HS2

Train Technical Specification

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1 Introduction

1.0.1 This Train Technical Specification (TTS) contains the technical requirements for the 'conventional compatible' Units being procured as part of the High Speed 2 Project. The Units will include on-board control-command and signalling (CCS) equipment, including on-board Automatic Train Operation (ATO) as part of their scope. The scope of the TTS also includes the Wayside Data System, which enables Train Data to be downloaded from and uploaded to the Unit as well as being stored, interrogated and communicated to and from other systems.

1.0.2 A single design of Unit is required that is capable of operating at the line speeds of both the HS2 Network and existing UK Main Line Network.

1.0.3 In preparing this specification, interfaces have been defined between the Unit and:

- the HS2 Network, including infrastructure, stations, energy supply systems and wayside signalling and communications systems;
- the UK Main Line Network and specifically the routes of this network over which HS2 services will operate - the Conventional Rail Network (CRN);
- other rolling stock operating on the CRN;
- staff working on-board the Unit or on the wider railway;
- passengers on HS2 services; and
- neighbours of the HS2 Network and CRN.

1.0.4 As far as possible, the interfaces with the Unit have been specified in terms of performance and functionality, rather than specifying the inner working of the Unit or specific design solutions.

1.1 Document structure and content

1.1.1 This document has the following sections:

- **2 - Abbreviations, definitions and defined terms.**
- **3 - Strategic goals and objectives** - sets out the high-level goals for the Unit's design.
- **4 - Operational duty** - provides high-level information about how and where the Unit will be operated. This section is supported by the Data Book[116], which details information about the HS2 Network and the CRN.
- **5 - Unit and Train formation** - defines key parameters about the length and layout of the Unit.
- **6 - Relevant Approvals -** sets out the top-level technical requirements from railway regulations under which the Units will be introduced. The regulations define the

applicable standards and hence a significant proportion of the total requirements for the Unit. Repetition of these requirements through the remainder of the specification, has been avoided, except where clarifications are required.

- **7 - Performance -** sets out the requirements for the performance of the Unit, which influences the capacity and capability of the Unit systems and defines the mechanical and electrical interfaces with the railway.
- **8 - Protection and driving** - sets out requirements for control-command and signalling systems and driving, including European Train Control System (ETCS) and ATO.
- **9 - Functionality and systems -** sets out requirements for how all other systems on-board the Unit should function, and how they should integrate with wayside systems.
- **10 - Interior design and components** - sets out requirements for individual parts of the interiors.
- **11 - Interior layout** - sets out the requirements for the arrangement of interior components in the Saloon and around the Unit.
- **12 - Wayside Data System** - sets out requirements for the separate software / server to enable Train Data to be downloaded from and uploaded to the Unit as well as being stored, interrogated and communicated to and from other systems. This is not part of the Unit, but is within the TMM's scope.
- **13 - References** - List of standards and documents referenced by this TTS. Individual TTS requirements defined how these references should be applied.

1.1.2 The TTS contains requirements for the design of the Unit. Requirements for processes that shall be undertaken by the Train Manufacturer and Maintainer (TMM) in designing the Unit to meet this TTS are defined in other schedules of the Manufacture and Supply Agreement (MSA). Links between this document and other schedules are highlighted where appropriate.

1.2 Document format

1.2.0.1 This TTS includes a combination of requirements and rationale to explain the source of the requirements. Requirements are provided in the following format:

1.2.0.2 TTS-1261 - Requirement Name (PQTS-107)

Example requirement text.

Rationale: *Explanation of the requirement*

- Each requirement has a unique ID (TTS-###) and name. Reference to the equivalent requirement of the Pre-Qualification Technical Summary (PQTS)[117] is also provided where applicable.
- Only text contained within the box is considered part of the requirement. There

may be a number separate statements separated by a line-break which must all be considered together as part of the requirement.

- All other text is provided for guidance and information. 'Rationale' for the requirement has been provided to explain the requirement's purpose and wider context.

- Cross-references have been included to highlight where particular requirements relate to each other.

1.2.1 Document format for ITT version of TTS

1.2.1.1 In this version of the TTS, released as part of the Invitation to Tender (ITT), a number of requirements have multiple values indicated by the following format:

1.2.1.2 TTS-1951 - Example Multi-value Requirement

Example introduction to multiple value requirement. The performance shall be:
Preferred 1: The most preferred value that will gain the highest score in Stage 2.1 of the Tender Evaluation. **Preferred 2:** A second, less onerous value that will gain a lower score in Stage 2.1 of the Tender Evaluation. **Mandatory:** The minimum value that must be achieved.

1.2.1.3 For each requirement, a total score will be awarded, based on the committed and demonstrated level of compliance - refer to Volume 1, Appendix A of the ITT.

1.2.1.4 The contracted TTS will be updated to show just the agreed requirement, rather than multiple values.

1.2.1.5 In this ITT version of the TTS, a number of requirements have missing values that will be populated in the contracted TTS, based on values provided by the tenderer. Instances where a value must be added are marked [●]. An explanation of where the input will be sourced from is provided in each case.

1.3 Collaboration in the design process

1.3.1 The TMM shall develop elements of the design of the Unit in collaboration with the Purchaser and the stakeholders in the High Speed 2 Project. Separate schedules of the MSA define the collaboration processes for:

- systems integration at interfaces between the Unit and other systems of the HS2 Network and CRN (MSA Schedule 11 and 13 respectively);

- the functional integration of the Unit with the operation of the railway and other railway systems (MSA Schedule 11); and

- the interior layout and design of the components of the interior (MSA Schedule 9, Appendix 1).

1.3.2 This TTS sets out requirements consistent with these collaboration processes:

- Section 7 sets out performance requirements related to interfaces, which support the systems integration process;
- Sections 8 and 9 set out requirements to define the range of required operational functionality; and
- Section 10 sets out requirements for interior design of the Unit. Section 11 sets out the requirements for the interior layout.

1.3.3 To support the collaboration process a number of requirements defining provision for future flexibility have been defined; this is indicated in titles of these requirements.

1.4 Tender Evaluation

1.4.1 Full details of the Tender Evaluation process are contained in the Invitation to Tender. Requirements of this TTS are either:

- mandatory, which is highlighted in the title of each requirement;
- scored; or
- contribute to the whole life value model.

2 Abbreviations, definitions and defined terms

2.1 System definitions

2.1.1 The top-level systems that are defined in this TTS are consistent with the Technical Specifications for Interoperability (TSIs) and subsystems defined in the Interoperability Directive[1].

Unit - A formation of vehicles, which can operate by itself or coupled to another Unit. A Unit comprises both On-board CCS and Rolling Stock subsystems and requirements referring to 'Unit' apply to both subsystems.

IM Unit - A Unit which has been fitted with infrastructure monitoring equipment.

Train - An operational formation of one or more Units, with all coupled Units controlled from a single Cab. Each Unit may be orientated in either direction.

- **200m Train** is a Train formed of one Unit
- **400m Train** is a Train formed of two coupled Units

Vehicle - a carriage or locomotive within the Unit, as defined in the LOC&PAS TSI[4].

On-board CCS - all parts of the Unit that form part of the 'on-board control-command and signalling subsystem' as defined in paragraph 2.4 of Annex II of the Interoperability Directive[1]. The On-board CCS is considered to be composed of the following sub-systems:

- **ETCS On-board**;
- **AWS/TPWS On-board** - the national train control system;
- **ATO On-board** - this is an ATO over ETCS solution, referred to as "ATO-OB" in [19];
- **GSM-R/GPRS Voice Radio On-board**;
- **Interoperable C-DAS** - this is available under ERTMS; and
- **National C-DAS -** where ERTMS is not available.

Rolling Stock - all parts of the Unit that form part of the 'rolling stock subsystem' as defined in paragraph 2.7 of Annex II of the Interoperability Directive[1]. The following systems, components and areas of the Rolling Stock, and the scope of each item, are defined to ensure clarity of requirements. The systems and components are not required to be procured to align with these scope definitions.

- **Auxiliary Power Supply** – all elements of the Unit that supply power to systems other than traction. This includes (if used) auxiliary convertors, main batteries, local batteries, battery chargers, capacitors and cabling from the transformer through to the systems. The definition of 'Auxiliary Power Supply' includes the air supply if this is used to power auxiliary systems such as doors.
- **Bulk Luggage Storage Area -** area for large luggage as defined in Section 10.6.3.
- **Cab -** the area of the Unit from where the Train Captain controls the Train.
- **Cab CCTV System** - a CCTV system recording images of the interior of the Cab - see Section 9.26.5.
- **Cab Door** – a door on the side of the Unit that leads from outside the vehicle to the cab only. Note that the Unit is not required to have dedicated Cab Doors.
- **Cab HVAC** – the HVAC for the Cab.
- **Call For Aid** – a device for summoning help.
- **Carbody** – the assembled structural shell of the Vehicle, excluding Windows and Exterior Doors.
- **Catering Area** – the area of the Vehicle immediately surrounding the catering facilities.
- **CCTV System** – a Unit-based closed-circuit television system - see Section 9.26.
- **Crew Control Point** – a touch screen, handset and other controls (if necessary) that enables Train Crew to access the train management system to give Train Crew a subset of controls and information for on-board systems.
- **CRN Pantograph** – a pantograph to be used on the CRN. This may be the same component as the HS2 Pantograph, provided it is compatible with both networks.

- **Digital On-board Repeater (D-OBR)** - A system for boosting public mobile networks for Passengers on-board the Unit.
- **Energy Metering System -** equipment and software to monitor the energy usage of the Unit. This may be incorporated into traction / line voltage systems.
- **Evacuation Doors** – Exterior Doors that form part of the primary evacuation route for controlled evacuation of all people on the Unit.
- **Exterior Door** – a door to the side of the Unit that leads to a Vestibule, from where a Saloon or a Cab can be accessed. It is recognised that the Moveable Step may be part of the same procured system, but the Exterior Door and Moveable Step are treated as separate systems for the purposes of requirements.
- **Evacuation Device** – a ramp / stepped device carried on the Unit that facilitates evacuation of people from the Unit to locations other than a platform.
- **Evacuation Wheelchair** – a device carried on the Unit, into which a wheelchair user can transfer in order to facilitate evacuation from the Unit - defined by TTS-330.
- **Exterior Doorway** – the area of the Vehicle around the Exterior Door including the aperture in the carbody, any trim and flooring.
- **Forward Facing/Rear Facing (FFRF) CCTV System** – a CCTV system showing images looking forward/rear from the Cab – see Section 9.26.2.
- **Full Seat Bay:** an arrangement of four seats around a table.
- **Full-width Partition** – a partition that fully divides a Vehicle, which includes an Interior Door.
- **Gangway** – a flexible connection that allows safe movement of people between Vehicles.
- **Half Seat Bay** – an arrangement of two seats opposite each other around a table.
- **Heating, Ventilation and Air Conditioning (HVAC)** – all of the systems and controls that provide heating, cooling and ventilation (including fresh air provision and exhaust of stale air).
- **HDL Seat** – a Passenger Seat used in the HDL as defined in Section 11.4.
- **HS2 Pantograph** – a pantograph to be used on the HS2 Network. This may be the same component as the CRN Pantograph, provided it is compatible with both networks.
- **HS2 Seat** – a Passenger Seat meeting the requirements of Sections 10.3.1 and 10.3.2 of this TTS.
- **Interior CCTV System** – a CCTV system recording images of the Saloon, Vestibules and other interior areas – see Section 9.26.4.

- **Interior Door** – a powered door that separates areas of the Vehicle, including between the Saloon, the Vestibule and the gangway. A Full-width Partition will include an Interior Door. The scope of the Interior Door includes any controls, sensors and drives. Doors for toilets are not part of the Interior Door scope.
- **Litter Bin** – a bin for the collection of waste from Passengers, compliant with Section 10.17.
- **Moveable Step** – a retractable device integrated into the Vehicle forming a step with the door threshold, fully automatic and activated/controlled in conjunction with the door release and closing sequences to reduce the gap in width and height between Vehicle and platform - as defined by EN 14752[40] with additional reference to door release.
- **Multi-Purpose Area** – a seating bay which can be converted into an open area for luggage or buggies - see Section 10.5.
- **On-board Ramp** – a manual device that is positioned between the vehicle door threshold and the platform.
- **Pantograph CCTV System** – a CCTV system showing images of the pantograph and pantograph well – see Section 9.26.3.
- **Partial Partition** – a partition that visually breaks-up the Vehicle into separate spaces but does not block the aisle clearway in any way.
- **Passenger Alarm** – a device for alerting the Train Captain in an emergency.
- **Passenger HVAC** – the HVAC for the Saloon, Vestibule, Toilets and Catering Areas.
- **Passenger Information System (PIS)** – all of the components that provide general audio and visual information to Passengers, including public address functionality.
- **Passenger Seat** – an individual seat for one passenger, including the mounting of that seat to the Vehicle and any facilities provided at that seat.
- **Premium Seat** – a Passenger Seat meeting the requirements of sections 10.3.1 and 10.3.4 of this TTS.
- **Public WiFi Network** - A system that provides WiFi to Passengers on-board the Unit and communicates with the Wayside.
- **Running Gear** – the wheels and suspension that provide support and guidance for the Vehicle.
- **Saloon** – the area of the Unit where passengers will normally sit, bounded by Full-width Partitions at each end.
- **Sanitary Systems** – the toilet bowl, flush, effluent system, fresh water supply and sink facilities. It is assumed that to meet the requirements of this TTS a 'bio-reactor' effluent system will be required.

- **Seating Position** – an individual Passenger Seat or Wheelchair Space and the space associated with that seat or space. (Note that Vestibule Seats are not considered Seating Positions).
- **Seat-back Table -** a table mounted to the back of a seat in front or to another feature if the seat faces a partition or other feature.
- **Signalling and Radio Frequency Monitoring System** – a system on IM Units measuring signal strength of CCS systems, as defined in section 10.4.2.
- **Standard Toilet** – a smaller Toilet, as defined by PRM TSI[6] sections 5.3.2.2 and 5.3.2.3 and section 10.16 of this TTS.
- **Tip-up Seat** – a sub-type of HS2 Seat meeting the requirements of Sections 10.3.1, 10.3.2 and 10.3.3.
- **Toilet** – the whole module containing the passenger facing elements of the Sanitary Systems and other facilities. This includes the door for the Toilet and any controls, locks and drives for this door.
- **Unattended Geometry Measurement System (UGMS)** – a system on IM Units measuring track geometry.
- **Unattended Overhead Measurement System (UOMS)** – a system on IM Units measuring OCS/OLE.
- **Universal Toilet** – a large Toilet, in particular providing facilities for wheelchair users, as defined by PRM TSI[6] sections 5.3.2.2 and 5.3.2.4 and Section 10.16 of this TTS.
- **Vestibule** – the area of the Unit immediately inside the Exterior Doors. Where separate requirements apply to the Saloon and Vestibule, the Interior Doors between the two will define the boundary.
- **Vestibule Seat** – a fold-down seat fitted in a Vestibule.
- **Wheelchair Space** – a position where a passenger using a wheelchair can locate their wheelchair as defined by PRM TSI Section 4.2.2.2.
- **Window** – The main bodyside windows for Passengers to view the outside of the Unit from the Saloon. This does not include windscreen, cab side windows, windows in Exterior Doors or internal glazing.

Wayside – a generic name for systems outside the Unit which the Unit will communicate with. This will include the Network Integrated Control Centre (NICC). The majority of the Wayside will be outside the TMM's scope, but the TMM will need to provide equipment to interpret and store Train Data that is transmitted to and from the Unit - the **Wayside Data System**.

Wayside Data System - software and data storage that enables Train Data to be downloaded from and uploaded to the Unit as well as being stored, interrogated and communicated to and from other systems.

The Wayside includes the **CCS Trackside** which is outside the scope of supply of the TMM. It comprises:

- **ATO Trackside -** the trackside component of the ATO; and
- **ETCS Trackside** - the trackside component of ETCS.

Special Operator Equipment - equipment that is designed, built and supplied by the TMM for use in operating the Units, which includes:

- rescue couplers - as required by TTS-375 - *see Section 9.8.3 for definition and Schedule 14 for quantity;*
- On-board Ramps - as required by TTS-268 - *one ramp per Vehicle with Wheelchair Spaces;*
- Evacuation Devices - as required by TTS-2802 - *two per Unit;*
- Evacuation Wheelchairs - as required by TTS-2802 - *four per Unit;*
- door barriers - as required by TTS-3337 - *one per Vestibule;*
- access keys for Train Captains, Train Crew and cleaners - as required, in part, by section 9.23 and TTS-740 - *see Schedule 14 for quantity;*
- contactless log-in cards (or similar) - as required by TTS-605 - *see Schedule 14 for quantity;*
- removable CCTV storage media - as required by TTS-558 - *see Schedule 14 for quantity;* and
- track circuit clips, flags and ladders - as required by TTS-3444 - *see requirement for quantities.*

2.2 Network and route definitions

Conventional Rail Network (CRN) – the parts of the UK Main Line Network over which HS2 services will operate, as defined in MSA Schedule 4. *Note that the CRN is not a subset of the HS2 Network.*

East Coast Mainline (ECML) – the conventional main line between London, Leeds, York, Newcastle and Edinburgh - see Data Book[116] for the list of CRN routes which form part of the ECML.

High Speed Two (HS2) Network – the new infrastructure and railway systems being constructed as part of the High Speed 2 Project over which HS2 services will operate. This is defined in Schedule 4 of the MSA. Note that the CRN is not a subset of the HS2 Network.

West Coast Mainline (WCML) – the conventional main line between London, Birmingham, Liverpool, Manchester and Scotland - see Data Book[116] for the list of CRN routes which form part of the WCML.

UK Main Line Network – The UK-wide main line rail network maintained and operated by Network Rail. The CRN is a subset of the UK Main Line Network.

More detailed definition of all routes is provided in MSA Schedule 4.

2.3 People

2.3.1 The following people are defined within this TTS. Where necessary, the range of sizes defined in TTS-291 shall be considered for each of these people.

Authorised Person - the Train Captain, any member of Train Crew, and any member of station staff who is authorised to carry out actions related to the Unit, or any person who is permitted to access the Unit when it is not in passenger service.

Catering Staff - an employee of the HS2 Train Operator, or their catering sub-contractor, who is responsible for staffing catering facilities and equipment.

Instructor - a person who instructs and trains trainee Train Captains.

Maintenance Technician - a person who undertakes maintenance tasks on the Unit. These include changes to the Unit the Train Captain or Train Crew are not permitted to make.

Passenger - a passenger of HS2 services who travels on an HS2 service.

Restricted Persons - a sub-group of Authorised Persons who are able to access particular security-related areas or devices.

Train Captain - The person with overall control of the Train, who will drive the Train on the CRN; and drive or provide supervision from the cab on the HS2 Network. The Train Captain will control the whole Train, including all coupled Units.

Train Crew - Authorised Persons on the Train while it is in service between stations, who are employed by the HS2 Train Operator, excluding the Train Captain and Instructor (if present).

User Population - any person using the Unit from within the range defined in TTS-291. This term is used for requirements relating to ergonomics and anthropometrics.

Wayside Staff - a person on remote from the Unit with access to the Wayside Data System. This person may work for the TMM, the HS2 Infrastructure Manager, the HS2 Train Operator or another party.

2.4 Layouts and payloads

2.4.1 The Unit is required to have flexibility for future internal reconfiguration during the design phase or later in the Unit's life. To achieve this, a number of layouts are defined within this TTS:

- **One-Space Layout (1SL)** which provides a single seating space throughout the whole Unit; the service offering would be varied by features other than seat arrangement. This layout is defined by the requirements in Section 11.1.
- **Two-Space Layout (2SL)** which is a variant on the 1SL that incorporates a different seat design in some Vehicles. This layout is defined by a set of changes to the 1SL requirements, which are listed in Appendix R. It is used in a number of the Stage 5 Whole Life Value requirements.
- **High Density Layout (HDL)** which is the maximum seating and standing capacity that the Unit can provide. This layout is used to define the envelope of future flexibility. This layout is defined by the requirements in Section 11.4.

2.4.2 It is anticipated that either the 1SL or 2SL will be selected prior to contract award as the base layout. The requirements for this base layout, and the layout itself, may be varied through the project according to the interiors collaboration process described in MSA Schedule 9, Appendix 1. The HDL will not be changed through the collaboration process as it represents the maximum envelope for the collaboration process and any future reconfiguration.

2.4.3 A number of payloads are defined for these layouts. These payloads are referenced throughout the TTS and the use of these payloads is summarised in Appendix B.

2.4.4 The following four definitions define the maximum payload conditions for the Unit, based on the HDL. The TTS contains requirements for safe operation of the Unit (such as braking, dynamics and axle loads) based on these payloads to ensure the Unit can safely be operated up to these limits in the future.

2.4.5 The definitions have the following clarifications to EN 15663[46]:

- Passenger mass per seat shall be 90kg including 10kg luggage;
- Passenger mass for standing areas shall be 80kg (i.e. no luggage); and
- Tip-up Seats and folding tables in Multi-Purpose Areas shall be considered to be in the 'down' / deployed position so that they act as seats with no standing area.

Rationale: *Data for the UK shows that the average mass is currently 76kg per person. 90kg has been specified to give 10kg provision of luggage per person and scope for average mass to grow. No luggage provision is made for standing Passengers, since luggage would weigh less than further Passengers that could stand where the luggage would be. The Multi-Purpose Area is intended to be reconfigured in the off-peak to provide additional storage (e.g. for buggies); it is not intended as a standing area.*

Normal Operational Payload (HDL) - operational mass under normal payload as defined in EN 15663[46] for high speed and long distance vehicles except that passenger mass shall be 90kg including luggage and Tip-up Seats shall be in the down position. This shall be calculated using the HDL defined in Section 11.4.

Normal Payload (HDL) - design mass under normal payload as defined in EN 15663[46] for high speed and long distance vehicles except that passenger mass shall be 90kg including luggage and Tip-up Seats shall be in the down position. This shall be calculated using the HDL defined in Section 11.4.

Exceptional Payload (HDL) - design mass under exceptional payload as defined in EN 15663[46] for high speed and long distance vehicles with 90kg per person for all seated passengers and [●] kg/m² in standing and catering areas and Tip-up Seats in the down position. This shall be calculated using the HDL defined in Section 11.4.

Update for contract - standing density to be updated based on the response to Section 11.4

Exceptional Payload (HDL+RA) - design mass under exceptional payload as defined in EN 15663[46] for high speed and long distance vehicles with 80kg per person for all seated passengers and 320kg/m² in standing and catering areas and Tip-up Seats in the down position. This shall be calculated using the HDL defined in Section 11.4. This payload is only used for requirement TTS-133.

Rationale: *This alternative value for Exceptional Payload is used solely for specification of Route Availability (RA) number in accordance with GE/RT8006[100]. Network Rail has confirmed that this separate payload condition should be used for consistency with existing analysis of underline bridges.*

2.4.6 The two definitions below define the payload conditions to be used for key performance requirements such as journey time, dwell time and energy consumption. A combination of the 1SL and 2SL will be used for these purposes. During the course of the contract, if changes are made to the layout from the base layout through the collaboration process, these payloads will change, and the impact on performance requirements will need to be assessed as part of agreeing the final scope of change. It is anticipated that these final payloads will be used for compliance with Mandatory Standards to support Relevant Approvals.

Normal Payload (1SL) - design mass under normal payload as defined in EN 15663[46] for high speed and long distance vehicles except that passenger mass shall be 90kg including luggage and Tip-up Seats shall be in the down position. This shall be calculated using the 1SL defined in Section 11.1.

Normal Payload (2SL) - design mass under normal payload as defined in EN 15663[46] for high speed and long distance vehicles except that passenger mass shall be 90kg including luggage and Tip-up Seats shall be in the down position. This shall be calculated using the 2SL, which is defined in Section 11.1 modified by Appendix R.

2.4.7 For the purposes of Relevant Approvals, Exceptional Payload in the 1SL / 2SL condition is defined as follows.

Exceptional Payload (1SL) - design mass under exceptional payload as defined in EN 15663[46] for high speed and long distance vehicles with 90kg per person for all seated passengers and up to 320kg/m² in standing and Catering Areas and Tip-up Seats in the down position. This shall be calculated using the 1SL defined in Section 11.1. If the 2SL is later chosen as the base layout, payloads will be based on the 2SL instead. The mass of standing passengers shall be varied to a single value for the whole Unit up to 320kg/m², but such that the payload of any vehicle is no higher than Exceptional Payload (HDL) of that vehicle.

2.4.8 The following payload is defined as the lightest possible payload. The 2SL is specified since this is considered to achieve the least amount of equipment inside a Vehicle. If the 1SL is chosen as the base layout, these requirements will be updated to refer to the 1SL prior to contract award.

