KTR v5.1

Key Train Requirements

Version 5.1

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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.

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

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

Introduction to Key Train Requirements (KTR)

Why use this document?

This document is intended to assist rolling stock procurers, 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, whilst not classified as mandatory, 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 are being reissued as Railway Industry Standards (RISs). Although not mandatory, RISs do contain industry agreed good-practice and it is essential that these are referred to in contractual documentation. If they are not referenced, alternative but equal processes can be used. For the moment it may be prudent to consider that RISs are treated as Applicable Laws and Standards for the purposes of contracts, except where Operator, Owner and Train Builder agree otherwise.

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 gives guidance on areas of significance and is referenced in ORR guidance which shows its importance.

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. Recommendations from RAIB reports or NIRs, should be considered during a train refurbishment or upgrade programme too.

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.

It is recommended that manufacturers review their product platforms against the document and prepare a commentary, that can be provided to potential customers.

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).

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 is categorised by:

(E) = Essential and '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 and consideration is required, should it be required, the requirement is considered essential.

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

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

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

This 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

Note that all hyperlinks to RSSB research projects have been changed to reflect the new RSSB website (www.rssb.co.uk). In some cases, a login to RSSB's SPARK may be required in order to see the information.

Contact RSSB at http://www.sparkrail.org/authentication/pages/register-info.aspx for more details.

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

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.

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

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.

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 have been 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, has additional information on ERTMS / ETCS fitment.

And a Glossary.

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).

Mass reduction through intelligent / innovative design is clearly beneficial, but this should not be pursued as an end in itself.

> 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.
>
> Details of this project can be found at:
> http://www.rssb.co.uk/library/research-development-and-innovation/research-brief-t712.pdf

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.

> For example, the RSSB Vehicle / Track Interaction Strategic Model (VTISM). Details of this project can be found at:
>
> https://www.rssb.co.uk/research-development-and-innovation/research-project-catalogue/t792

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.

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1.3 Couplers

1.3.1 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 Loc & Pas TSI

< 250 kph - Dellner 12 / Voith 136 / Faiveley 130 or equivalent, at a nominal 925 mm Above Rail Level

This removes a barrier to the interworking of rolling stock supplied by different manufacturers and facilitates emergency rescue.

RSSB Project '*T1003: Standardisation of Coupling Arrangements'* presents a business case for mechanical compatibility in couplers. The reports can be found here:

http://www.rssb.co.uk/library/research-development-and-innovation/research-brief-T1003.pdf

1.3.2 The ability for interworking with subsets of existing designs of rolling stock should be demonstrated, recognising the aspirations for the long-term use of the rolling stock (D).

This permits easier cascade of the rolling stock.

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

As a minimum this would include:

- Emergency brake
- Full service brake application
- Traction Control
- Door Control and Interlock
- Crew to Crew Communication
- Public Address
- Passenger Communication Emergency Alarm.

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

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1.3.4   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 - details of this project can be found at:

http://www.rssb.co.uk/library/research-development-and-innovation/research-brief-t958.pdf

1.3.5   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.

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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   Brake blending shall give a maximum jerk rate of 0.5 m/s^3 change between different modes of braking (E).

This is to ensure a comfortable ride and to ensure the safety of standing passengers. This was a value used by British Rail and is still considered appropriate.

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 predictable braking systems (D).

The ability of trains to provide predictable braking performance under all conditions (e.g. using 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.

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.

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The report can be found here:
https://www.rssb.co.uk/library/research-development-and-innovation/research-brief-t1099.pdf

'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.

1.5 Brake Application on Door Release

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.

1.6 Sanding Systems

1.6.1 The fitting of variable rate sanders in accordance with RSSB project T1107 should be considered (D).

The research has shown this to be very effective particularly in autumn.

The report for RSSB research *'T1107 Trials of sanders and sand laying rates'* can be found here:

https://www.sparkrail.org/Lists/Records/DispForm.aspx?ID=25656

RGS GMRT2461 issue 2 'Sanding equipment' is being updated to include T1107 with publication planned for late 2018.

1.6.2 Trace Heating of key parts of the sanding system should be provided (D)

Sand is an essential aid to traction and braking. Wet sand clogs pipes and could lead to train cancellation. Heated sand boxes can prevent this.

1.6.3   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 (E).

This is to ease filling, reduce manual handling and minimise spillage. An internal filler could be considered for DC 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

1.7   Consumable Tank Capacities and Servicing Requirements

1.7.1   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 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 3.10 and Appendix C for further requirements related to toilet provision).

1.7.2   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.

1.7.3   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.

1.7.4   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.

1.7.5   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.

1.7.6   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 applicable to equipment isolation switches e.g. Battery Isolators; and level indicators; e.g. coolant and fuel.

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

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

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

A request for a standard on AdBlue connectors on vehicles fitted with diesel engines has recently been made to RSSB.

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1.8   Windscreen Wiper Systems

1.8.1   Windscreen wipers shall remain effective throughout the design speed range of the rolling stock (E).

Dynamic effects on the windscreen wiper systems need to be considered to ensure windscreen wipers remain effective.

> This is applicable whether the driving cab is open ended or intermediate within a train consist. 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   The use of electrically powered windscreen wipers is recommended (D).

Electric wipers are considered more reliable now than pneumatic ones.

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   When testing the effectiveness of windscreen wipers all contaminants likely to end up on the windscreen should be tried (D).

Certain suppliers have not tested for real detritus, for example squashed and sun-baked flies.

1.9   Electrical Connectors, Jumpers and Cable Idents

1.9.1   External 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.

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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 increases 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).

'BS EN 50343:2014 Railway applications - Rolling stock - Rules for installation of cabling', is available from BSI.

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.

1.11 Reliability

1.11.1   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 - details of this project can be found at: http://www.rssb.co.uk/library/research-development-and-innovation/research-brief-t782.pdf

1.11.2   Rolling stock 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).

1.11.3   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).

1.11.4   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).

1.12 Meteorological Effects

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

Rolling stock of the future needs to be designed to provide more resilience to foreseeable 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.

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

The drawing of contaminated air through cabinets can lead to clogging and flashovers.

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.

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

S*now can be drawn into cooling systems via the louvers causing clogging, overheating and equipment failure.*

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

1.12.4   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.

1.12.5   Critical systems (e.g. warning horns [including heating them and preventing snow ingress]; cab and passenger doors; windscreen wipers; DCO cameras (known as On-train Camera / Monitor System); couplers [see also 1.3.5] and head, tail and marker lights) shall be protected from the effects of the build-up of snow and ice (E).

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

Reduction of the under-pressure below the train reduces the vulnerability to a build-up of snow and ice, which 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.

1.12.7   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.

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1.12.8   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.

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

> For all brake systems:
> - Incorporating a 'snow brake' feature which, when initiated, requests a controlled brake application during normal running whilst maintaining traction, without requiring a material reduction in speed.
>
> Possible options for dynamic brakes are the ability to select different dynamic blending settings, such as:
> - Suspension of cross blending so that the dynamic brake is only used on the motored wheelset, so that the trailer wheelsets use their friction brakes.
> - Raising the speed at which the dynamic brake is blended out to increase the work of the friction brakes.
> - Temporary isolation of the dynamic brake during snow and ice conditions.

1.12.11   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. A link to the research brief can be found at:
>
> http://www.rssb.co.uk/library/research-development-and-innovation/research-brief-T1052.pdf
>
> And to the report on SPARK here:
>
> https://www.sparkrail.org/Lists/Records/DispForm.aspx?ID=22488

1.12.12   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.

1.12.13   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.

1.13   Availability

1.13.1   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.

> The provision of 'strategic spares' needs to be considered. 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.

1.13.2   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.

Rail Delivery Group

National Rail

BRITAIN RUNS ON RAIL

1.13.3   Sufficient maintenance spares e.g. bogies, wheelsets, pantographs, engine rafts, air-conditioning modules etc should be procured during build for the life of the train and included in the lease to optimise availability later (D).

1.14   Maintenance and maintainability

1.14.1   Maintenance, overhaul and renewal requirements during the specified design life of the train shall be stated (E).

Although a train will have a design life, sub-systems will also require maintenance, overhaul or replacement during this period and this information is required for planning purposes.

1.14.2   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).

1.14.3   It shall be possible for all 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.

1.14.4   **Maintenance Manuals and Materials**

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

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

> The following suite of standards give 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:*

1.14.5   A Design Authority shall be identified and agreed at the time of train procurement, with specific responsibilities for ensuring that all documentation listed in 1.14.4 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.

1.14.6   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.

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

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

1.14.8   Exterior equipment covers, and access panels shall be fitted with secondary retention devices to ensure they do not infringe gauge if they 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.

> Whilst the ideal solution is to design access covers and panels such that, even when open, they do not infringe the vehicle gauge, an acceptable alternative may be the provision of secondary retention devices, which are detachable for maintenance purposes.

1.14.9   Roof mounted equipment that requires frequent maintenance activities, for example, filters, shall be designed so that access can be gained from below, possibly from within the vehicle (E).

Gaining access to roof mounted equipment requires the provision of costly and complex roof access equipment, severely restricting the locations where these maintenance activities can be undertaken.

1.14.10   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.

1.14.11   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.

1.14.12   **Maintenance Training Manuals and Materials**

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

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

Rail Delivery Group

National Rail

BRITAIN RUNS ON RAIL

1.14.12.3 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.

1.15   Spares

1.15.1   Spare items, sufficient to meet anticipated requirements for the expected design life of the train, should be supplied during train build (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.

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

1.16   Obsolescence Management

1.16.1   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 and IT hardware.

