loading information to on-board and station staff and passengers is beneficial so that passengers can be advised, in real-time, where there is space on the train. This will reduce station dwell times and provide data to analyse the match between passenger demand and provision of capacity.

Typical means of achieving this are: vehicle 'load weighing', CCTV and sensors over entry and exit points.

Additionally in the event of train failure the passenger count can provide the NOC / TOC Control with an idea of whether evacuation is possible.

3.9.2 The system shall be able to record the passenger numbers to within 5% or one person (whichever is the greater) of the actual number of people in each vehicle (E).

3.10 Passenger Information System (PIS)

3.10.1 The PRM TSI and *'EN 16584-2 Design for PRM use – General Requirements, Information'* have requirements for PIS, what follows is in addition to those requirements. Also RSSB is producing a guidance note for the PRM TSI, see Appendix G (I).

3.10.2 The following PIS features should be provided (D):

- Estimated times of arrival at stopping points en-route,
- Interfaces and integration with other remote information systems.

This feature is considered especially important since the on-train system forms part of the holistic 'whole system' PIS in support of providing the passenger with information from 'end-to-end' of their journey, such as Darwin and LUL Underground line status information.

- Accurate real-time intermodal / interchange running information; particularly at times of disruption.

Electronic advertising space should be capable of being given over to passenger information during disruption.

- Broadcast of accurate, real-time, information via the on-board audio / visual system, or,
- Updates to specific interactive locations in the train for ad-hoc use by passengers, or,
- Information to be provided for passengers to access using a personal device,
- Informing passengers of upcoming engineering works.

It is recommended that the research report '*Integrated Passenger Information: Delivering the Rail End to End Journey'* commissioned by the Department for Transport is considered when specifying the requirements for train-borne PIS systems.

https://www.yumpu.com/en/document/view/6632144/integrated-passenger-information-delivering-the-rail-end-aecom

3.10.3 The number / letter of the vehicle in the train consist shall be displayed on the exterior of the relevant vehicle on or adjacent to all its access doors regardless of whether open or closed, in a position that is readily visible to passengers when boarding (E).

The PRM TSI clause 4.2.2.7.2.(6) has a requirement for vehicles to be identified where seat reservations are provided, however it is considered good practice for all vehicles to be labelled in some way.

3.10.4 The Public Address system should be zonal (D).

This would permit the traincrew to select the vehicles in the train consist to which announcements would be made. It is anticipated that this would be useful for broadcasting specific messages in, say, first class passenger saloons or on train services which divide en-route.

3.10.5 The messages displayed on PIS shall only be sent from authenticated devices, i.e. it must prevent unauthorised messages being displayed (E).

Instances of inappropriate messages on scrolling displays have been known.

A password or authentication process may be a solution.

3.10.6 The PIS should be designed to facilitate fault identification by having a 'maintenance mode' where all the visual displays cycle through a self-test message and the audio system repeats sounds e.g. count 1 - 30 or repeatedly 'ping' all the speakers (D).

3.10.7 The location of any Call for Aid / Pass Comm / Emergency Egress Device that has been activated shall be displayed on the PIS screens within the train (as well as a form of audible alert to bring this to the attention of traincrew) to enable the quickest response from any member of on board crew (E).

3.11 Seat Reservation Systems

3.11.1 An electronic seat reservation system should be provided (B).

3.11.2 Where an electronic seat reservation system is provided, it should be possible to remotely upload and display seat reservations prior to passengers boarding the train (D).

Projects have experienced problems with remote upload of seat reservation systems, as a result of Wi-Fi / 3G /4G 'blackspots'. This is therefore an important aspect to be checked as part of an implementation project.

3.11.3 Where an electronic seat reservation system is provided, unreserved seats should be readily identifiable to passengers entering the passenger saloon from both ends of the vehicle (D).

Existing electronic seat reservation systems make it difficult for passengers without reservations to identify which seats are unreserved. The time taken to check the information for each seat, delays train boarding and therefore increases station dwell times. Informing of non-working reservation systems advises passengers more efficiently rather than relying on train crew. Removing reservations for stations that have been called at helps passengers identify seats that have become available.

A visual indication system could be employed to indicate seat availability. This should be adjacent to the seat and visible from the vestibule e.g. A red LED could be used to indicate a reserved seat whereas a green LED could be used to indicate an available seat.

3.11.4 Where an electronic seat reservation system is out-of-use a means to advise passengers should be provided (D).

3.11.5 Seat reservation indications should be removed from the display as they expire during the journey, e.g. on approach to the station where a reservation ends or within a set time after departure (D).

3.11.6 For live seat reservation systems, the means to reserve a specific seat by smart device during a journey should be provided (D).

Current live systems permit passengers to book a seat a short time prior to boarding, which may already be occupied, but not reserve one that they may be sitting in.

3.11.7 The seat reservation display and configuration data should be of a modular design to accommodate changes to seating layout (D).

The intent here is to allow saloons to be easily reconfigured without complex and costly configuration changes and alterations being required to the seat reservation indicators.

3.11.8 Coach and seat identification, to assist with seat reservation location, should be provided on the exterior of the vehicle adjacent to the entrance doors (D)

This enables passengers to be more efficiently directed towards their reserved seats.

3.11.9 The seat reservation system should include the wheelchair and bicycle space(s) (D).

3.11.10 The fitment of an occupancy detection system integrated to the seat reservation system landside under the control of the train operator should be considered (B).

This gives flexibility to the operator to control occupancy and reservations without onboard software changes.

3.12 Provision of Luggage Storage

3.12.1 The guidance in 'GMRT2100 Rail Vehicle Structures and Passive Safety' gives some useful pointers for the design of luggage storage (I).

3.12.2 RSSB also commissioned a research project to look at helping reduce the injuries that luggage cause on trains '*T1057: Investigating the risks posed by luggage to passengers and staff on trains and stations'* some aspects follow, but there may be others that suit a particular service (I).

The project can be found on Spark here: https://www.sparkrail.org/pages/libraryresults.aspx?k=t1057

3.12.3 Optimised luggage stowage space, including under-seat should be provided (D).

3.12.4 Luggage stacks or multi-purpose areas shall be provided and their locations identified by appropriate signage and labelling taking account of entry and egress and visibility of luggage by passengers (B).

Passengers perceive that there is inadequate provision of luggage storage facilities on board recent designs of rolling stock.

It is accepted that it can often be difficult to obtain the right balance between number of seats and the provision of adequate space for storing luggage. This balancing act can only be determined by consideration of the type of service the rolling stock is intended to operate.

3.12.5 Luggage stacks should be designed and located in such a way that luggage remains visible to passengers (E).

Passengers have expressed the view that they are particularly uncomfortable with having to leave their luggage effectively hidden from view in end-of-vehicle luggage stacks.

3.12.6 Where seating permits luggage to be stowed beneath, a device to restrain the luggage in the event of a collision shall be provided (E).

Typically, for a cabin bag of up to 45cm x 36cm x 20cm.

3.12.7 Overhead luggage racks should be able to safely store items of dimensions up to 56cm x 35cm x 45cm (D).

This requirement reflects current airline limits with respect to hand baggage and should deter large items being placed there.

3.12.8 Luggage stacks should provide easy access and safe stowage of items of dimensions up to 90cm x 75cm x 43cm (E).

This requirement reflects current airline limits with respect to hold baggage.

3.12.9 Multi-tier stacks shall provide safe luggage stowage so that larger items can only be stored in the lower area of the stack (E).

It is preferred that larger items are kept at a lower level.

3.12.10 Innovative solutions, for example seats that can be converted to store luggage when not in use should be provided (D)

In order to provide the flexibility to accommodate differing demands for seats and luggage space at different locations and times of day.

See the 'Tomorrow's Train Design Today' competition for some ideas, here: http://www.ribacompetitions.com/ttdt/finalists.html

3.13 Toilets

3.13.1 Typical passenger numbers, journey times and the availability of toilets at stations and other locations nearby should be considered when assessing the requirement for on-train toilets (I).

3.13.2 Whilst the provision of toilets on trains is now very much the accepted norm, it should not be automatically assumed that this is appropriate for all types of train operating all types of services. As an example, passenger capacity on metro-type services is frequently a critical factor in train design and the installation of toilets inevitably occupies a significant amount of space. It is therefore common practice worldwide not to provide toilets where this type of train is operating intensive services with frequent stops into and across large conurbations (I).

3.13.3 On-train toilet design requirements shall be in accordance with Appendix C (E).

Train toilet issues cause real problems to train operators the world over. Recognised good practice in toilet design, together with options for consideration, are included as Appendix C to this document.

3.13.4 To extend CET discharge periodicities, the fitting of bio-reactor waste technology should be considered (D).

Several European railway operators have fitted bio-reactor toilets to suit their operations, others have decided not to for various reasons, e.g. cross-border use, low winter temperatures. Some trials have taken place in GB, Scotrail have run a trial on a Class 334 and SWR are fitting to new Class 701s and more information should be sought from them. Some background information on bio-reactors is given in C.4.4.

3.13.5 All access panels within the toilet cubicle shall be secured to prevent unauthorised access (E).

Toilet areas are not monitored by CCTV nor are easily visible to train crew or other passengers, so persons could interfere with or hack into control systems in relative privacy.

3.13.6 Passive provision for the installation of a toilet system should be provided, where toilets are not specified (D).

Note 1:	In this context 'passive' means that the design has made the provision for the fitment of equipment by the designer purposely allocating free space and consideration of cabling, wiring, space for tanks and pipework to the relevant location(s).
Note 2:	This permits the subsequent transfer to other routes where toilet provision is required.

3.13.7 The current operational status of the toilets and the condition of header water and CET tank capacities should be continually available remotely for the maintenance depot (D).

There is a legal requirement in the PRM TSI 2014+2019 clause 4.5.2 that trains with defective Universal Toilets should only be in-service for a specified amount of time.

3.14 Cleanability

3.14.1 Interface points for seats and tables with the vehicle floor should be avoided (D).

This facilitates easier cleaning and visibility.

3.14.2 The interior shall be designed to prevent the build-up of dirt and dust in inaccessible places (E).

This helps to eliminate crevices that are hard to reach and clean, with unused spaces filled and radiused corners provided where surfaces meet, e.g. between panels and floors.

3.14.3 Passenger facing interior hard and soft surfaces shall be long-lasting and maintain their appearance at least until the appropriate overhaul period, when cleaned in line with manufacturer instructions (E).

This makes cleaning easier and helps to maintain their appearance for longer.

Carpets should not require abrasive chemical and processes to clean them. Deep pile carpets are not suitable as they tend to hold on to dirt.

3.14.4 Entrance matting shall be provided in vestibules where carpets are fitted in the saloon (D).

This can help prevent dirt being trodden throughout a carriage.

3.14.5 Seat covers should be made from an easily maintained material (D).

3.14.6 Crevices where sharp objects could be concealed shall be avoided (E)

To avoid the associated risk of injury to passengers, maintenance and cleaning staff from, for example, hypodermic needles.

3.15 Vandalism Mitigation

3.15.1 The risk of vandalism shall be considered to guide the amount of protective film or anti-graffiti measures required (E).

This could be on the interior and exterior.

3.15.2 All interior glazing and glass panels should be fitted with protective film ensuring that it can be subsequently removed and replaced without the removal of panels (D).

To protect the passenger facing side of bodyside windows, glazed panels and draught screens from damage and ensure the film can be changed easily by maintenance staff.

3.15.3 Interior fixtures should be graffiti-resistant to an agreed standard (D).

Anti-graffiti coatings can aid general cleaning as well as the removal of graffiti.

3.15.4 Interior labels and protective film and coverings shall be designed to prevent damage by passengers (D).

The picking of edges of labels and coverings means they will look unsightly and have to be changed

3.15.5 Seat cushions should have features that minimise damage from sharp objects (D).

This reduces the effects of acts of vandalism.

Sometimes a metal mesh is fitted between the moquette and the foam.

3.15.6 Exterior surfaces shall be coated to facilitate the easy removal of graffiti (D).

3.15.7 Exterior features of rolling stock shall be designed to minimise the possibility of persons riding or climbing on them (E).

This is to prevent irresponsible members of the public from 'train surfing', whilst the train is in motion, or using the jumper cables as a makeshift ladder to reach the vehicle roof, whilst stationary in a platform. This also applies to wagons fitted with ladders.

3.16 Interior Panels

3.16.1 Interior panels should be designed to be as damage resistant as possible (D).

3.16.2 Tamper-proof fastenings should be used to secure panels (D).

3.16.3 The use of self-tapping screws for fixing of interior panels shall be avoided (E).

The tapped holes become enlarged over time, making the fixings less effective and unsightly.

3.17 Flooring

3.17.1 The floor coverings shall be slip-resistant as measured by a pendulum test value of 30 to '*BS 7976-1 Pendulum testers*'. Specification and the effect of wear shall be considered when making this assessment (E).

Experience, particularly in relation to the operation of trains with hard floors, is that some flooring materials can become slippery when wet, resulting in passenger accidents due to slipping.

Guidance is given in HSE document '*Assessing the slip resistance of flooring*'. A copy of the guidance can be found at: http://www.hse.gov.uk/pubns/geis2.htm.

3.17.2 The pooling of water on floors shall be prevented (E).

This minimises the risk of wet floors creating a slipping hazard.

For example, a floor in vestibules could have a slight camber towards the access doors to allow water to drain away.

3.18 Interior Powered Doors (Excluding Toilet Doors)

3.18.1 Powered interior doors (excluding toilet doors) shall be designed in accordance with Appendix G of RSSB research project T1036 (E).

Passenger Focus highlighted to the Vehicle / Vehicle System Interface Committee (V/V SIC) the relatively high number of complaints they receive from passengers because of injuries that were caused by the internal doors on trains such that RSSB commissioned a research project T1036.

The PRM TSI and *'EN 16583-3 Railway applications – Design for PRM use – Equipment and components on board rolling stock – Part 3: Clearways and internal doors'* covers internal doors, but RSSB report T1036 adds detail. The report from RSSB research project '*T1036: On-board injuries associated with internal train doors to develop a specification for interior powered doors*' can be found on SPARK.

Appendix G of the report includes a specification for internal powered doors. In due course this may become a Railway Industry Standard but, in the meantime, the Appendix titled *'Onboard Injuries Associated with Internal Train Doors: Appendix G - Performance Specification for Power Operated Internal Doors on Passenger Carrying Rail Vehicles (T1036 Appendix)'* can be found here:

https://www.sparkrail.org/Lists/Records_StaffMembers/DispForm.aspx?ID=739

(RSSB membership is required to see this document on SPARK. Contact RSSB as outlined on page 10).

3.19 Passenger Special Spaces

3.19.1 Buggy Space, Cycle Store or Multi-Use Storage

3.19.1.1 Buggy storage space should be provided separately from areas for wheelchairs and cycles, where space and demand is insufficient and dependent on route, the multi-use space is available for cycles and buggies (D).

The objective is to minimise potential conflicts between different users of these spaces.

Note that provision for wheelchairs is mandated by Accessibility Regulations and is exclusively for this purpose when needed. Suitable signage is to indicate the priority of use.

3.19.1.2 The buggy space should be close to nappy-change facilities (D).

3.19.1.3 Cycle racks should be located in close proximity to access doors, positioned on suitable flooring and make optimum use of available space (D).

3.19.1.4 For all the buggy space, cycle store or multi-use storage areas, the assessment of flow of passengers passing through shall be demonstrated (E).

For additional reading see *Cycle Tool Kit & T1034 Understanding the business case for investment in Cycle-Rail*' in Appendix G.

3.19.2 Wheelchair Space

3.19.2.1 Requirements for wheelchair spaces, clearways and wheelchair accessible doors are included in the PRM TSI, supporting European Standards and guidance (I).

3.19.2.2 The wheelchair accessible doors shall be positioned within the train formation to ensure that they are always usable at all station platforms (E).

This choice of position can be affected by SDO, short or narrow platforms or platform furniture.

3.19.2.3 The floor covering in the wheelchair space should be a different design or colour to the surrounding floor (D).

This is to ensure that the space is kept clear for wheelchair users.

3.20 Passenger Power Supplies

3.20.1 Power supplies should be provided for the charging of mobile electronic devices and be plainly visible, readily accessible to passengers and appropriately positioned and labelled (D).

This could be from USB or 230 V sockets.

In the future the use of USB systems for charging most devices may reduce the need for a 230 V AC supply.

3.20.2 An ergonomic assessment shall demonstrate that 230 V sockets are positioned to maximise ease of use taking account of their location, the adjacent clear space, and orientation and inclination of the socket face (E).

Good accessibility improves safe operation, reducing the potential to damage plugs and chargers when removing them, for example, from under-seat sockets. Where clearance is limited, for example, sockets above table-tops, orientating the socket face at an angle or horizontal can give better access.

There have been instances of passengers getting minor electric shocks from under-seat mounted sockets, see *'NIR 3591 Damaged customer plugs in at-seat sockets'.*

3.20.3 For a 230 V power supply system the following shall be provided (B):

- Sockets compliant to '*BS 1363-2: 13A plugs, socket-outlets, adaptors and connection units. Specification for 13A switched and unswitched socket-outlets'*, specifically the plug insertion and removal forces specified.
- Protection by a RCD,
- The output from the socket to suit the type of equipment for which it is to be used,
- The reliability of the 230 V supply to be as high as possible,
- An efficiency of 85% over the 20-100% load range,
- Able to perform 20 restarts per hour without failure,
- 50 Hz to *'EN 50160: Voltage characteristics of electricity supplied by public electricity networks',*
- Any control software to *'BS EN 50657 Railways Applications. Rolling stock applications. Software on Board Rolling Stock',*
- *A minimum IP 21 rating in accordance with 'BS EN 60529 Degrees of protection provided by enclosures (IP code)'.*

Dependable availability of a power supply for electronic devices is now seen by passengers as being an essential requirement.

Some system earthing arrangements and methods for retention of wires in sockets may not meet the railway vibration requirements.

3.20.4 The 230 V power supply system design shall demonstrate the following has been considered (B):

- The power consumption and diversity and number of outlets to be installed.

Typically, 70 mA per socket is a reasonable value to use.

- That no switch is required on the outlets.

Having switches on sockets may lower reliability and is not essential.

- An indicator on one socket per circuit as a minimum to show the supply is live.

Inclusion of an indicator on each socket to show supply and aid fault-finding is acceptable.

- How the system can be isolated / reset and by whom,
- The supply is to be resettable by customer service staff with a safely and readily accessible reset.

Auto-resetting of the system could be an option, with a time delay before it tries again on the assumption that the cause of the trip has been removed.

- The level of trip rate should be agreed.

Recent examples have been 10 mA or 30 mA.

- The splitting of supplies, to feed each side of the carriage separately.

Splitting supplies within a carriage will increase availability. Alternating sockets from each inverter along each side of the carriage could lead to fault-finding issues. The overall consideration should be how to maximise system availability for passengers.

3.20.5 USB outlets for the charging of mobile electronic devices should be provided and be readily accessible to passengers where power constraints may limit 230 V supplies (D).

Mainly aimed at refurbishment of existing trains where spare power is limited.

3.20.6 The USB outlet should be designed to be easily changed when broken (D).

USB outlets were never designed for such use, merely as part of a computer. They are now used for many applications, but the connecting arrangement is not necessarily robust for this type of railway vehicle use. Hence, they need to be easy to change.

3.20.7 A check of push-in and removal force for 230 V sockets shall be included in the maintenance plan (E).

3.20.8 Inductive charging in tables should be considered (B).

3.21 Lighting

3.21.1 Lighting levels in passenger areas shall comply with '*BS EN 13272* '*Railway applications. Electrical lighting for rolling stock in public transport systems'* and not exceed 500 lux at 750 mm above floor level (E).

Lighting levels are to be sufficient to facilitate typical passenger activities such as reading, whilst not being so bright as to become intrusive and on some existing trains are seen by passengers as being either too bright and clinical, or too dim.

3.21.2 Lighting levels shall be checked with luggage on luggage racks and stacks (E).

Sometimes, where glass is used in luggage racks, the light shining through is reduced when items are placed on the rack. When defining the light level type testing this effect should be considered.