Working Order (2SL) - design mass in working order payload as defined in EN 15663[46] for high speed and long distance vehicles. This shall be calculated using the equipment of the 2SL defined in Section 11.2. If the 1SL is later chosen as the base layout, payloads will be based on the 1SL instead.

2.4.9 Appendix B has a summary of requirements that refer to a payload and which payload is applicable in each case. It also includes an explanation of how it is anticipated that the payload and HDL will be defined.

2.5 Other defined terms and abbreviations

3-pin Socket - is a 230V AC, 3-pin socket that complies with BS 1363-2[23] - *i.e. the normal UK socket.*

Abnormal PTI Conditions - vehicle conditions that affect the Platform-Train Interface that are unusual and rarely-experienced and not part of the normal maintenance cycle, including:

- Payload above the Normal Payload (HDL) limit
- [•]

*Update for contract **-** further Vehicle conditions to be added based on the response to requirement TTS-154, section 7.11.1 in the TTS Response Spreadsheet.*

Active Cab - the Cab of the Train that is currently being used by the Train Captain to control the Train.

ASDO - Automatic Selective Door Operation - a system / function for automatically restricting which Exterior Doors can open at a particular platform.

ATO - Automatic Train Operation, operated over ETCS.

ATO Stop - is a control in the Cab for unplanned, controlled stopping of the Train.

ATO Traction / Brake Control - is the feature of the driving function of ATO On-board as described in ATO over ETCS SRS[19] Section 7.1.5.

Automatic Information Programme (AIP) - is an automated set of visual and audible messages broadcast during a Service - see Section 9.25.3.

Automatic Train Stopping Management - is the feature of the driving function ATO On-board as described in ATO over ETCS SRS[19] Section 7.1.4.

AWS - Automatic Warning System - UK national train protection system - refer to RIS-0775-CCS[79].

Bicycle - a bicycle with 740mm wheels, a 580mm frame (i.e. seat tube measurement), 1050mm wheelbase and 460mm width handlebars.

CCS - Control-command and Signalling.

Connected Driver Advisory System (C-DAS) - a Driver Advisory System that includes two-way communication between the Train and the Wayside to enable the provision of schedule, routing and speed restriction updates to the Train in near real time, and also receipt of information from the Train to improve train regulation decisions. On the HS2 Network, C-DAS will operate over ETCS.

Contractually Protected Area - a minimum internal area which must be available for flexible reconfiguration of the interior, as defined in Section 11.

CRN Contact Quality Criteria - the criteria for assessing compatibility between a pantograph and the CRN OLE, defined by GM/RT2111[84] Clause 4.9.1.3.

Data Book - sets of data that support this TTS, providing details about the HS2 Network and CRN - *reference [116]*.

Design - the design of the Units and Equipment that is developed through the Design Phase and defined by the Design Documentation.

Driver Machine Interface (DMI) - this is specifically the DMI for On-board CCS and not other train control screens that may be provided.

Dwell Time - the time taken for a Unit to perform all normal aspects of station operations from wheels-stop to wheels-start including alighting and boarding of passengers.

EIRENE SRS - European Integrated Railway Radio Enhanced Network System Requirements Specification.

EMC - Electromagnetic compatibility.

Emergency Egress Device - a device for opening an Exterior Door in an emergency. This is referred to as an 'emergency-opening device' in the LOC&PAS TSI[4].

ETCS - European Train Control System.

ERTMS - European Rail Traffic Management System.

Eurobalise - a wayside transmission unit, used in an ERTMS/ETCS installation, that uses the magnetic transponder technology. Its main function is to transmit information through the air gap. The Eurobalise is a single device mounted on the track, which communicates with a Unit passing over it.

EUAR - European Union Agency for Railways - *Replaces the European Rail Agency (ERA)*.

Event - an occurrence on the Train that the Train records together with appropriate data and warnings - as defined in Section 9.5.1.

EVC - European Vital Computer.

Fit for Service - has the meaning given in Appendix 3 (Meaning of Fit for Service) to Schedule 5 (Performance Regime) of the TSA.

FHD - Full High Definition.

Fleet - all of the Units supplied as part of this Agreement (the MSA) and any further Units of the same design that are later supplied.

FMECA - Failure Mode, Effects and Criticality Analysis.

FRMCS - Future Railway Mobile Communication System.

Full Shut-down State - an operational state where the Unit is not connected to the 25kV power supply; all systems are switched off so no power is consumed - see section 9.7.2.

Grade of Automation level 2 (GoA2) - GoA2 is semi-automatic train operation where starting and stopping is automated, but a Train Captain remains in the cab and can drive the Train if needed and handle emergencies.

GNSS - Global Navigation Satellite System.

GPRS - General Packet Radio System.

GSM-R - Global System for Mobile Communications – Railway.

HS2 Platform - a platform nominally positioned at 1115mm above rail and an offset consistent with GC gauge (as defined in EN 15273-3[45]). For the purpose of Step-free Access requirements, any tolerance in platform height may be ignored (i.e. the impact of tolerance between the track and platform will be managed by HS2).

HS2 Train Operator - any entity nominated by the Secretary of State and/or the Purchaser to operate the HS2 Services.

Inactive Cab - any cab in the Train other than the Active Cab.

ITT - Invitation to Tender.

Key Management Centre - as defined in SUBSET-026[16] Chapter 2, section 2.5.

Large Bag - a bag with dimensions of 800 × 570 × 300mm.

Limited Heat Release State - is an operational State where systems are configured to minimise heat output from the Unit while providing the best on-board environment possible. See Sections 9.7.2 and 9.21.

LSVG - Lower Sector Vehicle Gauge.

MA - Movement Authority (with respect to ETCS).

MSA - Manufacture and Supply Agreement - *the overall contract for the supply of the Units*.

Maximum Line Speed - for the CRN, this is the current maximum permissible speed shown in the Sectional Appendix[111] (excluding any differential speed limits), amended by the line speed improvements listed in the Data Book[116]. Line speed improvements are locations where HS2 anticipates the line speed can be increased without significant modification to the current infrastructure. For the HS2 Network, this is the line speed shown in the Data Book.

Minimum Aesthetic Standards - will be a set aesthetic conditions that the Unit must maintain through its life. They will be developed from a set of aesthetic standards that will be agreed for Acceptance of the Units, but adjusted to take into account fair wear and tear.

mph - miles per hour - *note that all CRN speeds are given in mph and all HS2 Network speeds in km/h.*

NICC - Network Integrated Control Centre.

Normal Operation - the Unit is able to operate with full functionality and at full performance, subject to available line current. HVAC performance shall be in accordance with specified temperature limits in Section 7.16.

Notified National Technical Rule (NNTR) - as defined by the Interoperability Regulations.

NTC - National Train Control - *'Level NTC' refers to a train equipped with ETCS operating on a line equipped with a national signalling system.*

ORR - Office of Rail and Road established under the Railways and Transport Safety Act 2003.

OCS - Overhead Contact System - *name given on HS2 Network*

OLE - Overhead Line Equipment - *name typically used on CRN*

Operator - the party identified as the Operator in the Train Services Agreement (TSA).

Operator Settings - configurable train control settings that can be changed by the Operator, as defined in Paragraph 9.1.1.

Operational Diagram - a sequence of Services that the Unit will undertake in a day, as defined in Paragraph 9.2.1.

Passenger Service State - is an operational state where all systems are operational and fully functioning. See Section 9.7.2.

PEP - Platform Edge Protection - *a generic name for systems that include platform edge doors and other systems fulfilling a similar purpose*.

PEA - Passenger Emergency Alarm.

PRM - Persons of Reduced Mobility - this includes all passengers who may have some restriction on their mobility. See definition in section 2.2 of the PRM TSI[6].

PQTS - Pre-Qualification Technical Summary[117].

Platform Train Interface (PTI) - the interface between a platform and the Moveable Step and Exterior Door of the Unit.

RA - Route Availability (a*s* defined by GE/RT8006[100]).

RAIB - the Railway Accident Investigation Branch established by the Railways and Transport Safety Act 2003 and any successor body.

Railway Group Standards (RGS) - technical standards for railway assets, or equipment used on or as part of railway assets, as issued and maintained by the Rail Safety and Standards Board and authorised pursuant to the document known as the Railway Group Standards Code.

Railway Industry Standards (RIS) - technical standards that define functional or technical requirements to be met in circumstances where the management of the railway system does not need the use of Railway Group Standards.

RH - Relative Humidity.

Safe Location - a dedicated safe location on the HS2 Network where Trains can wait safely, and evacuation can be carried out if necessary.

Service - a journey between two points with a number of intermediate stops, or no intermediate stops.

Service Affecting Failure - *Refer to definitions in MSA and TSA for complete definition. In summary, a Service Affecting Failure is* a failure on the Unit that causes:

- a delay of 3 minutes or more at a terminal station or an intermediate point;
- a Unit to be withdrawn from service; or
- a Unit to be made available for service 3 or more minutes late.

Servicing State - is an operational state where systems are running at settings to permit cleaning, light maintenance or service preparation. See Section 9.7.2.

Shut-down State - is an operational state where the Unit is not connected to the 25kV power supply; all systems except those required to deliver Wayside control required in section 9.7.2.

Small Bag - a bag with dimensions of 560 × 450 × 250mm.

Software Update - a change that can be made that only requires a change to software, as defined in Paragraph 9.1.6.

Standby State - an operational state where all systems are running at reduced output to limit energy consumption and with limited functionality considering that no Passengers will be on-board. The Train may be stationary or running empty coaching stock. See Section 9.7.2.

Static Dwell Time Model - a model for assessing compliance with the 2-minute Dwell Time requirement TTS-161. It is defined in Appendix I.

State - one of the operational states for which different settings are set for on-board systems. States shall include those defined in Section 9.7.2 and any other states defined by the TMM in the design.

Stopping Point - the point where a Train is planned to stop under ATO control, as defined in the ATO over ETCS glossary[15].

Tender Vehicle Gauge - the vehicle gauge Tenderers will develop in response to the Gauging Challenge[122].

TMM - Train Manufacturer and Maintainer - the legal entity that enters into the MSA and the TSA as supplier of the Works and the Services.

Train Data - all of the data generated by each Unit. (Note that the MSA and TSA define this term prior to and after Acceptance, respectively.)

Train Protection and Warning System (TPWS) - UK national train protection system - refer to RIS-0775-CCS[79].

TSI - Technical Specification for Interoperability. Note that TSIs are referred to by their abbreviations and listed in full at the end of this document.

TTS - Train Technical Specification.

UTC - Universal Time Coordinated / Universal Coordinated Time.

VTT - Virtual Test Track - a data file representing the track characteristics and quality.

VUC - Variable Usage Charge.

WSP - Wheel-Slide Protection.

3 Strategic goals and objectives

3.1 HS2 Ltd has the following strategic goals for the design of the Unit:

- **Safety -** in line with regulations and standards, provide a safe and secure environment for all passengers and staff;
- **Customer experience -** a design that makes passengers feel safe, comfortable and welcome, is flexible in use and able to accommodate the needs of a diverse range of users including commuters, business users, families and those with luggage. This also covers staff experience, welfare and provision, which is essential for providing an exceptional passenger experience;
- **Performance -** delivering journey times between UK cities to support the HS2 business case;
- **Railway capacity -** a design that supports the operation of at least an 18 trains per hour per direction railway, with a PTI that is optimised for accessibility and short Dwell Times;
- **Environmental impact and sustainability -** a design and maintenance regime that minimises whole-life environmental impact, in particular with respect to carbon, noise emissions and resource efficiency including sustainable sourcing of materials;
- **Reliability -** a design and maintenance regime that delivers exceptional levels of reliability and operational robustness, ensuring delays are kept to a minimum in order to support the overall delay targets, and Trains never have failures that prevent them reaching their destination; and
- **Whole life, whole system cost -** a design solution that maximises value for money, consistent with the HS2 business case.

3.2 These goals will be achieved by compliance with the requirements of this document, and also through implementation of appropriate processes by the TMM defined by other Schedules of the MSA. To achieve these goals, the TMM will need to work collaboratively with the Purchaser, as contracting entity, and other stakeholders in the High Speed 2 Project. In particular, the TMM and the Purchaser will need to work with passenger user groups and the HS2 Train Operator to develop the user-facing elements of the Unit.

4 Operational Duty

4.1 The Train will operate services

- wholly on the HS2 Network; and
- on both the HS2 Network and the CRN

4.2 Initial trial operations and some future operations may be conducted on the CRN only.

4.3 Particular features of the HS2 Network include:

- railway systems designed for a maximum speed of at least 360 km/h;
- ETCS Level 2 with ATO over ETCS fitted;
- built to GC and GI2 gauges;
- HS2 Platforms built at a nominal height of 1115mm;
- 25kV OCS;
- both slab track and ballasted track;
- long tunnels, in particular under the Chilterns and London suburbs at the southern end of the route; and
- tunnels that are single bore and smaller than tunnels on other high speed lines. Micro-pressure wave mitigation is incorporated into tunnel portals.

4.4 Particular features of the CRN include:

- current maximum linespeeds up to 125mph on the ECML and 110mph on the WCML, assuming no tilt (linespeeds may be raised in the future through infrastructure works and re-signalling);
- structure gauge typical of UK Main Line Network;
- fitted with colour light signals protected by AWS and TPWS systems. ETCS may be fitted during the life of the Unit;
- platforms built to a nominal height of 915mm, but with significant variation; and
- 25kV OLE at variable height.

4.5 Detailed data about the HS2 Network and CRN is provided in the Data Book[116].

4.6 Appendix A describes the service operating parameters. In particular:

- Trains operating as single Units;
- Trains operating as two coupled Units throughout a journey; and
- Trains that split or join during the journey to serve multiple destinations.

5 Unit and Train formation

5.1 This section defines some key parameters that define the length and overall layout of the Unit. These are specified first since they need to be considered in all subsequent requirements.

5.2 The nominal length of the Unit shall be 200m. It has been determined that all Units should be the same length, with no requirement for a Unit to be capable of being lengthened or shortened. This supports the overall HS2 business case.

5.3 TTS-987 - Operational formation - Mandatory

The Unit shall be capable of Normal Operation as a single Unit or as two coupled Units.

Rationale: *The planned operation of HS2 services includes operation of both 200m and 400mTrains.*

Cross reference: *See also Requirement TTS-249 (Interworking Function) in Section 9.8.1.1 (Interworking)*

5.4 Requirements that are applicable to Units in operation in the above formations refer to '**200m Train**' or '**400m Train**' respectively rather than 'Unit'. References may also be made to '**Train**' to mean either of the two operational formations.

5.5 TTS-75 - Train Length - Maximum (PQTS-315) - Mandatory

The maximum length of two coupled Units, including all tolerances, shall be 404.0m.

Rationale: ***HS2 interface -*** *The HS2 Network has been designed assuming a maximum Train length of 400m+1% from the now- superseded HS RST TSI[10].*

5.6 TTS-1758 - Cabs - Mandatory

The Unit shall have Cabs at each end of the Unit, which are identical as perceived by a Train Captain.

Rationale: *It is considered that there is too much risk in trying to adopt a solution with a single cab and/or CCTV to avoid the cab being at the end of the Unit. The cabs must be identical to provide a common interface to the Train Captain. Minor differences that are not apparent to the Train Captain are acceptable, but the impact on maintenance and possible errors should be considered. Units will frequently change orientation in service.*

6 Relevant Approvals

See also MSA Schedule 10.

6.1 Authorisation and standards

6.1.1 To support authorisation, the Unit will need to comply with mandatory TSIs and NNTRs as they apply to the HS2 Network and the CRN, including those applicable to the On-board CCS.

6.1.2 TTS-984 - Standards (HS2) - Mandatory

The Unit shall comply with the TSIs for operation on the HS2 Network at 360km/h, subject to the non-compliances listed in Appendix O.

Rationale: *This includes compliance with TSIs for both Rolling Stock and On-board CCS subsystems. Compliance with the TSIs is a HS2 Sponsor's Requirement. The TSIs have an overall limit of 350km/h and particular technical specifications have lower limits (e.g. 320km/h for pantograph / OCS interaction). Refer to MSA Schedule 10 for details of the TMM's responsibilities regarding TSI-compliance at 360 km/h.*

6.1.3 ***Update for contract -*** *The content of Appendix O will be populated in the contracted version of the TTS using a list of non-compliances provided in the Tender.*

6.1.4 There are no NNTRs for HS2. Requirements for compatibility with the HS2 Network are defined within this TTS. MSA Schedule 11 defines the process for managing systems integration and hence demonstrating compatibility with the HS2 Network.

6.1.5 TTS-84 - Standards (UK MLN) (PQTS-306) - Mandatory

The Unit shall comply with the TSIs and NNTRs for operation on the UK Main Line Network at 125mph, subject to the non-compliances listed in Appendix O.

Rationale: *The UK Main Line Network has a set of NNTRs defined at https://www.gov.uk/government/publications/rail-interoperability-current-notified-national-technical-rules. The current maximum operating speed on this network is 125mph. Individual routes may have lower speed limits due to signalling, track curvature or other infrastructure constraints.*

6.1.6 ***Update for contract -*** *The content of Appendix O will be populated in the contracted version of the TTS using a list of non-compliances provided in the Tender.*

6.1.7 Compliance with the above requirements will be assessed by the Notified Body / Designated Body and documented in the technical file. Refer to MSA Clauses 10 and 11 and Schedule 10.

6.1.8 Additionally, capability to operate at 140mph on the CRN is required should this become possible during the life of the Units. To achieve this a small number of specific requirements for some interface areas have been included in this TTS where capability can be assessed prior to Acceptance.

6.1.9 Requirements to comply with the TSIs and NNTRs for the purposes of Relevant Approvals are not repeated in this TTS. The TTS only includes requirements related to these standards where:

- a certain implementation or clarification of a TSI or NNTR is required;
- compliance with a non-mandatory standard in addition to those necessary for authorisation is required; and
- compliance with a regulatory standard at the payloads defined for the High Density Layout for the purposes of future flexibility is required. See Section 2.4.

6.1.10 Where appropriate, at the start of each section, the TTS references the sections of Mandatory Standards that should be considered with the requirements of that section.

6.2 Compatibility

6.2.1 The operation of the Trains will need to be demonstrated as compatible with the operational routes in addition to compliance with Mandatory Standards.

6.2.2 TTS-83 - Compatibility Assessment (CRN) (PQTS-165) - Mandatory

The Unit, operated as a 200m Train or a 400m Train, shall be compatible with the CRN.

6.2.3 Where requirements have been identified to achieve compatibility, these are detailed within the TTS. These requirements are a subset of the full set of requirements to achieve compatibility. These are highlighted in the TTS with the text "CRN interface" at the start of the rationale.

6.2.4 There is no equivalent requirement to TTS-83 for the HS2 Network. The TMM's responsibilities for compatibility on the HS2 Network are defined in MSA Schedule 11. Requirements of this TTS that contribute to achieving compatibility are highlighted with the text "HS2 interface" in the rationale.

6.3 Safety

6.3.1 There are no specific requirements for safety in this TTS. Responsibilities for undertaking a risk assessment for the Unit in accordance with the Common Safety Method for Risk Evaluation and Assessment regulations[2] are defined in MSA Schedule 10.

6.4 Assurance

6.4.1 All requirements related to assurance are contained in MSA Schedule 10.

7 Performance

7.0.1 This section defines the performance of the overall Unit to achieve HS2's Sponsor's Requirements, and to define mechanical and electrical interfaces with other railway systems and rolling stock on the HS2 Network and the CRN.

7.1 Journey times

7.1.1 TTS-93 - Journey Time (HS2) (PQTS-32) - Mandatory

A 200m Train and a 400m Train shall both achieve a journey time of less than 00:45:30 (hours:minutes:seconds) between London Euston and Birmingham Curzon Street, in either direction, including two-minute stops at Old Oak Common and Birmingham Interchange. This requirement shall be achieved using the criteria specified in Appendix C.

Rationale: *The HS2 business case allows for a timetabled journey time of 00:49:00 (hours:minutes:seconds) from London Euston to Birmingham Curzon Street stations; this is inclusive of two-minute dwells at Old Oak Common and Birmingham Interchange stations. However, in order to provide an operational margin, the Unit will need to be capable of completing the journey in less time than that timetabled. It is considered that this requirement achieves the appropriate margin.*

7.1.2 TTS-94 - Journey Time (HS2+CRN, 200m) (PQTS-34) - Mandatory

A 200m Train shall achieve a journey time of less than 03:45:30 (hours:minutes:seconds) between London Euston and Glasgow Central, in either direction, including two-minute stops at Old Oak Common and Preston. This requirement shall be achieved using the criteria specified in Appendix C.

Rationale: *HS2 has a high-level requirement for London-Glasgow journey time of less than four hours. To achieve this, the Unit will need to achieve this performance on the existing infrastructure as described in the Data Book. HS2 will work separately with Network Rail to develop line-speed enhancements to ensure the four-hour requirement can be achieved with adequate margin. It is envisaged that these line-speed enhancements will not be included or referenced in this contract.*

The requirement is specified for a 200m Train only because the power supply on the CRN is currently limited to 300A. The power supply that may be available for 400m Trains is not yet determined.

7.2 Traction

See also LOC&PAS TSI[4] §4.2.8
Cross reference: *See also Requirement TTS-409 (Jerk Rate and Adjustment) in Section 9.11 (Jerk rate)*

7.2.1 TTS-98 - Minimum Acceleration 1 (PQTS-327) - Mandatory

From a stationary position, a 200m Train and a 400m Train shall both:
- achieve a speed of 360km/h; and
- cover a distance of 40km

in no more than 535 seconds on straight, level track. This requirement shall be achieved using the criteria specified in Appendix C.

Rationale: ***HS2 interface -*** *This requirement will be necessary to support capacity on the railway. This is the acceleration required by a Train leaving a station and re-joining the main line.*

7.2.2 TTS-908 - Minimum Acceleration 2 (PQTS-462) - Mandatory

From a starting speed of 200km/h, a 200m Train and a 400m Train shall both:
- achieve a speed of 360km/h; and
- cover a distance of 40km

in no more than 450 seconds on straight, level track. This requirement shall be achieved using the criteria specified in Appendix C.

Rationale: ***HS2 interface -*** *This level of acceleration is required to support the Phase Two timetable and the required service frequency in the core section of the HS2 Network. This is the acceleration required for a Train joining the HS2 Network at a junction.*

7.2.3 With reference to LOC&PAS TSI[4] Clause 4.2.8.1.2 (5), no residual acceleration at the maximum service speed of 360km/h is required.

7.2.4 TTS-220 - Rescue Performance

It shall be possible for a Train to start and propel another Train, that is the same length or shorter, from any point on the HS2 Network to the next station in the direction the rescued Train was travelling. The rescued Train shall be in the Exceptional Payload (HDL) condition. The rescuing Train shall be in any payload condition. This requirement shall be achieved for the full range of wheel sizes from new to fully worn and utilisation of adhesion shall not be higher than 0.19.

Rationale: ***HS2 interface -*** *This is the traction requirement to support rescue. Other requirements are specified for other features to support rescue, e.g. brake compatibility. Specification is only made for the HS2 Network because other rescue solutions may be available on the CRN, e.g. rescue locomotives.*

7.3 Braking

See also LOC&PAS TSI[4] §4.2.4 and GM/RT2045
Cross reference: *See also Section 9.10 (Brake control)*

7.3.1 TTS-101 - Full Service Brake Performance (HS2) (PQTS-131)

When operating on the HS2 Network, the full service brake deceleration of the Unit, shall be:

Speed Range (km/h)	Deceleration (m/s²)
360 to 300	0.55
300 to 230	0.56
230 to 170	0.71
170 to 0	0.82

The Unit shall be capable of achieving this deceleration for any payload up to Normal Payload (HDL) without regenerating to the 25kV power supply. For this requirement, the maximum adhesion limit shall be as stated in LOC&PAS TSI[4] Clause 4.2.4.6.1.

Rationale: ***HS2 interface -*** *This brake curve represents the full service brake application on the HS2 network under ATO control. This brake rate is necessary to support capacity of the railway. It must still be possible to achieve this performance if the overhead line is not receptive.*

7.3.2 TTS-102 - Normal Service Brake Performance (HS2) (PQTS-130)

When operating on the HS2 Network, the normal service brake deceleration shall be:

Speed Range (km/h)	Deceleration (m/s²)
360 to 300	0.37
300 to 230	0.38
230 to 170	0.44
170 to 0	0.55

The Unit shall be capable of achieving this deceleration, for any payload up to Normal Payload (HDL), using only regenerative electro-dynamic braking. For this requirement, the maximum adhesion limit shall be as stated in LOC&PAS TSI[4] Clause 4.2.4.6.1.