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, a data spreadsheet and a data example are available from the RSSB website.

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

1.18 Electrical Collector Systems

1.18.1 Future Proofing of Third Rail (750V DC) Rolling Stock

1.18.1.1 The modifications that would be required in order to accommodate a change in supply voltage for 750V DC third rail rolling stock to 900V DC shall be stated (E).

To improve capacity on the 750V DC third rail network, one potential option is to increase the power available by increasing the supply voltage to 900V DC. It is therefore important to understand the impact of such a change on new trains planned for procurement.

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 750V DC third rail system with the 25kV 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 750V DC system with 25kV Overhead was the subject of RSSB Project '*T950: Investigating the economics of the 3rd rail DC system compared to other electrification systems*' - details of this project can be found at:
>
> http://www.rssb.co.uk/library/research-development-and-innovation/research-brief-t950.pdf
>
> 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 750V DC shoegear should ensure that, in icy conditions, an appropriate minimum current can be drawn to maintain the best possible shoe contact to the rail (D).

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.

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

1.18.2 **Pantograph System Design**

1.18.2.1 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 RSSB research project found that the risks of using these insulators was minor, but that a risk assessment should be carried out.

> 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*' looked at the risks involved and this is now complete. Useful information on assessing the risks of using the polymer insulators is included.
>
> T1060 risk assessment report can be found here:
>
> https://www.sparkrail.org/Lists/Records_StaffMembers/DispForm.aspx?ID=916

1.18.2.2 A facility for the driver to isolate the pantograph automatic dropping device (ADD) shall be provided (E).

Occasionally an ADD operates and, without a means to isolate it, the pantograph cannot be raised. Although the train may not move if there is damage to the pantograph, a supply to the train can be maintained for HVAC purposes. Similarly, if there is minor damage to a carbon, the train could be moved at reduced speed to a place where passengers can be detrained.

1.18.2.3 There shall be no adverse effects on passenger facing equipment or need for on-train staff intervention in normal operation after passing through neutral sections (E).

Sometimes, once a supply is removed, the equipment returns to a start mode (e.g. HVAC) or needs resetting. The aim of this requirement is that the equipment continues in the mode it was in when the supply was removed.

1.19 Systems Architecture

1.19.1 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).

1.19.2 Separate Ethernet backbones for train safety systems / information systems and those intended for passenger access shall be provided (E).

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

1.19.3   Cat 7 cables, rather than Cat 5, should be used to maximise data transfer. Whichever Category of cable is used, thought should be given to its durability, band-width potential, future upgrading, and suitability for a railway environment (D).

> Some versions of Cat 7 cables may not be suitable for use in jumper cables between vehicles as it is 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 – procurers should check with suppliers for the latest options on cables for rail application.

1.19.4   Switch configuration should be set, to only accept the expected input format, to ensure that accidental or malicious inputs cannot be accepted (D).

1.19.5   Switches and access points should be in locked cupboards, to ensure malicious physical connections cannot be easily made (D).

1.19.6   Choice of connectors should be carefully considered to ensure system components cannot be incorrectly connected either accidentally, or maliciously and also standard backup USB stick ports should be avoided (D).

1.19.7   **Cyber Security**

1.19.7.1   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.

1.19.8   **High Integrity Software**

1.19.8.1   Guidance on procuring high integrity software on trains is given in the following guidance note *'GEGN8650 Guidance on High Integrity Software-Based Systems for Railway Applications'* and should be reviewed (I).

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

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

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

> The selection of GNSS and any augmentations will depend on its intended purpose. RSSB research project 'T892: Data and Analysis for a cost-effective GPS-based locator with simple augmentations' provides some good practice, details of this project can be found at:
> http://www.rssb.co.uk/library/research-development-and-innovation/research-brief-T892.pdf

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 limit the proliferation of antennae on a train's roof and reduce the risk of more expensive retrofitting activities.

> 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.

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

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

1.21.1   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.

1.21.2   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 Sight Glasses

1.22.1 Sight glasses for checking fluid levels 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.

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.

Rail Delivery Group

National Rail

BRITAIN RUNS ON RAIL

1.25   Pressure Limits

1.25.1   In tunnels the change of pressure should be in accordance with appendix A.2 of UIC 779-11: Ed 2 (2005), 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 1.25: Aural comfort limits

Routes	Pressure Change Limits
UK national network except HS1 and Cross Rail (Elizabeth Line) Central London Tunnels (Classified as Type A operation in UIC Fiche 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.

For sealed trains, base-line pressure comfort criteria are given in Appendix F (Section F4) of UIC Fiche 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 for passing in double track tunnels.

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

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 following report on SPARK at:

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

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 'a last mile' mode.
- Whether a static or dynamic changeover is required between modes. Dynamic changeover is preferred as this reduces journey time.
- Infrastructure changes to support in-service charging facilities, e.g. at stations, if electrical energy storage is used.
- The electrical safety of the High Voltage roof equipment when operating in other than electric mode.

More 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.*'

1.27   Train Control & Management System (TCMS) – Design

1.27.1   A master / slave concept for the Train Control & Management System (TCMS) data bus, using a second TCMS bus, should be provided (D).

The objective is to create system redundancy without introducing the additional weight and complexity associated with a relay switched system as a backup 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.

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

1.27.3   Provision should be made for drivers, and other members of train crew, to isolate /
         reset defective essential equipment through the TCMS (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.*

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).

1.28   Torque-tightening

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

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

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

1.29   Train Location and Movements (GPS) Project

The Train Location and Movements (TLM) Project is part of the railway Customer Information
Strategy programme of projects based on research work from National Rail Enquiries and a
Network Rail and RDG Proof of Concept Project (I).

The purpose of the project it 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).

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).

1.29.1   The on-train location sensing equipment shall collect data, store it and buffer it
         for transmission to shore, where it will be collated in the supplier's back office
         before onward communication to RDG's Train Location Gateway (E).

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

1.29.2   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 RSSB website.

1.30   Automating Train Preparation

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 (I).

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 provide a train status (I).

1.30.1   The monitoring and reporting of the train status to the person preparing the train for service should be provided (D).

Appendix H gives some suggestions of areas that the TCMS can help with this monitoring.

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 gauge (E).

Failure to consider the impact of aerodynamics in the risk assessments for a design of retention device 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/_layouts/15/Rssb.Spark/Attachments.ashx?Id=75NEMTS3ZVHP-8-2590

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 The propulsion system shall be designed to avoid single point failures (E).

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

2.2.3 Propulsion systems shall be designed such that that when one system fails, the remaining systems compensate to maintain 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 (E).

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

Rail Delivery Group

National Rail

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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 at:
>
> https://www.rssb.co.uk/library/improving-industry-performance/2016-05-rail-sustainable-development-principles.pdf
>
> The RSSB website also has some useful information, of which the document above is a part, at:
>
> http://www.rssb.co.uk/improving-industry-performance/sustainable-development/sustainable-rail-programme

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 '*IS0 22628: Road vehicles - Recyclability and recoverability - Calculation method*', 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 Manual', detailing the disassembly, identification and segregation methods and showing the 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
>
> Note: For information, ISO TC 269 are also preparing a railway standard on '*Recyclability and recoverability calculation method of rolling stock*'.

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

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 Electrically powered rolling stock shall be capable of providing energy-use data of an integrity level suitable for billing (E).

> 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 contact rail routes (D).

This is so a charge for electricity-usage will not be made when the train is running on diesel or battery and 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 contact 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

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

Management Systems, compliant C-DAS products will also give operational benefits where no Traffic Management System (TMS) is present.

Specifications for C-DAS are being proposed:

a. An Operational Concept which documents User Requirements can be found at http://www.rssb.co.uk/Library/groups-and-committees/2015-report-c-das-concept-of-operation.pdf.
b. *'RIS-0711-CCS Interface Requirements for Connected Driver Advisory System'* (due for publication soon) specifies interfaces to ensure that they are compatible with other current protocols and systems.
c. A system-level Concept of Operations is also currently in preparation.
d. A system requirement specification is available here: https://www.rssb.co.uk/library/improving-industry-performance/c-das-im-ssrsv1-1.pdf

Note: Other related documents for C-DAS on non ETCS-fitted trains can be obtained from Network Rail or the email on page 1 of this document.

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 high 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 high 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 at the correct on-board temperature.

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, such as Light Emitting Diode technology, shall be provided (E).

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

2.4.11 Where fitted, interior lighting that automatically adjusts, in a gradual manner, in response to ambient light levels should be provided (D).

This reduces energy consumption and extends equipment life.

The rate of adjustment should ensure that minimum lighting levels are achieved at all times, whilst avoiding a strobe effect.

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 Diesel engines shall report fuel consumption rates (E).

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

Rail Delivery Group

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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.

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

3. Key Requirements - Passenger Facing

Introduction

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).

3.1 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.

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

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

3.1.1.5   Functionality to allow traincrew to alter the setting of saloon HVAC should not be provided, however where it is, a variation of $\pm$ 3 °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 ENs 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.

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.

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

3.1.3 Emergency / Degraded Mode

3.1.3.1 HVAC systems shall 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).

This is to provide comfort in the event of train failure and to try and dissuade passengers from opening external doors and self-evacuating.

3.1.4 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.

3.1.5 Individual controls for ventilation for passengers for inter-urban or intercity rolling stock; similar to those on aircraft, should be provided (D).

Some form of local ventilation can help with perceived air movement particularly when it is very hot. Where there are opening windows this local ventilation may mean the window does not need to be open; so reducing noise.