3.21.3 Passenger-controlled reading lights should be provided, featuring the following (B):

- Modular design, able to facilitate a flexible interior layout,
- Train crew and maintenance staff are easily, and from a single location, able to override the local controls to force them all to be lit, to facilitate the identification of defective lighting components,
- A means provided to switch all lights off from a single location.

Passengers welcome the ability to influence the lighting levels of their immediate environment.

3.22 intentionally left blank

3.23 Litter & Recycling Bins

3.23.1 Clause in v5.1 deleted.

3.23.2 Where litter and recycling bins are provided, an assessment of their design including opening aperture size, capacity and maintainability shall be demonstrated (E).

Passengers perceive that there is inadequate provision of bins on board recent designs of rolling stock. There are either too few, they are not large enough or they are poorly identified. It may also be necessary to include recycling bins too.

The aperture should be a reasonable size for the common litter. The capacity should be designed around standard sizes of bin-liners.

3.23.3 The position of the bin should be considered to encourage awareness and use by passengers (D).

Placing by doors can be helpful.

3.23.4 The litter and recycling bin service door shall be fitted with a self-latching lock (B).

This would be to reduce the risk of it being left unlocked and swinging open.

3.23.5 Internal fixings should avoid damaging plastic bin liners (D).

3.24 Provision of Handholds and Handrails

3.24.1 Train interiors should be designed to maximise the provision of handholds / handrails for standing passengers and also for those walking through the train (D).

A shortage of accessible handholds and grab rails creates an uncomfortable travel experience for passengers who are required to stand and is frequently perceived by them as being 'unsafe'. Passenger Focus has identified the absence of accessible handholds as being a significant source of insecurity for standing passengers. This makes them less likely to move into areas of available floor space, so limiting capacity, and increases the risk of passengers falling under heavy braking. The RSSB research project 'T1147 Crowding on trains and in stations' *found that this also adds to health and safety and well-being of passengers*

For guidance on handholds and handrails see the PRM TSI, European Standards including *'EN 16585-2 Railway applications — Design for PRM use — Equipment and components on board rolling stock Part 2: Elements for sitting, standing and moving'* and guidance. Structural requirements are given in *'GMRT2100 Rail Vehicle Structures and Passive Safety'.*

Additional handholds could be the use of straps or poles as seen on metro systems.

The double or triple poles in the vestibule of suburban and metro trains, make it much easier to stand in this area with a sensible handhold, compared to a single pole, which limits the number of people who can hold on. It also minimises the impact of 'pole hoggers' who lean against the pole and stop other people holding it.

3.25 Provision of Occasional-Use Seating

3.25.1 Occasional-use seating should be provided in multi-use areas (D).

This could include tip-up and perch seats.

3.25.2 Multi-use areas with occasional seating shall have signage advising on priority for intended users in accordance with the operator's policy (E).

3.25.3 Occasional-use seating shall not be provided in vestibules (E).

Their use can be a barrier to efficient access / egress and increase dwell times.

3.26 Fixed Tables

3.26.1 Full-width tables shall be provided at bay seating, the design of which shall allow easy access to the window seat (B).

Sometimes passengers have difficulty in accessing the window seats where full-width tables are provided. Design features to improve access are:

- Tapered table top,
- Folding leaves,
- Minimise restrictions due to structural support,
- Clearance between top of seat cushion and table (See RSSB project *T1140*).

3.26.2 Fixed tables shall have a lip around the perimeter and a slip-resistant surface (B).

This reduces the risk of drinks spillage and, where drinks are spilled, the hazard from hot liquids running down onto passengers' legs whilst seated at a table.

When selecting the resistance of the slip-resistant surface the accelerations and cant deficiency / excess seen in service is to be considered.

3.27 Seat Back Tables

3.27.1 Folding seat back tables shall be provided at 'uni-directional' seating the size of which is sufficient to support and allow use of a laptop (B).

Often the size of table and the angle of the seat back means an open laptop has to teeter on the edge.

A typical size is 350 x 350 mm.

Other design features to achieve this may be:

- Folding table,
- Extendable or folding leaves.

3.27.2 Folding seat back tables shall have a lip around the perimeter and a slip-resistant surface (E).

This reduces the risk of drinks spillage and, where drinks are spilled, the hazard from hot liquids running down onto passengers' legs whilst seated at a table.

When selecting the resistance of the slip-resistant surface the accelerations and cant deficiency / excess seen in service is to be considered.

3.28 Coat Hooks

3.28.1 A coat hook should be provided at seat locations (D).

This frees up luggage storage and keeps clothing in the vicinity of the passenger.

The coat hook is to be positioned to minimise pilfering and designed to take into account interior passive safety requirements.

3.29 Differentiation Between Areas

3.29.1 Clear differentiation between areas, both internally and externally, should be provided, e.g. between first and standard class (D).

Sometimes first and standard class areas are almost the same with only an anti-macassar on a seat to differentiate. This causes arguments between passengers and train crew when errors are made.

Historic practice externally was the yellow band for first class, red for catering etc, but other indicators could be for wheelchair space, bicycle or multi-use space.

3.29.2 An indication on the front of the train to show its orientation to passenger and staff should be considered (D).

This could be something that is easy to recognise at the front of a train (say a coloured band on the coupler to denote the location of first class, PRM access, galley or luggage / bike space).

3.30 Platform Train Interface

3.30.1 It shall be demonstrated that the train design manages the Platform Train Interface (PTI) in such a manner as to minimise risks to passengers and keep station dwell times to a minimum, taking account of industry research undertaken in this area (E).

Potential hazards associated with the PTI have been an area of significant focus for the GB rail industry, with a great deal of research having been undertaken.

Following on from the Platform Train Interface Strategy published in January 2015, various projects have been taking place looking at understanding the gap / step from the train to the platform and how it can be reduced or made safer. The strategy can be found in the new PTI topic hub at:

https://www.rssb.co.uk/Insights-and-News/Key-Industry-Topics/Platform-Train-Interface/Stations-Platforms-and-Trains/Why-don-t-we-have-higher-platforms

Other PTI resources and guidance can be found here:

https://www.rssb.co.uk/Insights-and-News/Key-Industry-Topics/Platform-Train-Interface.

https://www.rssb.co.uk/Insights-and-News/Key-Industry-Topics/Platform-Train-Interface/Stations-Platforms-and-Trains/Assessing-the-step-gap.

The following RSSB research projects provide some useful design considerations for the train (and platform):

- *'T1037: Investigation of passenger vehicle footstep positions to reduce stepping distances and gauging constraints',*
- *'T1054: Evaluating platform gap fillers to reduce risk at the platform/train interface',*
- *'T1166: Minimising the impact of 'high and tight' platforms on the overall PTI step/gap dimensions'.'*

Search on the RSSB website (www.rssb.co.uk) for more information.

Requirements for step positions etc. are now given in '*EN 16586-1 Railway applications - Design for PRM use - Accessibility of persons with reduced mobility to rolling stock - Part 1: Steps for access and egress'.*

3.30.2 The gap (stepping distance) from train to platform shall be minimised (E).

The train to platform distance can be made worse where steps are mounted on the body end taper of longer vehicles and are parallel to the taper, rather than all or some of it parallel with the platform.

Examples are shown in Figure 3.30.2.

A. Bodyend taper step on straight

B. Bodyend taper step on curve

Figure 3.30.2: Examples of Bodyend Taper Steps

3.30.3 The height of the footstep above the platform should be kept as small as possible (D).

The lower the step the better it is for safer boarding and reducing dwell times.

Consideration should be given to the height of the train / vestibule floor relative to the standard platform height. Lower floors, nearer to the standard platform position, improve boarding and alighting for all passengers, with beneficial effects on station dwell times and safety.

Note: RGSs '*GIRT7020 GB Requirements for Platform Height, Platform Offset and Platform Width';* gives the platform height and offset dimensions and '*GMRT2173 Size of Vehicles and Position of Equipment*' has information about step position.

3.30.4 The provision of deployable steps should be considered (B).

A deployable step means the step can protrude further reducing the gap and may even be between the train floor and the platform, so providing an intermediate 'step'.

3.30.5 Where fixed steps are used, consideration should be given to provisions that enable the steps to be easily changed in case of route changes (D).

This gives a route specific height to the step but does not limit the fleet being cascaded.

Many platforms for historical reasons are higher than the preferred 915mm above rail level. The footsteps on trains are often positioned as high as possible to give the vehicles a go-anywhere status, but this means on some routes there is a big step.

3.31 Wheelchair Ramp Design

3.31.1 RSSB research project '*T759: Improving the methods used to provide access to and from trains for wheelchair users*' contains a lot of useful information on ramps, some is included already in the KTR, but more may be found in the following reports on SPARK (I):

- *'Improving the methods used to provide access to and from trains for wheelchair users (**T759** Report)',*
- *'Improving the methods used to provide access to and from trains for wheelchair users: appendices (**T759** Report)'.*
- *The project can be found here:* https://www.sparkrail.org/pages/libraryresults.aspx?k=t759

Also the PRM TSI, '*EN 16586-2 Railway applications - Design for PRM use - Accessibility of persons with reduced mobility to rolling stock - Part 2: Boarding aids'* and guidance give requirements for boarding ramps.

3.31.2 Special attention should be paid to the transition profile between the vestibule floor and any boarding aid to ensure that small wheels on wheelchairs cannot be trapped causing the wheelchair to tip (D).

3.31.3 Where a lug and hole is used to temporarily secure a portable wheelchair ramp their size shall be agreed with the user (E).

The industry is moving towards a common ramp to improve train operator usability. A common lug pitch of 425 mm and pin size ∅9.1 mm x 15 mm long is suggested.

Accessibility regulations require that wheelchair ramps be temporarily fixed to the train whilst in use. It does not suggest how, but at present this is done using a lug and hole arrangement of which there are three current hole pitches.

3.31.4 A visual indication, e.g. arrows, on the portable wheelchair ramp surface and vehicle to indicate the position of the lug and hole, should be provided (D).

This makes it easier for staff to position the ramp when deploying.

3.31.5 A portable wheelchair ramp or other installation, when in position, shall prevent the train doors from closing (E).

To prevent doors from being closed, either manually or automatically, whilst the ramp is deployed.

3.31.6 Where door auto-close is fitted, an override to prevent door closure whilst a portable wheelchair ramp or other installation, is in position, should be provided (D).

Often with short auto-close times the attempt by the door to close can be disconcerting to users and disabling it will assist with boarding.

An example of disabling the auto-close is to press and hold the external door push button for a short period. Re-enabling could be by pressing and holding again, or an auto-reset once the door is closed and locked by train crew.

3.31.7 On-train portable wheelchair ramp storage shall consider risks associated with retaining a ramp with its high-centre of gravity on a moving train (E).

There have been instances of ramps toppling and causing injury.

3.31.8 Securing devices for the on-train portable wheelchair ramp shall be self-latching or automatic, not relying on manual intervention (E).

Automated or self-latching devices ensure the ramp is retained without further human action.

3.31.9 The mass of the portable wheelchair ramp shall not exceed 12 kg (D).

The lower the mass the easier the ramp is to handle without injury, HSE recommendations for lifting should be followed.

3.31.10 The portable wheelchair ramp shall have at least two handles, suitably located for carrying and for positioning (E)

Sometimes the carrying handle(s) are not always positioned such that they help with positioning of the ramp.

3.31.11 The storage location for the on-train portable wheelchair ramp shall be as close as possible to the wheelchair accessible doors (E).

This reduces the distance the ramp has to be carried and having to move passengers out of the way.

3.31.12 The storage for the on-train portable wheelchair ramp shall protect passengers clothing from coming into contact with the ramp (E).

To stop passengers getting dirt on their clothes or being grazed by the ramp surface.

3.31.13 The area between the wheelchair ramp storage area and the external door should be protected for impact damage whilst staff are manoeuvring the ramp from one place to the other (D).

Reduces unsightly and costly repair of damage.

3.31.14 All external passenger doorways should incorporate securing points for access ramps for the use of all PRM users (D).

Access ramps may be used by staff to assist passengers with reduced mobility, who are not necessarily wheelchair-bound to board the train.

3.32 Mobility Scooter Access

3.32.1 RSSB research project '*T1055: Improving accessibility and safety for mobility scooter users travelling by rail'* evaluates what improvements should be made to assist mobility scooter users to board and alight from trains and to improve the processes used by staff in dealing with mobility scooter users on SPARK (I):

https://www.sparkrail.org/pages/libraryresults.aspx?k=t1055

3.33 External Access Doors

3.33.1 Door systems shall be fitted with static and dynamic anti-trap and drag functionality in accordance with clause 5.2.1.5 of '*BS EN 14752:2019 Railway applications — Body side entrance systems for rolling stock'* that prevents passengers, luggage or items of clothing from becoming trapped in the doors (E).

There are intelligent sensitive / safety edges and detection systems available that can determine if the trapped item is inside, or outside of the train and react accordingly.

A dynamic anti-trap and drag protection system can identify a thin item attached to a person (or animal) such as a strap, belt or lead.

There are instances where the obstacle detection system on doors will not identify a thin item attached to a person (or animal) such as a strap, belt or lead. Where a sensitive edge is used as part of the obstacle detection system, it is possible to re-energise the sensor system as the train starts to depart the platform to provide a drag protection function. This function is isolated once the train has attained a specified speed or travelled a specified distance.

This function is often provided in software and is built into the door control system by the manufacturer. The TOC should undertake a risk assessment in order to decide whether to enable this function as part of safe integration into their operation.

Standards available are: *'BS EN 14752:2019 Railway applications — Body side entrance systems for rolling stock'*, and a Railway Industry Standard *'RIS-2747-RST Functioning and Control of Exterior Passenger Doors on Vehicles'* covers a number of aspects of door control design; particularly regarding Selective Door Operation.

3.33.2 Provision shall be made to interrupt the train dispatch process and alert traincrew in a timely manner when an item has become trapped in an external access door (E).

There have been a number of accidents, involving fatalities or serious injuries, as a result of passengers, their luggage or clothing becoming trapped in the closing doors of a train that has then departed without this being detected see RAIB report on West Wickham.

The full report can be found at:
https://assets.publishing.service.gov.uk/media/56d04f05e5274a10f9000001/R032016_160229_West_Wickham.pdf

3.33.3 Clause in v5.1 now deleted.

3.33.4 Decals (e.g. shark's teeth) should be applied adjacent to the leading edge of door leaves (D).

This can make passengers more aware of the risks of door closure.

Examples are shown in Figure 3.33.4.

A. Internal view B. External view

Figure 3.33.4: Example of Shark's Teeth on Bi-Parting Doors

3.33.5 Where fitted, the door(s) autoclosure should be a significantly slower closing speed than normal door closure, the door close alarm should sound before the doors close (D).

The time that a door(s) takes to close when autoclosing, is suggested to be between 10 to 15 seconds.

RSSB research project *'T1102: Optimising door closure arrangements to improve boarding and alighting*' identifies practicable improvements to current door closure arrangements and informs long-term improvements to rolling stock design and relevant industry standards. One recommendation was:

Recommendation 5. Autoclosure – significantly slower door closing speed.

'Slow the time that a door takes to close when autoclosing, to between 10 to 15 seconds.'

A copy of the report titled *'Optimising door closure arrangements to improve boarding and alighting (T1102 Report)'* can be found here on SPARK:

https://www.sparkrail.org/pages/libraryresults.aspx?k=t1102

3.33.6 Local control of at least one passenger door on each side of the train, to enable authorised staff access when the train is powered and not in-service, should be provided (D).

This is to support service preparation activities, such as cleaning, catering logistics or security sweeps, to be carried out on depots, stabling locations or stations without the need to access the driver's cab.

3.33.7 It shall be possible to access the emergency door release device to enable maintenance testing without damaging any protective covers (D).

3.33.8 The door control system shall support functionality to minimise the time between the train coming to a stand and the doors opening (E).

Reducing this time gives longer boarding and alighting times.

Preparation of the doors for opening as the train approaches the platform, such as releasing pressure seals, pre-activation of pushbuttons etc are possible solutions.

3.33.9 The clearway for bi-parting doors should be sufficiently wide to enable two or more passengers to board / alight simultaneously (D).

On commuter or metro services, if passengers can board / alight side by side it helps with dwell time.

Work for Crossrail and Thameslink has shown this to be 1600 mm minimum.

3.33.10 Vestibule areas shall be designed to optimise passenger flow during access and egress (E).

On commuter or metro services the discouraging of 'door sentries' blocking the door area by having stand-back areas each side of the doorway, and handrails positioned away from the doorway.

Stand-backs should not be too large, typically 300 mm is sufficient and this is the size of a 95th percentile trunk depth PeopleSize 2020.

3.33.11 The fitting of status lighting around the doorway should be considered (D).

Having lighting around the doorway can indicate if the door is safe to enter or leave the train, is about to close, is locked out of use, or is not going to open due to SDO etc.

3.33.12 Where a passenger exterior door-close push button is provided, a shroud should be installed around the push button, whilst maintaining compliance with the PRM TSI (D).

There is no mandatory requirement to fit a close push button, but if it is chosen to do so, a shroud would prevent passengers accidentally leaning on or touching the pushbutton whilst alighting and trapping other passengers who are alighting or boarding should it close.

RSSB research project *'T1102: Optimising door closure arrangements to improve boarding and alighting*' identifies practicable improvements to current door closure arrangements and informs long-term improvements to rolling stock design and relevant industry standards. One recommendation was:

Recommendation 10. Door close push button - to control the risk associated with inadvertent operation of the door close push button.

'Fit shrouding around the door close push button to prevent inadvertent operation, taking into account: passenger sight-lines to the push button, visibility of 'halo' or other button illumination, and avoiding sharp-edges for the shrouding (control re-positioning or time-delay for operation, are not appropriate measures).

The door close alarm should sound before the doors close.'

A copy of the report titled *'Optimising door closure arrangements to improve boarding and alighting (T1102 Report)'* can be found here on SPARK:

https://www.sparkrail.org/pages/libraryresults.aspx?k=t1102

3.33.13 The status of each passenger door i.e. released, open, closed, locked, SDO disabled etc, shall be available in the cab for use during train preparation (E).

This clause is to support the idea of automation of train preparation, see Appendix H, by using a TCMS screen for example to check door operation.

3.34 Signage

3.34.1 The following signage, pictograms and tactile information are covered by the PRM TSI, guidance and '*EN16584-2: Railway applications - Design for PRM use – General requirements - Part 2: Information'* (I):

- Safety information and safety instructions,
- Warning, prohibition and mandatory actions signs,
- Information concerning the route of the train, including information about delays and unplanned stops,
- Information concerning the location of on-board facilities.

3.34.2 The PRM requirements on signage in 3.34.1 should also be applied to existing trains during interior changes (D).

RSSB are preparing a Project *19-015* for a Guidance Note for the PRM TSI, which will incorporate revised guidance on emergency and safety signs.

3.34.3 Signage for evacuation purposes shall be in accordance with the following RSSB documents and take note of the arrangement of labels in the PRM TSI: (E)

- *T052a Improvements to safety signage on passenger trains,*
- *T246 Development of common passenger safety signs,*
- *T422 Completing the set of passenger train safety signage to improve legibility and comprehension,*
- *RIS-2730-RST Vehicle Fire Safety and Evacuation.*

A large proportion of the safety signage used in passenger trains in Great Britain was optimised using internationally recognised best practice. The resulting signage is more legible and more easily understood, by a wider range of passengers and in a wider range of conditions, than was the case for earlier types of signage. This is so that passengers will now see consistency across the fleet.

3.34.4 Signage that is additional to, or that is not specified in 3.34.1 to 3.34.3, should take note of and use the following International standards to assess their clarity and unambiguity (D):

- *ISO 9186 suite: Graphical symbols — Test methods*
- *ISO 7000: Graphical symbols for use on equipment - Registered symbols*
- *ISO 7001: Graphical symbols — Public information symbols* (and its amendments).

3.35 Additional Portable Equipment

3.35.1 The Loc & Pas TSI clause 4.2.9.4 specifies mandatory on-board tools and equipment. Railway Industry Standard *'RIS-2730-RST Vehicle Fire Safety and Evacuation'* details further tools and equipment. The following clauses are for additional portable equipment to be available in the case of sustained delay or train stranding (I).