Rationale: ***HS2 interface -*** *Recovery of the majority of energy from braking is necessary to limit heat input into the tunnels. In addition, this supports energy efficiency.*

7.3.3 TTS-2609 - Emergency Brake Performance (HS2)

With reference to LOC&PAS TSI[4] clause 4.2.4.5.2 (9), the Unit shall be able to achieve a stopping distance in emergency braking from 350 km/h in Normal Payload (HDL) of not more than 5360 m. For this requirement, the maximum adhesion limit shall be as stated in LOC&PAS TSI[4] Clause 4.2.4.6.1.

Rationale: *This gives the design the flexibility to comply with the LOC&PAS TSI[4] Clause 4.2.4.5.2 (9) at a higher payload than the One-Space Layout or Two-Space Layout. 350km/h is specified for consistency with the LOC&PAS TSI.*

7.3.4 TTS-2610 - Emergency Braking Thermal Capacity

With reference to LOC&PAS TSI[4] clause 4.2.4.5.4 (3), the Unit shall be able to dissipate the braking energy from two successive emergency brake applications from 360km/h on level track, separated by the time to accelerate back to the specified speed. For this requirement, the Unit shall be in the Normal Payload (HDL) condition.

Rationale: *This Clause clarifies the Purchaser's requirements with respect to the LOC&PAS TSI[4] Clause 4.2.4.5.4 (3). The 'maximum braking load' defined in the TSI may be set at a value that permits this requirement to be satisfied.*

7.3.5 TTS-103 - Service and Emergency Brake Performance (CRN) (PQTS-127)

The Unit shall be able to achieve service and emergency braking performance in accordance with GM/RT2045[82] curves C1 (including low speed performance highlighted in grey cells) and D1 up to 140mph for any payload up to Exceptional Payload (HDL) without regenerating to the 25kV power supply. For this requirement, the maximum adhesion limit shall be as stated in LOC&PAS TSI[4] Clause 4.2.4.6.1.

Rationale: ***CRN interface -*** *These brake curves are for compatibility with the signalling spacing on the CRN (note that enhanced emergency braking is not required). This curve would be the brake performance when the Train Captain applied a full service brake in manual driving. It must still be possible to achieve this performance if the overhead line is not receptive. Exceptional Payload must be considered because the CRN has no allowance for managing reduced performance in Exceptional Payload conditions.*

7.3.6 TTS-957 - Hold Unit on Gradient

With reference to LOC&PAS TSI[4] Clause 4.2.4.2.1 (12), in the event of the braking energy supply being disrupted or the power supply failing, it shall be possible to hold the Unit in Exceptional Payload (HDL) condition in a stationary position on a 40 ‰ gradient by using the friction brake (or equivalent) of the main brake system alone, for at least two hours.

Rationale: *This gives the design the flexibility to comply with the LOC&PAS TSI Clause 4.2.4.2.1 (12) at a higher payload than the One-Space Layout or Two-Space Layout, and clarifies that the Purchaser requires the maximum braking load to be equivalent to exceptional payload for this requirement.*

7.3.7 TTS-1058 - Low Adhesion Braking Performance

Braking performance of the Unit shall be maximised in low adhesion conditions that are likely to be experienced on the CRN.

Rationale: *The CRN particularly suffers from low adhesion in autumn, due to the impact of leaf-fall. WSP and sanding systems are required to manage the levels of adhesion. No particular provisions for low adhesion are required for the HS2 Network, beyond compliance with LOC&PAS TSI[4] section 4.2.4.6.2.*

Cross reference: *See also Requirement TTS-824 (Sanding Equipment) in Section 9.12 (Sanding and adhesion control)*

7.3.8 TTS-958 - Adhesion-independent Braking Systems

The Unit shall not incorporate a track brake or eddy current brake.

Rationale: ***HS2 and CRN interface -*** *Track brakes and eddy current brakes are not commonly used on the UK Main Line Network, and their use is not under active consideration on HS2 Network.*

7.4 EMC

7.4.1 Overall EMC

7.4.1.1 TTS-1422 - EMC Standards

The Unit shall comply with EN 50121-3-1[57] [59] and EN 50121-3-2[58] [60], i.e. the 2006 and 2016/2017 versions of this standard.

Rationale: ***HS2 and CRN interface -*** *The HS2 Infrastructure Manager have overall responsibility for compatibility with respect to EMC on the HS2 Network. The TMM must meet this EuroNorm to support compatibility. Compliance also supports compatibility with the CRN. Compliance is required with a composite frequency range from both versions of the standard. The 2016 versions are required for the high frequency (>1GHz) radiated emission and immunity test limits as this is a credible hazard due to the proliferation of mobile communication devices operating in these higher frequency bands. Compliance with the 2006 versions is required for compatibility with Network Rail infrastructure.*

7.4.1.2 TTS-106 - EMC (CRN) (PQTS-330)

Electromagnetic emissions from a Train shall be limited to levels that will not create a hazard to the safe operation of infrastructure systems and equipment, or other existing rolling stock on the CRN. The Unit shall be immune to electromagnetic emissions from infrastructure systems and equipment, and other existing rolling stock on the CRN.

Rationale: ***CRN interface -*** *Achieving this requirement supports compatibility with the CRN. Responsibility for EMC with the CRN is allocated to the TMM. The Unit will need to be compatible with legacy infrastructure systems including power supply, signalling and communications, which may not meet modern standards. Additional equipment may be required to prevent interference.*

7.4.1.3 TTS-107 - EMC (Neighbouring Railways) (PQTS-411)

Electromagnetic emissions from a Train shall be limited to levels that will not create a hazard to the safe operation of infrastructure systems and equipment, or other existing rolling stock on neighbouring railways. The Unit shall be immune to electromagnetic emissions from infrastructure systems and equipment, and other existing rolling stock on neighbouring railways.

Rationale: ***CRN interface -*** *Achieving this requirement supports compatibility with the neighbouring railways. Responsibility for EMC with neighbouring railways, where this is due to the Unit, is allocated to the TMM. HS2 services will run in proximity to a number of other rail systems, including London Underground, Manchester Metrolink, Glasgow Subway and other parts of Network Rail infrastructure that do not form part of the CRN. As for the CRN, systems on these networks may not meet modern standards.*

7.4.2 Mobile telephone use

7.4.2.1 TTS-1484 - Mobile Telephone Compatibility

The Unit shall not cause excessive impediment to mobile telephones and other similar devices communicating with public networks.

Rationale: *Some recent rolling stock introduced in the UK has had characteristics that interfere with mobile phone signals. This interference should be minimised as far as possible.*

7.5 Energy collection

7.5.1 Electrical power supply

See also LOC&PAS TSI[4] §4.2.8.2 and GM/RT2111[84]

7.5.1.1 TTS-802 - Power Supply - Definition

With reference to LOC&PAS TSI[4] Clause 4.2.8.2.1 (2), the Unit shall comply with the requirements for the AC 25 kV 50 Hz system only.

Rationale: ***HS2 and CRN interface -*** *Compatibility with other power supply voltages / frequencies (e.g. 750V DC) listed in the TSI is not required.*

7.5.1.2 TTS-1488 - Power Supply Compatibility (HS2)

The Unit shall comply with EN 50388[64] for a 25kV system.

Rationale: ***HS2 interface -*** *The TMM's responsibility for electrical compatibility with the HS2 Network power supply will be to comply with this standard. Note that it will also be necessary to apply this standard for compatibility with the CRN (TTS-1487).*

7.5.1.3 TTS-3348 - Power Factor (HS2)

With reference to EN 50388[64] Clause 6.2, for line voltage below U_{max1} and regardless of the active power flow direction, inductive displacement power factor shall be above 0.95.

Rationale: ***HS2 interface -*** *This requirement is based on the requirement contained in prEN 50388-1[64A] and has been used in the specification of the HS2 power supply. It should be understood that during regeneration the power factor can only be allowed to decrease freely in the range of 1.1U_n and U_{max2} in order to keep voltage within limits.*

7.5.1.4 TTS-1487 - Power Supply Compatibility (CRN)

The Unit shall be compatible with the 25kV power supply systems on the CRN.

Rationale: ***CRN interface -*** *The TMM will have full responsibility for electrical compatibility with the CRN power supply. This will include compliance with applicable standards and compatibility with specific features of the CRN routes.*

7.5.1.5 TTS-2485 - Shore Supply

The Unit shall be compatible with a 400V power supply defined in LOC&PAS TSI[4] Clause 4.2.11.6 and EN/IEC 60309-2[68].
There shall be connections for this power supply at the ends of the Unit, in the vicinity of the auto-coupler.

Rationale: ***Depot interface -*** *This is to enable auxiliary supply when the pantograph cannot be raised. This is only required at the home depot of the Unit, since it is assumed Units will remain powered via pantographs when stabled elsewhere on the network. A position at the end of the Unit is specified to give the capability to provide auxiliary power from a locomotive.*

7.5.2 Pantograph

See also LOC&PAS TSI[4] §4.2.8.2.9 and GM/RT2111[84]

7.5.2.1 The following requirements refer to an **HS2 Pantograph** for the pantograph that will be used on the HS2 Network and a **CRN Pantograph** for a pantograph that will be used on the CRN. The Unit could be fitted with different types of pantograph for each network, or a single type of pantograph that complies with all the requirements for both the HS2 Pantograph and CRN Pantograph. However, a single type of pantograph that would satisfy all of the requirements below has not been identified, so it is assumed that two different types of pantograph will be fitted. It is further assumed that two of each pantograph type will be provided for redundancy, though this is also not specifically required.

7.5.2.2 TTS-398 - OCS Height Range (HS2)

With reference to LOC&PAS TSI[4] Section 4.2.8.2.9.1.1, the installation and movement range of the HS2 Pantograph shall allow mechanical contact with a contact wire at a height of 5.08 -0.02/+0.12m above rail level.

Rationale: ***HS2 interface -*** *This requirement for the HS2 Network is less onerous than LOC&PAS TSI[4] Clause 4.2.8.2.9.1.1, since the HS2 contact wire will be installed at a constant height (with tolerance). The wire will be installed at a nominal minimum height of 5.08 accounting for sag. Following wear on the wire the height is expected to increase the wire height to 5.12m. The Purchaser would support an 'innovative solution' or other approach to permit the HS2 Pantograph to only operate over a reduced height range and not comply with the LOC&PAS TSI Clause 4.2.8.2.9.1.1. Note that wire height at Washwood Heath depot may be at a different height.*

7.5.2.3 TTS-397 - OLE Low Height Limit (CRN)

With reference to Clause 4.5.1 of GM/RT2111[84], the Unit and the CRN Pantograph shall be compatible with a low wire height of 4.087m above rail level.

Rationale: ***CRN interface -*** *This minimum height limit has been defined from data provided by Network Rail. This data shows a number of low wire heights below the nominal minimum in RGS of 4.165m. Stagger is shown by the data to be compliant with NR/L2/ELP/21088[108].*

7.5.2.4 TTS-399 - Pantograph Spacing (HS2)

With reference to LOC&PAS TSI [4] Clause 4.2.8.2.9.7 (3), on a 400m Train, the separation between two active HS2 Pantographs shall be at least 200m.

Rationale: ***HS2 interface -*** *The HS2 Network's overhead line equipment will be compliant with the ENE TSI[8] and designed for 200m spacing. If a single HS2 Pantograph was fitted to each Unit, this requirement would not be achieved, because the orientation of Units will frequently change in service. Additional analysis of compatibility with the OCS would be required at the reduced spacing, and the TMM would be responsible for compatibility as described in MSA Schedule 11.*

7.5.2.5 TTS-990 - Pantograph Head Geometry (HS2)

With reference to LOC&PAS TSI[4] Clause 4.2.8.2.9.2 (1), the head geometry for HS2 Pantograph shall comply with EN 50367[63] Figure A.6.

Rationale: ***HS2 interface -*** *This is one of the two geometries permitted by LOC&PAS TSI §4.2.8.2.9.2. The HS2 Network has been designed for this geometry and not the wider 1950mm head.*

7.5.2.6 The head geometry for the CRN Pantograph is defined as a notified national technical rule to be EN 50367[63] Figure B.6. The head geometry defined in Figure A.6 is also permitted if this is compatible, but this is considered unlikely to be compatible with the CRN due to this profile's insulated horns.

7.5.2.7 TTS-401 - Contact Quality (HS2)

With reference to LOC&PAS TSI[4] Section 4.2.8.2.9.6, on both a 200m Train and a 400m Train, the HS2 Pantograph contact force and dynamic behaviour shall comply with the criteria of ENE TSI[8] Table 4.2.12 at 360km/h while operating on the HS2 Network. The HS2 Network's OCS is characterised by design document HS2-HS2-RR-REP-000-000056[120].

Rationale: ***HS2 interface*** *- The referenced document provides initial information about the OCS, that will be refined during the design development phases of the Unit and OCS, and integration of the two systems in accordance with MSA Schedule 11. This OCS is designed to enable the ENE TSI criteria to be applied at 360km/h, instead of the 320km/h limit specified in the TSI.*

7.5.2.8 The CRN contact force and dynamic behaviour criteria are specified in GM/RT2111[84] section 4.9.1 which defines a set of **CRN Contact Quality Criteria**.

7.5.2.9 The following requirements are based on these criteria and standards.

7.5.2.10 TTS-402 - Contact Quality (CRN, 200m Train)

On a 200m Train, the CRN Pantograph shall meet the CRN Contact Quality Criteria when operating over any part of the CRN at any speed up to the Maximum Line Speed.

Rationale: ***CRN interface*** *- Operation of a single Unit with a single pantograph up to the Maximum Line Speed is achieved by current rolling stock on the WCML and ECML, and so is considered achievable by the Unit.*

7.5.2.11 TTS-2856 - Contact Quality (CRN, 400m Train 100mph)

On a 400m Train, both CRN Pantographs shall meet the CRN Contact Quality Criteria when operating over any part of the CRN at any speed up to 100mph or Maximum Line Speed, whichever is lower.

Rationale: ***CRN interface*** *- Operation of a multiple units at 100mph is achieved by current rolling stock on the WCML and ECML using shorter pantograph spacing than is likely to be achieved with the HS2 Units. Therefore, this requirement is considered achievable by the HS2 Unit.*

7.5.2.12 TTS-2857 - Contact Quality (CRN, 400m Train, 125mph)

The TMM shall use reasonable endeavours to procure that on a 400m Train, both CRN Pantographs shall meet the CRN Contact Quality Criteria when operating over any part of the CRN at any speed up to Maximum Line Speed.

Rationale: ***CRN interface*** *- Operation of multiple units above 100mph has been investigated on a number of projects. Some units have been authorised for operation at 110mph on some sections of the WCML. A 400m Unit should achieve much larger pantograph spacing than trains of existing units, and improvements in pantograph design may permit this requirement to be achieved wholly or partially.*

7.5.2.13 The CRN OLE is defined by NR/L2/ELP/21088[108].

7.5.2.14 There is no requirement for the width (along the track) of the HS2 Pantograph other than that in the LOC&PAS TSI[4]; a single carbon solution would be acceptable.

7.6 Energy consumption

7.6.1 Energy consumption requirements have been set to manage significant parts of the long-term cost and environmental impact of operating the Unit.

Cross reference: *See also Requirement-Intro TTS-847 (Greenhouse Gas Emissions during Lifecycle) in Section 7.20 (Environmental impact)*

7.6.2 TTS-115 - HS2 1SL Energy Consumption (PQTS-49)

When operating on the HS2 Network, the average energy consumption of the Unit shall not exceed [●] kWh/Unit/km when calculated in accordance with the criteria specified in Appendix C and assuming the Normal Payload (1SL).

7.6.3 TTS-3327 - HS2 2SL Energy Consumption

When operating on the HS2 Network, the average energy consumption of the Unit shall not exceed [●] kWh/Unit/km when calculated in accordance with the criteria specified in Appendix C and assuming the Normal Payload (2SL).

7.6.4 TTS-1921 - CRN 1SL Energy Consumption

When operating on CRN, the average energy consumption of the Unit shall not exceed [●] kWh/Unit/km when calculated in accordance with the criteria specified in Appendix C and assuming the Normal Payload (1SL).

7.6.5 TTS-3328 - CRN 2SL Energy Consumption

When operating on CRN, the average energy consumption of the Unit shall not exceed [●] kWh/Unit/km when calculated in accordance with the criteria specified in Appendix C and assuming the Normal Payload (2SL).

Rationale: *Separate targets are set for the HS2 Network and the CRN because the operation, in particular speed, will be quite different on the two infrastructures.*

7.6.6 TTS-1923 - Annual Average Auxiliary Consumption 1SL

The Unit shall not exceed an average auxiliary consumption of [●] kW when calculated in accordance with the criteria and Energy Assessment Tool in Appendix C and assuming the Normal Payload (1SL).

7.6.7 TTS-3330 - Annual Average Auxiliary Consumption 2SL

The Unit shall not exceed an average auxiliary consumption of [●] kW when calculated in accordance with the criteria and Energy Assessment Tool in Appendix C and assuming the Normal Payload (2SL).

Rationale: *A further separate requirement is specified for auxiliary consumption to account for its relatively small proportion compared to traction consumption, and to enable assessment at all times of the year.*

7.6.8 ***Update for contract -*** *The missing values in requirements TTS-115, TTS-3327, TTS-1921, TTS-3328, TTS-1923 and TTS-3330 will be populated in the contracted version of the TTS using values provided for Stage 5 of the Tender Evaluation.*

7.6.9 TTS-3169 - Power Consumption - Standby State

The energy consumption of the Unit when in the Standby State shall be minimised.

Rationale: *This requirement is intended to define that when Units are stabled, their consumption should be reduced to as low a level as possible while protecting the Unit and allowing it to return to service within a reasonable timeframe. It is intended that the full definition of which consumers operate at reduced power will be finalised during the design phase.*

7.7 Auxiliary Power Supply

7.7.1 TTS-815 - Maintain Power through Transitions

Following a loss of 25kV power supply at neutral sections and the HS2-CRN transition, the Auxiliary Power Supply shall maintain full supply to all non-traction systems for at least 30 seconds, provided that the Unit is moving faster than 60km/h.
There may be short interruptions to power supply provided that these are not discernible to Passengers.

Rationale: *This requirement is to cover neutral sections and the transition between HS2 and the CRN. To avoid disruption to passengers, HS2 requires HVACs to continue to operate during the transition.*

7.7.2 TTS-1726 - 10-Minute Auxiliary Supply

Following an unplanned loss of 25kV power supply, the Auxiliary Power Supply shall maintain all passenger-facing systems, except

- heating;
- cooling;
- catering systems; and
- at-seat power sockets

at the same performance as before the power loss, for at least 10 minutes.
This shall be achieved at any external ambient temperature between -5°C and 30°C.

Rationale: *As far as possible, the Unit should maintain normal performance in the initial stages of disruption.*

7.7.3 TTS-3248 - 60-Minute Auxiliary Supply

Following an unplanned loss of 25kV power supply, the Auxiliary Power Supply shall maintain supply to the following systems and functions for at least 60 minutes:

- ventilation for all parts of the Unit; and
- reduced lighting level.

This shall be achieved at any external ambient temperature between -5°C and 30°C.

Rationale: *This supply is to maintain an acceptable passenger environment in the event of a loss of 25kV supply. The one hour duration is specified to ensure there is ventilation during an evacuation, which is predicted to take longer than 30 minutes that is specified for ventilation in the LOC&PAS TSI[4].*

Cross reference: *See also Requirement TTS-388 (CO2 Level - Emergency) in Section 7.16.1 (Saloon climate)*
See also Section 10.20.4 (Reduced lighting)

7.7.4 TTS-1176 - 180-Minute Auxiliary Supply

Following an unplanned loss of 25kV power supply, the Auxiliary Power Supply shall maintain supply to the following systems and functions for at least 180 minutes:
- train control including all displays in the Cab and at the Crew Control Point;
- train protection systems;
- external lights;
- emergency lighting;
- voice communication between Passengers, Train Captain, Train Crew and the Wayside;
- ten minutes of all passenger information colour display operation at any time within the 180 minutes;
- PEAs and call-for-aid devices;
- 10 cycles of Internal Doors;
- 2 cycles of External Doors and Moveable Steps;
- all CCTV and 10 minutes continuous transmission to the Wayside upon request; and
- 10 cycles of the Toilets and all Passenger-facing Sanitary Systems.

This shall be achieved at any external ambient temperature between -5°C and 30°C.

Rationale: *This supply is to maintain an emergency passenger environment and sufficient functionality in the event of a loss of 25kV supply. With respect to Toilets and Sanitary Systems, Passengers must be able to use the Toilet and Sanitary Systems for two hours. Effluent-management systems may be loadshed provided this does not restrict use of the Toilet. A number of cycles or duration is specified to allow sizing of the Auxiliary Power Supply - it is assumed that any number of cycles can be achieve in practice while there is still sufficient supply.*

7.7.5 TTS-2612 - 5-hour Auxiliary Supply

Following an unplanned loss of 25kV power supply, the Auxiliary Power Supply shall maintain the following functions for at least five hours:
- tail lights;
- any power necessary to enable coupling (e.g. coupler cover);
- any power necessary to enable brake control via the brake pipe (TTS-820); and
- any power necessary to control traction and braking of a rescuing Unit from the Cab of the failed Unit (TTS-3415).

This shall be achieved at any external ambient temperature between -5°C and 30°C.

Rationale: *This is to provide sufficient power to enable rescue to be undertaken. In this scenario, Passengers would no longer be on-board*

7.7.6 Note that TTS-1726, TTS-1176 and TTS-2612 should be considered to start at the same time and hence overlap, rather than starting sequentially.

7.7.7 TTS-1174 - Future Flexibility - Additional Auxiliary Capacity

The Auxiliary Power Supply shall enable new systems and equipment to be installed through the Unit's life. The Auxiliary Power Supply shall have a minimum of 10% additional capacity above the level necessary to deliver the performance and functions specified in this TTS for the 2SL, considering the normal range of operation. 10% additional capacity shall be available for both AC and DC supplies.

Rationale: *This additional capacity is specified to enable new systems to be added to the Unit during the design process or during future refurbishment.*

7.7.8 TTS-2475 - Future Flexibility - Additional Electrical Storage Capacity

The Auxiliary Power Supply shall have a minimum of 10% electrical storage above the level necessary to deliver requirements TTS-1726, TTS-1176 and TTS-2612.

7.7.9 Note that where the collaboration processes defined in MSA Schedule 9, Appendix 1 lead to changes to on-board power consumption, the TMM will need to report any impact on compliance with TTS-1174 and TTS-2475, and any other TTS requirements, which would be resolved via a Purchaser Change.

7.8 Structural integrity and Carbody

See also LOC&PAS TSI[4] §4.2.2, GM/RT2100[83] and guidance note GM/GN2686[97]

7.8.1 Requirements for Window and deadlight size and position are specified in Section 11.1.3. These requirements will affect the Carbody design and its structural integrity.

7.8.2 TTS-121 - Loadings in Service (PQTS-414)

The Unit shall withstand all loadings it will experience during its design life including:
- external pressure variations due to the passage through tunnels on the HS2 Network (described in the Data Book[116]) and CRN;
- external pressure loads due to passing other rolling stock;
- variation of payloads as defined below;
- track inputs that will be experienced traversing the CRN and HS2 Network;
- traction and braking forces, including forces experienced in multiple unit operation and during rescue by another Unit; and
- forces encountered during coupling.

For the purposes of these requirements, the payloads shall be assumed to be:

Payload	Percentage of journeys
working order	2%
Normal Operational Payload (HDL)	67%
Normal Payload (HDL)	30%
Exceptional Payload (HDL)	1%

Other data on the usage of the Unit is provided in Appendix A.

Rationale: *While meeting this requirement is inherent in delivering fit-for-purpose rolling stock, this has been separately specified to elicit assurance that this aspect of the design is being managed. In particular, the maximum operating speed and the tunnel dimensions mean that the fatigue loads may be higher than experienced on other high speed railways.*

7.8.3 TTS-3162 - Inter-vehicle Forces

The inter-vehicle connection shall be capable of transferring shear forces between adjacent vehicles of 100 kN in both the vertical and transverse directions simultaneously without significant permanent deformation.

Rationale: *This requirement is specified for inter-vehicle couplers in GM/RT2100[83], but is not notified. It is expected that this requirement will be transferred to a RIS. It is considered that rolling* *stock should comply with this requirement to manage the risk of separation of vehicles in a crash. Feedback from crash investigations has shown that compliance with this requirement is necessary.*

7.8.4 TTS-3163 - Body-Bogie Forces

Connections between the Carbody and running gear shall comply with GM/RT2100[83] section 4.2.