3.2 Passenger Security

Introduction

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. The report is available at (I): https://www.sparkrail.org/Lists/Records/DispForm.aspx?ID=17894

3.2.1 Closed Circuit Television (CCTV)

3.2.1.1 CCTV that provides coverage of passenger accessible areas, including areas used for storage of luggage, cycles etc, but excluding toilets, 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 National Rail CCTV Steering Group have published the following guidance '*National Rail & Underground Closed Circuit Television (CCTV) Guidance Document*' that should be considered.
>
> A copy of this document can be found at: https://www.raildeliverygroup.com/about-us/publications.html?task=file.download&id=469773914
>
> Note that an updated version is due for publication soon.
>
> The British Transport Police also has a document 'BTP CCTV Output requirements', which can be made available on request from RDG or the email address on page 1.

3.2.1.2 A facility to provide remote access on demand of CCTV images should be provided (D).

Experience has shown that having immediate access to images can offer significant benefits in enabling earlier resumption of services following incidents.

3.2.1.3 Where CCTV is fitted, system capabilities, in terms of image quality, data storage space and data retention time, shall be stated (E).

The use for which the images may be used may influence the recording rate and for how long the images are available.

3.2.2 Personal Security

3.2.2.1 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.

3.3 Passenger Ergonomics

Introduction

Passenger comfort is an important issue for UK (and European) rolling stock and is not straightforward to address when producing procurement specifications. Current work by RSSB on *T1140 Defining requirements for seat comfort* and by Eurospec on *Seat Comfort*, hopes to address this. More information will be included in future issues of KTR (I).

3.3.1 Seats

Figure 3.3.1 below should be used to identify which parts of the seat are being referred to in the following sections (I).

Key
1   seat cushion (back cushion)
2   seat squab (base)
3   seat shell (back)
4   seat shell (base)
5   armrest
6   anti-Macassar or pillow
7   headrest
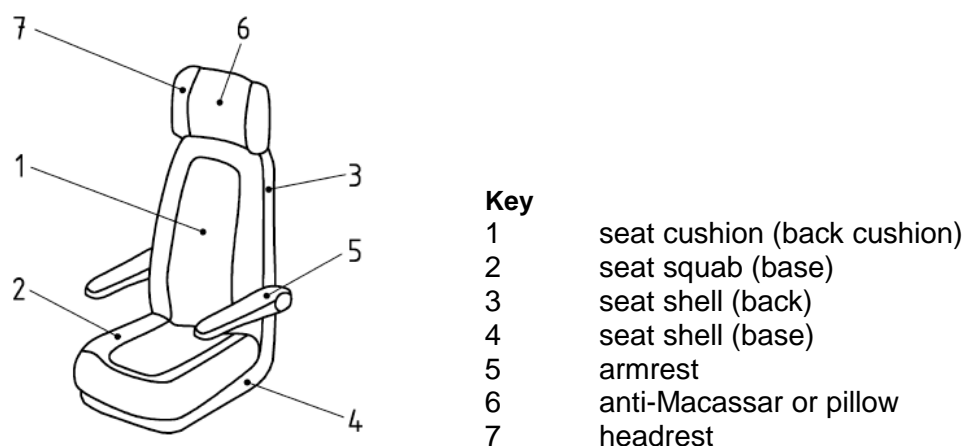
Figure 3.3.1: Seat components

3.3.1.1   Seat legroom should accommodate a 95th percentile male (based on the latest anthropometric data available for the GB population) (D).

There is no agreed standard that specifies acceptable legroom for UK rolling stock. It is recommended that current anthropometric data and associated forecasts for the life of the rolling stock are used to inform proposed seat pitches.

> Note 1: The current 95th percentile male figure would result in a dimension of 688 mm for airline seating. For absolute clarity, this is the dimension between the front face of the seat back cushion and the rear face of the seat in front and is therefore not 'seat pitch.' *[Source PeopleSize Pro 2008].*
>
> Note 2: Seat legroom should also take into consideration typical journey times.

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

3.3.1.2   The size of the seat squab should accommodate a majority of the population (based on the latest anthropometric data available for the GB population) (D)

> Note 1:   The current 95th percentile female figure hip breadth would result in a width of 466 mm for the squab. A 95th percentile male figure shoulder breadth is 516mm. When fixed armrests are used consideration should be given to the actual usable width. *[Source PeopleSize Pro 2008].*
>
> Note 2:   The depth of the seat squab to give thigh support should also take into consideration typical journey times.

3.3.1.3   The height of the seat squab above floor level should accommodate a majority of the population (based on the latest anthropometric data available for the GB population). It should not be too low nor too high (D).

> The PRM TSI 2015 requires, for priority seats, a seat squab height of 430 to 500mm.

3.3.1.4   Where provided, armrests should be moveable and of a length and height designed to accommodate a majority of the population (based on the latest anthropometric data for the GB population) (D).

> Note 1:   It is not considered to be appropriate to provide armrests in all circumstances.
>
> Note 2:   The current 95th percentile male figure would result in an armrest length of 442mm and for a comfortable height for a 50th percentile female of 200mm above the seat base cushion. [*Source PeopleSize Pro 2008].*
>
> Note 3:   Armrests are beneficial for passenger containment in the event of an accident.

3.3.1.5   Spacers between seat backs should be provided (D).

The spacer gives more shoulder and hip space without making wider seats. This also keeps the mass lower.

3.3.1.6   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 (I).

3.3.2 Window Position

3.3.2.1   Deadlights (the vehicle structure between window apertures) should be as narrow as practicable, and no greater than 450 mm wide (D).

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

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

3.3.2.2   The rolling stock design should ensure that all passenger seats are aligned to provide a view through the adjacent window (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.

3.4   Ride Quality

3.4.1   A Mean Comfort Index shall be no worse than 2.5 measured at any point along the saloon over the full range of vehicle speed, as defined in *BS EN 12299:2009 'Railway Applications – Ride Comfort for Passengers – Measurement and Evaluation'* when running on a track according Track Quality Class C as defined in *BS EN 13848-6:2014 'Railway applications – Track - Track geometry quality - Characterisation of track geometry quality'* (E).

It is recognised that a Mean Comfort Index of 1.5 can be achieved on route-defined reference track.

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   For all vehicle types when stationary, with traction supply available, auxiliary systems (including air conditioning) running and all doors closed, noise levels measured inside the saloon area of vehicles shall not exceed 65 dB $_{Leq, T=20s}$ measured according to *BS EN ISO 3381, 'Railway applications. Acoustics. Measurement of noise inside railbound vehicles'* (E).

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

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

3.5.2   For all vehicles 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 *ISO 1996-2:2007, 'Acoustics -- Description, measurement and assessment of environmental noise -- Part 2: Determination of environmental noise levels'* (E).

> Refer to Annex D of *'ISO 1996-2:2007 Acoustics -- Description, measurement and assessment of environmental noise -- Part 2: Determination of environmental noise levels'.*

3.5.3   The Preferred Speech Interference Level (PSIL), inside the vehicles under all operating conditions shall not exceed 70 dB $_{Leq, T=20s}$ measured according to *BS EN ISO 3381, 'Railway applications. Acoustics. Measurement of noise inside railbound vehicles'* for all vehicle types (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 *'BS EN ISO 3381, Railway applications. Acoustics. Measurement of noise inside railbound vehicles'* which defines measurement positions, operating conditions and environmental conditions.

3.5.4   The A-weighted equivalent continuous sound pressure level ($L_{pAeq,20s}$), measured in accordance with '*BS EN ISO 3381, 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 *BS EN ISO 3095*, '*Acoustics. Railway applications. Measurement of noise emitted by railbound vehicles'*, shall not exceed the following levels (E):

- Saloon – 75 dB(A)
- Vestibule – 80 dB(A)

These values can be adjusted based on existing stock measured values as they will be influenced by many factors such as:

- vehicle construction
- power source (or not) in the vehicle.
- type of passenger doors
- type of interior
- pressure sealing
- etc.

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

The intention is that the passenger experience, in terms of noise levels, should be broadly comparable to, and preferably better than, that offered by other forms of surface transportation such as road coaches and private cars.

3.5.5   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).

3.5.6   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.

3.5.7   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   Bodyside Windows

3.6.1   Bodyside windows should be standardised (D).

The number of variant sizes of bodyside windows should be kept to a minimum, to enable the stock holding of spare windows to be minimised.

3.7   Bodyshell Design

3.7.1   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.

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

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.

3.9 Passenger Counting

3.9.1 A means of passenger-counting shall be provided either: (E).

- On all vehicles to give real-time loading information, enabling passengers to be guided to the locations on platforms where space is available, so reducing station dwell times, or
- On a proportion of vehicles to achieve a better match between passenger demand and provision of capacity.

A relatively low-cost example of passenger counting is the use of the vehicle 'load weigh' signal, although other equivalent solutions exist.

3.10 Passenger Information System (PIS)

Introduction

The PRM TSI has requirements for PIS, what follows is in addition to those requirements (I)

3.10.1 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.

- Accurate real-time intermodal / interchange running information; particularly at times of 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 via a train-borne Wi-Fi network to be provided for use by passengers using a personal Wi-Fi device (refer to section 5.11).

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

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

- An interface with the vehicle Selective Door Operation system - where applicable (see 4.2.4.).

3.10.2   The number / letter of the vehicle in the train consist shall be displayed on the exterior of the relevant vehicle, in a position that is readily visible to passengers when boarding (E).

3.10.3   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.

3.10.4   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.

3.10.5   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).

3.11   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).

> A Light Emitting Diode (LED) system could be employed to indicate seat availability. LEDs should be adjacent to the seat and visible from the vestibule.