3.35.2 A physical barrier that can be placed across exterior passenger doors opened for ventilation shall be provided (E).

In the event of a sustained delay, particularly in very hot weather, with no electric supply, the passenger access doors can be opened to allow air circulation. The barriers are placed across the doorway to alert passengers that the door is open. This physical barrier could be a hazard tape or bar, integrated into the door system or stored elsewhere.

3.35.3 Consideration should be given to provision of some or all of the following items which should be stored in a cupboard accessible to staff (D):

- Extra high visibilty vests,
- Lighting sticks,
- Foil blankets,
- First aid kits,
- Evacuation steps / ramps / ladder,
- Door barriers, if not built-in,
- Bottled water.

The type of service planned would affect the equipment provided. Hi-vi vests can be provided to off-duty rail staff or volunteers.

The joint RDG and NR document *RDG NR GN SP01 'Guidance Note - Meeting the Needs of Passengers Stranded on Trains'* provides some information on possible scenarios and equipment that may be carried on board. It is available here:

https://www.raildeliverygroup.com/about-us/publications/acop/269-meetingtheneedsofpassengersstrandedontrains/file.html

This is complemented by *RDG GN015 'Guidance Note - Extreme Weather Arrangements, including Failure or Non-Availability of On-Train Environment Control Systems'.* It is available here:

https://www.raildeliverygroup.com/about-us/publications/acop/249-extremeweatherarrangements-includingfailureornon-availabilityofon-trainenvironmentcontrolsystems/file.html.

3.35.4 The availability of additional portable equipment in the event of a collision should be maximised by choice of its locations (D).

In the Great Heck accident of 2001, emergency equipment was located in the leading vehicle which was destroyed in the collision.

In addition, distribution of certain equipment (e.g. door barriers, foil blankets) along the train will aid speed of deployment.

4. Key Requirements - Operational

4.1 Door Control Concept

4.1.1 Door Control Decision

4.1.1.1 The Rolling Stock shall be capable of Driver Controlled Operation (DCO) and / or Driver Guard Operation (DGO) (or the provision made for retrofit of equipment) over the lifetime of the train as agreed with the specifier (E).

It is essential that the specifier determines the business requirement for DCO and / or DGO.

DCO can also be used for empty stock moves, even if not used for passenger operation.

4.1.2 Driver Controlled Operation (DCO)

4.1.2.1 Rolling stock shall either be capable of Driver Controlled Operation or the provision made for subsequent inexpensive retrofit of DCO equipment (E).

The intent is for DCO to be able to be retrospectively fitted in a cost-effective manner when required, if not originally installed.

In this context, 'inexpensive' means that the design has made the provision for the fitment of equipment by the designer purposely allocating free space and consideration of cabling to the relevant location(s).4.1.2.2 A train specified to be capable of DCO shall have Door Release and Close push buttons, and DCO CCTV Monitors at all driving positions (E).

Under DCO the Driver carries out Door Release upon arrival at the station and Door Close and Dispatch from the station.

4.1.2.3 A train specified to be capable of DCO shall have a DCO CCTV system fitted in accordance with Railway Industry Standard '*RIS-2703-RST - Driver Controlled Operation (DCO) On-train Camera / Monitors (OTCM)'* (E).

Live images from shore- or train-based CCTV are fed to monitors in the cab to allow the driver to view the platform train interface (dispatch corridor) through the process from door enable to the train departing. The point at which the monitors turn off can be specified by the operator to suit dispatch situations.

4.1.3 Driver Guard Operation (DGO)

4.1.3.1 A train specified to be capable of DGO shall have Door Release and Close push buttons, Signal Buzzers and Crew Voice Communication at all driving positions and at all Guard Operating Panel (GOP) positions (E).

Under DGO the Driver carries out Door Release upon arrival at the station (in order to be compatible with Selective Door Opening systems) and the Guard carries out Door Close and Dispatch duties (which may be in conjunction with platform staff or equipment).

4.1.3.2 The number and location of GOP positions at doorways along the train, to allow safe dispatch at all stations for all formations intended to be operated, shall be as defined by the specifier (E).

It is essential that the specifier defines the number and location of GOP positions to match their operational requirements, which may include GOP positions at both cab and passenger doorways.

4.1.3.3 Functionality of the DCO CCTV monitors (if installed) in DGO operation showing images of the dispatch corridor as the train departs and the point at which they switch to standby shall be in accordance with the requirements of the specifier (E).

It is essential that the specifier defines the functionality of the DCO CCTV monitors, including the view of the dispatch corridor and the point at which the images stop being displayed, to match their operational requirements.

4.2 Selective Door Operation (SDO)

4.2.1 SDO on a per vehicle basis shall be provided (or the provision made for subsequent inexpensive retrofit of SDO equipment, where this is initially not required) in accordance with Railway Industry Standard '*RIS-2747-RST Functioning and Control of Exterior Doors on Passenger Vehicles'* (E).

The lengthening of trains to meet passenger demand creates problems where platforms are then too short for these trains. In some cases, where footfall is relatively low and platform lengthening is either costly or impractical, SDO provides a practical alternative.

In this context, 'inexpensive' means that the design has made the provision for the fitment of equipment by the designer purposely allocating free space and consideration of cabling to the relevant location(s).

An RSSB research project *T1202 Guidance for introducing and managing Selective Door Operation (SDO)* is due for completion on late 2020 and should be viewed.

4.2.2 SDO for individual doors should be provided (or the provision made for subsequent inexpensive retrofit of SDO equipment, where this is initially not required) in accordance with Railway Industry Standard '*RIS-2747-RST Functioning and Control of Exterior Doors on Passenger Vehicles'* (D).

With individual doors being able to be inhibited by the SDO the distance for passengers to walk to use an available door is reduced.

In this context, 'inexpensive' means that the design has made the provision for the fitment of equipment by the designer purposely allocating free space and consideration of cabling to the relevant location(s).

4.2.3 A local indication, to advise passengers that a door has been inhibited by the SDO system and will not open, shall be provided (E).

Passengers may not notice, nor see PIS messages and when the door does not open, they believe this is because the traincrew have not released it. The door may be adjacent to a platform but because of the SDO design and / or stopping tolerances, may still be excluded from being released.

4.2.4 The validation of SDO operation shall be conducted prior to the train entering passenger service (E).

Validating the SDO can be difficult on a test track, therefore using shadow running or GNSS virtual testing is a good idea.

4.2.5 Train operators should consider if they wish to own the SDO parameters or database themselves or through the train builder (D).

Changes in platform length can be changed more quickly be the operator.

4.3 Location of Driver Resettable Controls and Isolation of Equipment

4.3.1 Driver resettable controls and isolation equipment, e.g. miniature circuit breakers (MCBs), shall be positioned inside the train where drivers can access them quickly in all normal operational conditions, preferably not in passenger areas (E).

When trains are crowded it can be extremely difficult, or even impossible, for drivers to gain access to equipment located in passenger areas. Any requirement to gain access to equipment from outside the train introduces safety risks and potential requirements to stop trains running on adjacent tracks.

4.4 Cab Design and Interfaces

4.4.1 The clauses 4.4.2 onwards are for adding more clarity or detail to cab design and interfaces and are in addition to the mandatory requirements of (I):

- The Loc & Pas TSI 1302/2014 as amended, chapter 4.9.1 in conjunction with the Loc & Pas TSI application guide ERA/GUI/07-2011/INT Version: 2.00 and *'GMGN2615 Issue 2.1 Guidance on the Conventional Rail Locomotives and Passenger Rolling Stock TSI'* and
- *'GM/RT2161 Issue 2 Requirements for Driving Cabs of Railway Vehicles'*.

4.4.2 The driver's cab shall be designed in accordance with the following EuroNorms (E):

- *BS EN 16186-1, 'Railway applications. Driver's cab. Anthropometric data and visibility',*
- *BS EN 16186-2, 'Railway applications. Driver's cab. Integration of displays, controls and indicators',*
- *BS EN 16186-3, 'Railway applications. Driver's cab. Design of displays',*
- *BS EN 16186-4, 'Railway applications. Driver's cab. Layout and access'.*

This will include, for example, ergonomics, dimensions, sight-lines, labelling etc.

The 2014 version (with amendments) of the Loc & Pas TSI still mentions that some European Standards are being drafted whilst those listed above are the issued ones. It is recommended to consult the application of the above mentioned European Standards instead with the assessment bodies and authorising entity prior to applying.

For guidance on anthropometric data for UK drivers, see Railway Industry Standard '*RIS-2761-RST Issue 1 - Rail Industry Standard for Driving Cabs*'.

Note: ASLEF, the train driver's union, has produced some documents on cab design, which can be found on their website. Versions of these have been part of previous KTRs, and the most recent one from October 2020 will be reviewed for the next version of KTR.

4.4.3 Driver cab controls shall be appropriately protected from accidental operation (E).

Delays have frequently been caused when members of traincrew have accidentally knocked equipment such as MCBs or desk push buttons with their bags, etc.

4.4.4 DSD pedals (where fitted) shall be vertically adjustable by the driver (E).

This is to aid driver comfort and use of controls across a wide spectrum of the population.

Experience has shown that Driver Safety Devices (DSDs) have proved difficult to design to satisfactorily accommodate the anthropometric range of drivers.

4.4.5 The DSD pedal installation shall be designed so that it is not susceptible to failure due to ingress of debris or moisture (E).

DSD pedals can get stuck due to the ingress of grit or stones from footwear.

4.4.6 Driving cabs shall be designed to ensure drivers are protected against Musculoskeletal disorders (MSDs) in accordance with Railway Industry Standard '*RIS-2761-RST Issue 1 - Rail Industry Standard for Driving Cabs'* (E).

Drivers are expected to drive trains for significant periods of time and it is therefore important to protect against MSDs if long term health problems are to be avoided.

4.4.7 Where cab equipment and controls need to be moved to permit fitment of European Train Control System (ETCS) displays and other ancillary equipment as part of the design, guidance is given in document '*ATOC/EC/GN/004 Guidance Note - ETCS Cab Human Factors Design Guidance*' which can be found at (I):

http://www.rssb.co.uk/rgs/oodocs/ATOCECGN004%20Iss%201.pdf

4.4.8 Glare and reflection studies of the cab environment to verify the driver's activities are not impaired under all feasible ambient lighting conditions shall be undertaken during the early stage of design (E).

It is imperative that the full percentile range of drivers are able to view indicators and displays necessary to ensure the safe operation of the train in all lighting conditions. Conducting a glare and reflection study early in the design process will help identify potential issues which would cause delays and be costly to rectify at a later stage.

Loc & Pas TSI clause 4.2.9.3.4 only refers to reflections from controls and indicators interfering with the line of sight of the driver. This requirement assesses the whole cab geometry for incidental direct and indirect glare and reflections from various surfaces, including controls and clothing to ensure that the readability of instruments and displays is not adversely affected. For example, this could be from low and lateral sunlight or during darkness, instrument lighting or light reflecting off an interior surface reflecting on instruments, displays or the windscreen.
Such studies could be undertaken, for example, by computer simulation and / or on a full-scale representative mock-up.

4.4.9 Driving cabs shall be operationally ready, i.e. ready for the train to be driven at turn-round, including after coupling or uncoupling, following the driver activating a cab, by inserting a master key, within two minutes. The systems that are to be operationally ready shall be agreed by all parties (E).

4.4.10 Driving cabs should be operationally ready, i.e. ready for the train to be driven at turn-round, including after coupling or uncoupling, following the driver activating a cab by inserting a master key, within one minute. The systems that are to be operationally ready shall be agreed by all parties (D).

On an increasingly congested network it is essential that platform occupancy should be kept to a minimum and that, whether a train is reversing at a terminal station or splitting / joining during a journey, the train is ready to move as quickly as possible after the driver enters the cab.

These requirements apply to all possible combinations of multiple unit formations and also encompass activities related to coupling and uncoupling and updating of train systems, for example, PIS.

4.4.11 On-board systems shall communicate with each other, so that drivers only have to enter data once (E).

This is in order to minimise time taken to enter data and to ensure data integrity.

4.4.12 A facility to accept a 'smart card' or other similar technology to activate train systems should be provided (D).

The issuing of staff with a contactless, phone-based, or smart card systems, limits access to role-specific systems, e.g. for energising appropriate systems (cleaners and maintenance staff), or aid train start-up times (drivers).

As an example, on the driver entering the train headcode and their ID No: any on-board systems (PIS, On-Train Data Recorder, Radio, etc.) should automatically configure as appropriate.

4.4.13 An exterior ambient temperature display in the cab, that the driver can read whilst seated in the normal driving position, should be provided (D).

An ambient temperature indication would warn drivers of freezing conditions, enabling them to respond accordingly.

4.4.14 The 'reading zone' for driver's papers, as defined in the TSI, or any surface, should be angled and not horizontal (D).

This is to prevent drinks from being placed on a surface that is not intended for this purpose.

4.4.15 A clock shall be displayed in the cab, synchronised to a recognised external time-source, that the driver can read whilst seated in the normal driving position (E).

4.4.16 A cup holder or place for a cup should be provided (D).

To provide a secure storage location for drinks, ensuring that spillages are minimised and kept well away from vulnerable equipment

4.4.17 USB ports or 230 V sockets for drivers to charge mobile devices should be provided (D).

To permit the charging of tablets and smart devices, which are being used increasingly for work-related activities.

For more guidance see 3.20.3, 3.20.4 and 3.20.6.

4.4.18 A space to securely locate a hand-held device or tablet, so that it can be seen from the driving position, should be provided (D).

To permit them to be seen whilst being used for work-related activities.

4.4.19 A position should be identified for use by driver trainers / assessors or for persons undertaking infrastructure checks, which provides the necessary sightlines for the line ahead and of the critical driving controls (D).

There have been instances of trainees having collisions or missing signals, where the position of the trainer is not always optimal to provide a driver's eye view of the line ahead or visibility of the trainee's use of the driving controls.

4.4.20 Cab access door handles, push buttons or levers shall be of sufficient height to be comfortably used by the range of UK drivers' anthropometric data as in *'RIS-2761-RST Issue 1 - Rail Industry Standard for Driving Cabs'* (E).

Particular problems have been encountered by traincrew towards the lower end of the height range in gaining access to cabs; particularly when the train is located where there is a high ballast shoulder.

Refer to the European Standard '*EN 16116-1: Railway applications. Design requirements for steps, handrails and associated access for staff. Passenger vehicles, luggage vans and locomotives*' and Loc & Pass TSI for more details.

For information, current TSIs state that the height should be measured from a ground level that is 200mm below top of rail.

Full compliance to *'BS EN 16116-1: 2013 Railway applications. Design requirements for steps, handrails and associated access for staff. Passenger vehicles, luggage vans and locomotives'* clause 7.2 may not be possible with the positioning of exterior steps below the cab door because of the typically curved cross section of UK gauging profiles.

4.4.21 Cab footsteps and the ballast below them should be lit when the cab door is open (D).

4.4.22 A means to enable the driver to judge the stopping position of the train at the platform correctly shall be provided (E).

Accurate stopping positions facilitate the management of platform-train interfaces such as:

- *The use of platform mounted cameras,*
- *Location of platform humps for wheelchair access,*
- *In relation to gaps at the platform edge,*
- *The location of the platform entrances and exits,*
- *The length of the train relative to the length of the usable platform.*

RSSB project *'17-003 Design, positioning and use of car stop markers'* found that the optimal method for accurately judging the stopping position is through a cab side window. This will be reflected in Railway Industry Standard '*RIS-3782-TOM Design, positioning and use of car stop markers on station platforms'* due for publication late 2020.

Ideally, the cab should be designed with a side window directly in line with the driver's seat. The size and position of the window should accommodate variations in driver height and any seat adjustments that can be made (for example, longitudinal position).Side windows that are located further back than the driver's seat are not suitable for judging stopping positions as they do not provide an adequate view of platform stop markers and other visual targets on the platform to align the train with. Also, turning the head and/or body to look through a window can contribute to musculoskeletal disorders.

Where in-cab DCO screens are fitted and should they fail a cab side window can be used to view platform screens.

RSSB has a research project looking at using technology to accurately help with stopping positions. This is '*T1175: Enabling drivers to reliably stop trains at stations'*.

4.4.23 Windscreens shall be designed to ensure that ghosting, or secondary images are not seen by the driver (E).

This could be reflections at night or day.

This is in addition to the Loc & Pas TSI clause 4.2.9.2.2 Optical characteristics.

4.4.24 Tail lights at both ends shall illuminate automatically on a powered train when there is no active cab (E).

4.4.25 The cables of PA handsets or similar shall not impede access to and operation of equipment below (eg push buttons, switches, indicators, displays etc) (E).

4.4.26 Driver's cabs shall be able to resist determined physical attack (E).

The NRSP requirement states the need to have a physically secure driving cab to resist reasonable attack with tools such as hammers and screwdrivers.

This requirement should consider compliance with the Loc & Pas TSI clause 4.2.9.1.2.2 about driver's cab emergency exit requirements.

The Loc & Pas TSI clause 4.2.9.1.2.1 generally requires the preventing of unauthorised access to the cab.

Note: Only if there is an over-riding safety need to do so, access to the cab can be given to unknown persons (e.g. from track side), however the operator should have a specific operational process in place for this circumstance.

4.4.27 The air flows in the cab shall be adjustable to avoid distraction / discomfort to the driver (E).

Air flows directly over or at a driver can cause a distraction.

The Loc & Pas TSI clause 4.2.9.1.7, the application guide and EN 14813-1 & 2 all give information on air flows and CO_2 levels.

The finding of the RAIB report on the Kings Cross bufferstop collision says the driver found the air flows distracting (Safety digest 15/2017: King's Cross).

4.5 Human Factors Mitigation - Design of Control Systems

4.5.1 In the event of a second 'master key' being made active (as a result of human error or otherwise), in a train consist, an alarm and an indication of the location of all keys shall be reported to the train crew (E).

Instances of 'master keys' being inadvertently left in cabs once they are no longer active are not infrequent. If this problem is not clearly identified to the driver, considerable delay can be caused before the reason is identified.

4.5.2 In the event of a second 'conductor key' being made active in a train-consist, there shall be an alarm, and an indication of the location of all keys, shall be reported to the train crew (E).

Instances of 'conductor keys' i.e. those belonging to other authorised train crew, being inadvertently left in control panels are not infrequent. If this problem is not clearly identified to the train crew, considerable delay can be caused before the reason is identified.

4.5.3 Such credible operational 'errors' as those listed in 4.5.1 and 4.5.2 shall not result in any damage to the train control systems or other train equipment (E).

4.6 intentionally left blank

Note, clause 4.6 in v5.1 now moved to clause 1.18.

4.7 Reminder of Number of Vehicles in a Train

4.7.1 Where rolling stock can operate in multiple formations, a system to remind the driver of the number of vehicles in the train shall be provided, either displayed on the Train Control Management System (TCMS) screen or, where no TCMS is provided, using a robust system that requires intentional amendment (E).

This assists drivers in using the correct stopping positions at platforms for the length of their train.

4.8 Closed Circuit Television (CCTV)

4.8.1 Forward Facing

4.8.1.1 Forward facing CCTV cameras shall be fitted in accordance with *RIS-2712-RST On-Train Camera Monitoring Systems* section 3.1 and Parts 2 & 4 (E).

4.8.1.2 The data from FFCCTV should be preserved from excessive heat, shock following the requirements for OTDR (D).

4.8.2 In-Cab CCTV

4.8.2.1 Clause in v5.1 now deleted.

4.8.3 Pantograph cameras

4.8.3.1 Pantograph cameras shall be fitted in accordance with *RIS-2712-RST On-Train Camera Monitoring Systems* section 3.2 and Parts 2 & 4 (E).

These provide useful data on the overhead line and on the pantograph performance, as well as for incident investigations.

In addition the following parameters, not in *RIS-2712-RST*, need to be considered:

1. The pantograph camera system should:

- Use progressive not interlaced scanning,
- Use a shutter of the “global” type,
- Ensure that the images recorded occupy the largest possible portion of each recorded frame, in particular, the full range of pantograph vertical movement shall occupy a minimum of 50% of the vertical height of the frame,

- Record detailed images without interruption under all lighting conditions including darkness and rapid changes between sunlight and dark conditions,
- Provide data download capability for image data to a laptop PC.