Rationale: *EN 13749[33A] and EN 15827[46A] specify a loadcase for the body-bogie connection, but this only considers longitudinal forces from the collision scenarios defined in EN 15227[43A]. GM/RT2100[83] additionally specifies vertical and lateral forces. Feedback from crash investigations has shown that retaining the bogie is an important goal, and GM/RT2100[83] is considered best practice in this area. This requirement was originally written for conventional, non-articulated bogies.*

7.8.5 TTS-2042 - Shock and Vibration

The components of the Unit shall comply with EN 61373[69].

Rationale: *This contributes to the general need for the Unit to be fit-for-purpose.*

7.8.6 TTS-1184 - Carbody Finish

The surface finish of the Carbody, Exterior Doors and other external surfaces visible to Passengers shall present a high quality finish that delivers:
- a smooth and continuous surface free from protuberances, sharp edges, weld spatter or manufacturing marks;
- a ripple-free appearance when painted or covered in high gloss materials;
- panel joints on the exterior that are not visually misaligned to an observer with normal eyesight standing 1m from the joint; and
- no undulations on any exterior surfaces exceed 2mm over 1m length, excluding Vehicle roof and under frame.

Rationale: *When viewed along the Unit, the exterior surfaces should present a high-quality impression to Passengers*

7.8.7 TTS-1216 - Paint Durability

The external paint system shall maintain the Minimum Aesthetic Standard for at least 15 years life, assuming that the nose section is repaired every 6 months and other parts of the Unit are repaired every 3 years.

Rationale: *This requirement aligns with rules on developing the Maintenance Plan in MSA Paragraph 4.9. 15 year life is based on best practice established on recent projects.*

7.8.8 TTS-1217 - Full Body Decals

The external paint system shall be compatible with installation and removal of decals, which may cover the whole exterior of the Unit.

Rationale: *Decals may be used to change the livery through the life of the Unit.*

7.9 Gauging

7.9.1 Vehicle gauge

See also LOC&PAS TSI[4] §4.2.3.1 and GM/RT2173[91].

7.9.1.1 TTS-123 - Vehicle Gauge (HS2) (PQTS-226)

While operating on the HS2 Network, at all speeds up to Maximum Line Speed, the Unit's vehicle gauge shall comply with the GC reference profile for the upper part and the GI2 reference profile for the lower part, both as defined in EN 15273-2[44], under all payloads.

Rationale: ***HS2 interface -*** *The HS2 Network is being built to these reference profiles. These gauges are larger than the Vehicle gauge for the CRN. A separate gauge is specified for the HS2 Network to highlight that the Unit could use this additional space while operating on the HS2 Network (e.g. to permit deployable aerodynamic devices).*

7.9.1.2 TTS-1826 - Lower Sector Vehicle Gauge (LSVG)

While operating on the CRN, the Unit shall remain within the LSVG defined by GE/RT8073[102] Appendix C considering dynamic vehicle movements while operating on the CRN and tolerances including all radial wheel wear and flange wear and wheel / rail interface movements. This shall be achieved for Exceptional Payload (HDL), at any speed up to 125mph.

Rationale: ***CRN interface -*** *Compliance with the LSVG has been requested by Network Rail. Even though larger lower sectors may be possible on some routes, this gauge provides an agreed long-term interface that both Network Rail and vehicle builders can work to.*

7.9.1.3 TTS-1471 - Vehicle Gauge (CRN) (PQTS-142)

While operating on the CRN, the Unit's swept envelope shall remain within the HS2 Vehicle Gauge[121].

Rationale: ***CRN interface -*** *Compliance with this agreed gauge is required to manage the risk of infrastructure changes on the CRN.*

7.9.1.4 ***Update for contract -*** *An HS2 Vehicle Gauge will be agreed as a separately-published document, which will become reference [121]. The Tenderer will propose a Tender Vehicle Gauge via the Gauging Challenge[122], which forms part of Stage 2.2 of the tender evaluation. This Tender Vehicle Gauge must meet the following requirements. For these requirements* ***Moderate Infrastructure Changes*** *and* ***Major Infrastructure Changes*** *are defined in the Gauging Challenge, and the CRN is considered as those parts of the CRN listed in the Gauging Challenge.*

7.9.1.5 TTS-3447 - Major Infrastructure Changes - Mandatory

Compatibility between the Tender Vehicle Gauge and the CRN shall not require any Major Infrastructure Changes.

7.9.1.6 TTS-3450 - Moderate Infrastructure Changes - Mandatory

Compatibility between the Tender Vehicle Gauge and the CRN shall only require Moderate Infrastructure Changes where these are necessary to achieve:
- compliance with other TTS requirements; or
- values stated in response to Stage 5 Whole Life Value requirements in the TTS.

7.9.1.7 ***Update for contract -*** *During the course of the MSA, TTS-3447 and TTS-3450 are covered by Schedule 13 and TTS-1471, so it will not be necessary to retain these requirements in the TTS.*

7.9.1.8 It is important that the requirement to be compatible with the CRN infrastructure gauge is not achieved through making the Vehicle cross section unnecessarily small. Therefore, a minimum interior cross-section requirement has been specified, which applies to the Contractually Protected Area - see section 11.3.

7.9.1.9 TTS-633 - Cross-section

The Vehicle shall maintain an interior space envelope along each side of the aisle for the full length of the Contractually Protected Area that is free of all equipment except:

- Passenger Seats;
- tables;
- facilities for Wheelchair Spaces;
- luggage stacks; and
- catering equipment.

The minimum size of the interior space envelope shall be:

Preferred 1: The minimum interior space envelope shall be as per Appendix D, Figure D1.
Preferred 2: The minimum interior space envelope shall be as per Appendix D, Figure D2.
Mandatory: The minimum interior space envelope shall be as per Appendix D, Figure D3.

Rationale: *A minimum cross-section is specified to achieve an acceptable level of passenger comfort, comparable with existing UK intercity rolling stock.*

Cross reference: *See also Requirement TTS-639 (Minimum Seat Width - HS2 Seat) in Section 10.3.2 (HS2 Seats)*
See also Requirement TTS-646 (Provision of Armrests - HS2 Seat) in Section 10.3.2 (HS2 Seats)
See also Requirement TTS-647 (Armrest Width - HS2 Seat) in Section 10.3.2 (HS2 Seats)
See also Requirement TTS-1924 (Retain Contractually Protected Area) in Section 11.3 (Contractually Protected Area)

7.9.2 Compatibility with train detection systems

See also ERA/ERTMS/033281[12] and GM/RT2173[91] §3.3

7.9.2.1 TTS-129 - Front End Overhang (PQTS-216)

With reference to GM/RT2173[91] Clause 3.3.1.e, the distance between the end of the Unit and the first axle shall be no more than 4.2m.

Rationale: ***CRN interface -*** *The LOC&PAS TSI[4] Clause 4.2.3.3.1.2, referencing ERA/ERTMS/033281[12] Clause 3.1.2.6 specifies a maximum overhang of 4.2m. It has not been possible to conclusively demonstrate whether or not an overhang longer than 3.226m (specified in GM/RT2173[91] Clause 3.3.1.e) is compatible with the CRN. The Purchaser will support a deviation for a longer overhang up to 4.2m (in accordance with TTS Appendix O and MSA Schedule 13) provided it is demonstrated that this overhang is necessary to meet aerodynamic and hence noise and energy consumption requirements. If the Unit has an overhang longer than 3.226m, the Unit will require roll back protection / hill-start functionality (TTS-259) to support any deviation (raised in accordance with the Railway Group Standards Code[77]) to GM/RT2173.*

7.9.3 Electrical clearance

7.9.3.1 TTS-3341 - Electrical Clearance (HS2)

The Unit shall comply with the electrical clearances specified in EN 50122-1[60A] Section 5.2.1 for: • a wire height as specified in TTS-398; and • an HS2 Platform positioned as specified in paragraph 7.15.3.1 of this TTS. The United Kingdom special national condition in Annex G of EN 50122-1 shall not be applied.

Rationale: ***HS2 interface -*** *This defines the conditions for the application of this standard. The UK special condition is not considered appropriate for new systems.*

7.9.3.2 TTS-2712 - Electrical Clearance (CRN)

The risk to Passengers: • on a nominal CRN platform; and also when • boarding the Unit due to electrical clearances shall be no worse than for existing rolling stock operating on the CRN.

Rationale: ***CRN interface -*** *Although the risks associated with electrical clearance are primarily defined by the OLE height (outside TMM control) and pantograph profile (set by standards), the installation of the pantograph and high voltage equipment on the roof can have a relative impact on safety compared to existing rolling stock. Class 390 and Class 800 are considered to have the highest risk due to the tapered carbody cross-section profile and position of the bodyside door respectively.*

7.10 Mass and static loads

See also GE/RT8006[100]

7.10.1 TTS-911 - Minimum and Maximum Mass and Axle Loads (PQTS-453)

The mass of the Vehicles of the Unit, and the axleload of each axle within the Unit, calculated in the Normal Payload (HDL) condition, shall be within ±10% of the values defined in Appendix E.

Rationale: ***CRN interface -*** *The mass limits and axle load limits are specified for the purpose of managing compatibility with underline bridges. The values in Appendix E will be used to assess compatibility and determine any infrastructure changes (at HS2 Ltd's cost) or operational restrictions.*

7.10.2 ***Update for contract -*** *Appendix E is currently blank. It will be populated in the contracted version of the TTS using values provided in the TMM Train Proposal.*

7.10.3 TTS-132 - Maximum Axle Load (PQTS-118)

The maximum axle load of any axle, in Normal Operational Payload (HDL), shall be not more than 17.0 tonnes.

Rationale: ***HS2 interface -*** *This is consistent with the INF TSI[9] Table 2, Clause 4.2.1, with previous high speed design limits and is the interface value for the HS2 Network for the design of the civil structures and track.*

7.10.4 TTS-133 - Maximum Route Availability (PQTS-119)

The Route Availability (RA) value of the Unit, calculated in accordance with GE/RT8006[100] with Exceptional Payload (HDL+RA), shall not exceed:

Preferred 1: The RA value shall not exceed RA3.
Preferred 2: The RA value shall not exceed RA4.
Preferred 3: The RA value shall not exceed RA5.
Preferred 4: The RA value shall not exceed RA6.
Preferred 5: The RA value shall not exceed RA7.

Rationale: ***CRN interface -*** *RA7 equates to axle-load of 22 tonnes (note the different payloads between TTS-133 and TTS-132), but is also dependent on axle spacing. RA7 is the limit for all CRN core routes and all proposed diversionary routes at the current 'permissible' linespeeds (typically 110mph). However there is a goal of increased linespeeds up to the 'EPS' speed limits at some locations (typically 125mph) and a lower RA number would reduce the impact on bridges where speeds are increased (current rolling stock operating at EPS limits is RA3). The payload to be used for this requirement is specified by GE/RT8006 and has been confirmed by Network Rail as applicable for this analysis. It is different from the exceptional payload definition used for other analyses.*

7.11 Track interaction

7.11.1 Track damage

See also LOC&PAS TSI[4] §4.2.3 and GM/TT0088[78]

7.11.1.1 TTS-1723 - Track Forces (PQTS-452)

The Unit shall comply with GM/TT0088[78] with a maximum normal operating speed (V_m) of 140mph and Exceptional Payload (HDL). Compliance shall be to Clauses 5.2, 6.2, 7.2 and 7.3. Alternative requirements in Clauses 5.3, 6.3 and 7.4 shall not be applied.

Rationale: ***HS2 and CRN interface -*** *Compliance with this standard at 140mph is required for future capability to operate at 140mph on the CRN. Compliance with this requirement will also ensure the unsprung mass is limited below the level that has been assumed for ground-borne noise and vibration (2.25 tonnes).*

7.11.1.2 TTS-137 - Variable Usage Charge (1SL) (PQTS-236)

The CRN Variable Usage Charge, calculated in the Normal Payload (1SL) condition in accordance with the Network Rail VUC calculator[128] shall be less than [•] p/mile/Unit when calculated in accordance with Appendix F.

7.11.1.3 TTS-3345 - Variable Usage Charge (2SL) (PQTS-236)

The CRN Variable Usage Charge, calculated in the Normal Payload (2SL) condition in accordance with the Network Rail VUC calculator[128] shall be less than [•] p/mile/Unit when calculated in accordance with Appendix F.

Rationale: *On the CRN, the Variable Usage Charge captures the cost of track interaction including all appropriate vehicle characteristics.*

7.11.1.4 ***Update for contract -*** *The missing values in requirements TTS-137 will be populated in the contracted version of the TTS using values provided in the Stage 5 Tender Evaluation.*

7.11.1.5 TTS-1236 - Tγ Limit - Mandatory

The T-gamma (Tγ) for each axle of the Unit shall lie below the curve shown in Appendix G, Table G1/Figure G2. The Tγ values shall be calculated in accordance with Appendix G.

Rationale: ***CRN interface -*** *The T-gamma curve limit has been used on other recent rolling stock procurements as a way of limiting track damaging characteristics of the proposed Vehicle / Running Gear. This curve is specified to limit any single axle, based on predicted values for power head and articulated designs.*

7.11.1.6 TTS-1715 - Whole Unit Damage

The 'whole-Unit damage', calculated in accordance with the methodology set out in Appendix G, shall not exceed the limit lines shown in Appendix G, Figure G5.

Preferred 1: The whole-Unit damage shall not exceed the dotted line of Figure G5.
Preferred 2: The whole-Unit damage shall not exceed the dashed line of Figure G5.
Mandatory: The whole-Unit damage shall not exceed the solid line of Figure G5.

Rationale: ***CRN interface -*** *These curves limit the overall damage of the whole Unit, and account for differences between power head and distributed traction, and different Running Gear solutions.*

7.11.1.7 TTS-1549 - Flange Lubrication

The Unit shall be fitted with a flange lubrication system that ensures all flanges on the Unit are lubricated and the lubrication is effective on all curves on the CRN.

Rationale: ***CRN interface -*** *It is inevitable that the Unit will project high rotational forces on the CRN due to the need for stability on the HS2 Network. Flange lubrication will reduce the wear on CRN curves. It is not possible to rely on flange lubrications systems on the infrastructure, as these are insufficient. It is not intended that flange lubrication will be necessary for operation on the HS2 Network.*

7.11.2 Track curvature

See also LOC&PAS TSI[4] §4.2.3.6

7.11.2.1 The following requirements make reference to payload conditions defined in section 2.4 and standard EN 15663[46] and suspension conditions. The possible suspension conditions are considered to be:

- inflated - secondary air suspension working correctly
- deflated - secondary air suspension has failed and the vehicle is resting on an emergency spring
- any - either of the above conditions

7.11.2.2 TTS-140 - Minimum Horizontal Curvature (CRN, Unit) (PQTS-207)

A 200m Train in working order, as defined by EN 15663[46], and with inflated secondary suspension shall be able to traverse the following minimum track curve radii on the CRN:
- horizontal single curve: 120m; and
- horizontal reverse curve: 150m - 3m straight - 150m.

Rationale: ***CRN interface -*** *This curvature is based on the minimum curvature on the depots. Studies have been undertaken to confirm this is the minimum radius curvature that the Unit needs to negotiate. No payload is included because this would be for empty coaching stock moves only. Inflated suspension is specified to prevent over-design to cope with deflation and worst-case curves together.*

7.11.2.3 TTS-1541 - Minimum Horizontal Curvature (CRN, 400m Train)

A 400m Train in any payload condition and any suspension condition shall be able to traverse the following minimum track curve radii on the CRN:
- horizontal single curve: 150m; and
- horizontal reverse curve: 165m - 3m straight - 165m.

Rationale: *This geometry corresponds to the tightest geometry identified on the CRN. HS2's analysis has determined that this equivalent, in terms of inter-Vehicle shear, to a 150m-6m-150m reverse curve (assuming a 25m Vehicle with conventional bogies).*

7.11.2.4 TTS-912 - Minimum Horizontal Curvature (Coupling) (PQTS-454)

The Unit shall be able to couple to another Unit without external assistance, and uncouple, on a 400m horizontal curve. Each Unit may be in any payload condition. Both Units shall have inflated secondary suspension.

Rationale: ***HS2 interface -*** *This radius is the minimum radius curve on the HS2 Network, where rescue must be possible by another Unit. Normal in-service coupling would take place on straight track. No value is specified for the CRN, because the Unit could be rescued by a range of different rolling stock.*

7.11.2.5 TTS-1233 - Minimum Horizontal Track Curvature (HS2)

A 400m Train in any payload condition and any suspension condition shall be able to traverse the following minimum track curve radii on the HS2 Network:
- 400m on passenger lines; and
- 190m within HS2 depots.

Rationale: ***HS2 interface -*** *The minimum curve radius on the HS2 Network is larger than the CRN. This larger minimum radius could be exploited by the Unit while operating on the HS2 Network in the same way as a larger vehicle gauge.*

7.11.2.6 TTS-351 - Minimum Vertical Curvature

A 400m Train shall be able to traverse the following minimum vertical curve radii in any payload condition and with inflated secondary suspension:
- minimum convex (crest) curve: 500m; and
- minimum concave (hollow) curve: 500m.

Rationale: ***HS2 and CRN interface -*** *The minimum vertical curves are taken from guidance note GM/GN2689. This is the best available source of data, although this may not reflect the actual CRN infrastructure. If these minima cannot be achieved, an alternative method of demonstrating compatibility with the CRN will need to be determined.*

7.12 Running behaviour

See also LOC&PAS TSI[4] §4.2.3, EN 14363[38], ERA/TD/2012-17/INT[11] and GM/RT2141[88]

7.12.1 TTS-2611 - Running Behaviour Capability

The Unit shall be capable of complying with EN 14363[38] [39] at any speed up to 360km/h in Normal Payload (HDL) and Exceptional Payload (HDL) as specified by EN 14363.

Rationale: *The Unit must still be able to comply with EN 14363 if the layout is changed to any layout up to and including the HDL through the Unit's life.*

7.12.2 TTS-1250 - Stability at High Conicity

The TMM shall demonstrate by analysis that the Unit suspension design shall maintain stability as defined by EN 14363[39] Section 7.6.5:

- when the equivalent conicity is 0.4, for any speed up to 140mph;
- when the equivalent conicity is 0.2, for any speed up to 360km/h; and
- for the full range of suspension wear.

Rationale: *The curving and speed profiles are very different between the HS2 Network and the CRN. It is possible that vehicles designed for stability on the HS2 Network at very high speeds may be too stiff in yaw on the CRN. In contrast, vehicles designed for good curving on the CRN will hunt, or exhibit lateral instability, on the HS2 Network. This requirement seeks to limit the proclivity of the Unit to hunt on the CRN. Critical speed hunting generally tends to be in the region of 4-8Hz, but lower frequency hunting will be noticeable and unpleasant. Whilst it can be viewed that this requirement is contained within compliance to EN 14363, notable cases of previous rolling stock designs being unable to meet stability requirements soon after acceptance suggest that the issue should be included as a requirement for specific emphasis, and absolute lack of ambiguity. The conicity of 0.4 is an assumed value of conicity that could be reached on the CRN following wear to the track and wheels.*

7.12.3 With reference to EN 14363[38] [39] and the requirements for overspeed testing specified therein, The HS2 Infrastructure Manager does not require overspeed testing for its purposes. However, it remains the TMM's responsibility to demonstrate to the Notified Body and to itself that EN 14363 is complied with at 360km/h.

7.12.4 With reference to GM/RT2141[88] Clause 2.4 (Resistance to roll-over induced by overspeeding), the Purchaser would support a deviation (raised in accordance with the Railway Group Standards Code[77]) to reduce the limit of 21° to 18°.

7.13 Ride quality

7.13.1 TTS-2621 - Ride Quality - HS2 (PQTS-155)

The Unit shall achieve a mean comfort index, N_{MV}, of no more than 1.2 while operating on the HS2 Network. This shall be measured:

- in accordance with EN 12299[31];
- while operating on the HS2 Network, which will have track quality that is no worse than that described in the Data Book[116];
- while operating at 360km/h; and
- with the Unit having Working Order (2SL) payload.

7.13.2 TTS-144 - Ride Quality - CRN (PQTS-155)

The Unit shall achieve a mean comfort index, N_{MV}, of no more than 1.5 while operating on the CRN. This shall be measured:
- in accordance with EN 12299[31] averaged across all five-minute sections of a run, except that the assessment will not be at a constant speed;
- on a run from Wigan to Carlisle on the CRN, which will have track quality that is no worse than that described in the Data Book[116];
- with the Unit operating at the current maximum permissible speed as defined in the Data Book[116], subject to acceleration and braking; and
- with the Unit having Working Order (2SL) payload.

The Engineer's Line References (ELRs) for the measurement zone are CGJ5, 0m 52ch to CGJ7 69m 09ch.

7.13.3 TTS-2620 - Ride Quality - Minimum (PQTS-155)

The mean comfort index, N_{MV}, of the Unit, measured in accordance with EN 12299[31], shall be no more than 2.0 on any single five-minute section, when operating:
- at any speed up to the Maximum Line Speed;
- both the HS2 Network and CRN, assuming track quality no worse than provided in the Data Book[116];
- any payload between Working Order (2SL) and Normal Payload (HDL); and
- the full range of wheel and suspension wear.

Rationale: *These levels of ride quality have been specified based on measurements of existing vehicles in-service on comparable infrastructures, including both conventional rolling stock on UK infrastructure and high speed trains on high speed infrastructure.*

7.14 Aerodynamics

See also LOC&PAS TSI[4] §4.2.6.2 and GM/RT2100[83] §7

7.14.1 TTS-146 - Pressure Sealing - Saloon (PQTS-188)

Throughout its operation on all parts of the HS2 Network and CRN, the maximum rate of change of pressure, in kPa, inside any Saloon shall be:

	over 1 sec	over 10 sec
Increase	+0.2	+1.5
Decrease	-0.5	-2.0

Rationale: *The defined pressure changes inside the Unit are considered to give an acceptable level of comfort for Passengers. Sudden pressure changes can occur due to transitions through tunnels, including at the exit of tunnels and the entry into the tunnel of a second train 150s behind. Outline tunnel designs are described in the Data Book[116]. Using these tunnel designs, an assumed cross-sectional area of 10m² for a conventional-compatible vehicle gauge and a sealing time-constant of 18 seconds, the increase and decrease in pressure through all of tunnels has been calculated. The figures in the table represent the worst case across all of these tunnels. In addition to tunnels, rapid changes could also occur at stations when Exterior Doors are opened if there is not appropriate control on the approach to the station.*

7.14.2 TTS-3200 - Pressure Sealing - All

Throughout its operation on all parts of the HS2 Network and CRN, the maximum rate of change of pressure inside any part of the Unit shall be:

- No greater than ±0.5kPa during any 1 second period; and
- No greater than ±2.5kPa during any 10 second period.

Rationale: *This requirement gives a lower pressure sealing requirement for non-passenger areas.*

7.14.3 TTS-217 - Maximum Cross-section

The Unit shall have a maximum cross-section of $11m^2$.

Rationale: ***HS2 interface -*** *This maximum cross-section has been used in the design of the tunnels. HS2's gauging analysis has shown that a Vehicle compatible with the CRN infrastructure will probably have a cross-section closer to $10m^2$.*

7.14.4 Tunnels on the HS2 Network include porous tunnel portals in the infrastructure design to mitigate the adverse effects of micro-pressure waves. Therefore it will not be necessary to include micro-pressure wave mitigation features in the Unit design.

7.14.5 TTS-221 - Slipstream on Passengers / Trackworkers

The maximum air speed, $u_{2\sigma}$, when a Unit passes at 300km/h shall not exceed 15m/s, measured at 3m from the track centreline, 0.2m above the track, in accordance with LOC&PAS TSI[4] Clause 6.2.3.13 and EN 14067-4[34] Clause 8.5.2 referenced therein.

Rationale: ***HS2 interface -*** *This is a more onerous version of LOC&PAS TSI §4.2.6.2.1, and is the compatibility requirement for the HS2 Network to ensure safety of passengers on platforms and trackworkers. The HS2 Network has been designed with an assumed reduction in slipstream impact compared to the LOC&PAS TSI. Analysis of existing streamlined high speed trains shows this should be achievable.*

7.14.6 TTS-222 - Head Pressure Pulse

With reference to LOC&PAS TSI[4] Clause 4.2.6.2.2 (3), both a 200m Train and a 400m Train, travelling at 250km/h shall not cause the maximum peak-to-peak pressure changes to exceed a value of 700Pa, as assessed over the range of height between 1.5 m and 3.0 m above the top of rail, and at a distance of 2.5 m from the track centre, during the passage of the head. This shall be assessed in accordance with LOC&PAS TSI Clause 6.2.3.14 and clauses of EN 14067-4[34] referenced therein.