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 (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).

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.

3.11.7   The seat reservation display 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 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).

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

3.12   Provision of Luggage Storage

Introduction

RSSB Guidance Note *GMGN2687 'Guidance on Rail Vehicle Interior Structure and Secondary Structural Elements'* gives some useful pointers for the design of luggage storage (I).

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. The report is available at (I):
http://www.rssb.co.uk/pages/research-catalogue/t1057.aspx

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

3.12.2   Luggage stacks or multi-purpose areas shall be provided 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.

3.12.3   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.

3.12.4   Where under-seat luggage stowage is required the space should be designed for an item up to 45cm x 36cm x 20cm (D).

Typically, a laptop size bag.

3.12.5   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.

3.12.6   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.

3.12.7   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.

3.12.8   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

Introduction

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).

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)

3.13.1   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.

3.13.2   To extend CET discharge periodicities, the fitting of bio-reactor waste technology should be considered (D).

3.13.3   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.

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3.13.4   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. |

3.14   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, 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, such as hypodermic needles, could be concealed, shall be avoided (E)

To avoid the associated risk of injury to passengers, maintenance and cleaning staff.

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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 knives etc (D).

This prevents seats being slashed and giving access to seat foam which could provide a fire source.

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.

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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.

Rail Delivery Group

National Rail
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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 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 here:
>
> https://www.sparkrail.org/Lists/Records_StaffMembers/DispForm.aspx?ID=738
>
> 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 can be found here:
>
> https://www.sparkrail.org/Lists/Records_StaffMembers/DispForm.aspx?ID=739

3.19   Buggy Space, Cycle Store or Multi-use Storage

3.19.1   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.

3.19.2   The buggy space should be close to nappy-change facilities (D).

3.19.3   Cycle racks should be located in close proximity to access doors, positioned on suitable flooring and make optimum use of available space (D).

3.19.4   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 in Appendix G.

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

3.20 Passenger power supplies

3.20.1 Power supplies should be provided for the charging of mobile electronic devices and be readily accessible to passengers and appropriately labelled. (D)

3.20.2 For a 230V power supply system the following shall be provided (B):

- Sockets compliant to '*BS 1363: 13A plugs, socket-outlets, adaptors and connection units. Specification for rewirable and non-rewirable 13A fused plugs'*.
- 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 inverter 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'*.

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.

3.20.3 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,* 70mA *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 reset and by whom.

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 splitting of supplies, to feed each side of the carriage separately

Rail Delivery Group

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> 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.

3.20.4   USB outlets for the charging of mobile electronic devices and be readily accessible to passengers should be provided where power constraints may limit 230 V supplies (D).

Mainly aimed at refurbishment of existing trains where spare power is limited.

3.20.5   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.

3.21   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.

3.23 Litter & Recycling Bins

3.23.1 Litter & recycling bins shall have a solid construction and be fitted with a self-closing device to enable the bin to contain a fire (B).

3.23.2 Where litter and recycling bins are provided, an assessment of their design and capacity 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.

3.23.3 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.

3.23.4 Internal fixings should avoid damaging plastic bin liners (D).

3.24 Provision of Handholds

3.24.1 Train interiors should be designed to maximise the provision of handholds / grab rails 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.

> For guidance on handholds and rails see the PRM TSI.
>
> Additional handholds could be the use of straps or poles as seen on metro systems.
>
> The double or triple grab poles in the vestibule of suburban and metro trains, make it much easier to stand in this area with a sensible hand hold, 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 Occasional-use seating should not be provided in vestibules (D).

The use of occasional-use seating in vestibule areas of metro and suburban services is not recommended due to the obstruction of other passengers so increasing 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).

Passengers have commented that they like such features. However, sometimes passengers have difficulty in accessing seats where full width tables are provided, so tapered or folding parts and no support leg improve this access.

Design features to achieve this may be:

- Folding or tapered tables.
- No support legs or support points positioned as close as possible to the vehicle bodyside (see section 3.11.1).
- Table access designed to accommodate a 95th percentile male (based on the latest anthropometric data available for the GB population).
- Table top at a height suitable to permit use of laptops or eating.

The current 95th percentile male seated thigh depth is currently 202 mm and therefore an additional margin will need to be added to this dimension to facilitate passenger access. In addition, if the table edge overlaps the leading edge of the seat this dimension should also be increased. *[Source PeopleSize Pro 2008].*

3.26.2   Fixed tables shall have a lip around the perimeter and a non-slip 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.

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.

3.27.2   Folding seat back tables shall have a lip around the perimeter and a non-slip 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.

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3.28 Coat Hooks

3.28.1 A coat hook should be provided at seat locations which is positioned to reduce pilfering (D).

Frees up luggage storage and keeps it in the vicinity of the passenger.

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.

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 at:

https://www.rssb.co.uk/pticontent/pti041-2015-01-platform-train-interface-strategy.pdf

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',*
- *'T1080: Understanding the influence of different platform edge step / gap arrangements on boarding and alighting accidents at the platform train interface'.*
- *'R370: Platforms and stepping'.*

Search on the RSSB website (www.rssb.co.uk) for more information.

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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

3.31   Wheelchair Ramp Design

Introduction

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 (I):

https://www.rssb.co.uk/pages/research-catalogue/pb001980.aspx
https://www.rssb.co.uk/pages/research-catalogue/pb001981.aspx

3.31.1   Doorways for wheelchair use should incorporate a deployable bridging plate (D).

A 'deployable bridging plate' could be a vehicle-based sliding step.

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3.31.2   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.

3.31.3   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.

3.31.4   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.

3.31.5   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 pushbutton 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.

3.31.6   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.

3.31.7   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.

3.31.8   The mass of the portable wheelchair ramp shall not exceed 12 kg (E).

The lower the mass the easier the ramp is to handle without injury, HSE recommendations for lifting should be followed.

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3.31.9   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.

3.31.10   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.

3.31.11   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.

3.31.12   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.

3.32 Mobility Scooter Access

Introduction

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 (I).

A link to the project is at:

http://www.rssb.co.uk/pages/research-catalogue/t1055.aspx

3.33   External Access Doors

3.33.1   Door systems shall be fitted with 'active anti-trap and drag' functionality 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.

Standards available are:

'BS EN 14752 Railway applications — Body side entrance systems for rolling stock'.

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   Lightweight access doors should be provided (D).

Faster acting doors with lower momentum could give shorter dwell times.

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   Recommendations 5 and 10 from RSSB research project T1102 should be considered in the design of door closure arrangements (D).

The recommendations are:

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.

Recommendation 10. Door close button - to control the risk associated with inadvertent operation of the door close button, the following should be implemented:

Fit shrouding around the door close button to prevent inadvertent operation, taking into account: passenger sight-lines to the 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).

Following activation of the close control, a slower / longer door close sequence might be appropriate (e.g. this could be the same as an updated arrangement for autoclosure).

The door close alarm should sound before the doors 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. A copy of the report can be found here:

https://www.sparkrail.org/Lists/Records_StaffMembers/DispForm.aspx?ID=855

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4 Key Requirements - Operational

4.1 Driver Controlled Operation (DCO)

4.1.1   Rolling stock shall 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 retrospectively fitted in a cost-effective manner if required.

> 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).
>
> DCO can also be used for empty stock moves*.*

4.1.2   Initial and future methods of operation and associated functionality shall be agreed with the specifier (E).

Door control panels for other on-board crew may need to be provided.

4.1.3   The DCO CCTV system (known as On-train Camera / Monitor System [OCMS]) shall provide compliant coverage of the doors and the dispatch corridor to monitors in the driving cab which shall display from door enable until the train has left the platform (E).

Live images from shore- or train-based CCTV are fed to screens in the cab to allow the driver to watch for safe dispatch as the train leaves.

4.1.4   It shall be possible for the Train Operator to select the point at which the screens in the cab switch off, on a time, speed, or distance basis (E).

This permits the screens to be left on until the risk associated with train dispatch has been met.

> RSSB Research project *'T1059: Evaluating the use of on-train driver only operation (passenger) monitors during station departures'* gives some useful background to this issue. The project brief can be seen here:
>
> https://www.rssb.co.uk/Pages/research-catalogue/T1059.aspx
>
> Some guidance is also given in Railway Industry Standard '*RIS-2703-RST - Rail Industry Standard for Driver Only Operated On-train Camera / Monitor Systems'* and the OPE TSI.

4.2 Selective Door Operation (SDO)

4.2.1 Vehicle level SDO operation shall be provided (or the provision made for subsequent inexpensive retrofit of SDO equipment, where this is initially not required) (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).

4.2.2 The SDO system shall not allow a member of traincrew to release the doors on the side of the train not adjacent to a platform i.e. provide correct side door enable functionality (E).

There are often instances of doors being released on the wrong side and this system will prevent this occurring.

4.2.3 Where active, the SDO system shall be able to mitigate the effects of a driver not stopping in the correct location along the platform (E).

There are often instances of doors being released when the whole train is not in the platform and this system will indicate to the traincrew that the train is stopped in the correct position or within the platform.

4.2.4 The SDO system should interface with the Passenger Information System (PIS) to provide sufficient notice to passengers of the side of the train of the next door release and from which vehicle / door to alight (D).

This enables passengers, where necessary, to move to doors for alighting, particularly when trains are heavily loaded. This allows more time to move to doors; so reducing dwell times and the risk of passengers being overcarried.

Note 1: Such information will have to be given in sufficient time to permit mobility impaired passengers to migrate to the correct doorways on the train.