2. Whether the camera is 3-channel colour or single-channel, each channel should have a minimum bit-depth of 8 pixels and 12 bits.

4.8.3.2 The pantograph camera systems shall record images which include the following (E):

- Images of all pantographs fitted to the train;
- The full width of the pantograph head, as viewed from the saloon roof, over the full range of vertical movement,
- Images of equipment up to a distance of 500mm above the contact wire (e.g. catenary and droppers) over the full range of wire heights.

4.8.3.3 The pantograph camera system shall record images when the train is in motion (E).

4.8.3.4 The pantograph camera system shall include a means of illumination so as to permit the pantograph to be seen in darkness (either in tunnels or at night) (E).

4.8.3.5 This illumination system shall provide a minimum of 40 lux at the pantograph head over the full range of vertical movement of the pantograph, including when stowed (E).

4.8.3.6 A system to keep the camera lens clean shall be provided (E).

A maintenance task needs to be included in the maintenance plan.

Good practice includes the use of scratchproof coatings; the glass sits flush / slightly above the surroundings to aid cleanability, etc.

4.8.3.7 Access to the pantograph camera images should be available to the driver or competent person so that incidents can quickly be studied (D).

4.8.4 Access to Images

4.8.4.1 Clause deleted as now included in RIS-2712-RST.

4.8.4.2 CCTV should include the functionality to monitor live footage by control room personnel (D).

It is important for both security and for operational / performance reasons

4.8.5 Disk Space & Bandwidth

4.8.5.1 Clause deleted as now included in RIS-2712-RST.

4.9 Emergency Equipment

4.9.1 The Loc & Pas TSI clause 4.2.9.4 specifies mandatory on-board tools and equipment. Railway Industry Standard *'RIS-2730-RST Vehicle Fire Safety and Evacuation'* details further tools and equipment (I).

4.9.2 Easily accessible emergency equipment shall remain attached at all reasonable loads that could be foreseen (E).

In the Watford derailment some emergency equipment came loose and could have further injured the driver, items like track circuit clips should remain securely attached to their brackets at reasonable loads, typically 5g.

The RAIB Watford derailment report 11/2017 is available from the RAIB website here:

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/636626/R112017_170810_Watford.pdf

4.9.3 The train diagnostic system should be advised if any locations containing any mandatory emergency equipment have been accessed (through the use of sensors, switches etc on doors) (D).

This clause is to support the idea of automation of train preparation, see Appendix H indicating if the cupboard(s) may have been entered.

4.10 Driver Training Manuals and Materials

4.10.1 A driver's manual detailing essential and supporting information shall be provided (E).

4.10.2 Driver training materials that consist of essential and supporting information shall be provided (E).

4.10.3 All driver training manuals and materials shall be provided in a format that is accessible to train drivers and trainers (E).

4.10.4 Driver training support tools or apps shall be provided (E).

This applies to new trains to ensure that the manuals and training materials are useable for train drivers rather than adapted from engineering documents. The manuals and materials need to be in a standard format, which will help to keep high training standards and provide consistency.

Manuals need to be in an electronic format, indexed and searchable, so they can be used with tablets and smart phones.

4.10.5 Consideration should be given to licensing of training support tools or apps including (D):

- The number of licences available,
- The type of licence,
- Future support.

4.10.6 Driver training shall be included on the train introduction plan (E).

Driver training is on the critical path for train introduction and can take a while particularly if there is a big difference in train technology, functionality and individual driver experience.

4.10.7 Sufficient training materials to enable a driver to rectify common faults to help minimise service disruption shall be provided (E).

This includes digital interactive and computer-based methods including virtual reality.

4.11 Crew Storage Areas

4.11.1 Designated storage areas for personal and work-related items, not accessible by passengers, shall be provided for train crew (E).

Train crew need to store personal and work-related belongings whilst they are on duty. This could be bags, coats or other items, including wet clothes.

4.12 Train Crew Local Door Controls

4.12.1 The access cover of train crew local door controls fitted in vestibules shall open so that the user is able to access the door controls without obstruction when stood on or close to the platform (E).

Covers that open towards the platform can block access. Covers also need careful consideration of their design so as to not to create a hazard when opened to staff (or passengers) – since they are typically at 'head height' and can have sharp edges.

4.12.2 Any PA handset cables associated with train crew local door control positions shall not impede the operation of the door control equipment (E).

5. Key Requirements - Communications and Diagnostics

5.1 Software Security

5.1.1 A demonstration that all software on board the train follows the key points outlined in Appendix D shall be provided and documented (E).

At present there are only strategies for cyber security. Until standards exist, Appendix D is considered the best approach.

Network and Information Systems (NIS) regulation – All railway operators are mandated Operators of Essential Services under NIS. The rail essential service is to: "enable the safe and secure movement of passengers and freight by rail without undue disruption or delay". Failure to protect the security and resilience of onboard train systems, could result in prosecution under NIS from the Rail sector Competent Authority – the DfT Cyber Compliance team. Fines can be up to £17m.

Train operators and suppliers should also seek to follow the points identified in the *'DfT Rail Cyber Security Guidance'* and should note any mandated cyber security requirements, e.g. National Rail Security Programme [NRSP].

RDG has also published a '*Rail Cyber Security Strategy 2017',* which can be found here:

https://www.raildeliverygroup.com/about-us/publications/96-2017-01-rail-cyber-strategy/file.html

5.1.2 Where onboard systems are located in passenger areas, means to secure unauthorised physical access to ports or connection points shall be provided (E).

This could be using high quality security locks.

The covers could be fitted with interlocks / sensors that advise the TCMS if tampered with.

5.1.3 Any ports in a train bus shall be closed or plugged to hide possible connection points (E).

This will mean that ports (RS232, USB etc) are not obvious.

An appropriate means to secure unauthorised physical access to ports or connection points may also be provided.

Ports could be configured securely e.g. only to accept the expected input to shut down when disconnected as per CIS (Center for Internet Security) benchmarks.

5.2 Clause intentionally left blank

Clause 5.2 Open Source Software in v5.1 now deleted.

5.3 European Rail Traffic Management System (ERTMS) / European Train Control System (ETCS)

5.3.1 ERTMS / ETCS is to be fitted in accordance with the CCS TSI specification #3 including considerations based on ERA Technical Opinions as published (I).

Information can be found on the Digital Railways website.

5.3.2 The on-board system of ERTMS / ETCS shall comply with the following UK National Standards, unless otherwise specified (E):

- *GERT8402 Issue 2 ERTMS/ETCS DMI National Requirements,*
- *RIS-0743-CCS Issue 1 ERTMS Key Management,*

And either,

- '*RIS-0797-CCS ERTMS/ETCS Baseline 3 Onboard Subsystem Requirements: Retrofit'* for the Retrofit to rolling stock,

Or,

- *'RIS-0798-CCS ERTMS/ETCS Baseline 3 Onboard Subsystem Requirements: New Trains'* for new build rolling stock.

It is no longer permitted to simply leave space for the equipment. ERTMS / ETCS has to be fitted to new vehicles in accordance with the CCS TSI. The latest ERTMS / ETCS baseline and release version is, as of 2019, the CCS TSI table A2.3 Specification #3.

5.3.3 The on-board system of ERTMS / ETCS shall also be fully compatible with the Infrastructure on the specified routes (E).

5.3.4 Change Requests (CRs) appropriate to the on-board equipment and infrastructure shall be declared by the manufacturer (E).

Change Requests indicate the backwards compatibility between earlier versions of ERTMS.

Change Requests are on the European Commission website here: https://ec.europa.eu/transport/modes/ertms-change-control-management-ertms-technical-requirements_en

5.3.5 The design of AWS / TPWS equipment shall be that it can easily be removed at a future date (E).

Two standards on AWS / TPWS are '*GERT8075 AWS and TPWS interface requirements'* and '*RIS-0775-CCS AWS and TPWS Application Requirements'*.

5.3.6 The status of train protection systems e.g. fault or isolated shall be available in the cab for use during train preparation (E).

This clause is to support the idea of automation of train preparation, see Appendix H, by using a TCMS screen for example to check AWS & TPWS status.

5.4 Automatic Train Operation (ATO)

5.4.1 The train shall be capable of ATO over ETCS routes to a specified GoA level (D).

Fitting ATO equipment on rolling stock being designed to operate on routes where ATO is planned to become operational (as per an agreed and published Industry Digital Railway Programme) within five years of service introduction even if it is not to be immediately used has been found to be more cost-effective in the long-run.

Current available standards for ATO over ETCS in the UK are:

- '*RIS-0797-CCS ERTMS/ETCS Baseline 3 Onboard Subsystem Requirements: Retrofit'* for the Retrofit to rolling stock,

Or

- *'RIS-0798-CCS ERTMS/ETCS Baseline 3 Onboard Subsystem Requirements: New Trains'* for new build rolling stock,
- *ATO over ETCS System Requirements Specification, ERA SUBSET-125, v0.1.0,*
- *ATO over ETCS ATO-OB / ATO-TS FFFIS Application Layer, ERA SUBSET-126, 0.0.16,*
- *ATO over ETCS ATO-OB / ETCS-OB FFFIS Application Layer, ERA SUBSET-130, 0.1.0,*
- *ERA ATO OVER ETCS GLOSSARY, v1.6.*

ATO specifications for GB specific implementation of ATO over ETCS are currently under development within Network Rail and due for completion by the end of 2020.

The 2022 TSI release is expected to reference the following ATO subsets, which are currently under development and due for publication by ERA:

- *ERA SUBSET-132: ATO-TS / ATO-TS Interface (FIS),*
- *ERA SUBSET-139: ATO-OB / Train Interface (FFFIS application layer),*
- *ERA SUBSET-140: ATO-OB / ORD Interface (FFFIS application layer),*
- *ERA SUBSET-143: ATO-OB Interface (FFFIS low level layers).*

There is also a TMS interface specification under development to be published by Shift2Rail and not ERA within the 2022 TSI (ATO-TMS interface: X2RAIL-131).

GoA = Grades of Automation, see UITP.org website for more information.

Further Information can be found on the Digital Railways website.

5.5 Remote Condition Monitoring (RCM) Systems – Train-based

5.5.1 RCM Systems

5.5.1.1 RCM has potential benefits for train operators; vehicle owners and vehicle maintainers. Hence, these parties should be invited to participate in the design and specification of new systems and provide input to business cases (I).

5.5.1.2 The train manufacturer shall provide a list of RCM systems available and their benefits (E).

5.5.2 Monitoring of consumables and waste

5.5.2.1 Levels of all consumables that are to be replenished regularly and of all waste material that require emptying (other than saloon and toilet litter) shall be monitored by the TCMS (E).

During servicing, consumables will need to be refilled and waste tanks emptied. To achieve this, the train may have to be moved to a location where suitable facilities exist.

For example, these could be: washer fluid, sand, flange lubrication, fuel, diesel engine additive, toilet water tanks, CET tanks.

5.5.2.2 The TCMS shall be configured to provide alerts, based on trend data for consumables and waste, to ensure timely replenishing or emptying such that normal operation is not affected (E).

5.5.2.3 Levels of consumables shall be capable of being exported from the TCMS via the train's data bus and associated train to shore communications systems (E).

5.5.2.4 Alerts for all consumables that may affect planned operations shall be notified to the train crew (E).

5.5.2.5 Levels of consumables and waste materials shall be clearly displayed adjacent to tanks / containers, so it can be clearly (visually) identified where replenishment / emptying is required (D).

5.6 Train Diagnostics / Prognostics

5.6.1 Train systems with intelligent diagnostics to assist depot staff with troubleshooting and fault finding should be provided, particularly for maintenance intensive systems (D).

5.6.2 Train systems and sub-systems should be provided with the functionality to remotely export data, via the train's data bus and associated train-to-shore communications systems, to allow timely intervention (D).

To assist with fault diagnosis and therefore inform effective maintenance and repair activities.

This communication should be via a secure wireless network from the train, at terminal stations or suitable intermediate stations such that interrogation or diagnostics can be performed before the train reaches the depot.

Some of the data (small messages) could be sent while underway (so Control can arrange to have a fitter waiting at the next station), or using a secure section of the train Wi-Fi.

5.6.3 Fault diagnosis of all systems or sub-systems on the train should be capable via a secure single interface (D).

5.6.4 Prognostic systems, which can / will predict and warn of pending failure should be provided (D).

5.6.5 The brake system shall report maintenance related messages associated with the performance of mechanical (pneumatic),dynamic brakes and WSP to the train diagnostic system (E).

This clause is to support the idea of automation of train preparation, see Appendix H and also help with maintenance planning.

5.7 Monitoring Infrastructure from the Train

5.7.1 Unattended Train-borne Infrastructure Measurement Systems shall be considered at an early stage in the procurement phase (E).

Discussions should be held between vehicle owner / operator and the Infrastructure Manager in order to establish the business case for the optimum condition monitoring solutions required to be fitted to all or part of a fleet of trains.

Network Rail has prepared a list of their requirements to meet this need and this can be found in Appendix F.

Note 1: RSSB research '*T857: Detailed review of selected remote condition monitoring areas'* has useful information and can be found on SPARK here: https://www.sparkrail.org/pages/libraryresults.aspx?k=t857.

Note 2: Also information for RSSB research '*T1010: Cross-industry remote condition monitoring programme'* can be found on SPARK here: https://www.sparkrail.org/pages/libraryresults.aspx?k=t1010.

5.7.2 clause in v5.1 now deleted.

5.8 Remote Condition Monitoring (RCM) Systems – Infrastructure-Based

5.8.1 RCM has potential benefits for infrastructure maintainers. Hence, these parties should be invited to participate in the design and specification of new systems and provide input to business cases (I).

5.8.2 The infrastructure maintainers shall provide a list of all available infrastructure-based RCM systems requiring equipment to be fitted to trains available and their benefits (E).

Examples are wheel impact load detection systems, hot axlebox detection systems and pantograph monitoring systems, where AVI tags are attached to the vehicle

5.8.3 Details of all other infrastructure-based monitoring systems that require interaction with the train and / or specific equipment to be installed on the train shall be provided to the train manufacturer (E).

5.9 Automatic Vehicle Identification (AVI)

5.9.1 Radio-frequency identification (RFID) Automatic Vehicle Identification (AVI) tags shall be fitted to all vehicles, in accordance with *RIS-0796-CCS Train to Infrastructure RFID Compatibility* (E).

Automatic Vehicle Identification when fitted to a train, helps with rapid train identification when passing trackside monitoring systems, e.g. wheel load measuring systems, either where limits are exceeded, or for condition monitoring. The condition data can then be shared automatically, thus contributing to a condition-based maintenance regime, and cost savings for the owner / operator / maintainer.

Having a number of vehicles in a train formation fitted with tags, reduces the chance of no readings because of faulty / missing / not read tags and therefore no data being recorded and allocated to that train. More information is given in the documents listed below.

RSSB has published a Railway Industry Standard '*RIS-0796-CCS Train to Infrastructure RFID Compatibility*', covering the Radio-frequency identification (RFID) Automatic Vehicle Identification (AVI) tag specification for rail. This is available from the Standards Catalogue on their website.

The RIS is based on Network Rail's AVI System Specification, which is available on SPARK here:

https://www.sparkrail.org/Lists/Records/DispForm.aspx?ID=24965

This in turn is based on the GS1 guideline '*RFID_in_RAIL_GS1_in_Eu_Final.pdf*', which can be found at:

http://www.gs1.eu/automatic-identification-and-gs1-epcis-sharing-standard-in-rail#publications

There is also a standard *EN 17230 'Information technology - RFID in rail'*, due for publication in the next year or so, again covering the same topic.

All four documents are compatible, except that the RIS & NR documents allow greater range of tag position, simply because the position specified in the GS1 & European Standard documents is often unachievable on GB rolling stock.

In addition there is '*RIS-2795-RST Track to Train RFID Compatibility'.*

5.10 Mobile Communications Reception

5.10.1 It shall be demonstrated that the rolling stock design does not cause excessive impediment to mobile telephones and other similar devices communicating with public networks (E).

Signal boosters could be considered for each vehicle if significant signal degradation is unavoidable due to Faraday Cage effects.

5.10.2 Mobile phone signals passing through windows shall not be attenuated by more than 3 dB (E).

Poor mobile communication with Wi-Fi or mobile is an annoyance to passengers and much customer information relies on this. Window films can reduce the signal strength.

5.11 Passenger Wi-Fi Access

5.11.1 Passenger Wi-Fi shall be provided (E).

Information for On-train Mobile Communication Gateways, and On-board Digital Repeaters can be found in Rail Industry Standard '*RIS-0700-CCS – Rail Industry Standard for Internet Access on Trains for Customer and Operational Railway Purposes*'.

5.11.2 Systems that provide the passenger with internet access should be deemed non-critical (D).

As such, it is important to protect the systems that are critical / important to the operation of the train and ensure that vital functions have a secure architecture (c.f. 1.19 - Systems Architecture), that they are protected and that they are separated as much as possible from any passenger facing systems.

5.11.3 The passengers' mobile devices should be protected from malicious interference via the on-board passenger facing systems (D).

As such, standard procedures should be taken to protect passenger devices and data from compromise via the on-board facing systems.

Information for On-train Mobile Communication Gateways, and On-board Digital Repeaters can be found in Rail Industry Standard '*RIS-0700-CCS – Rail Industry Standard for Internet Access on Trains for Customer and Operational Railway Purposes*'.

5.11.4 A provision to switch off public facing Wi-Fi quickly and easily by the driver or train crew when requested by security personnel shall be provided (E).

Section 14 of the NRSP *requires that Wi-Fi must be switched off when ordered to do so by a Police Officer – this is to prevent the Wi-Fi being used by terrorists to detonate a device or live stream a marauding terrorist attack*

5.12 On Train Data Recorders (OTDR)

5.12.1 The Loc & Pas TSI clause 4.2.9.6 references '*BS EN 62625-1: Electronic railway equipment - On board driving data recording system – Part 1: System specification'*. There is also a supporting Railway Industry Standard *'RIS-2472-RST Data Recorders on Trains'*, which also includes some additional requirements for GB practice (I).

5.12.2. In addition to the requirements in '*RIS-2472-RST Data Recorders on Trains'* the following functionality should be considered for the OTDR and remain within the ranges specified in '*BS EN 62625-1: Electronic railway equipment - On board driving data recording system – Part 1: System specification'* (E):

- An agreed interface standard for OTDR data exchange,.
- Spare channel capacity provision,
- Ability to change the sampling rate of individual channels (as a maintenance activity only),
- Ability to change the activation thresholds of individual channels (as a maintenance activity only).

'GMRT2472 Issue 1 Requirements for Data Recorders on Trains' called up the above functionality, when it was updated to issue 2 and referenced BS EN 62625-1: Electronic railway equipment - On board driving data recording system – Part 1: System specification' the above items were not included. When the RGS was withdrawn and the RIS produced, these were not included either. They are listed here as useful additions and will remain in the KTR for now.

5.12.3 Functionality to remotely download OTDR data should be provided, taking note of appropriate cyber security measures (D).

5.12.4 Means for the accessing raw OTDR data for analysis purposes shall be provided (E).

This would allow 'big data' databases to open the raw files be used for bulk analysis ot the data.

By providing a software driver (e.g. dll file) proprietary applications can be used to open the raw OTDR files so they can be analysed for trends etc.

5.12.5 The status of On Train Data Recorders (OTDR) e.g. faulty or healthy shall be available in the cab for use during train preparation (E).

This clause is to support the idea of automation of train preparation, see Appendix H, by using a TCMS screen for example to check OTDR *status.*

5.13 Global System for Mobile Communications – Railway (GSM-R) - Voice

5.13.1 Information

5.13.1.1 GSM-R is expected to remain as the main bearer for railway communications for the foreseeable future. Developments in specifications are extending the capability of GSM-R by use of GPRS and EDGE technology which increases the call capacity of the existing system (I).

5.13.1.2 GSM-R is used in two ways: for voice communications and for data transmission for ETCS. This section is for voice (I).