Rationale: *This is a more onerous version of LOC&PAS TSI §4.2.6.2.2, and is specified to improve passenger comfort on passing trains. The requirement for compatibility is that specified in the LOC&PAS TSI.*

7.14.7 TTS-3042 - Maximum Pressure Variation in Tunnels

With reference to LOC&PAS TSI[4] Clause 4.2.6.2.3 (1), a 400m Train shall be aerodynamically designed so that for the given reference case of train speed and tunnel cross section in case of a solo run in a simple, non-inclined tube-like tunnel (without any shafts etc.) the requirements for characteristic pressure variation in the following table shall be met:

Reference Case		Criteria for reference case		
V_{tr}	A_{tu}	Δp_N	$\Delta p_N + \Delta p_{Fr}$	$\Delta p_N + \Delta p_{Fr} + \Delta p_T$
250 km/h	63.0 m²	= 1600 Pa	= 2700 Pa	= 3700 Pa

Rationale: ***HS2 interface -*** *This more onerous version of LOC&PAS TSI §4.2.6.2.3 is specified to manage the maximum pressure applied to tunnel systems and the maximum pressure variation inside the Unit if the pressure sealing failed. The requirement is based on an analysis of a future type of unit, which is assumed to have an 11m² cross-sectional area.*

7.14.8 TTS-224 - Characteristic Wind Curves

The Characteristic Wind Curve (CWC) for the Unit's leading Vehicle and the adjacent Vehicle shall be, for all values, greater than or equal to the CWCs in prEN 14067-6[37] Tables 9, 10 and 11. The CWCs shall be assessed using reduced-scale wind tunnel measurements in accordance with EN 14067-6[36] Section 5.3.4 and the single track ballasted rail ground configuration (§5.3.4.11). The calculation of the wheel unloading shall be carried out using all of the three methods defined in EN 14067-6[36] Sections 5.4.2 to 5.4.4.

Rationale: ***HS2 and CRN interface -*** *This is a development of LOC&PAS TSI §4.2.6.2.4(3)(b). It is required that option (b) is adopted, and not option (a). In addition to defining the characteristic wind curve, it is required that it exceeds a minimum set of values defined in prEN 14067-6[37] to ensure a minimum performance is achieved.*

7.15 Access and egress

See also PRM TSI[6] §4.2.2.11 and GM/RT2173[91]

7.15.1 High-level goals

7.15.1.1 The Unit will need to interface with both HS2 Platforms (section 7.15.3) and CRN platforms (7.15.4). The Unit does not need to have compatibility with any other platform heights.

7.15.1.2 There are two high-level goals for the PTI described by requirements TTS-2635 and TTS-1963.

7.15.1.3 TTS-2635 - Optimal PTI - Accessibility

The PTI between the Unit and all stations on the HS2 Network and CRN shall enable the widest range of Passengers, including PRMs, to board and disembark the Unit unaided and with confidence.

7.15.1.4 TTS-1963 - Optimal PTI - Dwell Times

The PTI between the Unit and all stations on the HS2 Network and CRN shall minimise the time taken for all Passengers to board the Unit.

7.15.1.5 It is considered that these top-level requirements are generally achieved by the requirements in sub-sections 7.15.2 to 7.15.4, but a detailed review of the emerging and final design against these two requirements will still be necessary as part of the Platform Train Interface Plan required as part of Schedule 9 to the MSA.

7.15.1.6 Appendix H contains figures illustrating the requirements of this section.

7.15.2 Moveable Step

7.15.2.1 TTS-1324 - Moveable Step (PQTS-295) - Mandatory

The Unit shall have a Moveable Step at every Exterior Door, which shall be automatically deployed (unless inhibited) when the door is released, and fully retracted whenever the Unit is in motion.

Rationale: *A Moveable Step is considered necessary to provide an improvement in the PTI compared with existing rolling stock and to meet HS2 goals for accessibility.*

Cross reference: *See also Section 9.18.9 (Moveable Step)*

7.15.2.2 TTS-158 - Step-Vestibule Vertical Limit (PQTS-406)

The vertical distance between the Moveable Step and the floor of the Vestibule immediately inside the Exterior Door, v_2, shall not exceed:

Preferred 1: The v_2 threshold-step distance shall not exceed 20mm.
Preferred 2: The v_2 threshold-step distance shall not exceed 30mm.
Mandatory: The v_2 threshold-step distance shall not exceed 40mm.

Rationale: *Minimising the step between the Movable Step and the vestibule will aid access and egress. The preferred value of 20mm represents a step that almost all users can negotiate.*

7.15.2.3 TTS-2705 - Infill Slope at Threshold

If the v_2 threshold-step distance is greater than 20mm, there shall be an infill slope at the threshold, $\theta_{threshold}$, of no greater than 20° to the horizontal.

Rationale: *Applying a short slope at the door threshold may ease transition between the step and the vestibule, but the gradient and length of this slope are limited, and it must be ensured that a large enough stepping surface (TTS-157) is maintained.*

7.15.2.4 TTS-157 - Deployed Step Depth (PQTS-405)

When deployed at an HS2 Platform, the Moveable Step shall have a minimum horizontal surface depth perpendicular to the bodyside, h_{step}, of 240mm.

Rationale: *This ensures that the step is large enough for passengers to get their foot comfortably on to the step.*

7.15.2.5 TTS-1949 - Step Surface Angle

The top, walking surface of the Moveable Step shall have a maximum angle, θ_{step}, to the horizontal plane of 6.84°, when the Vehicle is on level track.

Rationale: *A step at an angle may permit a reduction in vertical discontinuities across the PTI. The angle is taken from the PRM TSI[6] Table 6. A steeper angle than specified would be too difficult to* *stand on. Adoption of an angle will need consideration of the PTI at stations with canted track - see data in the Data Book[116]. This maximum angle does not apply to short transitions between the step and the vestibule - see TTS-2705.*

7.15.2.6 TTS-264 - Moveable Step Width

The Moveable Step shall have a minimum width, parallel to the bodyside, of at least the clear usable width of the doorway.

Rationale: *The design of the PTI needs to consider Passengers who approach the doorway at an angle.*

Cross reference: *See also Requirement TTS-170 (Minimum Door Horizontal Clearway) in Section 7.15.5 (Doorway clearway width)*

7.15.3 Platform to Moveable Step interface (HS2)

7.15.3.1 The HS2 Platform will have the following dimensions:

- Height: 1115mm above rail level; and
- Offset: 1655mm from track centreline, adjusted for curves; platforms have a minimum curve radius of 1000m.

7.15.3.2 The TMM should assume that legal requirements allowing the use of platforms at such a height will be in place prior to the HS2 Network being brought into service.

7.15.3.3 TTS-153 - Platform-Step Vertical Limit (Normal) (PQTS-400)

Except under Abnormal PTI Conditions, the maximum vertical distance between the deployed Moveable Step and an HS2 Platform, $v_{1,normal}$, shall not exceed:

Preferred: The $v_{1,normal}$ step-platform distance shall not exceed +20/-0mm.
Mandatory: The $v_{1,normal}$ step-platform distance shall not exceed +30/-0mm.

Rationale: *The preferred value of 20mm represents a step that almost all users can negotiate; higher steps are negotiable but with decreasing success rates.*

7.15.3.4 TTS-154 - Platform-Step Vertical Limit (Abnormal) (PQTS-402)

Under all conditions including Abnormal PTI Conditions, the maximum vertical distance between the deployed Moveable Step and an HS2 Platform, $v_{1,abnormal}$, shall not exceed:

Preferred: The $v_{1,abnormal}$ step-platform distance shall not exceed +30/-5mm
Mandatory: The $v_{1,abnormal}$ step-platform distance shall not exceed +40/-10mm

Rationale: *It is recognised that the normal stepping distance tolerance cannot be achieved in all conditions, and that a larger tolerance may exist in some conditions, e.g. Exceptional Payload, deflated secondary suspension.*

7.15.3.5 TTS-156 - Platform-Step Horizontal Limit (PQTS-403) - Mandatory

The maximum horizontal gap between a deployed Moveable Step and the HS2 Platform, h_{gap}, shall be:
- 20mm to the furthest point of the step where the HS2 Platform is straight; and
- 20mm to the nearest point where the HS2 Platform is curved.

Rationale: *This is the largest gap that all users could comfortably negotiate.*

Cross reference: *See also Requirement TTS-2469 (Moveable Step Deployment Distance - HS2) in Section 9.18.9 (Moveable Step)*

7.15.4 Platform to Moveable Step interface (CRN)

7.15.4.1 Platforms on the CRN have a nominal design position of 915mm as defined by GIRT7020[99]. However, many of the platforms on the CRN fall outside the tolerance specified in this standard. The Data Book[116] contains current data on platform heights and offsets, for information only. The following requirement is specified for compatibility with these platforms.

7.15.4.2 TTS-151 - Step Position - PRM TSI (PQTS-289) - Mandatory

With reference to the PRM TSI[6] Clause 4.2.2.11 and Clause 7.3.2.6 (requirements for 'step position for vehicle access and egress'), the Unit shall comply with the requirements for a 915mm height platform at a platform offset as defined in GIRT7073[99A].

Rationale: ***CRN interface -*** *CRN platforms have a nominal height of 915mm.*

7.15.4.3 TTS-1055 - Compatibility with On-board Ramp

All Exterior Doorways shall allow the use of a boarding On-board Ramp, supplied by the TMM, which is manually positioned by an Authorised Person.

Rationale: *CRN Platforms are at a range of heights and currently use manually-deployed ramps to enable wheelchair access. The TMM may achieve compatibility with current ramps or specify / procure a new design.*

Cross reference: *See also Requirement TTS-307 (Door Auto-close) in Section 9.18.5 (Auto-close)*
See also Requirement TTS-1635 (Prevent Step Deployment) in Section 9.18.9 (Moveable Step)
See also Requirement TTS-1640 (Retract Step) in Section 9.18.9 (Moveable Step)
See also Requirement TTS-1651 (Local Auto-close Inhibit) in Section 9.18.5 (Auto-close)

7.15.4.4 TTS-3379 - On-board Ramp Angle

With reference to PRM TSI[6] Clause 5.3.2.9 (1), when positioned between an Exterior Doorway and a platform at 815mm above rail level, the maximum angle of the On-board Ramp shall be 18%.

Rationale: *The PRM TSI does not specify a platform height. 815mm is an estimate of the 5th percentile platform height based on available CRN data. If platforms are below this height, it should be assumed that ramps are available at the station.*

7.15.5 Doorway clearway width

7.15.5.1 TTS-170 - Minimum Door Horizontal Clearway (PQTS-413) - Mandatory

With reference to PRM TSI[6] Clause 4.2.2.3.2 (1), all Exterior Doorways shall have a minimum clear usable width of 900mm when the Exterior Door is open.
This 900mm clear width shall extend from the doorway to the centre-line of the Vehicle.

Rationale: *The PRM TSI[6] mandates a minimum of 800mm which is considered insufficient for manual wheelchair users as it only allows 50mm per side for the users hands. 100mm clearance for hands is* *considered necessary, leading to a dimension of 900mm. 900mm is also required for a person using crutches or a walking frame.*

7.15.6 Dwell Time

7.15.6.1 TTS-161 - Dwell Time Performance (PQTS-72) - Mandatory

The Unit shall deliver 95% confidence of achieving a Dwell Time of 2 minutes at intermediate stations, calculated in accordance with the Static Dwell Time Model in Appendix I using the 1SL.

Rationale: *Achievement of a two-minute Dwell Time is key to achievement of HS2 railway capacity and journey times. The Static Dwell Time Model evaluates the key architectural elements of the interior layout that impact the Passenger exchange part of Dwell Time.*

7.15.7 Evacuation

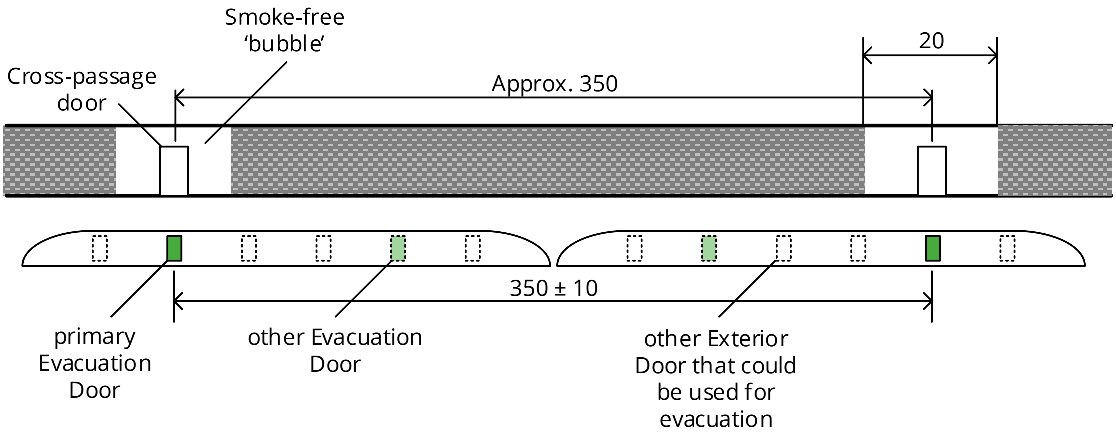
7.15.7.1 Certain doors on the Unit will be classified as **Evacuation Doors** for use during controlled evacuation in a tunnel. (This does not affect compliance with LOC&PAS TSI[4] Clause 4.2.5.5.9 (1)). These will be the primary route for a controlled evacuation of the Unit in the event of an incident in a tunnel.

7.15.7.2 TTS-165 - Evacuation Door Position (PQTS-239) - Mandatory

The Evacuation Doors shall be positioned along the length of the Unit such that when two Units are coupled, in any possible orientation, the centrelines of two Evacuation Doors are 350±10m apart.

Rationale: ***HS2 interface** - This is to support the tunnel evacuation strategy. The HS2 tunnels have cross passages every 350m±2m. The tunnel ventilation will be able to create a bubble of fresh air 10m in each direction from the cross-passage door. A 400m Train should be able to stop with at least one doorway of each Unit located in an air bubble adjacent to a cross passage.*

7.15.7.3 The following figure illustrates this requirement, comparing the tunnel design with the Train layout.



7.15.7.4 TTS-1697 - Future Flexibility - Emergency Exit Provision

With reference to LOC&PAS TSI[4] Clause 4.2.10.5.1 (10), each Vehicle that could contain more than 40 passengers in the Normal Payload (HDL) condition shall have at least three emergency exits.

Rationale: *This is a clarification of LOC&PAS TSI[4] Clause 4.2.10.5.1 (10) and EN 45545-4[55] section 4.3 - this requirement must be applied for the HDL. A layout of 2+1 seating, which may be agreed as part of the interior collaboration process, could mean that only two emergency exits are required.*

7.15.7.5 TTS-1698 - Evacuation Time

With reference to LOC&PAS TSI[4] Clause 4.2.10.5.1 (12) and the Application Guide[13], it shall be possible to evacuate the complete Unit in the Normal Payload (HDL) condition in less than three minutes. For this requirement:
- evacuation is to a nominal CRN platform and an HS2 Platform, i.e. two assessments;
- time to open doors and deploy steps is included in the three minutes - doors are assumed to be fully operational;
- passengers in wheelchairs are assumed to remain in their wheelchair, but may be assisted; and
- luggage (i.e. baggage) is left on-board the Unit.

Rationale: *This is a clarification of LOC&PAS TSI[4] Clause 4.2.10.5.1 (12) and the Application Guide[13], defining how the Clause must be applied for both networks.*

7.15.7.6 In addition to the above requirements affecting the overall layout of the Unit, detailed requirements for evacuation equipment are contained in Section 10.11.

Cross reference: *See also Requirement TTS-2802 (Evacuation Equipment Cupboard) in Section 10.11 (Equipment and storage)*
See also Requirement TTS-2973 (Future Flexibility - Extra Emergency Equipment) in Section 10.11 (Equipment and storage)

7.15.8 Doorway positions

7.15.8.1 TTS-299 - Door Arrangement - Symmetry - Mandatory

The Exterior Doors shall be located in symmetrical positions, either side of both the lateral and longitudinal centre-lines of the Unit.

Rationale: *Adoption of a PEP system is still under consideration. The HS2 Network has a triangular junction near Birmingham, which will cause Units to be frequently turned around and hence the orientation of the Unit at a platform cannot be guaranteed. The Exterior Doors must align with the PEP system regardless of the orientation of the Unit.*

7.15.8.2 TTS-1660 - Train Captain's Door Location - Mandatory

It shall be possible to access the Cab from the exterior of the Unit without needing to pass through a Saloon.

Rationale: *This is specified to ensure there is reasonable access to the Cab, either via dedicated cab doors, or through Exterior Doors positioned close to the rear of the Cab.*

7.15.8.3 TTS-2629 - Door Arrangement - Consistency

The position of all Exterior Doors, except the Exterior Doors closest to the Cab, shall be in a consistent position relative to the end of the vehicle.

Rationale: *This will minimise the need for any PEP installation to be customised to a particular rolling stock design. It is assumed, but not required, that there will be an Exterior Door between the Cab and first Saloon.*

7.16 Internal climate

See also LOC&PAS TSI[4] §4.2.5.8 and §4.2.9.1.7

7.16.1 Saloon climate

7.16.1.1 The requirements of this section are based on EN 13129[32] with some amendments. All terminology is consistent with and defined in EN 13129.

7.16.1.2 TTS-383 - Heating Performance - Mandatory

The Unit shall be able to maintain the mean interior temperature, T_{im}, of the Saloon at 21°C or higher, when:

- the external temperature is -6°C;
- the Unit is at any speed from stationary to 360km/h;
- no solar load;
- no Passengers in the Saloon; and
- fresh air is provided at a rate that would provide 15m³/h/passenger if there were 30% of Normal Payload (HDL) in the Saloon.

Rationale: *These conditions are developed from EN 13129[32] Section 7.1.1 as it applies to HS2 (Zone I winter), with an increase in the external temperature to the normal minimum used for the UK.*

7.16.1.3 TTS-384 - Cooling Performance - Mandatory

The Unit shall be able to maintain the mean interior temperature, T_{im}, of the Saloon at 25°C or lower, when:

- the external temperature is +29°C;
- there is 45% RH;
- the Unit is at any speed from stationary to 360km/h;
- there is 600W/m² equivalent solar load;
- the Unit is in Normal Payload (HDL) condition; and
- 15m³/h/passenger fresh air (as per EN 13129[32] Table 11) is provided.

Rationale: *This is the same requirement as EN 13129 Section 7.1.1, except that the external temperature has been increased by 1K from Zone III summer conditions to account for future climate change.*

7.16.1.4 TTS-1074 - Full Capacity Range

The Passenger HVAC shall continue to operate at full capacity between the following limits:
- -15°C T_{em}, no solar load;
- +34°C T_{em}, 30% RH, 600W/m² equivalent solar load (external operation); and
- +43°C T_{em}, 30% RH, no solar load (tunnel operation)

while the Unit is at any payload up to Exceptional Payload (HDL).

Rationale: *This is the same requirement as EN 13129[32] Section 7.1.2, except that the external temperature has been increased by 1K from Zone III summer conditions to account for future climate change. In addition, tunnel conditions have also been specified. Payload up to Exceptional Payload has been added. The Unit may see a payload between Normal and Exceptional in degraded conditions, and full HVAC capacity must be maintained.*

7.16.1.5 TTS-1075 - Reduced Capacity Range

The Passenger HVAC shall continue to operate at reduced capacity up to the following limits:
- +39°C T_{em}, 25% RH, 600W/m² equivalent solar load (external operation); and
- +50°C T_{em}, 30% RH, no solar load (tunnel operation).

Rationale: *This is the same requirement as EN 13129[32] Section 7.1.2, except that the external temperature has been increased by 1K from Zone III summer conditions to account for future climate change. In addition, tunnel conditions have also been specified.*

7.16.1.6 TTS-1083 - Quality of Saloon HVAC Regulation

The Passenger HVAC shall regulate the mean interior temperature, T_{im}, of the Saloon to the target internal temperature, T_{ic}, in accordance with EN 13129[32] Section 9.3.

Rationale: *Implementation of EN 13129 Section 9.3.*

Cross reference: *See also Requirement TTS-385 (Temperature Regulation) in Section 9.20.1 (HVAC control)*

7.16.1.7 TTS-1084 - Comfort Conditions

Comfort conditions defined in EN 13129[32] Sections 10.1.1 to 10.1.4, inclusive, shall be complied with at all locations within the Saloon. For the purposes of this requirement, the normal range and extended range of q1,q2 shall be:
- Winter, normal: $T_{em} \geq 0$°C;
- Winter, extended: -6°C $\leq T_{em} <$ 0°C;
- Summer, normal: $T_{em} \leq$ +23°C; and
- Summer, extended: +23°C $< T_{em} \leq$ +29°C.

Rationale: *This is modified from EN 13129 by a 1K increase in summer temperatures to account for climate change and a 4K increase in minimum temperature to account for normal UK minimum temperature.*

7.16.1.8 TTS-1066 - Conformity Level

The overall conformity level with TTS-1083 and TTS-1084, calculated in accordance EN 13129[32] Section 4 and Annex B, shall be Level A or B (i.e. ≥ 93%).

Rationale: *The overall conformity level is a measure of how well the HVAC system provides a comfortable environment for passengers. The methodology is defined in EN 13129.*

7.16.1.9 TTS-1085 - Fresh Air

For payloads up to Normal Payload (HDL), the Passenger HVAC shall be able to supply at least the fresh air levels in accordance with EN 13129[32] Table 11.

Rationale: *Implementation of EN 13129 Clause 10.1.5.1*

Cross reference: *See also Requirement TTS-1087 (Fresh Air Regulation) in Section 9.20.1 (HVAC control)*

7.16.1.10 TTS-2463 - CO_2 Level - Across Route

With reference to LOC&PAS TSI[4] Clause 4.2.5.8 (2), the Passenger HVAC shall be able to maintain the CO_2 level in the Saloon and the Vestibule below 1600 ppm, while the Unit is operating a Service from Birmingham Curzon Street to London Euston and return, with no perturbation and a 28 minute dwell at London Euston as per TTS-915. This shall be achieved for an external temperature of 20°C. The external CO_2 concentration, C_{ext}, shall be assumed to be 400 ppm. The Unit shall be in Normal Payload (HDL) condition.

Rationale: *This reduces the CO_2 concentration compared to the LOC&PAS TSI and gives a more applicable assessment. The HS2 Network will have long tunnels where provision of fresh air will be more difficult due to pressure sealing limitations, including multiple trains in tunnels - see TTS-146. The HVAC must control the fresh air over the journey, potentially supplying more fresh air outside of the tunnels, to ensure this requirement is achieved. The 1600ppm level is specified as a good quality environment, based on the level specified in draft versions of EN 14750 for a Category A vehicle. The external CO_2 concentration is taken from EN 13129[32], section 10.1.5.*

7.16.1.11 Two different requirements are specified for emergency ventilation. In the majority of environmental conditions, TTS-388 would apply. In high temperature conditions it is necessary to provide increased air flow to manage heat and humidity in the stalled Unit. This would be achieved in combination with opening doors (TTS-3247), if necessary, and switching emergency ventilation mode.

Cross reference: *See also Requirement TTS-3247 (Emergency Ventilation) in Section 9.18.2 (Train-wide door control)*
See also Requirement TTS-3270 (Emergency High Ventilation Mode) in Section 9.20.1 (HVAC control)

7.16.1.12 TTS-388 - CO_2 Level - Emergency

With reference to LOC&PAS TSI[4] Clause 4.2.5.8 (2), following a loss of the 25kV power supply, the Passenger HVAC shall maintain the CO_2 levels below 10,000 ppm for 60 minutes, assuming fresh air can be drawn into the Unit at a CO_2 concentration, C_{ext}, of 400 ppm. The Unit shall be in Exceptional Payload (HDL) condition.

Rationale: *This extends the duration specified in the LOC&PAS TSI from 30 minutes to 60 minutes*

Cross reference: *See also Requirement TTS-3248 (60-Minute Auxiliary Supply) in Section 7.7 (Auxiliary Power Supply)*

7.16.1.13 TTS-3269 - Fresh Air Flow - Emergency

Following a loss of the 25kV power supply, the Passenger HVAC shall provide $5m^3$/h/Passenger of fresh air for 60 minutes. The Unit shall be in Normal Payload (HDL) condition. Interior Doors may be held open and Exterior Doors may open slightly or other similar measures may be taken to improve air-flow.

Rationale: *In high temperatures, it is predicted that the fresh air flow necessary to maintain 10 000 ppm CO_2 will be too low to manage heat-related illness in Passengers. A higher rate of fresh air is required to reduce humidity. Since the Unit will be stalled measures such as opening Exterior Doors slightly can be used to maximise the air flow.*

Cross reference: *See also Requirement TTS-3247 (Emergency Ventilation) in Section 9.18.2 (Train-wide door control)*

7.16.1.14 TTS-1094 - Vestibule Temperature Regulation

The temperature T_{im} in each Vestibule shall be regulated with respect to the T_{ic} for that Vehicle in accordance with EN 13129[32] Table 13 (row 2).