Note 2: RSSB has developed the requirements for a national, vehicle based automatic SDO system utilising track mounted Radio-frequency identification (RFID) tags and on-board readers as a Railway Industry Standard *'RIS-2795-RST Rail Industry Standard for Track to Train RFID Compatibility'* available from the RSSB website.

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 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'*
- *PD CEN/TR 16823, 'Railway applications. Driver's cab. Background information on anthropometric data'*

The Loc & Pas TSI mentions that some ENs are being drafted, those listed above are the issued ones.

4.4.2   The design of driving cabs should incorporate a standard arrangement of key controls, for example (D):

- Traction
- Brakes
- Doors
- Couplers

Driver training requirements, together with the risk of driver error, are significantly increased if the layout of key controls and the way in which they operate vary significantly between different designs of train. As an example, a failure to standardise on the direction of movement (i.e. forwards or backwards) for the traction / braking functions of a combined power / brake controller may create significant difficulties.

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 pushbuttons with their bags, etc.

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4.4.4   Driving cabs shall be designed to comfortably accommodate a 5th percentile UK female to a 95th percentile UK male (based on the latest anthropometric data available for the GB population) (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 satisfactorily to accommodate both the 5th percentile female and the 95th percentile male. Combined with the adjustable driver's seat and in order to maintain sight-lines the pedal should be adjustable for height. One method is to use a two height plate (known as a 'shoebox') as shown in Figure 4.4.4.
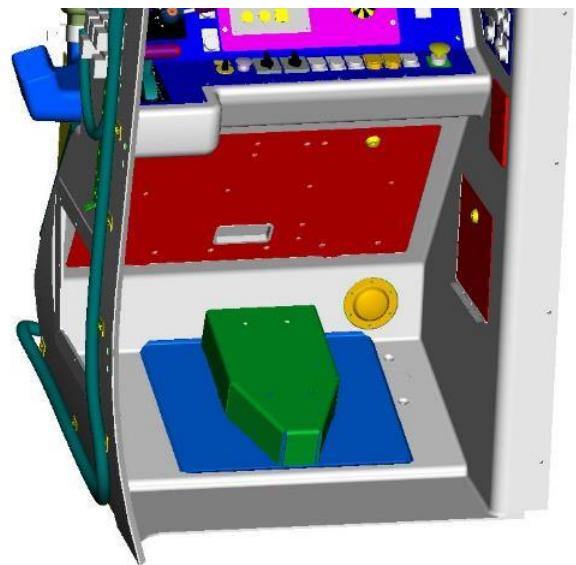
A. DSD 'Shoebox'   B. DSD 'Shoebox' in position
Figure 4.4.4: Example of DSD 'Shoebox'

4.4.5   Driving cabs shall be designed to ensure drivers are protected against Musculoskeletal disorders (MSDs) (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.

RSSB has developed an assessment method for MSD, as detailed in Project *'T940: Development of a tool to assess and manage musculoskeletal disorder risk in train drivers'.* Details of this project can be found at:
http://www.rssb.co.uk/library/research-development-and-innovation/research-brief-t940.pdf

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

4.4.6   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

4.4.7   In-cab display equipment (computer screens and all other cab controls, indicators and instruments) shall be legible in all lighting conditions (including darkness and direct sunlight), with adjustable brightness functionality to cater for the range of lighting conditions experienced (E).

4.4.8   A manual override of the automatic brightness levels should also be provided (D).

There have been numerous problems in the past whereby indications in the cab have either been too bright, so affecting driver vision in darkness, or unable to be seen in bright sunshine. The use of screens has also introduced problems of sunlight reflecting off the screen, preventing its display from being seen. A manual override allows drivers to choose the brightness level particularly at night.

Note 1:   RSSB Project '*T906: ERTMS/ETCS driver/machine interface options for future train cab design*' provides guidance on some of these aspects - details of this project can be found at:

http://www.rssb.co.uk/library/research-development-and-innovation/research-brief-t906.pdf

Note 2:   A potential enhancement would be for the brightness of cab display equipment to automatically adjust to the ambient light level e.g. day / night / tunnels etc.

4.4.9   Driving cabs shall be operationally ready, i.e. ready for the train to be driven at turn-round, following the driver activating a cab by inserting a master key, within two minutes (E).

4.4.10   Driving cabs should be operationally ready, i.e. ready for the train to be driven at turn-round, following the driver activating a cab by inserting a master key, within one minute (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.

Rail Delivery Group

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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, 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 3.20.2, 3.20.3 and 3.20.5.

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, buttons or levers shall be of sufficient height to be comfortably used by a 5th percentile female and a 95th percentile male (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.

4.4.21   The driver shall be able to judge the stopping position of the train at the platform (E).

The use of dispatch cameras and platform humps for wheelchair access requires more accurate stopping positions.

> An approach previously adopted to assist with this has been provision of a cab side window.
>
> RSSB are proposing a Project '*17-003 Design and Position of Car Stop Markers'*. which will include the ability to see stop markers.

4.4.22   The designs for pictograms used in cabs shall, as far as is practicable, adopt those provided in RSSB research project '*T1076: Standardising pictograms in train cabs'* (E)*.*

To assist drivers in using controls in a range of different trains by making signage as standardised as possible.

> RSSB research project '*T1076: Standardising pictograms in train cabs'* project report can be found here:
> https://www.sparkrail.org/Lists/Records/DispForm.aspx?ID=24178

Rail Delivery Group

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4.4.23   Windscreens should be designed to ensure that ghosting, or secondary images are not seen by the driver (D).

This could be reflections at night or day.

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   Supply System Changeovers

4.6.1   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 or on the move (D).

Much time can be wasted, when stationary, during these changeovers. Therefore, 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.

4.6.2   For trains that are multi-mode (i.e. able to work from an electrification system or be self-powered) it shall be possible for the changeover between modes to be made, including pantograph / shoegear raising / lowering where applicable, whilst the train is operating at normal line 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 creates an unacceptable impact on performance.

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 effort to amend (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, with night vision capability and image quality sufficient to support the investigation of incidents, shall be fitted to all rolling stock (E).

The availability of good quality images from forward facing CCTV cameras has been highlighted by the Rail Accident Investigation Branch (RAIB) as a vital source of evidence when investigating accidents and incidents. It can also provide key evidence to the British Transport Police (BTP) in enabling fatalities to be confirmed as not suspicious, enabling services to be resumed more quickly.

'*GMGN2606: Guidance on the Fitment of Forward and Rear Facing Cameras to Rolling Stock*' should be considered and a copy of the document can be found at:

http://www.rssb.co.uk/rgs/standards/GMGN2606%20Iss%201.pdf

4.8.2 In-cab CCTV

4.8.2.1 Rolling stock should be designed to facilitate the inexpensive retrofit of in-cab CCTV cameras (D).

The CCTV footage from these in-cab cameras would be used in the event of an incident to determine the actions of the driver and therefore the proposed camera mounting positions should facilitate this. The images should be synchronised with forward-facing CCTV and On Train Data Recorders.

> 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:   A RSSB research project *'T1100: Exploring the use of in-cab CCTV in the rail industry'* has completed. The research brief on Spark is provided here: https://www.sparkrail.org/Lists/Records_StaffMembers/DispForm.aspx?ID=810
>
> And the report here: https://www.sparkrail.org/Lists/Records_StaffMembers/DispForm.aspx?ID=840

4.8.3 Pantograph cameras

4.8.3.1 Pantograph cameras shall be provided (E).

These provide useful data on the overhead line and on the pantograph performance, as well as for incident investigations.

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).

Rail Delivery Group

National Rail
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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.
>
> There is some best practice around ensuring we use scratch proof coatings, that the glass sits flush / slightly above the surroundings to aid cleanability, etc.

4.8.4 Remote Access to Images

4.8.4.1 CCTV images should be remotely accessible on demand (D).

Experience has shown that having immediate access to images can offer significant benefits in enabling earlier resumption of services following incidents.

4.8.5 Disk Space & Bandwidth

4.8.5.1 Where CCTV is fitted, the system design in terms of the amount of data storage space, bandwidth and data retention time shall take account of operator requirements (E).

4.9 Emergency Equipment

4.9.1 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/6366 26/R112017_170810_Watford.pdf

Rail Delivery Group

National Rail

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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   Driver manuals, training, simulation and aids for training to the remit in the proposed RDG guidance note shall be provided (E).

This is part of the industry drive for consistency in driving manuals and training materials linked to the Driver Academy Program.

> Note: The RDG guidance note is being drafted and will be issued in due course.
>
> Request a copy via the email address on page 1.

Rail Delivery Group

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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.

> 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].
>
> https://www.rssb.co.uk/Library/improving-industry-performance/2016-02-cyber-security-rail-cyber-security-guidance-to-industry.pdf
>
> RDG has also published a '*Rail Cyber Security Strategy 2017'*, which can be found here:
>
> https://www.raildeliverygroup.com/about-us/publications.html?task=file.download&id=469772253

5.1.2   Where vulnerable onboard systems need to be in passenger areas, the covers shall be fitted with interlocks that advise the TCMS if tampered with. Alternatively, high-quality locks shall be used to prevent unauthorised access (E).

This will alert the driver to possible unauthorised entry but won't stop the train.

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.

5.2   Open Source Software

5.2.1   Open Source Software (OSS) should be used for non-safety critical systems that collect, process or store data. A list of these systems is to be provided (D).

This allows more chance of making changes once the warranty period has ended or the systems stop being supported by the OEM.