5.13.1.3 On-Board GSM-R voice equipment includes a cab radio assembly, Drivers Control Panel (DCP), handset and cradle, cab loudspeaker, roof-mounted antenna and associated cabling. (I)

5.13.2 Voice Radio

5.13.2.1 The GSM-R voice radio (E):

- Shall be compliant to the Technical specifications for ETCS and GSM-R and these are published in the Control Command and Signalling (CCS) Technical Specification for Interoperability (TSI). This is currently GSM-R Baseline 1.
- For operational use in GB shall be compliant to '*RIS-0794-CCS Rail Industry Standard for GSM-R Train Voice Radio'*,
- Needs be authorised for use in the UK.

Currently the Siemens Nexus Version 4 is the only fixed installation cab mobile radio authorised for use on the GB railway network. Version 4 contains a new 4G - resistant radio module and is modified to receive (Global Navigation Satellite System) GNSS data (for GPS).

5.13.2.2 If using the Siemens SVR401 the most recent software version available should be employed (D).

Currently this is Version 4. Siemens radios with version 3.6 or below whilst reliable, are increasingly susceptible to public network interference and do not have the improved fault-logging facility. This radio is known as the Nexus.

5.13.2.3 The use of separate 4G Band Pass Filters instead of a modified radio is not recommended (D).

No filters are currently authorised for use on the GB network and if chosen the implementer would need to arrange this. These devices can be more expensive and may be less effective than the new 4G-resistant Radio Modules. They may also require a large space envelope.

5.13.2.4 If an alternative onboard GSM-R system is proposed, the implementer will need to arrange for it to be authorised for use in the UK and provide any additional user training and maintenance tools etc (E).

5.13.2.5 If an alternative onboard GSM-R system is proposed, the implementer shall demonstrate reliability to a minimum level of 50,000 hours MTBF noting that the reliability currently being achieved with GSM-R voice mobile systems already in GB operation is over 300,000 hours MTBF (E).

5.13.3 Cab Equipment

5.13.3.1 The Textual DCP includes Urgent and Railway Emergency Call (REC) push button facilities and a 4-line Text Screen and has been subject to stringent testing. Testing included the display type and legibility in all lighting conditions, as well as form, function, position and tactile characteristics of push buttons and switches (I).

5.13.3.2 The handset, including a speaker, microphone and Press-To-Talk (PTT) push button, sits in a fixed cradle (I).

5.13.3.3 The Textual DCP should be located within reach of the driver whilst driving (D).

5.13.3.4 The handset and cradle should be located within reach of the driver whilst driving (D).

5.13.3.5 The cab loudspeaker should be suitably located to take account of the ambient noise generated when the vehicle is operating at full power and maximum vehicle speed (D).

Instances have been found where under certain circumstances the sound from the loudspeaker is not at its optimum and is difficult to hear.

Although Safety relevant acoustic signals are defined within the Loc & Pas clause 4.2.9.3.4 (6), it is a good idea to ensure the loudspeaker is suitably positioned.

5.13.3.6 All components used by the Driver should be subject to a Human Factors assessment to determine the correct location within the Driving Cab (D).

5.13.3.7 The Siemens DCP should be provided with a REC warning label in accordance with GSM-R Bulletin No.9 (D).

https://cdn.networkrail.co.uk/wp-content/uploads/2016/12/GSM-R-Bulletin-09-DCP-REC-Button-Warning-Label-Application-Version-1-new-format.pdf

5.13.3.8 The operator of the vehicles should be consulted with regard to which (if any) of the DCP REC accessory options they wish to be implemented (D).

Options are available to reduce the risk of inadvertent operation of the DCP REC Push button. These are specially designed components supplied as accessories for DCP.

Option 1 is a raised shroud which fits around the existing inset push button, this requires a single action to operate the REC button. Option 2 is a spring-loaded clear Flap, which fits around and over the existing inset push button, this requires a double action to operate the REC push button.

5.13.4 Roof-mounted Antenna

5.13.4.1 A dual GSM-R / GNSS Antenna is now the preferred standard (D).

Antennas are available with the same mounting footprint as the current single GSM-R antenna and allows enhancement of fault logging by providing accurate time and location.

5.13.4.2 The Antenna profile should be resistant to becoming trapped or damaged from overhanging foliage or other gauge encroachments when the vehicle is operating in either direction (D).

Antennae with the 'shark's fin' type cover have been damaged in service by obstructions becoming trapped while the vehicle was operating in the reverse direction.

5.13.4.3 To limit the proliferation of antennae on a train's roof and reduce the risk of more expensive retrofitting activities a combined antenna should be considered (D).

Currently a combined GSM-R / GNSS antenna is fitted and in the future, a Long-Term Evolution (LTE) antenna would be fitted to each driving vehicle. An optional Long Term Evolution (LTE) antenna that facilitates faster data transfer is available for use with the other features provided in the Siemens cab radio outlined below. Please note that broadband antennas which serve LTE and GSM-R usually have a reduced antenna gain with may reduce the signal quality. Network Rail has instructed Siemens to develop a single combined GSM-R / GNSS / LTE antenna. This antenna is being specifically developed for use with the Siemens V4.0 GSM-R cab mobile, which contains both GNSS and LTE modules. If an alternative antenna solution is to be implemented, then this would require both Siemens and Notified Body (NoBo) approvals to be completed.

5.13.5 Additional Opportunities

5.13.5.1 A local battery back-up for the GSM-R voice radio to maintain communication when the main power is lost shall be provided (E).

So drivers have continuous access to a railway emergency call facility and with their control.

RAIB report *05/2016 Godmersham* recommendation 5 asks that drivers have continuous access to a railway emergency call facility in the event of an accident that affects the on-board train radio.

5.13.5.2 The version 4 software development offered the opportunity to make some additional modifications to the cab radio as well as improving 4G resistance (I).

These include:

- Aerial sockets for GNSS / GPS and LTE Antennae,
- Additional processor with extra memory which improves the cab radio processing power, allowing for new applications,
- A Siemens 'Nexus Voice' circuit card.

5.13.5.3 Hardware separation between existing cab radio functionality and the new Nexus Wi-Fi module has been provided to improve cab radio cyber security (I).

5.13.5.4 Additional applications available on the cab radio will require the provision of the additional LTE Antenna described above and include (I):

- Nexus Connect Wi-Fi hub solution, which, in conjunction with the Ethernet Bridge, provides a wireless backbone over PA/data cables, to enable data transfer throughout the train,
- Nexus RCM system, which is a Remote Condition Monitoring (RCM) feature, enabling users to monitor track assets using in-service trains. The Version 4 cab radio contains Accelerometers to measure lateral and vertical train movement and can store live RCM data and report track defects back to the maintenance department,
- Nexus CRMT module, which allows users to remotely manage cab radios from a ground system. It allows software updates, pre-defined text messages, phone book updates, temporary speed restriction and inventory information to be accessed and verified/updated on the cab radio without the need to visit the train, thereby reducing maintenance costs,
- Nexus Lodestar Driver Advisory System which provides drivers with speed advice, providing information needed to help improve journey energy performance, whilst maintaining adherence to the timetable by travelling at the optimum speed.

For information on the 'Nexus' opportunities see the following:

https://press.siemens.com/global/en/pressrelease/siemens-mobility-upgrade-more-11000-communication-radios-network-rail

and

https://www.mobility.siemens.com/global/en/portfolio/rail/automation/signaling-on-board-and-crossing-products/rail-communications/cab-radios-and-on-board-communication.html

5.13.6 Further Information

5.13.6.1 For further information on the existing system, visit the Digital Railway website (I):

5.13.6.2 Network Rail have provided the following email address for GSM-R related enquiries, they can also provide bulletins and other information (I):

NRTenquiries@networkrail.co.uk

5.14 Global System for Mobile Communications – Railway (GSM-R) - Data

5.14.1 GSM-R is used in two ways: for voice communications and for data transmission for ETCS. This section is for data (I).

5.14.2 The European Union Agency for Railways and the European Commission strongly supports that any new Cab Radio or ETCS Data Only Radio (EDOR) shall be compliant with the *'UIC CODE 951 EIRENE System Requirements Specification version 16.0.0'*, which can be found here (E):

https://uic.org/IMG/pdf/srs-16.0.0_uic_951-0.0.2_final.pdf

General information about GSM-R can be found on the UIC GSM-R web page here:

https://uic.org/rail-system/gsm-r/

5.15 Future Railway Mobile Communications System (FRMCS)

5.15.1 Space provision should be made specifically to fit a FRMCS antenna to each driver's cab along with associated cable route space and equipment. This shall be separate from the GSM-R cab mobile antenna (D).

This will reduce the risk of more expensive retrofitting activities.

Care needs to be taken with antenna spacing as clearance is required between each one.

Note 1: The 2019 version of the CCS TSI expects national plans to include arrangements for migrating to FRMCS from the 2022 version of the TSI. Although, if FRMCS is available before then, it can be introduced earlier.

Note 2: The current strategic planning from UIC and ERA envisages FRMCS from 2023 (for early adopter) with GSM-R being supported until at least 2030. There will need to be a migration to FRMCS whereby both FRMCS and GSM-R will co-exist for a period of time until all trains are fitted and the Infrastructure updated.

Note 3: There are a number of workstreams working on developing the standards for FRMCS, the radio technology choice, the antenna system and the legal framework amongst others.

Appendix A – Items Intentionally Excluded from KTR

Items listed below are those that the group developing this document have discussed and have taken the positive decision (at this stage) not to include any guidance in the KTR. Such decisions have been taken for various reasons that typically include an inability of the group participants to agree on specific requirements, or that it is very difficult to specify any meaningful requirements.

This list is provided for completeness to inform the industry that the issue has been considered and has not been omitted from the KTR development process.

Note: This list will be reviewed continuously as part of the ongoing review and updating process for this document.

Items purposely excluded:

Item	Reason
• Floor level emergency lighting	Preference is for passengers to remain inside vehicle
• Additional tactile / braille signage on labels and controls	Awaiting research
• UIC/UNIFE TecRecs	Status unclear
• Wheelchair restraints	Not liked by users and potentially harmful in the event of an accident
• Driverless trains	Too advanced at present, though in Rail Technical Strategy (RTS)
• Standard measure of rolling stock energy efficiency	Awaiting standards and research
• Maintenance requirements and downtimes	Too specific
• Heated 750 V DC shoegear	Awaiting updates from manufacturers
• SMART technology for coupling	See RTS and Shift2Rail
• Resistance to terrorist attacks	Awaiting government guidance
• Cab 'not-to-couple' sign	Operations issue
• Sleeper train design	Awaiting information

Appendix B – List of Research and Innovation sources and Useful Information

Listed below are useful links to sources of information and research and innovation programmes currently taking place in Britain and continental Europe. Also sources of information for research and incidents.

List of Research and Innovation Sources

Horizon 2020
https://ec.europa.eu/programmes/horizon2020/

- Shift2Rail
  http://www.shift2rail.org/
- Roll2Rail
  http://www.roll2rail.eu/
- IT2Rail
  http://www.it2rail.eu/
- In2Rail
  http://www.in2rail.eu/

Digital Railway
http://digitalrailway.co.uk/

UK Rail Research and Innovation Network (UKRRIN)
https://www.ukrrin.org.uk

Rail Supply Group
http://www.railsupplygroup.org/

Supply Chain Forum
https://www.railsupplygroup.org/wp-content/uploads/2017/09/RSG-Brochure-Jan-2016.pdf

Rail Technical Strategy
RTS 2020
https://www.rssb.co.uk/Research-and-Technology/Future-of-the-railway
ReFocus 20 point plan
https://www.raildeliverygroup.com/files/Publications/New-Folder/2019-01_20_Point_Plan_Issue14.pdf

UK National Cyber Security Centre
https://www.ncsc.gov.uk

Other sources of information

NIR online*
https://www.nir-online.net/NIROnline

SPARK*
https://www.sparkrail.org

RSSB
http://www.rssb.co.uk

Network Rail
https://www.networkrail.co.uk/who-we-are/publications-resources/

RAIB
https://www.gov.uk/government/organisations/rail-accident-investigation-branch

Rail Delivery Group
https://www.raildeliverygroup.com/about-us/publications.html

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

(* Requires a login)

Appendix C - Toilet Design Requirements

C.0 Introduction

C.0.1 The detailed recommendations listed below have been derived from a range of stakeholder feedback provided by train operators, owners and manufacturers, together with Transport Focus. (I).

C.0.2 The list is not intended to be exhaustive and those specifying toilets for new or refurbished trains should take into account this Appendix and the following documents (D):

- EuroSpec 'Specification for toilets of railway vehicles', available here:

  https://eurospec.eu/wp-content/uploads/2020/02/EuroSpec-Toilets-for-railway-vehicles-v3.0.pdf.

To make inroads into improving toilet design, European Operators have jointly developed some common requirements for on-train toilets that should encourage suppliers to improve their products across Europe. These requirements have been captured in this EuroSpec document. The Rail Delivery Group (RDG) is a partner in the EuroSpec consortium. Copies of other EuroSpecs can be obtained free of charge via the EuroSpec website at www.eurospec.eu.

- *EN 16362, Railway applications — Ground based services — Water restocking equipment,*
- *EN 16922, Railway applications – Ground based services – Vehicle waste water discharge equipment,*
- *EN 16585-1, Railway applications — Design for PRM Use - Equipment and Components On Board Rolling Stock — Part 1: Toilets,*
- *EN 16584-1, Railway applications — Design for PRM use - General requirements: — Part 1: Contrast,*
- *EN 16584-2, Railway applications — Design for PRM use - General requirements: — Part 2: Information.*

In addition CEN TC 256 WG 43 are working on the following standard:

- *WI00256955 Railway applications — Passenger rolling stock hygiene equipment.*

(Note: The WI is a working code for standard writing, it will not receive a number until it is complete).

Information is available from BSI.

- *Persons with Reduced Mobility TSI. Commission Regulation (EU) No. 1300/2014 (PRM TSI).*

Available to download from here: https://www.era.europa.eu/activities/technical-specifications-interoperability_en

C.0.3 **Note**: Where there is any conflict between items listed below and requirements contained within mandatory Standards or legislation, then the law takes precedence (I).

C.1 Toilet Controls

C.1.1 The design of all toilet controls and their pictograms, should be intuitive, simple to use and consistent across different types of train (D).

Having a flush push button or a dryer outlet away from a sign or in a less obvious place is confusing and annoying to passengers. Sometimes pictograms are not obvious, so a written description can often help.

C.1.2 The provision of a tactile map on the exterior wall of the toilet, indicating the location of the toilet bowl, washbasin, door lock etc, to blind or partially sighted passengers should be considered (D).

Helps the person understand the location of equipment inside the toilet

C.1.3 Toilet flush controls shall be visible at all times, including when the toilet seat is raised (E).

Even with signage the push button behind a toilet lid is not obvious.

C.1.4 Soap / Water / Hand Dryer

C.1.4.1 The layout of Soap / Water / Hand Dryer shall be carefully considered taking account of user-feedback (E).

Transport Focus has advised that research amongst a group of persons of reduced mobility, who may still be seated on the toilet, has indicated that the best layout is soap furthest away, water central and dryer nearest to the person.

C.1.4.2 Automatic activation for Soap / Water / Hand Dryer, using sensors, should be provided (D).

This improves hygiene in the toilets.

C.1.4.3 Soap / Water / Hand Dryer operation shall not be linked to a sequence (E).

Sometimes soap is not required and also passengers like to check there is water before applying soap.

C.1.4.4 Activation sensor locations and dispensing and outlet points for Soap / Water / Hand Dryer shall be obvious and clearly identified (E).

Many dispense and outlet points are in non-intuitive positions leading to passenger frustration.

The sensor location could be indicated by using a light beam.

C.2 Powered Toilet Doors and Door Controls

C.2.1 Powered toilet doors shall not be used on non-Universally Accessible Toilets (E).

Powered doors are viewed as a significant source of toilet unreliability and it is therefore recommended that these only be used where required to meet legislation, such as the PRM TSI.

C.2.2 Where powered toilet doors are used:

C.2.2.1 Powered toilet doors shall be designed to auto-reset after forced manual operation (E).

This is so they don't lock themselves out of use.

C.2.2.2 Powered toilet door controls shall be located as close as practicable to the door (E).

This is where users intuitively expect to find them.

C.2.2.3 Door locking should be activated by a lever (although it may operate an electrical switch) (D).

This action is associated by users with operating a door lock giving more confidence that the door has been locked.

C.2.2.4 Pressing the 'Door Open' push button from the inside shall automatically unlock the door (this requires the lock lever to automatically move back to the unlocked position) (D).

This saves having complicated instructions next to the push buttons.

C.2.2.5 Controls outside the toilet shall have 'Open' and 'Close' push buttons, so that the door can be readily closed from outside (E).

This means the door does not have to remain open and should someone prefer not to have the door locked a carer or parent can remain outside having closed the door.

C.2.2.6 Operation of the door lock should be accompanied by an appropriate sound and an audible announcement and visual indication 'Toilet door is locked', meeting the needs of passengers with visual or auditory impairment (D).

An audible 'clunk' reassures users that the door is locked.

C.2.2.7 'Door Close' operation from inside shall take precedence over 'Door Open' activation from outside, although a secure override should be provided for staff use (D).

Toilets should be the last place of refuge for a person feeling threatened.

C.2.2.8 Since there is no standard toilet design, passengers have commented that they would welcome a common method of locking the powered toilet door (I).

Note: The renderings in Figure C.2.2.8, are based on examples from '*EN16584-2 Railway applications – Design for PRM use General requirements – Part 2: Information';* Annex O and suggest an arrangement that should be considered for all new designs.

Figure C.2.2.8 – Suggested methods for common locking of powered toilet doors

C.3 Toilet Indicators Outside of the Toilet

C.3.1 An indicator on the exterior of the toilet cubicle shall be provided, which can be readily understood by passengers, to show whether a toilet is engaged or has been locked out-of-use (two different indications required) (E).

This saves persons waiting outside an out-of-use toilet thinking it is engaged.

C.3.2 An indicator on the exterior of the toilet cubicle shall be provided, for staff information only, to advise when a toilet has remained locked for more than, say, 20 minutes (B).

To draw the attention of staff to a collapsed person or potential fare dodger.

C.3.3 Features of the design specified in C.3.2 should include (D):

- An external indicator on the outside of the cubicle to be provided adjacent to each door, with an option to provide a notification to the driver – primarily for use when trains are operating with only a driver as on-train staff, i.e. DCO,
- A reset of the timer if the toilet is vacated and reoccupied prior to being checked by on-train staff,
- A reset of the timer when controls such as flush or washbasin spray are activated.

C.3.4 Indications of low consumables in Universally Accessible Toilets should be flagged to on-train staff and / or Control so that arrangements can be made to move the person of reduced mobility or restock (D).

There have been instances where persons in wheel chairs have not been able to use the Universally Accessible Toilet as it is out-of-use, leaving them in embarrassing situations.

C.4 Tank Capacities and Range

C.4.0 Toilets tanks should be large enough to cope with high, regular demand (D).

C.4.1 The provision of toilets should be based on the following minimum ratio of seats to toilets (D):

- For intercity or inter-urban services, 85 seats per toilet,
- For short distance / commuter services, 125 seats per toilet.

Given the critical importance of toilets to passenger comfort, particularly on longer journeys, toilet provision, in terms of the ratio of seats to toilets, requires careful consideration.

C.4.2 A CET discharge periodicity of 2-3 days is believed to be typical and is usually aligned with other light maintenance tasks. However, a comparison between maintenance cycles and tank discharge frequency, requires separate consideration. For example, light maintenance cycles may be significantly different for diesel trains than electric trains, which require servicing significantly less frequently (I).

C.4.3 Where unplanned events prevent trains fitted with CETs from returning to a depot to discharge, consideration should be given to the adoption of mobile tanking equipment where the supporting infrastructure allows (I).

C.4.4 To extend CET discharge periodicities the fitting of bio-reactor waste technology should be considered (D).

The design of train toilet systems has changed little since CETs were installed on GB rolling stock. Bio-reactor systems have been developed that treat waste before discharging grey water to the track. Such systems offer significant benefits in terms of extending toilet servicing periodicities up to 90 days. The case for introducing this technology needs to be considered when procuring new toilet systems or trains.

Note 1: Clause 4.2.5.1 of the Loc & Pas TSI No 1302/2014, permits 'treated water' to be released to the track. Suppliers of toilet systems that discharge grey water to track should apply the requirements of the European Directive for bathing water quality 2006/7/EC.