Rationale: *Implementation of EN 13129 Clause 10.2*

7.16.1.15 TTS-2059 - Draughts through Vestibule

The Passenger HVAC shall minimise drafts in the Saloon when the Exterior Doors and Interior Doors are both open and there is a significant difference in temperature between interior and exterior.

Rationale: *To assist with dwell times, automatic opening of vestibule doors is specified, but this creates the risk of draughts through the saloon.*

Cross reference: *See also Requirement TTS-1813 (Automatic Interior Door Opening - Stations) in Section 9.34 (Interior Doors)*

7.16.1.16 TTS-1080 - Door Opening Sequence

During three sequences of
- one minute with Exterior Doors and Interior Doors open; and
- 19 minutes with all doors closed,

the range of mean interior temperature, T_{im}, of the Saloon, with respect to T_{ic}, shall be within the q2 limit defined in EN 13129[32] Clause 10.1.1.

Rationale: *Implementation of EN 13129 Clause 8.6, using the cycle proposed in the EN.*

7.16.1.17 TTS-1096 - Toilet Temperature Regulation

The mean interior temperature, T_{im}, in each Toilet shall be regulated with respect to the T_{ic} for that Vehicle in accordance with EN 13129[32] Table 13 (row 3).

Rationale: *Implementation of EN 13129 Clause 10.2*

7.16.1.18 TTS-1098 - Catering Temperature Regulation

The mean interior temperature, T_{im}, of Catering Areas shall be regulated with respect to the T_{ic} for that Vehicle in accordance with EN 13129[32] Table 14.

Rationale: *Implementation of EN 13129 Clause 10.3*

Cross reference: *See also Section 10.8 (Catering)*

7.16.1.19 TTS-1099 - Temperature Limits

Surface temperatures and air flows in the Saloon shall comply with EN 13129[32] Table 15. For the purposes of this requirement, the normal range and extended range shall be:
- Winter, normal: $T_{em} \geq 0°C$
- Winter, extended: $-6°C \leq T_{em} < 0°C$
- Summer, normal: $T_{em} \leq +23°C$
- Summer, extended: $+23°C < T_{em} \leq +29°C$

Rationale: *This is modified from EN 13129 by a 1K increase in summer temperatures to account for climate change and a 4K increase in minimum temperature to account for normal UK minimum temperature.*

7.16.1.20 TTS-1428 - Manage Smells

The Passenger HVAC shall minimise the spread of smells from the Toilets and Catering Area into the Saloon and Vestibule.

Rationale: *Managing smells, particularly around Toilets adjacent to Vestibules is important to passengers' perception of the Vehicle.*

7.16.1.21 TTS-1125 - Future Flexibility - HVAC Performance

The Passenger HVAC shall enable all performance requirements to be met following addition or removal of:
- a Full-width Partition at the halfway point in the Saloon;
- a Toilet; and
- a Catering Area.

Rationale: *It must be possible to make changes to the interior with minimal impact on the HVAC system.*

7.16.2 Cab climate

7.16.2.1 The requirements of this section are based on EN 14813[41] with some amendments. All terminology is consistent with EN 14813.

7.16.2.2 TTS-1128 - Heating Performance

The Unit shall be able to maintain the mean interior temperature, T_{im}, of the Cab at 18°C or above, when:
- the external temperature is -10°C;
- the Unit is at any speed from stationary to 360km/h;
- there is no solar load;
- the Cab is empty; and
- fresh air is provided at 50% of its maximum operational rate.

Rationale: *Implementation of EN 14813[41] Clause 7.1*

7.16.2.3 TTS-1129 - Cooling Performance (External)

The Unit shall be able to maintain the mean interior temperature, T_{im}, of the Cab at 22°C or below, when:
- the external temperature is +29°C;
- there is 45% RH;
- the Unit is stationary;
- the Cab is occupied by two people;
- there is 600W/m² equivalent solar load; and
- 60m³/h fresh air is provided to the Cab.

Rationale: *This is derived from EN 14813[41] Clause 7.3 for a Category A train with fresh air for two people (Train Captain and an instructor) and an increase of 1K to account for climate change.*

7.16.2.4 TTS-1284 - Full Capacity Range

The Cab HVAC shall continue to operate at full capacity between the following limits:
- -15°C T_{em}, no solar load;
- +34°C T_{em}, 30% RH, 600W/m² equivalent solar load (external operation); and
- +43°C T_{em}, 30% RH, no solar load (tunnel operation).

Rationale: *Implementation of EN 14813[41] Clause 6.3*

7.16.2.5 TTS-1285 - Reduced Capacity Range

The Cab HVAC shall continue to operate at reduced capacity up to the following limits:
- +39°C T_{em}, 25% RH, 600W/m² equivalent solar load (external operation); and
- +50°C T_{em}, 30% RH, no solar load (tunnel operation).

Rationale: *Implementation of EN 14813[41] Clause 6.3*

7.16.2.6 There are no requirements for pre-heat / pre-cool times. In normal service, it is expected that pre-heating and pre-cooling will be triggered automatically.

Cross reference: *See also Requirement TTS-1313 (Automatic Pre-heat / Pre-cool) in Section 9.20.1 (HVAC control)*

7.16.2.7 TTS-1139 - Cab Comfort Parameters

The comfort parameters of EN 14813[41] Sections 9.1 to 9.5 inclusive shall be complied with for a Category A Vehicle.

Rationale: *Implementation of EN 14813.*

Cross reference: *See also Requirement TTS-1138 (Cab Temperature Control) in Section 9.20.1 (HVAC control)*

7.16.2.8 TTS-1143 - Cab Fresh Air Flow

The Cab HVAC shall be capable of supplying 60m³/h fresh air to the Cab:
- in Normal Operation; and
- following a loss of the main 25kV power supply (see TTS-3248).

Rationale: *This provides sufficient fresh air for two people in the cab, based on the minimum quantities specified in EN 14813[41].*

Cross reference: *See also Requirement TTS-1144 (Cab Fresh Air Regulation) in Section 9.20.1 (HVAC control)*
See also Requirement TTS-3248 (60-Minute Auxiliary Supply) in Section 7.7 (Auxiliary Power Supply)

7.16.3 Air filtration

7.16.3.1 TTS-1681 - Air Filtration

The Cab HVAC and Passenger HVAC shall filter untreated air to a level at least equivalent to grade G4 in accordance with EN 779[29].

Rationale: *This is the filtration level recommended in EN 13129[32]. While EN 779 has been replaced by EN ISO 16890-1[73], there is no clear consensus on the equivalent measure.*

7.17 Heat output

7.17.1 Both Euston and Old Oak Common stations are planned to be relatively enclosed. Heat emissions from the Units could cause excessive temperatures inside the station environments at these locations. The following requirements and the requirements of Section 9.21 of this TTS are specified to manage heat output from the Unit. It is anticipated that some flexibility will be required with settings to enable systems to be adjusted to manage the heat from the Units.

7.17.2 TTS-914 - Heat Release - OOC Station (PQTS-449)

During the dwell at Old Oak Common station, the rate of heat release from the Unit shall not exceed 700kW, averaged over a two-minute dwell, assuming an external temperature of 35°C. The Unit is assumed to be in Normal Payload (1SL) condition. Exterior Doors are assumed to be open for 90 seconds of the dwell. The Unit may switch to a Limited Heat Release State to achieve this requirement.

Rationale: ***HS2 interface -*** *Old Oak Common station has restrictions on its ventilation. It is considered that the Unit will have to adopt specific settings while at the station to limit heat output (e.g. reducing traction cooling).*

7.17.3 TTS-915 - Heat Release - Euston Station (PQTS-458)

During the dwell at Euston station, the rate of heat release from the Unit shall not exceed 350kW, averaged over a 28-minute dwell (described below), assuming an external temperature of 35°C. The Unit is assumed to be in Normal Payload (1SL) condition. Exterior Doors are assumed to be open for 2 minutes at the start of the dwell and 10 minutes at the end of the dwell. The Unit shall be in a Standby State from 2 minutes to 18 minutes of the dwell. The Unit may switch to a Limited Heat Release State to achieve this requirement.

Rationale: ***HS2 interface -*** *Euston station has restrictions on its ventilation, and hence heat output must be limited.*

Cross reference: *See also Section 9.21 (Heat management)*

7.17.4 TTS-1317 - Heat Release Evenness

When stationary, the Unit shall emit heat evenly along the Unit such that no Vehicle emits more than 25% of the total heat output.

Rationale: ***HS2 interface -*** *The design of the station ventilation systems is being based on an even heat output along the Unit.*

7.18 Acoustics

See also NOI TSI[7] and GM/RT2160[89]

7.18.1 External noise

7.18.1.1 TTS-178 - Pass-by Noise (PQTS-186)

The limit value for the A-weighted equivalent continuous sound pressure level at a speed of 360km/h ($L_{pAeq,Tp,(360km/h)}$) measured in accordance with EN ISO 3095[71], 3.5m above rail level, 25m from the track shall be [●] dB.

Rationale: *This requirement extends the NOI TSI evaluation of pass-by noise to 360km/h, and also changes the measurement position to 25m from the track. 25m has been the basis for analysis carried out to date. The requirement is specified in accordance with conditions in EN ISO 3095 so that it is assessable. These conditions will not be completely reproducible on the HS2 Network (e.g. HS2 Network will have slab track). The TMM's V&V plan will need to propose suitable V&V activities to address this.*

7.18.1.2 ***Update for contract -*** *The missing value in requirement TTS-178 will be populated in the contracted version of the TTS using the value provided in the Stage 5 Tender Evaluation.*

7.18.1.3 TTS-3201 - Pass-by Noise 200km/h

The limit value for the A-weighted equivalent continuous sound pressure level measured at a speed of 200km/h in accordance with EN ISO 3095[71], 1.2m above rail level, 7.5m from the track and normalised to 80km/h in accordance with formula (1) of the NOI TSI[7] ($L_{pAeq,Tp,(80km/h)}$) shall be 80dB.

Rationale: *To ensure there is no negative impact on operation on the CRN, compared to existing rolling stock, the Unit needs to meet the NOI TSI for a maximum operational speed of 200km/h.*

7.18.1.4 TTS-181 - High-level Noise (PQTS-250)

The external pass-by noise of the pantograph and upper body aerodynamics shall be minimised.

Rationale: *Noise barriers on the infrastructure can be provided to mitigate low-level noise (particularly wheel-rail noise), and therefore aerodynamic noise from the roof and pantographs will become a more dominant noise source. Managing high level noise is important for achieving the HS2 Environmental Minimum Requirements.*

7.18.1.5 TTS-861 - Stationary Noise - Depot

At any measurement position required to demonstrate compliance to NOI TSI[7] Clause 4.2.1 the limit for the maximum AF-weighted sound pressure level (L^{i}_{pAFmax}), at any time shall be 85dB.

Rationale: *Loud noises from trains in depots can be particularly annoying for neighbours of the depot. The NOI TSI[7] specifies a requirement for the air dryer exhaust valve, however, all other equipment should also not exceed this limit.*

7.18.2 Internal noise - Saloon and Vestibule

7.18.2.1 TTS-183 - Open Air Saloon Max Noise Level (PQTS-192)

The A-weighted equivalent continuous sound pressure level ($L_{pAeq,20s}$) at any point within the Saloon, measured in accordance with EN ISO 3381[72] and Appendix P, while the Unit is operating in the open, at 360km/h on reference track as defined in EN ISO 3095[71], shall not exceed:

Preferred 1: The open air saloon maximum noise level shall not exceed 73dB(A).
Preferred 2: The open air saloon maximum noise level shall not exceed 74dB(A).
Preferred 3: The open air saloon maximum noise level shall not exceed 75dB(A).
Preferred 4: The open air saloon maximum noise level shall not exceed 76dB(A).

Rationale: *The maximum saloon noise level is specified to account for noise at locations such as above running gear and beneath the pantograph, if these occur in the Saloon.*

7.18.2.2 TTS-3237 - Open Air Saloon Average Noise Level

The average A-weighted equivalent continuous sound pressure level ($L_{pAeq,20s}$) between all Saloons, measured in accordance with EN ISO 3381[72] and Appendix P, while the Unit is operating in the open, at 360km/h on reference track as defined in EN ISO 3095[71], shall not exceed:

Preferred 1: The open air saloon average noise level shall not exceed 69dB(A).
Preferred 2: The open air saloon average noise level shall not exceed 70dB(A).
Preferred 3: The open air saloon average noise level shall not exceed 71dB(A).
Preferred 4: The open air saloon average noise level shall not exceed 72dB(A).

Rationale: *The average saloon noise level provides a target for the quietest part of the Saloons, but considering all Vehicles.*

7.18.2.3 TTS-184 - Tunnel Saloon Noise Level (PQTS-420)

The A-weighted equivalent continuous sound pressure level ($L_{pAeq,20s}$), measured in accordance with EN ISO 3381[72], at any point within the Saloon, measured while the Unit is operating in the Northolt Tunnel, as defined in Appendix P, at 320 km/h, shall not exceed:

Preferred 1: The tunnel saloon noise level shall not exceed 76dB(A).
Preferred 2: The tunnel saloon noise level shall not exceed 77dB(A).
Preferred 3: The tunnel saloon noise level shall not exceed 78dB(A).
Preferred 4: The tunnel saloon noise level shall not exceed 79dB(A).

Rationale: *A high proportion of the HS2 network is in tunnel or cutting or behind a noise barrier or parapet. Therefore, internal noise levels in these locations will have a significant impact on Passengers' perception of the journey.*

7.18.2.4 For the purposes of TTS-184, Northolt Tunnel shall be as defined in Appendix P, section P.3.3.

7.18.2.5 TTS-1344 - Saloon Noise (Stationary)

The A-weighted equivalent continuous sound pressure level ($L_{pAeq,20s}$), measured in accordance with EN ISO 3381[72], at any point within the Saloon shall not exceed 62dB(A), while the Unit is stationary, with all systems running.

7.18.2.6 TTS-1350 - Vestibule Noise

The A-weighted equivalent continuous sound pressure level ($L_{pAeq,20s}$), measured in accordance with EN ISO 3381[72], at any point within the Vestibule shall not exceed 80dB(A), while the Unit is operating at 360km/h in the open on reference track as defined in ISO 3095[71].

7.18.3 Internal noise - Cab

7.18.3.1 TTS-865 - Cab Interior Noise - Open Track

With reference to NOI TSI[7] Section 4.2.4, the A-weighted equivalent continuous sound pressure level ($L_{pAeq,20s}$), measured in accordance with EN 15892[47], in the Cab shall not exceed the 76 dB(A), while the Unit is operating on reference track as defined in EN ISO 3095[71] at 360km/h.

Rationale: *This requirement is more onerous than the NOI TSI to account for the high proportion of high speed running and tunnel operation on the HS2 Network.*

7.18.3.2 TTS-866 - Cab Interior Noise - Tunnels

The A-weighted equivalent continuous sound pressure level ($L_{pAeq,20s}$), measured in accordance with EN ISO 3381[72], in the Cab shall not exceed 80 dB(A), while the Unit is operating in the Northolt Tunnel, as defined in Appendix P, at 320km/h.

Rationale: *This covers noise emissions in the two long tunnels at the southern end of the HS2 Network.*

7.18.3.3 TTS-1169 - Cab Interior Noise - Stationary

The A-weighted equivalent continuous sound pressure level ($L_{pAeq,20s}$), measured in accordance with EN ISO 3381[72], in the Cab shall not exceed 62 dB(A), while the Unit is stationary with all systems operating, except external warning devices.

Rationale: *This requirement is specified to manage the noise of in-cab HVAC systems.*

7.18.3.4 TTS-1346 - Detonator Audibility

With reference to Clause 2.1.1 of GM/RT2160[89], the Train Captain shall be made aware when the Unit runs over a detonator at any speed up to 140mph.

Rationale: *Audibility of detonators is only required on the CRN. It is recognised that reducing noise levels in the Cab may mean it is not possible to adequately hear detonators in the Cab. The Purchaser would support a deviation (raised in accordance with the Railway Group Standards Code[77]) to adopt an alternative solution to inform the Train Captain.*

7.18.4 General noise requirements

7.18.4.1 TTS-1354 - Annoying Noise Features

The Unit shall minimise bangs, rattles, squeaks, pure tones, whistling, scraping or grating sounds that could cause annoyance or alarm to passengers, Train Captain and Crew, and neighbours of the railway.

Rationale: *There are numerous features of existing rolling stock that should be avoided such as:*
- loud circuit breakers
- Exterior Doors that make a grating sound when they open
- Persistent mechanical noise from HVAC units
- rattling and vibrating interior panels
- tonal noise from open jacking points

7.18.4.2 TTS-1967 - Pure Tones

The noise limits specified in sections 7.18.1, 7.18.2 and 7.18.3 shall be reduced by 3dB(A) if significant pure tones in the 'one-third octave' bands centred on 100 Hz - 10 kHz, are present. The significance of pure tone noise in this context shall be assessed using the 'one-third octave' method in Annex K of ISO 1996-2[70A]. The 'possible choice' values presented in Annex K of ISO 1996-2 for identifying the presence of prominent tones shall be adopted.

Rationale: *Pure tone elements (e.g. whistles and hums) within a sound spectrum can be particularly noticeable and annoying, even when they do not necessarily contribute significantly to the overall A-weighted level.*

7.18.5 Communication audibility

7.18.5.1 TTS-871 - STI PA Level

The spoken information shall have a minimum STI-PA level of
- 0.58 in Saloon, including all Seating Positions; and
- 0.45 in Vestibules and Toilets;

in accordance with EN 60268-16[67].

Rationale: *A higher value of STI-PA has been required compared to the PRM TSI[6], based on the quality of service that should be delivered.*

Cross reference: *See also Requirement TTS-1405 (Volume Adjustment) in Section 9.25.2 (Audio information)*

7.19 Operational environment

See also LOC&PAS TSI[4] §4.2.6.1

7.19.0 It is recognised that it is difficult to specify requirements for operational environment which can be validated and to test every scenario specified. The requirements of this section define the scope of operational environment interfaces. It is expected that these requirements will be demonstrated through reference to particular design features that address each requirement. The TMM will need to propose appropriate V&V activities and reference existing design precedents to show the robustness of these designs.

7.19.1 Temperature and altitude

7.19.1.1 TTS-186 - Climate Zone Definitions (PQTS-94)

With reference to LOC&PAS TSI[4] Section 4.2.6.1.1 and EN 50125[61], the climatic zone T1 shall apply.

Rationale: *This is the zone applicable to the UK.*

7.19.1.2 TTS-189 - Tunnel Environment - Summer (PQTS-112)

The Unit shall be capable of Normal Operation in the tunnels that will transition from 25°C at the tunnel entry portal to 35°C within the tunnel. Tunnel relative humidity will vary between 30% and 50% during summer.

Rationale: *These are the estimated temperatures in normal summer conditions.*

7.19.1.3 TTS-190 - Tunnel Environment - Winter (PQTS-135)

The Unit shall be capable of Normal Operation in the tunnels that will transition from -6°C at the tunnel entry portal to 30°C within the tunnel. Tunnel relative humidity will vary between 90% at the cool end of the tunnel and 20% to 30% at the warmest part of the tunnel.

Rationale: *These are the estimated conditions in normal winter conditions.*

7.19.1.4 TTS-191 - Tunnel Congestion Conditions - Average (PQTS-136)

The Unit shall be capable of Normal Operation when the tunnel temperature is an average of 43°C, with variations around the vehicle.

Rationale: ***HS2 interface*** *- This is the estimated temperature in the tunnel during operational congestion when trains stop in the tunnel and air flow through the tunnel is reduced. The temperature around the Unit will depend on the Unit's heat release characteristics.*

7.19.1.5 TTS-192 - Tunnel Congestion Conditions - Maximum (PQTS-137)

The Unit shall be capable of Normal Operation when the tunnel temperature is an average of 50°C, with variations around the Vehicle, for up to five minutes.

Rationale: ***HS2 interface*** *- This temperature is predicted during the initial stages of operational congestion in tunnels. In these circumstances, the tunnel ventilation system may be required to reverse the prevailing airflow direction and the average temperature in the tunnel is predicted to rise to 50°C.*

7.19.1.6 Note that Normal Operation is defined as full performance, including full performance of traction systems (see Section 2). The temperature of 15°C specified in requirements in Section 7.1 and 7.2 is only specified to enable consistent, comparable simulations.

7.19.2 Precipitation and fluids

7.19.2.1 TTS-187 - Maximum Snow and Flood Water Levels (PQTS-386)

The Unit shall be capable of Normal Operation when:
- snow is up to 200mm above the rail level; and
- flood water is up to 50mm below the rail level.

Rationale: *The UK Rule Book[104] specifies these as the limits of normal operation. The limit of flood water is the bottom of the rail head, which is approximately 50mm below rail level. The same rule will be applied to the HS2 Network.*

7.19.2.2 TTS-340 - Ice and Snow

The Unit shall be capable of Normal Operation under all snow and ice conditions that the Unit may encounter in service.

Rationale: *Particular types of snow have caused issues for previous rolling stock in the UK. In particular, dry, powdery snow has caused issues with traction systems, and this was then made worse by travelling into tunnels.*

7.19.2.3 TTS-2181 - Ice Build-up

The Unit shall be resistant to the build-up of snow and ice, and subsequent detachment of large blocks of ice.

Rationale: *Trains on High Speed 1 have suffered damage in cold weather when ice formed around the bogie and bolster, and then detached when the mass was too large or the train entered warmer tunnels. The detached ice caused significant damage to underframe equipment and could cause damage to lineside equipment.*

7.19.2.4 TTS-1749 - Protect Passengers and Staff

The Unit shall protect Passengers, the Train Captain and Train Crew and interior furnishings from all fluids that the Unit will encounter in service, including precipitation and traversing a wash plant.

7.19.2.5 TTS-337 - Fluids and Chemical Resistance

The Unit shall be resistant to degradation from all fluids and chemicals that the Unit will encounter in service.

Cross reference: *See also Requirement TTS-886 (Use of Cleaning Chemicals) in Section 7.23.2 (Cleanability)*

7.19.2.6 TTS-2830 - Precipitation Level

The Unit shall be capable of Normal Operation with precipitation of up to 60mm/h including hail, sleet, and snow.

7.19.3 Other elements of the operational environment

7.19.3.1 TTS-188 - Dust and Particles (PQTS-111)

The Unit shall be resistant to all dust and particles that the Unit may encounter in service.

Rationale: *In addition to normal levels of dust the Units will be exposed to higher levels of dust, including concrete, associated with construction following opening of each phase, particularly in the tunnels.*

7.19.3.2 TTS-2874 - Accumulation of Debris

The Unit shall prevent leaves, litter and other debris accumulating within the Vehicle roof, underframe or other areas where they could affect operation of the Unit or become a fire risk.

Rationale: *Leaves may get sucked into parts of the underframe or may fall onto the roof when the Unit is stabled. These should not be able to cause blockages or accumulate such that they become a fire risk.*

7.20 Environmental impact

7.20.1 TTS-847 - Greenhouse Gas Emissions during Lifecycle

The total life-cycle (upstream, core and downstream) global warming potential impact of the Unit, measured in kg CO_2 equivalent per passenger km, calculated in accordance with EN ISO 14025[74], the Product Category Rules for Rolling Stock[112] and Appendix J, shall be:

Preferred 1: The life-cycle global warming impact shall be no more than 0.00233 kg CO_2 eq / passenger km.
Preferred 2: The life-cycle global warming impact shall be no more than 0.00275 kg CO_2 eq / passenger km.

Rationale: *The requirement is consistent with requirements for the High Speed 2 Project to minimise carbon emissions and supports the strategic goal to design, construct and operate the railway to reduce carbon.*

7.20.2 TTS-2195 - Recyclability

The recyclability of the Unit, calculated using UNIFE Recyclability and Recoverability Calculation Method Railway Rolling Stock[113], shall be:

Preferred 1: The recyclability shall be at least 95%.
Preferred 2: The recyclability shall be at least 90%

Rationale: *This is specified to align with goal of adoption of circular economy principles.*

7.20.3 TTS-2192 - Recoverability

The recoverability of the Unit, calculated using UNIFE Recyclability and Recoverability Calculation Method Railway Rolling Stock[113], shall be:

Preferred 1: The recoverability shall be 99%.
Preferred 2: The recoverability shall be 95%.

Rationale: *This is specified to align with goal of adoption of circular economy principles.*

7.20.4 TTS-2199 - Contaminants

The Unit shall prevent any potentially contaminative fluids from being released from the Unit into the environment. Any non-contaminative fluids may be released, so long as the necessary contents or approvals in accordance with HS2 Ltd's Water Resources and Flood Risk Consents Standard[123] have been obtained.