> More information relating to OSS is contained in the RSSB Knowledge Search Report '*S179: Open source software*' which can be found at:
>
> http://www.sparkrail.org/Lists/Records/DispForm.aspx?ID=14717

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

5.3 European Rail Traffic Management System (ERTMS) / European Train Control System (ETCS)

Appendix I gives further information on fitment of ETCS in the UK (I)

5.3.1 ERTMS / ETCS equipment on rolling stock being designed to operate on routes where ERTMS is planned to become operational (as per an agreed and published Industry ERTMS Programme) within five years of service introduction should be installed (D).

5.3.2 For all other rolling stock, provision should be made for inexpensive retrofit of ERTMS / ETCS equipment (D).

Fitting ERTMS even if it is not to be immediately used has been found to be more cost-effective in the long-run.

In this context 'inexpensive' means that the design has made the provision for the fitment of equipment by the designer purposely allocating free space for internal equipment such as the Driver Machine Interface (DMI) and European Vital Computer (EVC); external equipment such as the Doppler Radar and Balise Reader; together with; power supply requirements and consideration of cabling to the relevant location(s).

5.3.3 The on-board system of ERTMS / ETCS shall comply with the following:

- '*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

unless otherwise specified (E).

The latest ERTMS / ETCS baseline and release version is currently Baseline 3 Release 2.

5.3.4 The on-board system of ERTMS / ETCS shall also be fully compatible with the Infrastructure on the specified routes (E).

Rail Delivery Group

National Rail

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5.3.5   Change Requests (CRs) appropriate to the on-board equipment and infrastructure shall be declared by the train manufacturer (E).

Change Requests indicate the backwards compatibility between earlier versions of ERTMS.

> RSSB's website includes information on ERTMS / ETCS here:
>
> https://www.rssb.co.uk/improving-industry-performance/ertms
>
> And on Change Requests at the European Commission website here:
>
> https://ec.europa.eu/transport/modes/ertms-change-control-management-ertms-technical-requirements_en

5.4   Automatic Train Operation (ATO)

5.4.1   The train shall be capable of ATO 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.

> GOA = Grades of Automation, see UITP.org website for more information.
>
> RSSB's website includes information on ATO here:
>
> https://www.rssb.co.uk/improving-industry-performance/ertms
>
> The relevant document is:
>
> https://www.rssb.co.uk/Library/improving-industry-performance/ATO%20-%20GB-New-Train-On-Board-Subsystems-Requirements-Specification-STE_ATO_REQ_001-Issue-1.pdf?web=1

5.5   Remote Condition Monitoring (RCM) Systems – Train-based

Introduction

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   The train manufacturer shall provide a list of RCM systems available and their benefits (E).

Rail Delivery Group

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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).

Rail Delivery Group

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5.6.4   Prognostic systems, which can / will predict and warn of pending failure should be provided (D).

5.7   Train Monitoring Infrastructure

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 with the Infrastructure Manager in order to establish the business case for the optimum condition monitoring solutions required for a fleet of trains.

5.7.2   All on-board monitoring equipment possibilities shall be discussed with the Infrastructure Manager (E)

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 at:
>
> http://www.rssb.co.uk/library/research-development-and-innovation/research-brief-t857.pdf
>
> Note 2:   Also information for RSSB research '*T1010: Cross-industry remote condition monitoring programme'* can be found at:
>
> https://www.sparkrail.org/pages/libraryresults.aspx?k=t1010

5.8   Remote Condition Monitoring (RCM) Systems - Infrastructure Based

Introduction

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).

5.8.1   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).

5.8.2   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).

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

5.9 Automatic Vehicle Identification (AVI)

5.9.1 Radio-frequency identification (RFID) Automatic Vehicle Identification (AVI) tags shall be fitted to all relevant 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. 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 & EN documents is often unachievable on GB rolling stock.

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

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).

> It is recommended that the outputs of RSSB Project *'T964: Operational Communications'* are used to inform any decisions with regards to the provision of on-board Wi-Fi services on rolling stock. Of particular relevance is the *'Rail Mobile Communications Service Handbook'* that the project produced and can be found at:
>
> http://www.rssb.co.uk/library/research-development-and-innovation/research-brief-t964.pdf

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*'.
>
> https://www.rssb.co.uk/rgs/standards/ris-0700-ccs%20iss%201.pdf

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

5.12 On Train Data Recorders (OTDR)

5.12.1. In addition to the requirements in '*GMRT2472 Requirements for Data Recorders on Trains*' the following functionality shall be provided by the OTDR (E):

- In-built GPS time stamp.
- In-built GPS location stamp.
- Open interface standard for OTDR data. No proprietary decryption software should be permitted.
- Spare channel capacity provision.
- Ability to change the sampling rate of individual channels.
- Ability to change the activation thresholds of individual channels.
- OTDR vehicle connector should be designed to facilitate access for wiring changes etc.
- OTDR to be designed to also perform the role of ERTMS Juridical Recorder Unit (in terms of ERTMS functionality).

GMRT2472 Issue 1 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. They are listed here as useful additions.

> *'GMRT2472 Requirements for Data Recorders on Trains'* can be found on the RSSB Standards website.
>
> *'BS EN 62625-1: Electronic railway equipment - On board driving data recording system – Part 1: System specification'*, is available from BSI.

5.12.2   Functionality to remotely access OTDR data should be provided (D).

5.13 Global System for Mobile Communications – Railway (GSM-R) - Voice

Introduction

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).

GSM-R is used in two ways: for voice communications and for data transmission for ETCS. This section is for voice (I).

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)

5.13.1 Voice Radio

5.13.1.1 The GSM-R voice radio:

- 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 should be compliant to RIS-0794-CCS.
- needs be authorised for use in the UK (E).

Currently the Siemens Nexus Version 4 is the only fixed installation cab mobile radio authorised for use in the UK, operating with Version 4 software and containing a new 4G - resistant radio module and is modified to receive (Global Navigation Satellite System) GNSS data (for GPS).

5.13.1.2 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.

5.13.1.3 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.

5.13.1.4 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).

5.13.1.5 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).

5.13.2 Cab Equipment

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 buttons and switches (I).

The handset, including a speaker, microphone and Press-To-Talk (PTT) button, sits in a fixed cradle (I).

5.13.2.1 The Textual DCP should be located within reach of the driver whilst driving (D).

5.13.2.2 The handset and cradle should be located within reach of the driver whilst driving (D).

5.13.2.3 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 as its optimum.

Although Safety relevant acoustic signals are defined within LocPas 4.2.9.3.4 (6), it is a good idea to ensure the loudspeaker is suitably positioned.

5.13.2.4 All components used by the Driver should be subject to a Human Factors assessment to determine the correct location within the Driving Cab (D).

5.13.2.5 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

5.13.2.6 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 Pushbutton. These are specially designed components supplied as accessories for DCP.

Option 1 is a raised shroud which fits around the existing inset 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 button, this requires a double action to operate the REC button.

5.13.3 Roof-mounted Antenna

5.13.3.1 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.

5.13.3.2 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.

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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.

5.13.4   Additional Opportunities

5.13.4.1   Depending on the application, it may be desirable to implement the option for an Uninterruptable Power Supply (UPS), which has its own battery to maintain power in case the normal power supply is interrupted (D).

This can have a high maintenance cost and is not considered essential.

5.13.4.2   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.

5.13.4.3   Hardware separation between existing cab radio functionality and the new Nexus Wi-Fi module has been provided to improve cab radio cyber security (I).

5.13.4.4   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:
>
> https://new.siemens.com/uk/en/company/topic-areas/intelligent-infrastructure/digital-railway.html
>
> https://w3.siemens.co.uk/mobility/uk/en/rail_solutions/rail_automation/news/pages/network-rail-to-trial-nexus-voice-cab-radio.aspx

5.13.5 Further Information

5.13.5.1 For further information on the existing system, RSSB's website includes a page on GSM-R here (I):

https://www.rssb.co.uk/improving-industry-performance/gsm-r

5.13.5.2 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

Introduction

GSM-R is used in two ways: for voice communications and for data transmission for ETCS. This section is for data (I).

5.14.1 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 following specification (E).

http://www.era.europa.eu/Document-Register/Documents/SRS-16.0.0%20UIC%20951-0.0.2.pdf

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5.15   Future Railway Mobile Communications System (FRMCS)

5.15.1   Space provision shall 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 (E).

This will reduce the risk of more expensive retrofitting activities.

Note1:	The 2019 version of the TSI will expect 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.
Note3:	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:

- Floor level emergency lighting – preference is for passengers to remain inside vehicle
- Additional tactile / braille signage on labels and controls
- UNIFE TecRecs – status unclear
- Wheelchair restraints – not liked by users
- Driverless trains – too advanced at present, though in RTS Portfolio
- Standard measure of rolling stock efficiency – awaiting standards and research
- Maintenance requirements and downtimes – too specific
- Heated 750V DC shoegear – awaiting updates from manufacturers
- SMART technology for coupling – future part of Research Project T1137 or RTS Portfolio
- Resistance to terrorist attacks - awaiting government guidance
- Seat layouts and arrangements including provision of 3 + 2 seating – business decision
- New weather categories – awaiting new guide from Network Rail
- Cab 'not-to-couple' sign – operations issue
- Monitoring the Platform / train interface – awaiting further update of PTI Strategy
- Darkness operated headlights – needs more development
- Sleeper train design – awaiting information
- Train floor height, door widths, steps – awaiting RSSB research outputs

Appendix B – List of research and innovation sources and useful information

Listed below are useful links to research and innovation programmes currently taking place in Britain and continental Europe. And 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/	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 2012 http://www.rssb.co.uk/library/future%20railway/innovation-in-rail-rail-technical-strategy-2012.pdf Solutions Catalogue http://www.rssb.co.uk/Library/research-development-and-innovation/rail-technical-strategy-solutions-catalogue.pdf ReFocus 20 point plan https://www.raildeliverygroup.com/files/Publications/engportal/TheTwentyPointPlan/20PPIssue13.pdf

Other sources of information

NIR online* https://www.nir-online.net/NIROnline SPARK* https://www.sparkrail.org (* Requires a login) Network Rail https://www.networkrail.co.uk/who-we-are/publications-resources/	RAIB https://www.gov.uk/government/organisations/rail-accident-investigation-branch RSSB http://www.rssb.co.uk Rail Delivery Group https://www.raildeliverygroup.com/about-us/publications.html

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Appendix C - Toilet design requirements

Introduction

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.