Note 2: With retrofit, a check of the vacuum toilet already installed needs to be undertaken for compatibility with a bio-reactor waste tank.

Note 3: The definition of grey water includes toilet wash basin waste and kitchen sink waste.

Some background to Bio-reactor toilets

1. RSSB hold in SPARK two relevant documents:

   - *T692 Water Recycling for Train Toilets* (2007),

   - *S242 Next Generation Closed Loop Train Toilets Technology* (2016).

   S242 provides a list of various technologies and also summarises by updates on the technologies that came out of projects in T692. It should be noted that S242 suggested that AKW A+V Protec were no longer operating, but they are active and the supplier of the two current UK bio-reactor projects: a trial on Scotrail Class 334, and the fit at build on SWR Class 701 trains.

2. A Bio-reactor system should be developed with the selected supplier against a clear duty cycle specification in respect of the daily and hourly usage rates, flush volumes, and servicing frequencies required.

3.	The Bio-reactor module should be thought of as the “back office” and ought to be capable of integration with most toilet OEM modules simply taking the toilet effluent from them and processing and storing it in replacement of the conventional system where it passes to a CET tank.
3.1.	The critical factors in capacity are:
3.1.1.	The main tank sizes – how much liquid in processing and how much solid waste can the Bio-reactor module hold – this drives the long term servicing interval.
3.1.2.	The number of processing tanks, their size and cycle time – how many litres can each tank process in how long and how many processing tanks are there – this drives the short term toilet usage rate that the system can support.
3.1.3.	How “over use” is managed – does the module isolate (not preferred) or can it operate “over-capacity” with the liquid level rising from the liquid tank into the solid tank until treatment and water drop catches up?
3.1.4.	Processing tank(s) capacity, process timings, and volume rate to drop that results.
3.1.5.	The “grey” water drop arrangement – it is slightly acidic and there may be limitations on dropping it.
3.1.5.1.	Water Drop arrangements and the distribution over track and vehicle underside.
3.1.5.2.	Restrictions on dropping – train speed, geolocation restrictions.
3.2.	Servicing is at extended intervals by comparison with conventional CET but the servicing regime requires specialist equipment with functionality and the use of acidic reagents not normally present in CET plants.

C.4.5 All multiple units shall have a minimum of two toilets provided (B).

To avoid major problems in the event of one toilet becoming defective.

C.4.6 The capacity of the fresh water tank should be maximised (D).

At least two days’ worth will reduce the likelihood of running out of water and a toilet being locked out-of-use.

Some recommendations are given in ‘*EN 16922 Railway applications – Ground based services – Vehicle waste water discharge equipment*’.

C.4.7 The capacity of the waste tank should be double that of the fresh water tank (unless a bio-reactor waste technology is fitted) (D).

Reduces the likelihood of running out of water and a toilet being locked out of use.

However, this ratio may need to be varied depending on the nature of the service to be operated. Some recommendations are given in '*EN 16922 Railway applications – Ground based services – Vehicle waste water discharge equipment*'.

C.4.8 A separate toilet cubicle with only a waterless urinal should be provided. Hand cleaning could be using hand sanitisers. (D).

Where difficulties are experienced in providing sufficient tank range for the planned duty cycle, this may reduce the overall demand for water.

C.4.9 When water tank levels are low, priority should be given to hand washing facilities over toilet flushing (D).

C.4.10 The toilet system should continue to evacuate the bowl even when no water is available for flushing. Under these circumstances toilet cubicles shall remain available for use and the door should not automatically be locked (D).

There have been instances of trains stranded for extended periods of times, where out of service toilet facilities have resulted in hygiene issues and passenger self-evacuation from the train.

C.5 Ease of Manufacture / Maintainability

C.5.1 Line-replaceable components within the toilet shall be capable of replacement in less than 30 minutes (E).

Availability of toilets is critical and the system design should ensure that components are easy to change.

C.5.2 Non-line-replaceable components, such as hoses, should ideally be specified to remain serviceable for the expected life of the rolling stock or, if this is not practicable, at least up to a Half Life Overhaul (D).

C.5.3 Suitable facilities should be designed and provided to enable Train Managers to unblock toilets in service (D).

Some toilet systems have the functionality for staff to attempt to remove a blockage, i.e. a reverse or service flush.

C.5.4 Manual facilities for the draining of water tanks, in addition to automatic frost draining shall be provided (E).

Should a train have no power or batteries are flat, a means to drain manually is required.

C.5.5 CET tank installations shall be designed to be readily removable without contravening manual handling guidance (E).

Simple off-the-shelf equipment is preferred.

C.5.6 Any specialist equipment to facilitate removal of CET tank installations shall be provided (E).

C.6 Design of Toilet Water Filling and Waste Tank Emptying

C.6.1 The toilet water filling and waste emptying design shall comply with *'EN 16922: Railway applications – Ground based services – Vehicle waste water discharge equipment'* and *'EN 16362, Railway applications — Ground based services — Water restocking equipment*' (E).

C.6.2 To prevent the over-pressurising of water tanks, the cross-sectional area of the overflow shall be at least double that of the inlet (E).

C.6.3 The toilet system shall be designed to prevent leaks from pipework and ensure that leakage does not occur in inaccessible locations or above electrical equipment (E).

C.6.4 The routing of pipework in toilet systems shall ensure that (E):

- All joints are easily accessible,
- Any leakage does not affect electrical equipment,
- Accumulation of water does not cause structural corrosion,
- Any leakage is appropriately managed.

C.6.5 It shall be possible to drain the water systems completely (E).

To prevent freezing and stagnant water. Pipe runs should be short with few bends and with a continuous fall towards the outlet.

C.7 Main Customer Amenities

C.7.1 <u>Toilet Tissue Dispensing</u>

C.7.1.1 Toilet tissue dispensers shall be capable of easily dispensing tissue without shredding or damaging it, even when the dispenser has been filled to its maximum capacity. (E).

C.7.1.2 It shall not be possible to over-fill the toilet tissue dispenser (E).

C.7.1.3 Where toilet tissue is leaved and loaded as a stack, the dispenser shall clearly indicate the correct orientation (E).

C.7.1.4 The toilet tissue dispenser shall be designed to accept whole multiples of a standard refill pack (E).

If the dispenser takes whole multiples of common on the market sizes of refill packs it is less likely to become jammed.

C.7.2 Hand Washing

C.7.2.1 Soap dispensers shall be designed not to leak or clog (E)

C.7.2.2 Soap dispenser lids that require removal for filling shall be retained to the container (E).

C.7.2.3 Where access is provided to the soap dispenser via a panel / door, it shall not be possible for this to be closed unless the soap dispenser is closed correctly (E).

C.7.2.4 Any drips from the soap dispenser shall fall into the washbasin; not onto the vanity unit top or floor (E).

C.7.3 Hand Drying

C.7.3.1 High velocity air dryers should be provided and located so as not to cause a slipping hazard (D).

Using less energy and reflecting the new norm for public toilets, but blown water should be prevented from going on to the floors.

C.7.3.2 The hand dryer shall take its supply air feed from inside the toilet cubicle in a position where it is not susceptible to malicious blockage (E).

This keeps the air pressure inside the toilet cabin neutral and prevents transient smells being expelled into the passenger environment.

C.7.4 Toilet Bowl

C.7.4.1 Toilet seats and lids shall remain stable in the raised position for the entire range of train operating conditions (E).

To prevent accidents when they fall due to train movements.

Over centre hinges or magnets are a preferred solution.

C.7.4.2 Robust metal hinges shall be used for the toilet seat and lid (E).

C.7.4.3 Slow-close hinges for toilet seats and lids should be provided (D).

In the event of a seat or lid be dropped will not cause damage or noise.

C.7.4.4 Preference should be given to white sanitary ware (D)

This looks more 'domestic' and less industrial and it is easier to see when surfaces are clean.

C.8 Other Customer Amenities

C.8.1 The location of the deployed nappy changing table should prevent access to the toilet bowl and encourage the disposal of used products in the waste bin (D).

Experience shows that nappies are a major contributor to blockages of toilet bowls.

C.8.2 Where a nappy changing table is provided a hook to hold nappy bags should be available (D).

C.8.3 A dispenser for sanitary waste bags should be provided in all toilets (D).

C.8.4 A waste bin adjacent to the toilet bowl shall be provided for sanitary items and nappies in all toilet cubicles (E).

C.8.5 Hooks for coats, bags and walking aids shall be provided, sufficient to cope with the size and weight of bags likely to be taken into a toilet and configured such that they prevent items from coming into contact with the floor or other horizontal surfaces (e.g. top of vanity unit) (D).

Passengers are encouraged to not leave possessions unattended and therefore provision should be made for them to be taken into toilet cubicles.

C.8.6 In a universally accessible toilet cubicle, hooks for coats and bags should be placed at heights to accommodate a range of users (D).

C.8.7 A shelf should be provided (D).

Somewhere for handbags or other items to be placed.

Note that persons with medical conditions, for example stoma bags, would find a hook or shelf useful.

C.8.8 Consideration should be given to measures to make toilets feel less claustrophobic; for example, through provision of a suitably obscured window (D).

C.9 Resistance to Misuse / Vandalism

C.9.1 Toilet Blockage

C.9.1.1 The type test specified for the toilet system shall include common blockage items (E).

Industry experience is that many different items are placed into toilet bowls, including nappies, sanitary waste, drinks can, coins, wet wipes, syringes and needles. Good practice is to ensure that the outlet of the toilet bowl is the smallest orifice in the whole toilet waste system.

C.9.1.2 Signage and an audible warning of typical items not to be placed into the toilet bowl should be provided, however, it should be brief and to the point (D).

C.9.1.3 Access points shall be provided at potential system blockage locations (E).

C.9.2 Vanity Units

C.9.2.1 Vanity units shall be designed to take account of train operation when a train is standing on maximum canted track and include a lip around the vanity unit / wash bowl to retain water (E).

Water can get splashed and drip onto passengers and can cause a slipping hazard if it falls to the floor.

C.9.2.2 Joint lines and use of sealant on vanity units should be minimised (D).

Joints can leak, and sealant become unsightly and discoloured over time.

C.9.2.3 An integrated splash back and hand basin moulding should be provided (D).

This reduces the likelihood of leaks and dirt traps.

C.9.2.4 An overflow shall be provided in the hand basin (E).

To ensure that should the drain become blocked, water will not fall to the floor but be drained.

C.9.2.5 A sensor to cut off the water supply in the event that the overflow becomes blocked should be provided (D).

To ensure that should it become blocked, water will not continue to flow and fall to the floor.

C.9.2.6 The hand basin tap shall automatically shut off after a pre-determined period of operation (E).

This will conserve water and reduce the risk of flooding.

C.9.3 Other Items

C.9.3.1 Access doors for emptying waste bins shall automatically lock when closed, only requiring a key to open (E).

This should ensure that they can be closed should they swing open without a key.

C.9.3.2 Surfaces shall be graffiti-resistant (E).

C.9.3.3 Panels should be flush and adequately secured and the number of seams / edges minimised (D).

C.9.3.4 The design of the toilet cubicle should minimise the opportunity to hide illicit items (D).

This prevents hypodermic needles, drugs and weapons being concealed for example in light fittings and bins, with the associated risk of injury.

C.10 Health and Hygiene

C.10.1 Odour Prevention

C.10.1.1 Extraction systems shall create a negative pressure in the toilet compared to the remainder of the vehicle interior (E).

Thus, helping to prevent the release of unpleasant odours.

C.10.1.2 Scent dispensing facilities should be provided (D).

This helps to mask odours via either scent dispensers or scent gel in the toilet bowl.

C.10.2 Legionella

C.10.2.1 Water taps on washbasins shall not atomize the water and fresh water storage tanks shall be protected from heat sources such as vehicle exhausts or solar gain, so far as is practicable (E).

To reduce the likelihood of legionella.

Note 1: RSSB Project '*T985: Identification and analysis of risks posed by legionella bacteria in on-train non-potable water systems*' provides guidance on additional good practice - details of this project can be found at:

http://www.rssb.co.uk/library/research-development-and-innovation/research-brief-t985.pdf

Note 2: RDG when ATOC has also produced a Guidance Note '*ATOC/GN013: ATOC Guidance Note - Control of Risk Posed by the Presence of Legionella Bacteria in On-train Non-potable Water Systems',* copies of which can be found at:

http://www.rssb.co.uk/rgs/oodocs/ATOCGN013%20Iss%202.pdf

C.10.2.2 Water systems shall facilitate ease of chlorination and removal of lime scale (E).

To reduce bacteria and prevent blocking.

C.10.3 Ease of Cleaning

C.10.3.1 The toilet cubicle floor shall be a single moulded floor-pan (E).

This makes cleaning easier and reduces the likelihood of water leaking into the structure.

C.10.3.2 All cubicle interior surfaces shall be non-absorbent, stain-resistant and a high gloss finish (E).

C.10.3.3 Trace heating of the toilet cubicle floor to reduce the risk of wet floors should be provided (D).

This dries any water and leakage from toilets that can cause slip hazards and get trodden through the vehicle.

C.10.4 Other

C.10.4.1 A sanitising hand gel dispenser should be provided in addition to soap and water (D).

This helps reduce the spread of germs and can be used in the absence of wash basin water or for cleaning the toilet seat.

C.10.4.2 The emission of noises from the toilet cubicle should be minimised (D).

The operation of the toilet flushing system and any announcements within can be a nuisance to passengers seated close-by.

Appendix D – Software Security

The following gives guidance for the design of software and its future updating and amending.

D.1 Introduction

This is an emerging area which the industry needs to address. It is a complex area and general information is given below, but it is recommended that specialist advice is sought.

CENELEC System and Safety Standards should be used throughout this appendix and the overarching *BS EN 61508 'Functional safety of electrical/electronic/ programmable electronic safety-related systems'* suite of standards for all Safety Systems recommends Security Risk are identified throughout the asset lifecycle using the '*BS EN IEC 62443 'Security for industrial automation and control systems'* suite of standards.

Note 1: *BS EN 50128 'Railway applications. Communication, signalling and processing systems. Software for railway control and protection systems'* provides a specific interpretation of *BS EN 61508* for railway applications.

Note 2: CENELEC are currently drafting a European Standard on cybersecurity for railways '*prEN 50701 Railway Applications – Cybersecurity*'.

Note 3: Shift2Rail are doing work on software and cybersecurity.

D.2 System Architecture

D.2.1 Security Requirements

Poorly designed network architectures that lack a 'defence-in-depth' approach to security may be vulnerable to cyber exploitation. Secure network architectures contain a combination of network segmentation, communication traffic control, and communication traffic monitoring: segmentation is used to separate functional sets of network hosts into groupings; traffic control is currently implemented with routers and firewalls to prevent unauthorised access between different subnets; and traffic monitoring validates what traffic is allowed and alerts when unauthorised traffic is detected.

Security can be enhanced by partitioning networks into multiple segments and placing technical security controls (currently e.g. firewalls, unidirectional communication devices, or virtual private network [VPN] concentrators) between the network segments. Hardware, software, and firmware that restrict communications are important tools in establishing an appropriate cybersecurity defensive architecture.

The network architecture is how a network is designed and segmented into logical, smaller functional subnets (i.e. network security zones) for the purpose of communication.

The following shall be provided by a supplier:

- Recommendations as to the design and configuration of network security zones within the procured product.
- Information on all communications (e.g. protocols) required between network security zones, whether inbound or outbound, and identification of each network component of the procured product initiating communication.
- A method to restrict communication traffic between different network security zones and documentation on all methods and equipment used to restrict communication traffic.
- Verification that disconnection points are established between the network security zones and methods to isolate the zones to continue limited operations.
- A means whereby network traffic may be monitored, filtered, and / or alarmed (e.g. alarms for unexpected traffic through network security zones) and filtering and monitoring rules.
- Documentation on all firewalls and rule-sets supplied for normal and emergency operations. If the purchaser has the responsibility of procuring their own firewalls, appropriate firewall rule sets and rule set guidance for normal and emergency operations. The basis of the firewall rule sets for inbound and outbound traffic should be 'deny all', with exceptions explicitly identified.
- The purchaser with access, including administrative rights as and when required, to network components of the procured product, including all firewalls.
- Documentation on all remote access entry pathways and ensure that they can be enabled or disabled by the purchaser as needed.

D.2.2 Communication Traffic Monitoring

Recording specific system activity in the form of logging generates an audit trail. Failure to perform logging against a consistent time source makes it difficult to monitor activity, perform diagnostics and identify potential cyberattacks in time to take protective actions or carry out forensic activities in the event of a successful cyberattack. Without timely access to information with consistent time-stamps on system activity, post-event investigations may not yield conclusive results and the risk of similar events occurring in the future would remain high.

The following shall be provided by a supplier:

- Standard time synchronisation in the procured product (e.g. Global Positioning System [GPS], Network Time Protocol [NTP] and IEEE 1508-2008). If the supplier is not providing a standard time synchronisation, then they shall provide an alternative authoritative time source and configure the product to synchronise to that time source instead.

- Logging capabilities and / or the ability to support the purchaser's existing logging system. Logging capabilities provided shall be configurable by the purchaser and support the purchaser's security auditing requirements. As a minimum, the following time-stamped events shall be captured:
    - Information requests and server responses,
    - Successful and unsuccessful authentication and access attempts,
    - Account changes,
    - Use of privileged accounts,
    - Application start-up and shutdown,
    - Application failures,
    - Major application configuration changes.

- An approach for collecting and storing (e.g. transfer or log forwarding) security log files. Recommendations for log management and Security Information and Event Management (SIEM) integration methods (e.g. syslog); mirroring log files to a secure secondary location should also be considered.

- Detail of all log management capabilities that the procured product is capable of generating and the format of those logs and should identify which logs are enabled.

D.2.3 End Point Device Security

End point devices (e.g. sensors) can be used as access points to other systems that perform command and control functions. Such devices are used to provide system control at the lowest level of a process and are vulnerable to communication interception and modification. Hardware and software (e.g. portable configuration computers) are sometimes needed to program these devices. End point devices and configuration computers need to be secured by physical and cyber means.

End point devices are a part of the entire system and need to be able to communicate with the rest of the system while performing specific control functions. If the communication from the network to the device or from the device to the network is intercepted and modified, the controlled process could be adversely affected. Therefore, it is necessary to verify that both the device itself and the communication to and from the device are secured to achieve integrity of the communication. In addition, modifications to the control function of the device can affect the integrity of the data transmitted and the actions taken by the control system. To avoid this, it is necessary to secure the device from both cyber and physical modifications.

The following shall be provided by the supplier:

- Physical and cyber security features, including but not limited to authentication, encryption, access control, event and communication logging, monitoring, and alarming to protect the device and configuration computer from unauthorised modification or use.

- A clear identification of the physical and cyber security features and the methodology(ies) for maintaining the features, including the methods to change settings from the vendor configured or manufacturer default conditions.

- Verification that the addition of security features does not adversely affect connectivity, latency, bandwidth, response time, and throughput, when connected to existing equipment.

- Detailed assurance that all software components that are not required for the operation and maintenance of the device have been removed or disabled and provision of documentation on what has been removed and / or disabled.

- Within a pre-negotiated period, appropriate software and service updates and / or workarounds to mitigate all vulnerabilities identified with the product (at that time or later) and to maintain the established level of system security.

- Clear and written verification documentation that the safety system is certified after incorporating the security devices.

D.3 Secure Development Practices

Secure product development practices are a set of processes integrated into the System Development Life Cycle (SDLC) that reduce the security risks of a developed product. These practices help to develop more robust hardware, software, and firmware with fewer weaknesses and vulnerabilities, as well as to identify and remediate weaknesses and vulnerabilities before deployment. Secure development practices ensure that security is integrated into all phases of the SDLC and should be considered a key component of systems development.

The following shall be provided by the supplier:

- Summary documentation of its secure product development life cycle including the standards, practices (including continuous improvement), and development environment (including the use of secure coding practices) used to create or modify the provided system hardware, software, and firmware. Where applicable, the provision of documentation that sets out how the most critical application security weaknesses (including Open Web Application Security Project (OWASP) Top 10 and / or SANS Institute Top 25 Most Dangerous Software Errors) are addressed in the SDLC.