Rationale: *Compliance with HS2 Ltd's standard is necessary to support HS2 Ltd's legal requirements. The TMM will need to provide information about any fluids that can be released to support any consents or approvals that may be necessary. Release of 'grey' water from bio-reactor toilets will need to be in controlled locations to prevent it entering the wider environment.*

Cross reference: *See also Requirement TTS-2641 (Grey Water Release) in Section 9.32 (Toilets and Sanitary Systems)*

7.21 Fire

See also LOC&PAS TSI[4] §4.2.10 and GM/RT2130[85]
Cross reference: *See also Section 9.22 (Fire and smoke detection)*
See also Section 10.21 (Fire extinguishers)

7.21.1 TTS-197 - Fire Categorisation (PQTS-146)

With reference to LOC&PAS TSI[4] Section 4.2.10, the Unit shall be assessed as Category B.
With reference to EN 45545[53] [54] [55] [56] the Unit shall be assessed as:
- Operation Category 3; and
- Design Category N.

Rationale: *The HS2 Network contains long tunnels that considerably exceed the 5km limit for Category A rolling stock, and do not have intermediate rescue stations. Although the Unit must have ATO capability, there is no intention to operate without any staff (Design Category A).*

7.21.2 TTS-320 - Running Capability

Following the outbreak of a 'Type 2' fire on-board the Train, as the Train enters any tunnel on the HS2 Network, at any speed, the Train shall maintain at least the following functions until the Unit has exited the far end of that tunnel:
- braking control;
- traction control;
- traction power sufficient to maintain a minimum speed of 80km/h;
- public address and communication to the Wayside via the GSM-R voice radio;
- PEAs and call-for-aids;
- ventilation and control of fresh air intake / recirculation;
- external and internal door control and power;
- ATO / ETCS; and
- emergency lighting.

The maintenance of these functions shall be assessed in accordance with EN 50553[65].
Refer to the Data Book[116] for tunnel lengths, gradients and cross-sections.

Rationale: ***HS2 interface -*** *This requirement is in addition to the LOC&PAS TSI[4] section 4.2.10.4.4. Rather than specify simply a time-based duration, the Train must be able to get to a place of safety considering the distance and route profile along the network and impacts on traction of the fire. In addition to braking and traction, specified in the TSI, additional functions are specified. Note that this is not to say that other functions should be de-activated in this scenario.*

7.21.3 TTS-3249 - Maintain Communications

Public address and internal voice communications between Train Crew and the Train Captain shall be protected from fire by:
- providing redundant connections between components; and
- protecting cabling that provides basic voice communications and any necessary power supply in accordance with PH60 classification when tested in accordance with EN 50200[61A] or equivalent.

Rationale: *If a Train stops in a tunnel with a significant fire, and it is then chosen to evacuate the Train, it must be possible to maintain communications throughout the Train. It is predicted that the* *evacuation process could take up to 60 minutes. It is only necessary to maintain basic communications functions.*

7.21.4 TTS-1311 - Fire Barriers - General

Fire barriers shall be provided in accordance with EN 45545-3[54], except that the longitudinal position of the barrier between adjacent passenger areas (Table 1, point 5) shall be as per TTS-321.

Rationale: *EN 45545-3 specifies a maximum spacing of 30m for barriers in passenger areas, which is considered too far apart considering the likely length of Vehicles and the evacuation scenarios.*

7.21.5 TTS-321 - Cross-section Fire Barriers

With reference to LOC&PAS TSI[4] Section 4.2.10.3.4, the Unit shall have a full cross-section partition fire barrier at each end of each Vehicle, either:

- between a vestibule that is at the end of the Vehicle and the Saloon, or
- adjacent to the Gangway, provided that TTS-900 and TTS-2078 are adequately complied with.

The fire barrier shall meet EN 45545-3[54] for a barrier between adjacent passenger areas (Table 1, point 5).

Rationale: ***HS2 interface -*** *A more onerous requirement than the LOC&PAS TSI[4] is specified to permit passengers to be evacuated to adjacent Vehicles in the event of a fire. It must be possible for a passenger in a wheelchair to be moved to a place of safety beyond a fire barrier. Therefore, if there is no barrier between the Saloon and Vestibule, it must be possible to evacuate passengers to and adjacent vehicle, which requires the wheelchair to pass through the gangway (TTS-900, TTS-2078). The development and adoption of alternative non-physical fire containment and control systems in place of a fire barrier is not supported.*

Cross reference: *See also Requirement TTS-900 (Inter-Vehicle Gangway Clearway - Minimum) in Section 10.12 (Gangway)*
See also Requirement TTS-2078 (Inter-Vehicle Gangway Clearway - Maximisation) in Section 10.12 (Gangway)

7.21.6 TTS-1297 - Peak Heat Release

The Unit design shall ensure that for all reasonably foreseeable fire scenarios, the peak heat release rate does not exceed 7MW from ignition of the fire. Scenarios shall include a passenger luggage fire source of up to 500kW.

Rationale: ***HS2 interface -*** *A 7MW peak heat release has been used in the fire strategy for the tunnels.*

7.22 Reliability

7.22.1 There is an HS2 Sponsor's Requirement for an overall railway reliability of a moving annual average delay per HS2 service on the HS2 Network of no greater than 30 seconds at an HS2 station destination or the HS2 Network/CRN boundary. To support this, requirements for mean distance between Service Affecting Failure have been specified in the in the TSA as part of the Performance Regime (TSA Schedule 5).

7.22.2 These requirements are included in the TTS in a slightly different form such that the reliability of the design of the Unit (the **"Design"**) is considered through design and up to Acceptance.

7.22.3 TTS-200 - MDBSAF (HS2) (PQTS-195)

The Design shall be capable of achieving a mean distance between Service Affecting Failures of at least 300,000 km while operating on the HS2 Network. Train operation parameters in Appendix A shall be used for assessment of this requirement.

7.22.4 TTS-3282 - MDBSAF (CRN)

The Design shall be capable of achieving a mean distance between Service Affecting Failures of at least 160,000 km while operating on the CRN. Train operation parameters in Appendix A shall be used for assessment of this requirement.

7.22.5 In addition to the requirements for mean distance between Service Affecting Failure, the following requirements are specified for no single point failure.

7.22.6 TTS-2638 - NSPF Causes Train Immobilisation

No single point failure of the Unit's traction, power supply, braking or train control systems shall cause a Train to be immobilised.

Rationale: *Achievement of this requirement is necessary to manage the risk of Trains becoming stalled in tunnels. The requirement applies to 200m Trains and 400m Trains. Although a 400m Train gives a level of redundancy, it must be ensured that a fault on one Unit does not immobilise both Units.*

7.22.7 TTS-3280 - NSPF Causes No Ventilation

No single point failure on the Unit shall lead to a Vehicle having no ventilation.

7.22.8 TTS-3281 - NSPF Causes No PA

No single point failure on the Unit shall lead to a Vehicle have no public address.

7.23 Maintenance and servicing

Cross reference: *See also Section 9.29 (Maintenance and servicing)*
See also Section 9.29.1 (Train preparation)

7.23.1 Durations and times

7.23.1.1 TTS-2803 - Fresh Water Storage

The Unit shall have sufficient fresh water storage for Sanitary Systems for at least three days' operation. For the purposes of this requirement, it shall be assumed that each toilet and handwash is used 10 times per hour.

Rationale: *The Unit may not have access to potable water every day. To enable refilling, TTS-2644 requires access to water fillers at all locations.*

7.23.1.2 The following two requirements relate to emptying effluent from the Unit. The periodicities specified are based on the use of a 'bio-reactor' system that processes effluent into 'grey' water and solid waste. The grey water is sufficiently treated that it can be dropped from the Unit at any location that is 'tanked', i.e. water will run-off into a sewer rather than the wider environment. This water has a high salt content and so should not be dropped while the Unit is at speed to avoid corrosion issues as well as control of the fluid. The solid waste takes up relatively small space on the Unit and hence can be stored for longer between emptying. For the purpose of these requirements, it shall be assumed that there are 120 uses of each Toilet per day.

7.23.1.3 TTS-2639 - Grey Water Emptying Periodicity

It shall be possible to operate the Unit for at least 24 hours without the need to empty 'grey' water from the Unit.

Rationale: *The Unit should be stationary at a tanked location at least once every 24 hours. The Unit will need to store grey water until this time.*

7.23.1.4 TTS-2184 - Solid Waste Emptying Periodicity - Mandatory

It shall be possible to operate the Unit for at least 30 days without the need to empty solid waste from the Unit.

Rationale: ***HS2 interface -*** *Complying with this requirement allows a significant reduction in depot facilities for emptying CET tanks. It also means that the operation of the Units has far greater flexibility with less likelihood of Toilets being locked out due to full effluent tanks.*

7.23.1.5 TTS-3173 - Sand Storage

Each sanding location shall have sufficient storage for 45kg of sand per wheel, i.e. 90kg per sanding location.

7.23.1.6 TTS-3174 - Screen Wash Storage

Each cab shall have a screen-wash tank of at least 50 litres.

Rationale: *This storage capacity is specified to achieve 10 days between refilling, but since usage will vary through the year and cannot easily be defined, storage capacity has been specified.*

7.23.1.7 TTS-2807 - Flange Lubrication Storage

The Unit shall have sufficient storage of flange lubricant for at least [10 / ●] days' operation.

Rationale: *Flange lubrication must last for the minimum exam periodicity. The minimum exam periodicity is 10 days, but the TMM may increase this, which would require this duration to be increased.*

7.23.1.8 ***Update for contract -*** *The missing value in requirement TTS-2807 is the minimum exam periodicity specified in the Tender.*

7.23.1.9 TTS-2576 - Time between Automatic Inspection

The Unit shall be capable of at least three days / 57 operational hours / 9000km without needing to be examined by an automatic vehicle inspection system.

7.23.1.10 TTS-2577 - Time between Exam

The Unit shall be capable of operation for at least ten days and 190 operational hours and 30,000 km without needing a planned exam to be carried out over a pitted road.

7.23.2 Cleanability

7.23.2.1 TTS-886 - Use of Cleaning Chemicals

The exterior and interior finishes, including any films and decals in the scope of this Agreement, shall withstand damage and deterioration from the range of detergents and abrasive materials that may be used in the cleaning processes, such that there is no loss or change in texture or colour of the finishes.

Rationale: *The Unit will be cleaned at a number of depots, so the Unit must be compatible with a range of chemicals. An indicative list of chemicals is provided in Appendix K.*

Cross reference: *See also Requirement TTS-1217 (Full Body Decals) in Section 7.8 (Structural integrity and Carbody)*

7.23.2.2 TTS-882 - Interior Cleanability Design 1

The interior shall not have crevices, abrupt changes of section or other internal features where dust and dirt can accumulate.

7.23.2.3 TTS-1985 - Interior Cleanability Design 2

All soft furnishings, including carpet and seat coverings shall be cleanable using standard vacuum cleaner fittings. A single floor tool, 270 × 90 mm, shall be able to access all parts of the floor.

7.23.2.4 TTS-884 - Interior Replacements

Floor coverings and seat cushions and covers shall be replaceable by one person, without removing any other equipment except catches or strips that hold these in place. These items shall resist removal by Passengers.

7.23.2.5 TTS-885 - HVAC Grilles Cleanability

Ventilation and extraction ducts/grilles, and other such features, shall be accessible and cleanable using standard cleaning equipment.

7.23.2.6 TTS-1185 - Wash-plant Compatibility

The exterior of the Unit shall avoid features that prevent the wash-plant from effectively cleaning the Unit. Any hatches or covers shall resist opening or damage.

7.23.2.7 TTS-1989 - High Pressure Hose Compatibility

The exterior of the Vehicle, including Running Gear, shall be compatible with cleaning by high pressure hose.

7.23.3 Access for servicing tasks

7.23.3.1 TTS-2185 - Toilet Tank Emptying Access

It shall be possible to empty solid waste from both sides of the exterior of the Unit, using an evacuation nozzle as defined in LOC&PAS TSI[4] Appendix G, Figure G1.

Rationale: *Depot facilities for emptying toilet tanks will only have access to one side of the Unit, which could be either side.*

7.23.3.2 TTS-3342 - Drain Grey Water

It shall be possible to drain 'grey' water from the underside of a Vehicle from a point ±100mm from the longitudinal centre-line of the Vehicle.

Rationale: ***HS2 interface -*** *In normal service, grey water would be dropped from the Unit at defined locations.*

Cross reference: *See also Requirement TTS-2641 (Grey Water Release) in Section 9.32 (Toilets and Sanitary Systems)*

7.23.3.3 TTS-3339 - Manual Emptying of Grey Water

It shall be possible to empty 'grey' water manually by connecting an evacuation nozzle as defined in LOC&PAS TSI[4] Appendix G, Figure G1.

Rationale: *This is intended to allow water to be emptied from a Unit that is not able to return to an acceptable location for release of water.*

7.23.3.4 TTS-2644 - Re-fill Fresh Water

It shall be possible refill all fresh water tanks of a Vehicle from both sides of the Vehicle. The filling points shall be accessible from:
- track level;
- a nominal CRN platform; and
- an HS2 Platform.

Rationale: *The HS2 Platform will be 300-400mm from the Unit. A design solution will be required to safely bridge this gap to enable water to be re-filled. The Moveable Steps could be used with additional equipment to permit access to the fillers if they are not adjacent to Exterior Doors.*

7.23.3.5 TTS-2804 - Re-fill Screen Wash

It shall be possible to refill screen-wash from both sides of the Vehicle at:
- track level;
- a nominal CRN platform; and
- an HS2 Platform.

Rationale: *This also covers the ability to refill in depots, which will have maintenance platforms within the range of the HS2 and CRN platforms.*

7.23.3.6 TTS-2805 - Re-fill Sand

It shall be possible to refill sand hoppers from track level.

7.23.3.7 TTS-2808 - Re-fill Flange Lubricant

It shall be possible to refill flange lubricant from track level.

7.23.4 Damage and vandalism

7.23.4.1 The following four requirements specify maximum replacement times for items on the Unit that it is considered could be damaged or vandalised during operation of the Unit.

7.23.4.2 TTS-1214 - Maximum Repair Time - Normal Dwell

It shall be possible to replace at least the following items due to damage and vandalism within 18 minutes in a station environment:

- the seat back and seat base cushions of any Passenger Seat; and
- communications handsets in the cab or at public address positions.

Rationale: *18 minutes is the normal duration between services at a terminal station.*

7.23.4.3 TTS-3038 - Maximum Repair Time - Extended Dwell

It shall be possible to replace at least the following items due to damage and vandalism within 45 minutes in a station environment:

- internal speakers;
- interior PIS display screens;
- interior luminaires;
- CCTV cameras;
- seat-back table;
- temporary repair to up to 2m of carpet from the aisle;
- at-seat sockets;
- seat reservation displays; and
- film applied to any glazed surfaces.

Rationale: *45 minutes is a longer dwell time at a terminal station that could be achieved by changing a Unit to a different diagram.*

7.23.4.4 TTS-2580 - Maximum Repair Time - Stabling

It shall be possible to replace at least the following items due to damage and vandalism within 6 hours while the Unit is in a station:

- Passenger Seat shell;
- Train Captain's seat;
- Instructor's seat;
- table;
- any section of carpet;
- Interior Door;
- individual Passenger-facing elements of the Toilet, including the Sanitary Systems;
- interior panelling;
- catering equipment; and
- cab controls and screens.

Rationale: *6 hours would be available if the Unit was stabled away from a depot at night. The Unit may be at a stabling siding, but for the purposes of this requirement, it should be assumed that replacement items can be brought on to the Unit via a platform or staging.*

7.23.4.5 TTS-2581 - Maximum Repair Time - Depot

It shall be possible to replace at least the following items due to damage and vandalism within 6 hours in a depot environment with pit, crane and any staging required:
• windscreen wipers;
• coupler cover;
• any detachable exterior panels;
• obstacle deflector;
• horns and covers;
• exterior lights;
• Exterior Doors;
• Gangways including the time to separate the Vehicles and re-couple Vehicles;
• external antennas;
• Running Gear-mounted equipment included brake actuators/callipers and axle-end probes; and
• underframe-mounted signalling equipment.

Rationale: *This covers items that require the Unit to be returned to a depot for repair.*

7.23.4.6 TTS-3276 - Maximum Repair Time - Windows

It shall be possible to replace both the windscreen and Windows within 6 hours in both a station and a depot. This time shall include any curing time and the time to assemble suitable staging if required (e.g. at a station).

7.24.4.7 The following requirements cover design of the Unit to minimise the possibility and effects of damage.

7.23.4.8 TTS-2864 - Paint Durability

The finish of the Carbody, Exterior Doors and other exterior surfaces visible to Passengers shall be resistant to chips, scratches and marks from ballast strikes and other items the Unit is likely to contact.

Rationale: *Deterioration of the external paint will affect Passenger's perception of the quality of the service.*

7.23.4.9 TTS-883 - Interior Durability

Surfaces of the Unit shall be resistant to:
• scuffing and accidental damage; and
• permanent damage from graffiti or vandalism.

7.23.4.10 TTS-1319 - Vandalism Resistance

The design of the Unit shall resist vandalism, including:
- slots into which liquids can be poured;
- items that can be pried open or off their mountings; and
- fixings that can be unscrewed or opened with normal tools.

7.23.4.11 TTS-745 - Signage Robustness

All labelling and signage shall be resistant to forced removal and deliberate defacing activities.

7.23.4.12 TTS-2582 - Damage Resistance

The Unit, and in particular the front end of the Unit, shall be designed to minimise damage when it strikes foreseeable items at up to 360km/h. The Unit shall minimise the consequences of this damage.

Rationale: *HS2 is keen to ensure that where possible the Unit is designed to withstand impacts from foreseeable object strikes, e.g. ballast strike, and that the implications of repairing any damage are minimised.*

8 Protection and driving

8.0.1 In normal operation on the HS2 Network, Trains will be protected by ETCS and operated under ATO (GoA2), with ATO data provided over ERTMS. ATO will only be available when the ETCS On-board has been granted a Full Supervision Movement Authority.

Rationale: *It has been determined that a level of automatic control is necessary to achieve the capacity and reliability of HS2 operations. It is considered that ATO (GoA2) offers the appropriate level of automation.*

8.0.2 On the CRN and the transition area, the Trains will be protected by lineside colour-light signalling fitted with AWS/TPWS and initially operated in manual driving mode. Driving advice will be available via a C-DAS, provided the necessary traffic management systems are available on the CRN. Parts of the CRN may be migrated to ETCS during the life of the Unit.

8.0.3 The following table shows the initial train protection systems and driving mode combinations:

Network	Train Protection	Driving Mode	Driving Advice	Radio
HS2	ETCS L2 or L3 hybrid	Automatic (GoA2)	Not required	GPRS over GSM-R
HS2	ETCS L2 or L3 hybrid	Manual (1)	interoperable C-DAS	GPRS over GSM-R
CRN	AWS / TPWS	Manual	national C-DAS	GPRS over GSM-R or GSM-R
CRN	AWS / TPWS	Manual	None (2)	GPRS over GSM-R or GSM-R
future	*ETCS (3)*	…	…	*FRMCS (4)*

(1) ATO should be operational on HS2 for the majority of time
(2) C-DAS should be operational on CRN, but traffic management systems may not be available
(3) ETCS not yet fitted to CRN, but may be fitted during the life of the Unit
(4) FRMCS being developed as the future replacement for GSM-R

8.1 Standards and documentation

8.1.1 TTS-2456 - ETCS Baseline

With reference to Annex A of the CCS TSI[5], the ETCS On-board shall comply with the Baseline 3 Release 2 set of specifications.

8.1.2 TTS-3273 - EUAR Opinions

The On-board CCS shall comply with EURA opinions:
- ERA/OPI/2017-2[13A], including all referenced solutions to change requests; and
- ERA/OPI/2017-5[13B].

8.1.3 TTS-2246 - ETCS GB Specification

The ETCS On-board and AWS/TPWS On-board shall be compliant with the GB Onboard New Trains Subsystem Requirements Specification[106] including those 'preferred' and 'application-specific' requirements listed in Appendix L.

Rationale: *This document represents the UK industry view of on-board ERTMS specifications. This includes requirements for AWS/TPWS.*

8.1.4 Refer to subsequent sections for standards and documentation on specific systems and functions

8.2 General requirements

8.2.1 Data entry

8.2.1.1 TTS-2300 - Automated Data Entry

Automated data entry into the On-board CCS shall be provided, based on
- train running number from the Operational Diagram Allocation functionality;
- Driver ID from the Train Captain's login; and
- other data about the current Train formation.

This shall require acknowledgement by the Train Captain.

Rationale: *Automatic data entry reduces the potential errors associated with the train data entry process by the Train Captain.*

Cross reference: *See also Section 9.2 (Diagram allocation)*

8.2.1.2 TTS-2301 - Preset Manual Data Entry

If automated data entry is not available, presets shall be provided to the Train Captain that cover the two normal Train formations and possible rescue formations and degraded operation modes.

Rationale: *The preferred option for fixed formation units is to have automatic data entry but if this functionality is not available, fixed data should be used since it minimises the risks associated with data collection and incorrect entry by the Train Captain. During abnormal operation (e.g. rescue) automatic data entry will not be available and hence the Train Captain will have to enter data.*

8.2.2 Driver Machine Interface (DMI)

8.2.2.1 TTS-2303 - Speed Indication Transition

During any transition between ATO, ETCS and AWS/TPWS and between possible odometry sources, the position of the speed indicator on the DMI shall not alter as a result of the changeover process.

Rationale: *Speed will need to be displayed in either km/h or mph depending on the mode. The 'needle' should not change position when the measurement units change.*

8.2.2.2 TTS-2305 - Redundant Display

If DMI functionality is provided on a second DMI, the second DMI shall show the same information with the same size, layout and format as the main DMI.

Rationale: *Failure of the DMI is a potentially significant failure, and use of another in-cab screen (e.g. the train control interface screen) to mitigate this is often adopted. This second screen must have the same display as the main DMI to ensure a common interface for the Train Captain and not be compressed, split or otherwise changed.*

8.2.2.3 TTS-2306 - Fault Indications on DMI

Visual fault indications on the DMI shall not be suppressed at any time other than during isolation of the faulty sub-system.

Rationale: *This requirement will contribute to efficient driving.*

8.2.2.4 TTS-2307 - On-board CCS Sub-components' Status

The Train Captain shall be able to access a maintenance menu on the DMI that will indicate the status of the On-board CCS sub-systems.

Rationale: *This requirement will support operational performance by quickly identifying On-board CCS or CCS Trackside failures.*

8.2.2.5 TTS-2269 - Secondary DMI

The Cab shall permit a temporary installation of a second DMI for the Instructor.

Rationale: *During driver training, the Instructor will require clear visibility of the DMI display, including both the main display and a temporary secondary display, such as a laptop screen showing the DMI.*

Cross reference: *See also Requirement TTS-2027 (Instructor Visibility - ETCS DMI) in Section 10.9.2 (Cab sightlines)*

8.2.3 Wheel calibration

8.2.3.1 TTS-2323 - Odometry Calibration

Odometry calibration shall not require specific additions or changes to the HS2 Network.

Rationale: *It is preferable for the On-board CCS solution to re-calibrate itself automatically to account for a reduction in wheel diameters as wheels wear. The HS2 Network will not include provision to facilitate an automatic calibration system (see also TTS-2324, TTS-2325 and TTS-2326) for the On-board CCS solution. Automatic calibration systems can rely only upon the ETCS/ATO infrastructure that would otherwise be available. Eurobalises will not be located to any higher accuracy than that* *stated against Q_NVLOCACC or Q_LOCACC; however, the value for Q_LOCACC is expected to be more accurate in ATO specific areas.*

8.2.3.2 TTS-2324 - Automatic Odometry Calibration 1

Automatic calibration of the wheel diameter shall not lead to different speeds calculated by the ETCS On-board and ATO On-board.

Rationale: *This functionality ensures consistency between ATO and ETCS speed calculation.*

Cross reference: *See also Requirement TTS-100 (ATO Stopping Accuracy) in Section 8.6.4 (ATO stopping accuracy)*

8.2.3.3 TTS-2325 - Automatic Odometry Calibration 2

Automatic calibration of wheel diameter shall be sufficiently accurate to support the stopping accuracy requirements.

Rationale: *This functionality ensures consistency between different systems' measurements (e.g. ETCS and ATO).*

8.2.3.4 TTS-2326 - Automatic Odometry Calibration 3

When automatically calibrating wheel diameter, erroneous values of wheel diameter shall be automatically detected and corrected (e.g. by repeating calibration).