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'.

> 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 the 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.*

> Available from BSI.

- *Persons with Reduced Mobility TSI. Commission Regulation (EU) No. 1300/2014 (PRM TSI)*

> Available to download here:
>
> http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R1300&from=EN

Note: Where there is any conflict between items listed below and requirements contained within mandatory Standards or legislation, then the law takes precedence.

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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 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 for Soap / Water / Hand Dryer shall be obvious and clearly identified; e.g. by using a light beam (E).

Many dispense and outlet points are in non-intuitive positions leading to passenger frustration.

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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' 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 buttons.

C.2.2.5   Controls outside the toilet shall have 'Open' and 'Close' 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, suggest an arrangement that should be considered for new designs.
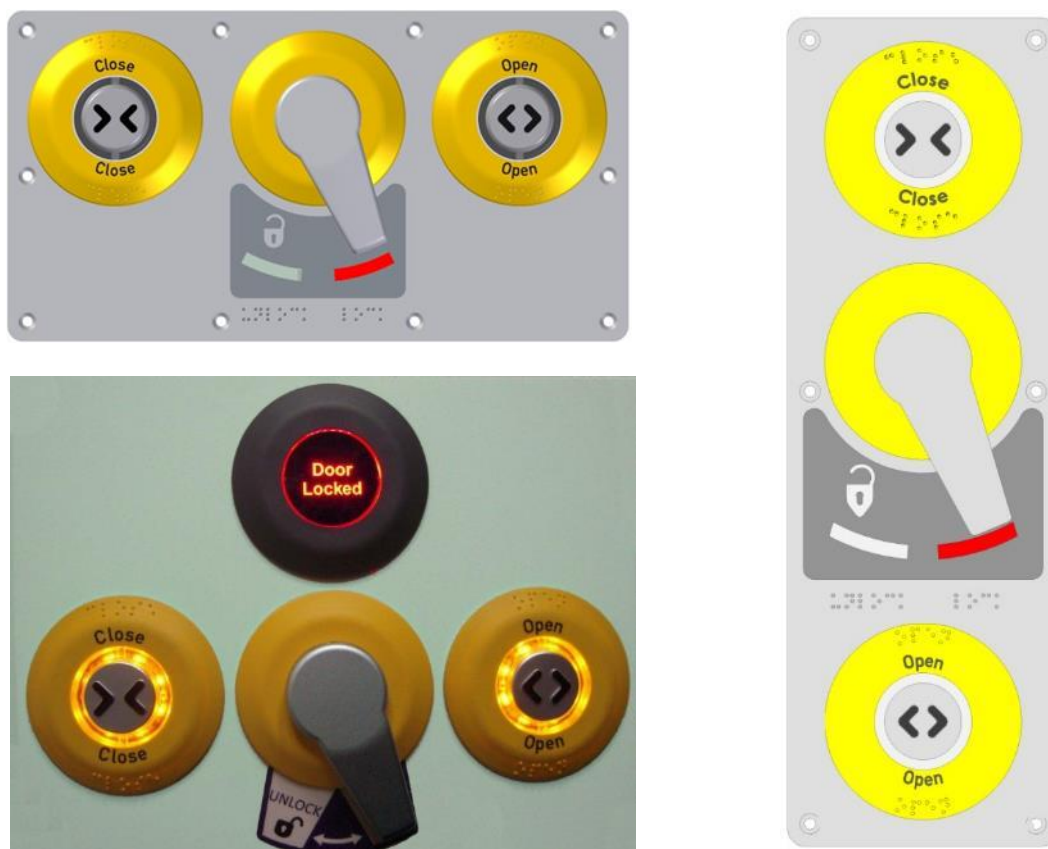
Figure C.2.2.8 – Suggested methods for common locking of powered toilet doors

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.

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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.4.1   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.

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. And washing 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 shall be given to hand washing facilities over toilet flushing (E).

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C.4.10 The toilet system shall 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 (E).

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).

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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):

- o all joints are easily accessible
- o any leakage does not affect electrical equipment
- o accumulation of water does not cause structural corrosion
- o 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　Toilet Tissue Dispensing

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   Where a nappy changing table is provided a hook to hold nappy bags should be available (D).

C.8.2   A dispenser for sanitary waste bags should be provided in all toilets (D).

C.8.3   A waste bin adjacent to the toilet bowl shall be provided for sanitary items and nappies in all toilet cubicles (E).

C.8.4   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.8.5   In a universally accessible toilet cubicle, hooks for coats and bags should be placed at heights to accommodate a range of users (D).

C.8.6   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.8.7   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.

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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 areas

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, 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.

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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).

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.

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:

  o Information requests and server responses

  o Successful and unsuccessful authentication and access attempts

  o Account changes

  o Use of privileged accounts

  o Application start-up and shutdown

  o Application failures

  o 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 or / 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.

- Information as to the country (or countries) of origin of the procured product and its components (including hardware, software, and firmware) and furthermore should identify the countries where the development, manufacturing, maintenance, and service for the product are provided. Prior agreement from the purchaser before making any change to such arrangements should be sought.

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.

- o Work with purchasers to identify and mitigate the risk from the exploitation of all such product vulnerabilities.

- o 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:

  - o System name / function
  - o Hardware make and model
  - o Operating system(s)
  - o Operating system version(s)
  - o Major software components
  - o Software version including patch level(s)
  - o Systems interfaces
  - o 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.

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,*
- etc,
- 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 preferred strength grade. Property class 12.9 fasteners should not normally be specified due to concerns about internal and environmental hydrogen embrittlement.

E.4   Due to the effect on the thread dimensions to accommodate the coating thickness and the subsequent risk this has on thread stripping, fasteners with a galvanised coating should be avoided. Coatings should be able to be accommodated within the standard thread tolerance classes (6g for bolt threads and 6H for nut or internal threads). The finish used on the fastener should be appropriate for the application considering the corrosion resistance required.

E.5   The preferred tightening approach is torque tightening, that is, tightening the fastener to a specified torque value. Torque-angle and other tightening approaches can be considered but only after due regard is given to increasing the size and / or number of fasteners in the assembly to allow the torque tightening approach to be used.

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 in 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   Bracketry supporting particularly heavy equipment such as engines, transformers, fuel tanks etc., with a high consequence if detachment occurs should incorporate tethering or interlocking features, that will provide secondary retention in the event of fastener failure.

Appendix F – Monitoring Infrastructure from the Train

F.1 Document purpose

This appendix summarises Network Rail's HQ and routes' aspirational requirements for the inclusion of infrastructure monitoring equipment on passenger rolling stock.

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 Safety, Technical and Engineering directorate. The primary contact is Kevin Hope, Principal Engineer [Mobile Monitoring] - kevin.hope@networkrail.co.uk

F.4 Requirements

Key: IM items in a solid box are considered a 'must have' by Network Rail.

IM items in a dotted box shall have the business case for fitment assessed and agreed between the route and the train operator. Fitment of dotted box items may supersede solid boxed items where the capability provided is over and above the solid boxed 'must have' item.

F.4.1 Track

IM 001 Vehicle ride measurement is required. Ride measurement systems are generally mounted (rigidly) inside the vehicle and consist of tri-axial accelerometers, possibly enhanced with gyroscopes. This data, combined with appropriate analytics, could be beneficial in reducing Emergency Speed Restrictions due to driver reported rough rides and unexpected track geometry faults. It may also be possible to eventually use these outputs to verify that remedial work has been successful.

IM 002 Tri-axial axlebox accelerometers with an appropriate frequency response are required.

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.

IM 004 An enhanced Track Geometry measurement system capable of measuring full rail profiles (field and gauge side) in plain line and profiles within S&C should be considered.

F4.2 Electrification & Plant

IM 005 The measurement of the current collection performance of pantographs on electric trains powered by OLE is a requirement of the Energy TSI (for infrastructure built post-TSI introduction). It is also a requirement of Network Rail standard *NR/L2/ELP/27325 Train Borne Monitoring of Traction Power Contact Systems*.

IM 006 A pantograph camera at each pantograph position is requested with appropriate illumination of the pantograph / OLE to ensure acceptable image quality. Camera specification should be agreed during the vehicle specification phase.

IM 007 Consideration should be given to the fitment of TSI and NR compliant OLE measurement equipment to the pantographs of electric vehicles travelling at speeds of 100mph or less.

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 could be beneficial in determining wire condition and wire wear.

IM 009 The ability to easily 'hot swap' different types of pantograph cameras e.g. High Definition, thermal, UV corona would be beneficial.

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.

IM 011 For electric vehicles powered from conductor rails consideration should be given to the measurement of the interaction between conductor rail and shoegear.

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

F4.3   Video, imaging and survey

IM 012 Forward / rearward facing video capability is required, with appropriate illumination to ensure acceptable image quality from the cameras.

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).

IM 014 Forward / rearward facing thermal imaging cameras should be considered.