- A Quality Assurance program and evidence that the software and firmware of the procured product have undergone Quality Control testing to identify and correct potential cybersecurity weaknesses and vulnerabilities. This testing should include fuzz testing, static testing, dynamic testing, and penetration testing. Positive and appropriate negative tests to verify that the procured product operates in accordance with its requirements and without extra functionality, as well as monitor for unexpected or undesirable behaviour during such tests should be used. This testing may be done by the supplier or an independent entity. Provision of summary documentation of the results of the testing that

includes all unresolved vulnerabilities and recommended mitigation measures for each.

- Summary documentation of its coding reviews, including defect lists and plans to correct identified vulnerabilities.
- A contingency plan for sustaining the security of the procured product in the event that the supplier is no longer willing or able to support the product (e.g. security-related procedures and products placed in escrow).

Note: The purchaser should have the right to request documentation of the implemented cybersecurity program, including recent assessment results and / or conduct periodic [at a pre-negotiated frequency and scope] on-site security assessments at the supplier's facilities. The purchaser should also have the right, at his sole discretion, to conduct such assessments using an appropriate and independent third-party.

D.4 Third-Party Supplied Systems / Software / Modules

It is important that software development procedures utilised by a third-party on behalf of a supplier are as robust as those of the contracted supplier. As such, it is recommended that the following should be provided:

- Summary documentation of any third-party product development life cycle including the standards, practices (including continuous improvement), and development environment (including the use of secure coding practices) used to create or modify third-party provided system hardware, software, and firmware. Where applicable, documentation on how the most critical application security weaknesses (including OWASP Top 10 or SANS Institute Top 25 Most Dangerous Software Errors) are addressed in the third-party's SDLC.

D.5 Documentation and Tracking of Vulnerabilities

When security vulnerabilities are discovered in hardware, software, and firmware, the timely application of corrective actions and / or mitigation steps can reduce the likelihood that adversaries will be able to exploit these vulnerabilities. Some of these vulnerabilities may be publicly disclosed before a supplier can develop remedies; others may be kept from disclosure until remedies are available. Security breaches may also affect the cybersecurity of the procured product. Such breaches may involve a compromise of security involving the supplier's organisation, or any organisation involved in the product's supply chain. Security breaches may result in the loss of sensitive product design information, information on the purchaser's use and configuration of the product, a compromise of access control information for the deployed products (e.g. compromise of access control information that the supplier uses to perform maintenance on a deployed product), or other security-sensitive information. If the purchaser is informed of a security breach in a timely manner, it may be possible to apply mitigating measures to maintain adequate levels of security.

It is therefore recommended that:

i) prior to contract award,
ii) post contract award but prior to product delivery, and
iii) post product delivery, suppliers are required to:

- Provide purchasers with information about product hardware, software and firmware versions and vulnerabilities (identifying which of the vulnerabilities have been publicly disclosed) and any actions they have taken to redress those vulnerabilities,
- Notify purchasers of identified security breaches within their organisations and supply-chains,
- Work with purchasers to identify and mitigate the risk from the exploitation of all such product vulnerabilities,
- Remedy security vulnerabilities in a timely manner.

Note: The information to be provided should include a description of each vulnerability and its potential impact, root cause, and recommended compensating security controls, mitigations, and / or procedural workarounds and corrective actions.

D.6 Security Risk Assessment

The supplier and / or purchaser should undertake a security-informed risk assessment on each system that:

- Identifies threats, vulnerabilities and impact,
- Analyses likelihood and consequences, and
- Ultimately evaluates risks against risk appetite and demonstrates the adequacy of the assessment process and suitability of the techniques employed.

The supplier and / or purchaser should document and implement one or more cybersecurity policies for applicable systems, which will address the risks that have been identified.

D.7 Full Systems Software Identification / Classification & Impact Assessment

Systems and software that require protection from cyber threats, first need to be identified and sufficient information about their condition recorded and maintained to:

- Allow appropriate controls to be deployed,
- Provide a common reference between government agencies and duty holders, and
- Provide a basis for assurance activities.

It is therefore recommended that the following identification activities are undertaken:

- Systems and software are recorded in a structured, indexed, searchable repository.
- The supplier records sufficient information about identified systems to allow effective assessment of system vulnerability. This should include as a minimum:
  - System name / function,
  - Hardware make and model,
  - Operating system(s),
  - Operating system version(s),
  - Major software components,
  - Software version including patch level(s),
  - Systems interfaces,
  - Communication protocols supported.
- Suppliers should document a policy that sets out the principles applied to determine system risk rating.

D.8 All Software

Obsolescence management should be covered by contractual arrangements for the design life of the rolling stock and should include all rolling stock-related hardware, software and firmware.

Note: Good practice in obsolescence management can be found in *'BS EN IEC 62402 Obsolescence Management'*.

Appendix E - Fastener Guidance

The following is guidance prepared for industry by V/V SIC.

E.1 Metric coarse fasteners should be specified to current standards, i.e:

- *BS EN ISO 4014, Hexagon head bolts. Product grades A and B,*
- *BS EN ISO 4017, Fasteners. Hexagon head screws. Product grades A and B,*
- *BS EN ISO 4033, Hexagon high nuts (style 2). Product grades A and B,*
- *BS EN ISO 7042, Prevailing torque type all-metal hexagon high nuts. Property classes 5, 8, 10 and 12,*
- *BS 3692:2014, ISO metric precision hexagon bolts, screws and nuts – Specification,*
- or equivalent internationally recognised standard.

Wherever possible, fasteners such as prevailing torque nuts should be to these standards rather than specifying trade names such as 'Philidas', 'Aerotight', etc.

E.2 If a locking device is to be used, those of proven ability in resisting self-loosening should be specified. Helical spring (split) washers should not be used as they have been shown to be ineffective in preventing self-loosening.

E.3 Fasteners to property class 8.8 is the default strength grade. Higher grades can be used where justified and note taken of internal and environmental hydrogen embrittlement in Property class 12.9 fasteners.

E.4 Galvanised coating of fasteners shall not be used.

E.5 The preferred tightening approach is torque tightening, that is, tightening the fastener to a specified torque value. Other means of tightening may be used where appropriate.

E.6 The design should be such that the joint will not slip or separate under the action of applied forces when the scatter in the bolt preload is taken into account as well as any relaxation effects. Short grip length ratios (the ratio of distance from under the fastener head to the nut or mating thread face to the thread diameter) are prone to loosening due to a preload loss relaxation / embedding effects. Whenever possible the grip length should be greater than twice the bolt diameter to avoid excessive relaxation losses.

E.7 Consideration shall be given that access to the fasteners, ensures that special tools and adapters are not required. Consideration on serviceable parts / assemblies should be assessed by a SAM exercise (Service, Accessibility and Maintenance) so that the fasteners can be removed and re-tightened without special regimes being needed.

E.8 The bearing stress under the nut or bolt head bearing face must be lower than the permissible bearing stress of the joint material. This may necessitate the use of hardened washers or flange headed fasteners.

E.9 Wherever possible the use of a nut and bolt through a clearance hole is preferable to use of a tapped hole. Where a tapped hole is unavoidable, it should be 'through' rather than 'blind' to avoid the risk of dirt build-up / hydraulic lock. The length of thread engagement should be selected taking into account the strength properties of the tapped substrate material to avoid the risk of thread stripping.

E.10 It is preferred to have more than the minimum number of fasteners to provide redundancy in the event of individual fastener failure. This is particularly important for heavy equipment such as engines, transformers, fuel tanks etc. Secondary retention methods may be employed where the above is not practical.

Other Guidance

There is some guidance on bolted joints, secondary restraints and fastener redundancy in *RIS-2780-RST Rail Vehicle Structures*; CEN/TC256/SC2/WG2 is working on an EN for bolted joints in rail vehicles (referred to in *RIS-2780-RST*).

RDG has produced guidance for fasteners on legacy fleets:

'RDGECGN007 Issue 1 GN Use of Fasteners for legacy Fleets - Issue 1' which is available here:

https://catalogues.rssb.co.uk/rgs/oodocs/RDGECGN007%20Iss%201.pdf

Appendix F – Monitoring Infrastructure from the Train

F.1 Document purpose

This appendix summarises Network Rail's requirements for the inclusion of unattended infrastructure monitoring equipment on passenger rolling stock.

It is requested that this document is used as a guide but also as a prompt during the discussions to finalise requirements for specific vehicles / fleets.

F.2 Background

Network Rail operate a fleet of dedicated Infrastructure Monitoring (IM) vehicles to collect data about the condition of its assets. The IM fleet has been extremely successful in collecting the asset data required to mitigate safety risks such as derailments, dewirements and broken rails.

A feasibility study was carried out by Network Rail in 2015 to establish whether the data collected by the IM fleet could instead be collected by in-service (TOC or FOC) vehicles. Although the study concluded that a dedicated measurement capability would be required for the foreseeable future there is undoubtedly an opportunity to make greater use of in-service vehicles to collect data about Network Rail assets. This data, which would supplement the data collected by the IM fleet, and which could be collected with a regularity that could not be achieved by the IM fleet should allow areas where asset condition / performance is deteriorating rapidly to be detected and addressed before network availability is affected.

Network Rail's vision in this area is to safely and efficiently remove, where practicable, service affecting failures through the use of monitoring, reliability engineering, analytics and trusted information systems. Although this appendix only describes monitoring requirements (and more specifically monitoring requirements from in-service vehicles) it is acknowledged that all elements mentioned in the vision statement above need to be delivered in order to achieve the vision.

F.3 Point of Contact

This document has been written by Network Rail's Technical Authority directorate. The primary contact is Kevin Hope, Engineering Expert [Monitoring] - kevin.hope@networkrail.co.uk.

Documents mentioned are available from Network rail, BSI and RSSB.

F.4 Requirements

Note: The following requirements may not need to be applied to all vehicles in a fleet or class. The number to be fitted should be established with Network Rail.

F.4.1 Track

IM 001 Vehicle-track interaction monitoring equipment should be fitted to rolling stock to detect potential driver-reported rough-ride locations (D).

IM 002 Tri-axial axlebox accelerometers (with an appropriate frequency response) should be considered (B).

Ongoing R&D work at Network Rail has demonstrated that estimates of track system stiffness can be derived from the outputs of these transducers, which may be useful in proactively managing potential rough ride locations.

IM 003 Fitment of a Track Geometry measurement system capable of measuring to *NR/SP/TRK/042 Track Geometry Recording* and *NR/L2/TRK/001/mod11 Inspection and Maintenance of Permanent Way, module 11 Track Geometry – Inspections and Minimum Actions,* should be considered (B).

IM 004 An enhanced Track Geometry measurement system capable of measuring full rail profiles (field and gauge side) in plain line and profiles within Switch & Crossings should be considered (B).

F4.2 Electrification & Plant

IM 005 Electric rolling stock fitted with a pantograph(s) that will operate at a speed greater than 100mph should have an overhead line measurement system that complies with *'EN 50317 Railway applications. Current collection systems. Requirements for and validation of measurements of the dynamic interaction between pantograph and overhead contact line'* and *NR/L2/ELP/27325 Train Borne Monitoring of Traction Power Contact Systems'* (D).

IM 006 Electric rolling stock fitted with a pantograph(s) that will operate at 100mph or less should have an overhead line measurement system that complies with *'EN 50317 Railway applications. Current collection systems. Requirements for and validation of measurements of the dynamic interaction between pantograph and overhead contact line'* and *NR/L2/ELP/27325 Train Borne Monitoring of Traction Power Contact Systems'* (B).

IM 007 A pantograph camera at each pantograph position is required with appropriate illumination of the pantograph / OLE to ensure acceptable image quality. The camera specification should be agreed during the vehicle specification phase (E).

Also see section 4.8.3.

IM 008 The ability to accommodate pantograph cameras with different views to the current standard view e.g. angled views or looking directly upwards at a location slightly away from the pantograph / wire contact point should be considered, to determine wire condition and wire wear (B).

IM 009 The ability to easily exchange different types of pantograph cameras e.g. High Definition, thermal, UV corona would be beneficial (B).

The use of higher definition cameras will need larger data storage and perhaps different data cables.

IM 010 If a Track Geometry measurement system is fitted (IM 003) an enhancement should be considered for electric vehicles powered from conductor rails to measure conductor rail profile (and wear) and conductor rail position relative to running rails (B).

IM 011 For electric vehicles powered from conductor rails consideration should be given to the measurement of the interaction between conductor rail and shoegear, e.g. forces, accelerations (B).

F4.3 Video, Imaging and Survey

IM 012 Forward / rearward facing video capability shall be provided, with appropriate illumination to ensure acceptable image quality from the cameras (E).

IM 013 Consideration should be given to the integration of forward / rearward facing cameras with a laser scanner to capture survey data which allows measurements to be made within images (positioned video pixels) (B).

IM 014 Forward / rearward facing thermal imaging cameras should be considered (B).

IM 015 clause from v5.1 now deleted.

IM 016 A conductor rail / insulator imaging system (with suitable illumination) and thermal imaging system should be considered, potentially as an enhancement to the track geometry system (IM 003) (B).

F4.4 Signalling & Telecoms

IM 017 The ability to monitor lineside communication signal strength e.g. GSM-R (voice and data) should be considered (D).

IM 018 Consideration should be given to performance monitoring of signalling assets, e.g. track circuits, balises, TPWS, AWS, axle counters, noting the requirement to monitor some assets in both an occupied and unoccupied state (B).

F4.5 General requirements

F4.5.1 The following general requirements apply to all measurement systems outlined in IM 001 – IM 018. This ensures that the captured data can be utilised for the desired asset management application (I).

IM 019 All data shall be stamped with the following information at point of capture (a detailed specification is available to ensure it is possible to accurately synchronise data from different sources) (E):

- Speed and direction,
- Train information e.g. vehicle number,
- Operating information e.g. train headcode,
- Location information:
  - Recorded data should be associated with a position record derived from and L1 / L2 frequency GNSS receiver / antenna,
  - Data will contain, as a minimum:
    - GPS date and timestamp,
    - Longitude and latitude (ETRS89 co-ordinates, decimal degrees to 7 decimal points),
  - Additionally, the data should provide:
    - GNSS receiver Standard Deviation details of the position record,
    - Details of direction of travel from tachometer polarity source if used.

IM 020 Provision should be made for storage of raw data and on-board processing hardware such that conditions requiring immediate attention can be identified and data volumes requiring transmission from the vehicle are reduced (D).

IM 021 A means of transmitting 'alert data' from train to shore whilst the train is in operation should be provided (D).

IM 022 A means of transmitting full (raw and / or processed) datasets from train to shore when the train is stationary for a prolonged period e.g. terminal station, depot should be provided (D).

IM 023 A means of remotely accessing measurement systems to monitor performance and diagnose / resolve system faults should be provided (D).

IM 024 In order to facilitate greater exploitation of asset data all measurements should be made available in an open source format rather than a Supplier's proprietary format (D).

RSSB research '*T1010: Cross-industry remote condition monitoring programme'* describes this approach and can be found at:

https://www.sparkrail.org/pages/libraryresults.aspx?k=t1010

Follow-on work to develop a proof of concept for this approach to cross-industry data sharing, now known as '*IMP-RCM-01 Cross Industry Remote Condition Monitoring Pilots*' is available here:

https://www.sparkrail.org/Lists/Records/DispForm.aspx?ID=24972

IM 025 All measurement systems shall be specified such that system maintenance activities are aligned to routine vehicle maintenance intervals (D).

IM 026 The ability to accommodate modular measurement systems would be advantageous e.g. systems which can be attached to standard vehicle couplers (D).

IM 027 Data being gathered by sensors to monitor vehicle performance could also be beneficial for the monitoring of infrastructure condition / performance. This is particularly relevant at the wheel / rail interface and pantograph / wire interface. To maximise the potential usefulness of this data it should be stamped with the context information outlined in IM 019 and made available in an open format as required by IM 024 (D).

IM 028 In order to future-proof new rolling stock and allow for the cost-effective retro-fit of monitoring equipment it would be prudent to allow space, an electrical power provision and connections to peripheral supplies as outlined in IM019 such that new equipment could be accommodated. Equipment would most likely be required on and around the bogie, inside the vehicle body and on the vehicle roof (D).

Appendix G - Useful information and research projects

RSSB Tools and Models

A list of useful tools and models can be found on the RSSB website.

TSI Guidance

In addition to the EUAR application guides RSSB has produced some guidance to explain how the requirements are affected by GB practice:

GMGN2615 Guidance on the Locomotives and Passenger Rolling Stock TSI,

GIGN7619 Guidance on the Safety in Railway Tunnels Technical Specification for Interoperability,

GLGN1600 Guidance on the Energy TSI,

GEGN8611 Guidance on the Application of the Control Command and Signalling TSI,

GIGN7608 Guidance on the Infrastructure Technical Specification for Interoperability,

GMGN2460 Guidance on Compliance with Noise and Vibration Legislation in the Railway Environment

Guidance for PRM TSI to be drafted soon. (Currently known as Case for Change – 19-015).

Electrical and Data Control Compatibility between Trains

RSSB have completed a research project *'T1137 Electrical and Data Control Compatibility between Trains'* to look at electrical coupling, both wired and wireless.

Shift2Rail also have a project looking at wireless connections under the scope of IP2 and projects X2Rail-1 and Connecta.

Transposition of EMF (Electromagnetic Field) Directive

To assist with compliance to Directive, *2013/35/EU*, RSSB has produced a guidance note *'GLGN1620: Guidance on the Application of the Control of Electromagnetic Fields at Work Regulations'*.

Cycle Tool Kit

RDG has produced a 'Cycle tool kit' with a chapter 'Cycle Carriage', which contains some useful information for cycle storage areas. The document can be found at:

https://www.raildeliverygroup.com/component/arkhive/?task=file.download&id=469762597

Cycle-Rail

RSSB has carried out research *'T1034: Understanding the business case for investment in Cycle-Rail'*. The research can be found at:

https://www.sparkrail.org/pages/libraryresults.aspx?k=T1034

Axle End Equipment Design

RSSB published a knowledge search on SPARK: '*S228 Review of secondary locking methods for railway wheelset axle bearings'. The link is here:*

https://www.sparkrail.org/Lists/Records/DispForm.aspx?ID=22667

Water Recycling for Train Toilets

RSSB Project '*T692: Water Recycling for Train Toilets*' investigated this area during 2007 – details of this project can be found at:

https://www.sparkrail.org/Lists/Records/DispForm.aspx?ID=552

Clean Air & Decarbonisation Research

RSSB are running a suite of Clean Air Research, known as CLEAR projects, some are listed below:

- *T1186 CLEAR: Rail emissions and air quality mapping,*
- *T1187 CLEAR: Fleet wide assessment of rail emissions factors,*
- *T1188 CLEAR: Analysis of air quality onboard trains,*
- *T1189 CLEAR: Rolling stock emissions testing,*
- *T1190 CLEAR: Assessment of air quality at depots,*
- *T1191 CLEAR: Air Quality Personal Monitoring,*
- *T1192 CLEAR: Revised Guidance on Air Quality and Health Effects in Rail,*
- *COF-AIR-01 CLEAR: FY 2019/20 management.*

RSSB are running a suite of Decarbonisation Research, known as DECARB projects, some are listed below:

- *T1197 DECARB: Carbon Measurement,*
- *T1199 DECARB: Cost of different traction options to meet WebTAG requirements,*
- *T1200 DECARB: Model improvements to T1145 Options for traction energy decarbonisation in rail.*

Track Circuit Assisters (TCA) Risk tool

Clause in v5.1 now moved to 2.7.2.

Antennas on Roofs

RSSB has published a Guidance Note '*GKGN0602 Guidance on Train Rooftop Antenna Positioning'*, its scope is the train-borne arrangements for implementation and installation of rooftop radio antennas that support legacy, new digital radio communication systems and Global Navigation Satellite Systems (GNSS) on the GB railway. It includes guidance on the selection of the antennas, their mounting locations and arrangements, as well as information concerning the associated radio frequency components.

Dispatch of Trains

RSSB has published a standard *'RIS-8060-CCS Engineering Requirements for Dispatch of Trains from Platforms'*, which sets out the minimum engineering requirements for the facilities used in dispatching trains from platforms.