IM 015 A rail / fastener / sleeper imaging system (with suitable illumination) should be considered, potentially as an enhancement of the vehicle ride measurement system (IM 001) and / or track geometry system (IM 003).

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).

F4.4   Signalling & Telecoms

IM 017 The ability to monitor lineside communication signal strength e.g. GSM-R (voice and data) is required.

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.

F4.5   General requirements

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.

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):

- Velocity input (speed and direction)
- Train information e.g. vehicle number
- Operating information e.g. train headcode
- Locational 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

Rail Delivery Group

National Rail   BRITAIN RUNS ON RAIL

– Details of direction of travel from tachometer polarity source if used.

IM 020 Provision shall 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.

IM 021 A means of transmitting 'alert data' from train to shore whilst the train is in operation is required.

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 is required.

IM 023 A means of remotely accessing measurement systems is required to monitor performance and diagnose / resolve system faults.

IM 024 In order to facilitate greater exploitation of asset data all measurements shall be made available in an open source format rather than a Supplier's proprietary format.

> 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 is currently underway to develop a proof of concept for this approach to cross-industry data sharing under RSSB work package '*R685 - RCM Implementation*', now known as '*IMP-RCM-01 Cross Industry Remote Condition Monitoring Pilots*'.

IM 025 All measurement systems shall be specified such that system maintenance activities are aligned to routine vehicle maintenance intervals.

IM 026 The ability to accommodate modular measurement systems would be advantageous e.g. systems which can be attached to standard vehicle couplers.

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.

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.

Appendix G - Useful information and research projects

RSSB tools and models

A list of useful tools and models can be found here:

https://www.rssb.co.uk/about-rssb/products-services/tools-models

Electrical and Data Control Compatibility between Trains

RSSB have commenced 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 brief can be found at:

http://www.rssb.co.uk/library/research-development-and-innovation/research-brief-t1034.pdf

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:

http://www.rssb.co.uk/library/research-development-and-innovation/research-brief-t692.pdf

Track Circuit Actuators / Assisters (TCA) Risk tool

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 enquirydesk@rssb.co.uk.

Antenna 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*'.

There is a supporting web page and video here:

https://www.rssb.co.uk/Pages/depots-a-new-design-guidance-note.aspx

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.rssb.co.uk/horizonscanningcontent/s221-sensor-technology-v1.0.pdf

Eurospec documents

Current published EuroSpecs are:

- Toilet v2.0
- HVAC v 2.0
- Documentation 1 v2.0
- Requirements Management 1 v2.0
- Pantograph contact strips
- Wheel and brake disc

- Sliding steps v1.1
- Automatic coupler

Eurospec documents in production:

- Toilet v3.0
- HVAC v3.0
- Sliding steps v2.0
- Seat comfort
- Global comfort evaluation
- LCC Approach
- Doors
- Train parking noise
- Updating software on trains
- TCMS MMI
- Common requirements (Trivial IDs)
- Watertightness test for a trainset
- Alternative energy supplies

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:

http://cordis.europa.eu/publication/rcn/13162_en.html

http://uic.org/cdrom/2006/wcrr2006/pdf/529.pdf

Appendix H – Suggestions for Automating train preparation (TP)

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) monitor multiple systems on the train, such as the train consist and the status of doors, brake systems etc.

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 siting 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:

a. Braking System Requirements

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

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

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

The TCMS displays the passenger door status i.e. released, open, closed, locked, SDO disabled etc.

e. Air Suspension

The TCMS displays air suspension status e.g. isolated, inflated or deflated.

f. Train Protection Systems, including AWS & TPWS

The TCMS reports the status of the train protection systems e.g. fault or isolated.

g. **DSD Vigilance**

The TCMS reports the status of the DSD / Vigilance e.g. fault or isolated.

h. **Emergency Bypass Switch (EBS)**

The TCMS reports the status of the EBS e.g. operated.

i. **On Train Data Recorders**

The TCMS reports the status of the OTDR e.g. fault or healthy.

j. **Toilets**

There is a legal requirement that 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 Actuators (TCA)**

The TCMS reports the status of the TCA e.g. fault or isolated.

l. **Safety system isolation**

The TCMS reports the status of the safety system, e.g. TIS, has been operated or isolated.

m. **Wheel Slide Protection**

The TCMS reports the status of the WSP e.g. fault or isolated on the TMS.

n. **Fire Systems**

The status of Fire Systems should be reported on the TCMS e.g. pressure or fault etc.

o. **Pantographs**

Can be checked by the AVIS system.

Appendix I – Additional information on ERTMS / ETCS fitment

A number of strategies exist for fitting ETCS equipment to rolling stock and these are covered by:

- *RIS-0797-CCS Iss1. ERTMS/ETCS. Baseline 3 Onboard Sub-System Requirements: Retrofit EOSS*
- *RIS-0798-CCS Iss1. ERTMS/ETCS. Baseline 3 Onboard Sub-System Requirements: New Trains*
- DR Requirements*: ETCS Baseline 3 GB ETCS Ready Onboard Subsystem Requirements*

Although the functionality of an ETCS fitted train is expected to be similar from an operational perspective, the ETCS onboard systems are all proprietary systems with the same base components but packaged in a different supplier form and with different interfaces / inter-wiring. This is a major factor to be considered in fitment strategies.

The alignment of the above documents to possible fitment strategies are explained in the following table:

Fitment Strategy	Requirement
Existing rolling stock to be fully fitted	*RIS-0797-CCS Iss1. ERTMS/ETCS. Baseline 3 Onboard Sub-System Requirements: Retrofit*
New rolling stock to be fully fitted	*RIS-0798-CCS Iss1. ERTMS/ETCS. Baseline 3 Onboard Sub-System Requirements: New Trains*
Existing rolling stock to be totally pre-wired with later fitment achieved by plugging in system components.	*RIS-0797-CCS Iss1. ERTMS/ETCS. Baseline 3 Onboard Sub-System Requirements: Retrofit* Supplemented with a contract instruction to only pre-fit all wiring to allow full functionality being achieved at a later day by 'plugging in equipment' such that it minimises fitment costs/time at the time full functionality is required. RIS-0797-CCS Iss1 *provides the final functionality required as this strategy requires the ETCS system supplier to be identified at the design stage and the instruction highlights the need for a partial fitment approach. It is highly recommended that First in Class testing and partial authorisation is considered with this approach minimising the risk of fleet modifications at the time of enactment of full functionality.*

Fitment Strategy	Requirement
New rolling stock to be totally pre-wired with later fitment achieved by plugging in system components	*RIS-0798-CCS Iss1. ERTMS/ETCS. Baseline 3 Onboard Sub-System Requirements: New Trains.* Supplemented with a contract instruction to only pre-fit all wiring to allow full functionality being achieved at a later date by 'plugging in equipment' such that it minimises fitment costs/time at the time full functionality is required. RIS-0798-CCS Iss1 *provides the final functionality required as this strategy requires the ETCS system supplier to be identified at the design stage and the instruction highlights the need for a partial fitment approach. It is highly recommended that First in Class testing and partial authorisation is considered with this approach minimising the risk of fleet modifications at the time of enactment of full functionality.*
New or Existing Rolling Stock to be partially wired allowing later choice of ETCS supplier	*ETCS Baseline 3 GB ETCS Ready Onboard Subsystem Requirements* [1]. This specifies the expected rolling stock functionality such that ETCS train functionality including power and interface wiring can be pre-fitted. It also specifies space and cable duct provision to allow any of the current supplier's equipment to be installed at a later date according to the Requirements of the *RIS-0797-CCS Iss1. ERTMS/ETCS. Baseline 3 Onboard Sub-System Requirements: Retrofit* [1] – Document can be located at the following link: https://www.rssb.co.uk/Library/improving-industry-performance/GB%20ETCS-Ready-Onboard-Sub-system-Requirements-Specification.pdf

Unless otherwise advised by, for example, the franchising or other funding authority, the intent is for the Sponsor to require full fitment at new build as the default position, unless it can be demonstrated by, for example, the rolling stock supplier, that an alternative strategy minimises the whole life cost of procuring, operating and maintaining the rolling stock.

The main difference between fully pre-wired and partial pre-wired is the capability of the partial pre-wired to avoid 'ETCS Supplier lock-in', however this option requires space provision larger than any supplier equipment (they all have different shape and sizes) and there will be design and greater integration risks at the time when the full fitment is enacted.

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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	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	
C-DAS	Connected Driver Advisory System	
CEN	European Committee for Standardisation	Standards
CET	Controlled Emission Toilet	
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	
DMI	Driver Machine Interface	
DOO	Driver Only Operation	See DCO
DPI	Delay Per Incident	
DSD	Driver Safety Device	
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 Norm	Standards
ENTOSS	ETCS New Trains Onboard Sub-System	
EOSS	ETCS Onboard Requirements Sub-system Specification	
ERTMS	European Rail Traffic Management System	
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 GPS.
GNSS	Global Navigation Satellite System	
GOA	Grades of Automation	

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Term	Definition	Context
GPRS	General Packet Radio Service	Known as 2.5G
GPS	Global Positioning by Satellite	
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
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	
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	
NIR	National Incident Reports	
NR	Network Rail	
NRSP	National Rail Security Programme	
NRT	Network Rail Telecom	
NTP	Network Time Protocol	
NTR	National Technical Rule	
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	
RAIB	Rail Accident Investigation Branch	
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	

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Term	Definition	Context
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	
TCA	Track Circuit Actuator	
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
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	
UPS	Uninterruptable Power Supply	
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	
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 4.4.4   London Midland trains

Figure C.2.2.8   ATOC

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