Designing Maintenance Depots

RSSB have published a guidance note '*GIGN7621 Guidance for the Development and Design Considerations of Passenger Rolling Stock Depots*'.

Sensor Technology

RSSB has produced a Knowledge Search on new types of sensors and their associated technologies '*S221 – Sensor Technology'*. The document can be found here:

https://www.sparkrail.org/Lists/Records/DispForm.aspx?ID=22774

Adhesion Materials

In addition to the flange lubrication and top of rail friction management standards there are these:

EN 15427 – 1-3 – Wheel/Rail Friction management – Adhesion materials – equipment and application

EN 15427 – 2-3 – Wheel/Rail Friction management – Adhesion materials – Properties and characteristics

ERTMS / ETCS

The following documents available form RDG, maybe useful in preparing for ETCS and their signalling schemes:

RDG-GN/NTI/001 Delivering Good Schemes ETCS v1.0.dox

https://www.raildeliverygroup.com/about-us/publications/acop/256-gndeliveringgoodschemesetcsv1-0/file.html

RDG-GN040 - Delivering good schemes_conventional re-signalling_iss1_Apr17. Dox

https://www.raildeliverygroup.com/about-us/publications/acop/242-deliveringgoodschemes-conventionalre-signalling/file.html

Eurospec Documents

Current published EuroSpecs are:

- Automatic couplers (v1.0),
- Air conditioning (v2.0),
- Pantograph strips (v1.0),
- Documentation (v2.0),
- Requirements management (v.2.0),
- Sliding steps (v2.0),
- Toilets (v2.0),
- Wheel with brake disks for EMU-DMU (v1.0),
- Parking Noise (v1.0),
- TCMS Data Transfer (v1.0),
- Seat Comfort (v1.0),
- Watertightness test specification for rolling stock (v1.0),
- Common requirements (Trivial IDs) (v1.0),

Eurospec documents in production:

- Air conditioning (v3.0),
- Toilets (v3.0),
- Requirements management (v.3.0),
- Global comfort evaluation,
- LCC Approach,
- Exterior Doors,
- Updating software on trains,
- TCMS MMI,
- Alternative energy supplies,
- On-board data.

Available to download free from www.eurospec.eu.

MODTRAIN

Part of the European project MODTRAIN developed a standard driving cab. Much of this is in the Euronorms, but the following may provide some useful background:

https://cordis.europa.eu/project/id/506652/reporting

New Trains Introduction

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

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

Rail Delivery Group
National Rail

Appendix H – Suggestions for Automating Train Preparation (TP)

H.1 Introduction

Currently a significant time is spent manually checking systems as part of train preparation after maintenance, at the start of the day or at station turn-round. Modern trains monitor equipment and systems, potentially negating the need for manual checking.

The Train Control & Management System (TCMS) monitors multiple systems on the train, such as the train consist and the status of doors, brake systems etc, so it seems sensible to use these to report train status.

An inspection of the exterior of rolling stock can be performed by an Automatic Vehicle Inspection System (AVIS). These systems are being developed with the capability of identifying and reporting faults. Some systems also have the added benefit of being able to record images of the inspections for subsequent playback. The location of these systems is crucial so that the majority of a fleet is monitored on a regular basis. In addition, plans need to be in place for continued train operation should the system break down or the network suffer from some significant perturbation e.g. WCML being severed. Maintaining staff competency to cover these eventualities could potentially pose a challenge.

It is recommended that the following systems are reported into the TCMS to simplify the Train Preparation process. Each one has been added to the relevant part of the KTR, or added to a new clause in section 1.27 TCMS:

a. Braking System Requirements (see 5.6.5)

The system should report error messages associated with the performance of mechanical (pneumatic) and dynamic brakes and advise the staff of any isolated brakes or locked axles.

b. Driving Cab Equipment (see 4.9.3)

The system should advise if the Emergency Equipment cupboard has been accessed and that the contents should be checked.

c. Headlights, Marker and Tail Lights (see 1.27.6)

Rolling stock is fitted with ‘mimic panels’ that indicate, inside the cab, the lights being displayed at front and rear. The TCMS should also report the status of the lights being displayed and advise the staff of any failure.

d. Passenger Doors (see 3.33.13)

The TCMS displays the passenger door status i.e. released, open, closed, locked, SDO disabled etc.

e. Air Suspension (see 1.27.7)

The TCMS displays air suspension status e.g. isolated, inflated or deflated.

f. Train Protection Systems, including AWS & TPWS (see 5.3.6)

The TCMS reports the status of the train protection systems e.g. fault or isolated.

g. DSD Vigilance (see 1.27.8)

The TCMS reports the status of the DSD / Vigilance e.g. fault or isolated.

h. Emergency Bypass Switch (EBS) (see 1.27.9)

The TCMS reports the status of the EBS e.g. operated.

i. On Train Data Recorders (see 5.12.4)

The TCMS reports the status of the OTDR e.g. fault or healthy.

j. Toilets (see 3.13.7)

There is a legal requirement in the PRM TSI 2014+2019 clause 4.5.2 that trains with defective Universal Toilets should only be in-service for a specified amount of time. It is suggested that the TCMS should identify Toilets (not only the Universal toilet) that have been locked out-of-use. Universal toilets locked out-of-use should be remotely reported back to the maintenance location so that action can be taken to rectify. Most modern rolling stock offers this functionality.

k. Track Circuit Assisters (TCA) (see 2.7.3)

The TCMS reports the status of the TCA, where fitted, e.g. fault or isolated.

l. Safety system isolation (see 1.27.10)

The TCMS reports the status of the safety system, e.g. TIS, has been operated or isolated.

m. Wheel Slide Protection (see 5.6.5)

The TCMS reports the status of the WSP e.g. fault or isolated.

n. Fire and Smoke Detection Systems (1.27.11)

The status of Fire and Smoke Detection Systems should be reported on the TCMS e.g. pressure or fault etc.

o. Pantographs

Can be checked by the AVIS system.

Appendix I – Intentionally Blank

In v5.1 was titled 'Additional information on ERTMS / ETCS fitment'

Content has been deleted as now covered in the CCS TSI.

Appendix J – Catering Equipment

J.1 Galley

It is assumed that food is cooked or heated in the galley.

The galley can be closed if out of use or if no staff are present.

The containers are secured with lockable latches.

The trolley space doors can be locked by a common locking mechanism on each galley side.

The following equipment and built-in components are provided in the galley:

- Storage for a defined number of refrigerated trolleys,
- Storage for a defined number of non-refrigerated trolleys,
- Storage for non refrigerated containers,
- Convection ovens,
- Steam oven,
- Microwave(s); but modified to take into account neutral sections,
- Combined microwave / convection oven,
- Hob,
- Coffee/tea machines with restraints for pots / jugs,
- Hot-water dispensers (operating at 95°C) or steam heating,
- Water heater,
- UV steriliser,
- Water pump,
- Water filter / softener,
- Toaster,
- Plate warming cupboard,
- Waste bin – in addition consideration for fat disposal – not down the sink drain,
- Hand wash basin,
- Dish wash basin,
- Knife drawer,
- Sink with tap, soap dispenser and paper-towel dispenser,
- Storage space for fresh bottled water - if storage of drinkable water is not available,
- Storage spaces for a total of 150 l of waste,
- Several illuminated work surfaces that incorporate emergency lighting,
- Approx. 3.3 m² galley staff working floor space,
- Fire extinguisher; Depending on appliances but suggest that a CO_2 be provided due to the amount of electrical appliances in the vicinity. Also consider an AFFF.
- Fire blanket,

- Switchgear cabinet for the power supply for the kitchen,
- Cooling unit for bar,
- Grey water tank capacity,
- Wardrobe for train crew,
- Ice maker,
- Freezer.

J.2 Bar

It is assumed that specialty coffees, hot drinks, hot snacks and pre-packed food is prepared and sold in the bar.

The bar can be closed if out of use or if no staff are present.

The containers are secured with lockable latches.

The trolley space doors can be locked by a common locking mechanism on each side.

The following equipment and built-in components are provided in the bar

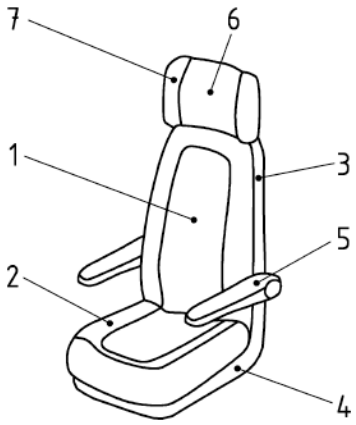
- Refrigerated container storage,
- Non refrigerated container storage,
- Coffee specialty machine,
- Microwave, but modified to take into account neutral sections,
- Panini grill,
- Combined microwave / convection oven,
- Hot-water dispenser (operating at 95°C),
- Water heater,
- UV steriliser,
- Water pump,
- Water filter / softener,
- Toaster,
- Waste bin,
- Hand wash basin,
- Dish wash basin,
- Storage space for bottled water,
- Refrigeration glass-cabinet possibly integrated in the sales counter,
- Sink with tap, soap dispenser and paper-towel dispenser,
- Several illuminated work surfaces that incorporate emergency lighting,
- Lockable drawer for money and EPoS,
- Lockable entrance door,
- Fire extinguisher,

- Social and queuing space,
- Cooling unit for bar,
- Switchgear cabinet for power supply to the bar,
- Grey water tank.

Appendix K – T1140 Seat Comfort Parameters

K.1 In the tables K.1 and K.2 below are explanations of the T1140 parameters that can be found in the appendices in T1140 report *'Defining the requirements of a seat comfort selection process: appendices Revised August 2019'*. Also notes on additional factors or considerations, to be cognisant of when applying the T1140 report, are included (I):

K.2 To help understand the main terms used for seat components in this appendix, refer to figure K.1 (I).



Key

1	seat cushion (backrest)
2	seat squab (base)
3	seat shell (back)
4	seat shell (base)
5	armrest
6	headrest
7	headrest wings or ears

Figure K.1: Seat components

K.3 Table K.1 describes the parameters within the control of the seat manufacturer (I).

Table K.1 Seat parameters within the control of the seat manufacturer.

T1140 Parameter	T1140 optimum seat comfort requirements	Further points to consider
Seat Base Height above floor	440 +0 / -15 mm	PRM TSI 2019, Appendix H stipulates a seat height between 430mm and 500mm for priority seats.
Seat Base Depth	435 +0 / -5 mm	PRM TSI 2019, Appendix H stipulates a minimum seat depth 450mm for priority seats.
Angle of Seat	-8° to -15°	No further notes.
Angle between seat and back	95° to 105°	No further notes.

T1140 Parameter	T1140 optimum seat comfort requirements	Further points to consider
Seat width (distance between armrests)	460 mm	• The seat width of seats other than longitudinal seating is affected by the cross-sectional dimensions of the GB loading gauge. • PRM TSI 2019, Appendix H stipulates a minimum width of 450mm for priority seats.
Seat width for longitudinal seating	555 mm	No further notes.
Backrest width	525 mm	• The seat width of seats of transverse seats is affected by the cross-sectional dimensions of the GB gauge. • PRM TSI 2019, Appendix J stipulates a minimum clearway width of - 450mm below 1000mm above floor level, and - 550mm between 1000mm and 1950mm above floor level. • The T1140 minimum backrest width is deemed only possible for 2+1 seating arrangements due to GB gauge constraints.
Armrest height above seat squab	240 mm	• Armrests where fitted to full height seats should be movable to facilitate easy access to the seat. • Armrests should be fixed on longitudinal seating. • PRM TSI 2019 requires that armrests fitted to priority seats can be stowed flush with the seat back to facilitate easy access to the seat. • The armrest height value represents the best compromise for taller and shorter people.

T1140 Parameter	T1140 optimum seat comfort requirements	Further points to consider
Underside of headrest to seat squab	670 mm	Only applicable for full height seats.
Point of contact, nape of neck	590 – 756 mm	Only applicable for full height seats.
Padding: • Seat pad • Back pad • Minimum % compression • Maximum % compression • Long term seat durability	 50mm 25mm 40% 70% 5% or less deformation after cycles	The PRM TSI requires compliance at all times. Any seat sagging can reduce height or pitch contravening this legal requirement. This should be considered in the design
Seat backrest height above seat squab	Not included as a Passive Safety issue.	See *'GM/RT2100 issue 6 Rail Vehicle Structures and Passive Safety'* section G A.12.2.6.
Seat accessories • Armrests	 Preferred.	See T1140 report.

K.4 Table K.2 shows the parameters that are applicable for the seating installation (I).

Table K.2 parameters that are applicable for the seating installation

T1140 Parameter	T1140 optimum seat comfort requirements	Further points to consider
Legroom clearance under table	650mm +/- 5mm	No further notes.
Legroom clearance under tablet	650mm +/- 5mm	Tablet here refers to a fold-down seat-back table.

T1140 Parameter	T1140 optimum seat comfort requirements	Further points to consider
Legroom, bay seat arrangement	1390 mm	• The demand of overall train seating capacity might not allow the proposed Seat legroom. • The legroom and distance between bay seat arrangements affects the interior passive safety requirements set out in GMRT2100 Issue 6. • PRM TSI 2019, Appendix H stipulates a minimum legroom of 1500 mm for priority seats. • Seat legroom should also take into consideration typical journey times.
Legroom, airline seat arrangement	695 mm	• The demand of overall train seating capacity might not allow the proposed seat legroom. • The legroom and distance between airline seats affects the interior passive safety requirements set out in GMRT2100 Issue 6. • PRM TSI 2019, Appendix H stipulates a minimum legroom of 680mm for priority seats. • Seat legroom should also take into consideration typical journey times.

Glossary

Abbreviations and some terms used are explained below:

Term	Definition	Context
4G	Fourth generation of mobile phone communications standards	
AC	Alternating Current	
ADD	Automatic Drop Device	Part of Pantograph
ATO	Automatic Train Operation	
AVI	Automatic Vehicle Identification	
AVIS	Automatic Vehicle Inspection System	
AWS	Automatic Warning System	
BRIC	Mobile Radio Modules	
CCTV	Closed-circuit television	Also known as “Network video surveillance system (NVSS)“ or “Digital video recording system (DVRS)“
C-DAS	Connected Driver Advisory System	
CEN	European Committee for Standardisation	Standards
CET	Controlled Emission Toilet	
CIS	Center for Internet Security	
CR	Change Request	Related to ERTMS / ETCS
CRMT	Cab Radio Maintenance Terminal	
DC	Direct Current	
Deadlight	The structure on the interior of a train between the bodyside windows.	
DCO	Driver Controlled Operation *(Note: Dispatch and door control may also be within the train as well as in the driver’s cab).*	Also known as DOO.
DCP	Driver’s Control Panel	For GSM-R voice radio
DfT	Department for Transport	
DGO	Driver Guard Operation	
DMI	Driver Machine Interface	
DOO	Driver Only Operation	See DCO
DPI	Delay Per Incident	
DSD	Driver Safety Device	
DVRS	Digital video recording system	Also known as “Network video surveillance system (NVSS)“ and a modern term for CCTV.
EBS	Emergency Bypass Switch	
ECS	Empty Coaching Stock	
EDGE	Enhanced Data for Global Evolution	also known as Enhanced GPRS or EGPRS
EDOR	ETCS Data Only Radio	
EN	European Standards	
ENTOSS	ETCS New Trains Onboard Sub-System	
EPoS	Electronic Point of Sale	
EOSS	ETCS Onboard Requirements Sub-system Specification	
ERTMS	European Rail Traffic Management System	
ERRI	European Rail Research Institute	

Term	Definition	Context
ETCS	European Train Control System	
ETRS89	European Terrestrial Reference System 89	Geodata system for Europe
EVC	European Vital Computer	
FRMCS	Future Railway Mobile Communications System	
Galileo	Europe's Global Navigation Satellite System	
GLONASS	Globalnaya Navigazionnaya Sputnikovaya Sistema	Russian version of GNSS.
GNSS	Global Navigation Satellite System	
GoA	Grades of Automation	
GOP	Guard's Operating Panel	
GPRS	General Packet Radio Service	Known as 2.5G
GSM-R	Global System for Mobile Communications – Railway	
HSE	Health and Safety Executive	
HVAC	Heating, Ventilation and Air Conditioning	
IEC	International Electrotechnical Commission	Standards
IM	Infrastructure Monitoring	In this document only
Intercity	Type of service, generally longer distance with more comfort and higher speeds, generally >100mph.	
IP	Internet Protocol	
ISO	International Standards Organisation	Standards
KPI	Key Performance Indicators	
KTR	Key Train Requirements	
LED	Light Emitting Diode	
Loc & Pas TSI	Locomotives and Passenger Rolling Stock TSI	
LRU	Line-replaceable unit	
LTE	Long Term Evolution	
MCB	Miniature Circuit Breaker	
MSD	Musculoskeletal Disorder	
MSG-3	Maintenance Steering Group-3	methodology for developing scheduled maintenance tasks and intervals
MTB	Magnetic Track Brake	
MTBF	Mean Time Between Failure	
MTIn	Miles per Trust Incident number	
Multi-mode	Includes Bi-Mode, Tri-Mode or other combinations of traction power supply	able to work from an electrification system and be self-powered
NIR	National Incident Reports	
NOC	National Operations Centre	Part of Network Rail
NR	Network Rail	
NRSP	National Rail Security Programme	
NRT	Network Rail Telecom	
NTP	Network Time Protocol	
NTR	National Technical Rule	

Term	Definition	Context
NVSS	Network video surveillance system	Also known as “Digital video recording system (DVRS)“ and a modern term for CCTV.
OEM	Original Equipment Manufacturer	
OCL	Overhead Contact Line	See OLE
OLE	Overhead Line Equipment	Also known as OCL
ORR	Office of Rail and Road	
OSS	Open Source Software	
OTCM	On-train Camera / Monitor System	
OTDR	On Train Data Recorder	
OWASP	Open Web Application Security Project	
PA	Public Address	
PDFC	Passenger Demand Forecasting Council	
PIS	Passenger Information System	
PRM TSI	Persons with Reduced Mobility TSI	
PSIL	Preferred Speech Interference Level	
PTI	Platform-Train Interface	
PTT	Press To Talk	
R&D	Research and Development	
RAIB	Rail Accident Investigation Branch	
RAMS	Reliability, Availability, Maintainability and Safety	
RCD	Residual-Current Device	
RCM	Remote Condition Monitoring	
RDG	Rail Delivery Group	
REC	Railway Emergency Call	For GSM-R voice radio
RFID	Radio-Frequency IDentification	
RGS	Railway Group Standard	
RIS	Railway Industry Standard	
RS232	Recommended Standard 232	Computing connection system
RSSB	Rail Safety & Standards Board	
RTS	Rail Technical Strategy	
SAM	Service Accessibility and Maintenance	
S&C	Switches & Crossings	
SDLC	System Development Life Cycle	
SDO	Selective Door Opening	
SIM DB	Network Rail SIM database	
SIEM	Security Information and Event Management	
SPARK	RSSB library	Sparkrail.org
Suburban	Type of service with more frequent stops, lower speeds (< 100mph) and commuter type services.	
TCA	Track Circuit Assisters	
TCMS	Train Control & Management System	Not to be confused with TMS
TIS	Traction Interlock Switch	
TLG	Technology Leadership Group	
TLM	Train Location and Movements	
TMS	Traffic Management System	Used in ERTMS

Term	Definition	Context
TOC	Train Operating Company	
TP	Train Preparation	
TSI	Technical Specification for Interoperability	
UIC	International Union of Railways	
UNIFE	The Association of the European Rail Industry	
USB	Universal Serial Bus	Computer connection system
V/T SIC	Vehicle / Track System Interface Committee	
V/V SIC	Vehicle / Vehicle System Interface Committee	
VPN	Virtual Private Network	
VTISM	Vehicle / Track Interaction Strategic Model	
VUC	Variable Usage Charge	
WCML	West Coast Mainline	
Wi-Fi	WLAN (Wireless Local Area Network)	

Picture and figure credits / acknowledgements:

Figure 3.3.1 CEN / BSI

Figure 3.30.2 David Polhill

Figure 3.31.3 David Polhill

Figure C.2.2.8 ATOC