Rationale: *Inconsistent measurement of wheel diameter should not impact operations.*

8.2.4 Communication requirements

8.2.4.1 The installation of CCS antennas should consider GK/GN0602. This provides guidance on positioning to avoid interference.

8.2.5 Future capability

8.2.5.1 TTS-2371 - Data Radios

A minimum of Three Edge-capable GSM-R/GPRS Data Only Radios (EDORs) shall be provided.

Rationale: *It is necessary to have two data only radios for ETCS and one for ATO. The second radio for ETCS is to enable communication with a second RBC.*

8.2.5.2 TTS-470 - Additional Space for Future Equipment

Additional space shall be provided for the fitment of future CCS / ATO equipment close to each ETCS EVC installation. This space shall be equipped with 19" rack mounts and provide a minimum of 6U of height and 450mm depth. There shall be 1U ventilation space above and below the space provided.

Rationale: *There may be a need in the future to upgrade the functionality of the on-board equipment which requires additional components to be fitted to the Unit and connected to existing signalling equipment.*

8.2.5.3 TTS-2376 - Future Flexibility - 'Future Rail Mobile Communications System (FRMCS)

The Unit shall be capable of being migrated to the FRMCS. This shall allow for a situation where current GSM-R/GPRS is used in some locations alongside FRMCS in others.

Rationale: *FRMCS is the project to develop a successor to GSM-R (http://uic.org/frmcs)*

8.2.6 On-board CCS Performance

8.2.6.1 TTS-3031 - CCS Accuracy for Distances

The accuracy of distance measured on-board shall better than or equal to ± (5m + 1% s), i.e. the over reading amount and the under reading amount shall be equal to or lower than (5m + 1% s), where 's' is the measured distance.

Rationale: *This is a modification of Performance Requirements for Interoperability[16A] Clause 5.3.1.1 to support the CCS functionality required on the HS2 Network.*

8.2.6.2 TTS-3411 - ATO Accuracy at ATO Passing Points

The Unit shall achieve an accuracy of measured Train location at ATO passing points that is better than or equal to ± 1 m.

8.2.6.3 TTS-3412 - Accuracy of Train Speed

The Unit shall achieve an accuracy of measured Train speed that is better than or equal to ± 2 km/h at all possible speeds.

8.3 ETCS

8.3.1 ETCS functions

8.3.1.1 TTS-234 - ETCS (PQTS-238)

The Unit shall be able to operate at the following ETCS application levels:
- Level NTC;
- Level 0;
- Level 1;
- Level 2; and
- Level 3.

Rationale: *Level NTC is required for initial operation on the CRN.*
Level 0 is required for shunting and rescue
Level 1 is required for operation at the exit of the depot.
Level 2 is required for operation on the HS2 Network and it is planned that this will be adopted across the CRN.

8.3.1.2 TTS-2255 - Integrity Function Performance

The on-board train integrity system for ETCS Level 3 shall be SIL4.

Rationale: *The integrity of the train integrity system is not yet specified as part of Level 3 functionality.*

8.3.1.3 TTS-2256 - Split Train Locations

If the Train is accidentally split, it shall be possible for the CCS (i.e. integrated on-board and track-side subsystems) to locate all parts for the Train.

Rationale: *In Level 3, in case of splitting, it is essential to be able to locate all parts of the train if limited train detection is fitted to the infrastructure.*

8.3.1.4 TTS-2257 - ATO ETCS Service Brake Inhibit

When ATO On-board is Engaged (EG), the ETCS On-board shall inhibit the calculation of the service brake intervention limits (SBI1 and SBI2).

Rationale: *This is required to enhance ETCS performance.*

8.3.1.5 TTS-2258 - Braking Correction Factor

The correction factor Kdry_rst shall be obtained using Monte Carlo methodology.

Rationale: *The tolerance and reliability of the brake system is captured within the ETCS parameter Kdry_rst which has a direct impact on the assumed deceleration of the Train. Monte Carlo analysis is specified to ensure the calculated performance is as high as possible, thus maximising capacity.*

8.3.2 ETCS performance

8.3.2.1 The following timings are specified for the ETCS On-board sub-system to support overall times specified for the Unit in section 9.7.3.

8.3.2.2 TTS-2309 - ETCS Power-up Time

The ETCS On-board system shall take no more than 75 seconds to go from No Power (NP) mode to requesting a Movement Authority (MA).

Rationale: *The RBC will grant the Movement Authority so delay to obtain FS MA will depend on trackside delays.*

8.3.3 Key management

8.3.3.1 TTS-2330 - Key Management - Receive Updates

The On-board CCS shall be capable of accepting both on-line and off-line key management updates from the Key Management Centre.

Rationale: *Compliance with HS2 cybersecurity specification may require online key management.*

8.3.3.2 TTS-2331 - Key Management Centre Identification

The On-board CCS shall be capable of identifying the correct Key Management Centre.

8.3.3.3 TTS-2332 - Key Management - Request Updates

The On-board CCS shall be capable of requesting an on-line update for the on-board keys to the correct Key Management Centre at any time.

Rationale: *The HS2 Units will be operated on both the HS2 Network and the CRN, which will be managed by NR Key Management System.*

8.4 AWS / TPWS

See also GE/RT8075[103]

8.4.1 TTS-236 - Conventional Signalling Systems (PQTS-242) - Mandatory

The Unit shall be fitted with AWS/TPWS equipment for operation on the CRN.

Rationale: *The CRN routes are currently fitted with three/four aspect lineside signalling with AWS and TPWS (defined by GE/RT8075). These systems may be upgraded to ETCS within the life of the Unit.*

8.4.2 TTS-2337 - AWS/TPWS DMI Integration

The AWS/TPWS cab desk displays shall be integrated onto the ETCS DMI.

Rationale: *A single DMI for use at all times is considered to be the preferred solution from a human factors perspective.*

8.4.3 TTS-3139 - AWS/TPWS Standard

The DMI for the AWS/TPWS On-board system shall have functionality and layout as defined in RIS-0775-CCS[79] Part 5 and Appendix D.

Rationale: ***CRN interface -** Compliance with the RIS ensures a similar interface to other UK rolling stock.*

8.4.4 TTS-2336 - AWS/TPWS with EVC Isolation

The AWS/TPWS, including the DMI, shall be available whether or not the EVC is isolated.

Rationale: *This requirement ensures that even when the EVC is isolated, it is possible to run the service on the CRN.*

8.4.5 TTS-2335 - No Suppression in NTC SH Mode

The AWS/TPWS shall not be suppressed when the ETCS On-board is in Level NTC Shunting (SH) mode.

Rationale: *Some AWS/TPWS implementations permit AWS/TPWS to be suppressed when the unit is shunting. This functionality should not be possible.*

8.4.6 TTS-2339 - AWS/TPWS Power-up Tests

The ETCS On-board shall not prevent AWS/TPWS power-up tests from being undertaken when the ETCS On-board is in Standby (SB), Isolation (IS) or No Power (NP) modes.

Rationale: *This requirement contributes to the performance requirements on the CRN.*

8.5 Protection during HS2-CRN transition

8.5.1 TTS-237 - Signalling Transition - Speed (PQTS-41)

The Unit shall be able to transition from the ETCS on the HS2 Network and to AWS/TPWS on the CRN, and vice-versa at all speeds up to Maximum Line Speed.

Rationale: *HS2 Trains will need to transition between the HS2 Network and CRN (and vice versa) without needing to stop in the transition zone.*

Commercial in Confidence

8.5.2 TTS-238 - Signalling Transition - Continuous Protection (PQTS-294)

Throughout each train protection system transition the Unit shall remain protected by at least one of the train protection systems.

Rationale: *The Trains must always under the protection of one of the applicable signalling systems.*

8.5.3 TTS-437 - Failure to Transition Reporting

Failure of the Unit to complete a transition between protection systems shall be recorded as an Event.

Rationale: *Failures will need to be investigated as soon as possible to ensure the disruption is minimised.*

8.5.4 TTS-1742 - Transition Self-Test

The Units shall include the ability to run a self-test in advance of making a transition or in the depot to provide prior warnings of any failures that could prevent the Unit from transitioning to or from the HS2 Network.

Rationale: *Failures that could prevent a Train from transitioning to or from the HS2 Network are likely to have a significant impact on the operation of the railway. Early warning of these failures is key to putting appropriate mitigation in place.*

8.6 ATO

8.6.1 ATO functions

8.6.1.1 TTS-2341 - ATO GoA Level - Mandatory

The ATO On-board shall support Grade of Automation (GoA) 2 functionality.

8.6.1.2 TTS-2248 - EU ATO Specifications

The ATO On-board and Interoperable C-DAS shall be compliant with the ATO over ETCS European development, specifically:

- the operational concept [17];
- UNISIG specifications for ATO [19] [20] [21];
- the release notes [21A];
- amendments to existing specifications [18]; and
- glossary document [15],

except where modified by requirements of this TTS.

Rationale: *These documents represent the European industry view of ATO On-board specifications.*

8.6.1.3 TTS-2249 - GB ATO Specification

The ATO On-board system shall be compliant with the ATO – GB New Trains Onboard Subsystem Requirements Specification[22].

Rationale: *This document represents the UK view of ATO On-board specifications.*

8.6.2 ATO Stop and Safe Location

8.6.2.1 **ATO Stop** is an additional function compared to the ATO over ETCS SRS[19]. The purpose of this function is to enable the Train Captain to command the Train to stop at the next **Safe Location**. A Safe Location is a pre-defined location on the HS2 Network where Trains can wait safely, and evacuation can be carried out if necessary. If it is not necessary to make an emergency brake application, this enables more control of where Trains make un-planned stops.

8.6.2.2 TTS-2359 - ATO Stop Button

An ATO Stop control shall be provided on the cab desk. (This is in addition to the ATO Disengage input specified by ATO over ETCS SRS[19] Clause 8.1.1.4.)

Rationale: *This enable the Train Captain to command the ATO to bring the Train to a stop, under the ATO's control.*

8.6.2.3 TTS-2356 - ATO Stopping

If the Train Captain presses the 'ATO Stop' control, the ATO On-board shall automatically stop the Train at the next Safe Location at which the Train can stop at full service brake deceleration.

8.6.2.4 TTS-3110 - ATO Stop Report

The ATO On-board shall report to the ATO Trackside when the ATO Stop control is activated.

Rationale: *This is to enable an alarm to be triggered at the NICC. It is expected that the Train Captain will contact the traffic management controller in the NICC to explain the on-board issue.*

8.6.2.5 TTS-3111 - ATO Stop Planned Location

When the ATO Stop control is activated, the ATO On-board shall report to the ATO Trackside the location (i.e. the Safe Location) where the Train is expected to stop.

8.6.2.6 TTS-3112 - ATO Stop Actual Location

When the Train has stopped following activation of the ATO Stop control, the ATO On-board shall report the Train's location, as determined by the On-board CCS, to the ATO Trackside.

Rationale: *For controlled stop in a tunnel, this would allow the tunnel ventilation system to be configured around the stopping position.*

8.6.3 Transitions between networks

8.6.3.1 TTS-2342 - HS2-CRN Transition

When a Train transitions from the HS2 Network to the CRN:
- the ATO On-board shall transition to Disengaging (DE) state;
- the Train Captain shall be required to select "ATO Disengage" or make a brake application within 5 seconds; and

• the Train shall continue at its current speed, unless a brake application is made by the Train Captain.
The ATO On-board shall not cause the Train to stop if the transition is performed correctly.
If the Train Captain does not select "ATO Disengage" or make a brake application, the ATO On-board shall apply a full service brake.

Rationale: *This functionality is based on the "Losing ATO Operational Conditions" scenario described in ATO over ETCS SRS[19] Section 9.10.3.*

8.6.3.2 TTS-3378 - CRN-HS2 Transition

When a Train transitions from the CRN to the HS2 Network:
• the ATO On-board shall transition through to ATO Ready (RE) state;
• the Train Captain shall select "ATO Engage"; and
• the ATO On-board shall change to ATO Engaged (EG) state.
It shall not be necessary to stop the Train through this process.

8.6.4 ATO stopping accuracy

8.6.2.1 The performance criteria in this section are based on standards[70] [75] for similar systems.

8.6.4.2 TTS-100 - ATO Stopping Accuracy (PQTS-122)

When ATO On-board stops the Train at a Stopping Point that is a station, the Unit shall achieve the following stopping accuracies:
• ± 0.50 m for 99.997% of all station stops;
• ± 0.75 m for 99.9993% of all station stops; and
• ± 1.00 m for 99.9999% of all station stops;
when making a stop at any rate up to full service brake deceleration.

Rationale: ***HS2 interface -*** *This level of accuracy is necessary for compatibility with a PEP system. Since this is still under consideration, the Unit will need to capable of achieving this. If low adhesion is reported (i.e. lower than specified in the LOC&PAS TSI[4] (as defined in TTS-101) the ATO will require a lower brake rate.*

Cross reference: *See also Requirement TTS-101 (Full Service Brake Performance (HS2)) in Section 7.3 (Braking)*
See also Requirement TTS-2276 (Poor Adhesion Response) in Section 8.6.5 (Other ATO functions)
See also Requirement TTS-3144 (Report WSP in Automatic Mode) in Section 9.10 (Brake control)

8.6.4.3 TTS-3095 - BTM Design

The balise transmission module shall use the 'balise reference mark' or the highest point of the 'Eurobalise main lobe zone' to recalibrate the odometry subsystem.

Rationale: *This functionality supports odometry performance requirements for ATO.*

8.6.4.4 TTS-2349 - Stopping Adjustment

When the Train comes to a stop at a Stopping Point, if the Train has either:
• overrun the Stopping Point by a distance less than a maximum overrun distance; or
• stopped short of the Stopping Point,
the On-board ATO shall not disengage and shall automatically re-align the Train with the Stopping Point.

Rationale: *This contradicts ATO over ETCS[19] Clause 7.1.4.4. This is necessary to achieve the required level of service reliability. Automatic re-alignment will minimise delays caused by inaccurate stopping at platforms. A maximum overrun distance will be defined. Provided the overrun is less than this, the Train should move backwards to re-align. Beyond this maximum overrun distance, manual re-alignment will be required.*

Cross reference: *See also Requirement TTS-3031 (CCS Accuracy for Distances) in Section 8.2.6 (On-board CCS Performance)*

8.6.4.5 TTS-2350 - Stopping Approach Adjustment

The ATO On-board shall adjust the Automatic Train Stopping Management, if the Train has overrun three stopping points consecutively.

Rationale: *This is to achieve the required level of service reliability. A number of factors which are random in nature can cause degradation of the stopping accuracy. This can cause delays and adversely impact service reliability. This function intends to compensate the performance degradation by automatically adjusting the speed profile on approach to stopping points.*

8.6.5 Other ATO functions

8.6.5.1 TTS-2344 - ATO Isolation

The ATO On-board shall not fail in a way that interferes with manual driving or ETCS On-board. This shall be achieved by enabling the Train Captain to isolate the ATO On-board.

Rationale: *The ATO On-board is not required to have the same integrity as ETCS On-board. It is possible that ATO On-board could provide traction demands when not intended. The Train Captain must be able to isolate the ATO to prevent this.*

8.6.5.2 TTS-2346 - No Traction Out of ATO

When the ATO On-board exits Engaged (EG) state, the Train shall not respond to any traction demand from the traction-brake controller until the controller has first been returned to the neutral / coast position.

Rationale: *The ATO over ETCS operational concept requires that selecting braking will disengage the ATO, but selecting traction will have no impact. If traction is selected for more than 5 seconds, an alarm should be sounded - ATO over ETCS SRS[19] Clauses 8.2.9.1 / .2. If the traction/brake controller is moved to the traction position and then ATO disengages, the Train could respond to the traction demand unless this is suppressed. This requirement is not currently included in the ATO over ETCS SRS.*

8.6.5.3 TTS-2276 - Poor Adhesion Response

The ATO On-board shall be capable of modifying the ATO Operational Speed Profile and traction / braking commands according to “low adhesion information” received from the ATO Trackside, as specified in ATO over ETCS SRS[19] Section 7.6.

Rationale: *This requirement permits ATO brake and acceleration rates to be modified in low adhesion conditions. The decision to lower rates will be made by the traffic controller. The commands may be sent to one Train or several Trains in an area.*

8.6.5.4 TTS-2352 - Automatic Speed Reduction

The ATO Traction / Brake Control shall take account of any speed restrictions that are necessary due to exceptional conditions or failures with the Rolling Stock (e.g. deflated secondary suspension).
The Train Captain shall be given a warning that the speed limit has been applied.

Rationale: *This function is intended to implement temporary rolling stock speed restrictions due to high payloads or failures. It is anticipated that another system would have to enforce the speed restriction, but the ATO On-board should not attempt to overcome this.*

8.6.5.5 TTS-2353 - Automatic Payload Adjustment

The ATO Traction / Brake Control shall take account of the Train payload information when defining the ATO output commands, unless traction and braking sub-systems already account for payload.

Rationale: *This enables efficient driving with the optimum energy consumption.*

8.6.5.6 TTS-2310 - Automation of Preparation and Stabling

The On-board CCS shall provide functionality for automation of the preparation and stabling processes, including changes of Train direction.

Rationale: *This is specified in the ATO over ETCS Operational Requirements[17] (3.1, 3.2 and 5.1) and includes 'Automatic Start of Mission' and 'Automatic End of Mission' functionality. This functionality will speed-up station turnarounds and transfers into and out of service.*

8.6.5.7 TTS-2354 - Expected Arrival Time Information

The ATO On-board shall be able to provide next station, expected arrival time and other similar information to other systems on the Unit.

Rationale: *This information can be used by the PIS.*

Cross reference: *See also Requirement TTS-2878 (AIP Through Journey) in Section 9.25.3 (Automatic Information Programme (AIP))*

8.6.5.8 There are other requirements in Section 9 of the TTS related to ATO.

Cross reference: *See also Requirement TTS-318 (Automatic Door Control) in Section 9.18.2 (Train-wide door control)*
See also Requirement TTS-488 (Vigilance - Driving Modes) in Section 8.11 (Other protection systems)
See also Requirement TTS-946 (Automatic Sanding Activation) in Section 9.12 (Sanding and adhesion control)
See also Requirement TTS-1400 (ODA Auto Login) in Section 9.2 (Diagram allocation)
See also Requirement TTS-1761 (Vigilance - Adjust X Value) in Section 8.11 (Other protection systems)
See also Requirement TTS-2039 (Report WSP) in Section 9.10 (Brake control)
See also Requirement TTS-2472 (PEP System Interlock) in Section 9.19.2 (Door and PEP control)
See also Requirement TTS-2497 (Data Recording - Delay) in Section 9.5.2 (Data recording)
See also Requirement TTS-2751 (Standing in ATO) in Section 10.9.1 (Cab design)
See also Requirement TTS-2878 (AIP Through Journey) in Section 9.25.3 (Automatic Information Programme (AIP))
See also Requirement TTS-2942 (AIP Journey Time Update) in Section 9.25.3 (Automatic Information Programme (AIP))
See also Requirement TTS-3144 (Report WSP in Automatic Mode) in Section 9.10 (Brake control)

See also Requirement TTS-3383 (Vigilance - Variable X Value) in Section 8.11 (Other protection systems)

8.7 Manual driving (GoA1)

8.7.1 The Train will be manually driven when it is operating on the CRN and on some occasions on the HS2 Network. Requirements for manual control of the Train are contained in the LOC&PAS TSI[4] with an additional function below.

Rationale: *It is envisaged that there may be certain scenarios where manual driving is required on the HS2 Network.*

Cross reference: *See also Section 9.10 (Brake control)*
See also Section 9.9 (Traction control)

8.7.2 TTS-2177 - Speed Control

The Unit shall have a speed control function that allows the Train Captain to set a fixed speed that the Unit will maintain using traction and braking until the function is cancelled.

Rationale: *This will support the Train Captain through long sections with a constant speed limit.*

8.7.3 TTS-3428 - Speed Limiter

The Unit shall have a speed limiter function that limits the maximum speed of the Train while giving the Train Captain full control of traction and braking up to that limit.

Rationale: *This would enable a temporary speed restriction to be enforced on the CRN (this function can be achieved via ETCS on the HS2 Network).*

8.8 Shunting

8.8.1 TTS-1485 - Slow Speed Control

The Unit shall have a speed control function that allows a low maximum speed to be set and allows the speed of the Unit to be held at this limit.

Rationale: *It is envisaged that this would be used for operation in depots, sidings and for moving through wash plants.*

8.8.2 TTS-1575 - Slow Speed Adjustment

The Train Captain shall be able to adjust the slow speed control (TTS-1485) in increments of 1km/h up to a maximum 25km/h, and select a pre-set 'train wash' speed that is adjustable as an Operator Setting.

8.8.3 TTS-2030 - Automatic Depot Speed Limit

It shall be possible to automatically apply a maximum value for slow-speed control depending on the depot the Unit is currently located in.

Rationale: *Different depots may have different maximum speed limits.*

8.8.4 TTS-415 - Reverse Driving

It shall be possible to manually drive the Train in reverse, i.e. away from the Active Cab.
In this mode, the Train shall apply a speed limit.
The speed limit shall be an Operator Setting for the Fleet.

Rationale: *This is intended to be used for depot and shunting operations or situations where a Train needs to be manually set back at a station. The full operational controls to support this movement need further development.*

8.8.5 TTS-1579 - Reverse Driving CCTV

When moving in reverse, images from the FFRF CCTV camera(s) in the rear Cab shall be displayed to the Train Captain.

Rationale: *This is to allow the Train Captain visibility of the direction of travel.*

Cross reference: *See also Section 9.26.2 (FFRF CCTV)*

8.8.6 TTS-3191 - Reverse Driving Windscreen Wipers

When moving in reverse, it shall be possible to activate the means of clearing the view of the FFRF CCTV camera(s) (e.g. windscreen wipers) on the rear Cab from the Active Cab.

Rationale: *If the FFRF CCTV is used for rear visibility, it must be possible to ensure a clear view.*

Cross reference: *See also Requirement TTS-597 (Keep FFRF Cameras Clear) in Section 9.26.2 (FFRF CCTV)*

8.9 National C-DAS

8.9.1 TTS-244 - Connected Driver Advisory System (C-DAS) (PQTS-44)

The Unit shall include a National C-DAS that will provide advice to the Train Captain when driving manually on the CRN.

Rationale: *Correct presentation of Trains at junctions with the HS2 Network is necessary to achieve the high reliability of operations on the HS2 Network. Furthermore, achievement of consistent, on-time running based on real-time railway conditions and the possibility of delivering energy efficiency are key to overall goals of the High Speed 2 Project.*

8.9.2 TTS-2885 - Compliance with National C-DAS Specification

The National C-DAS shall comply with the Interim System Requirements Specification for C-DAS[107].

8.9.3 TTS-477 - National C-DAS Information to Train

The National C-DAS shall enable the receipt of schedule, routing and speed restriction updates by the Train in near-realtime, with information presented to the Train Captain to ensure on time running.

Rationale: *In order to deliver correct presentation of trains at the HS2 Network it is envisaged that a C-DAS system will be required to deliver dynamic advice to the Train Captain.*

8.9.4 TTS-3365 - National C-DAS Train to NICC

The National C-DAS shall enable the Train to send information to the NICC to improve regulation of the service.

8.9.5 TTS-3366 - National C-DAS Default Information

In an area where there is no data provided by a network operation centre, the National C-DAS shall operate with the most recent updates received from a control centre or pre-configured data.

8.9.6 TTS-3367 - National C-DAS Reporting

The Train shall, via the National C-DAS, continuously report its location and its performance against the plan.

Rationale: *The Train is required to report to the Wayside on its location to allow the HS2 traffic management system to plan for its arrival on the network.*

8.9.7 TTS-3024 - C-DAS Visualisation

The National C-DAS shall present information on the ETCS DMI.

Rationale: *This is intended to reduce cognitive workload associated with moving between the CRN and the HS2 Network by ensuring the Train Captain is always provided with driving information on the same display.*

8.10 Voice radio

See also CCS TSI[5]

8.10.1 TTS-481 - Compatibility with GSM-R - Mandatory

The Unit shall be equipped with a voice radio system capable of GSM-R communication and GSM-R over GPRS communication.

Rationale: *The GSM-R voice radio shall allow the Train Captain to communicate with the signaller, for the passing of urgent safety-related data between the Unit and the Wayside and to fulfil emergency communication capability requirements.*

8.10.2 TTS-2250 - GSM-R RIS Specification

The GSM-R/GPRS Voice Radio On-board shall be compliant RIS-0794-CCS[81].

8.10.3 TTS-2057 - GSM-R Voice Radio Volume Adjustable

With reference to RIS-0794-CCS[81] Clause 8.2.27.1 and EIRENE SRS[14] Clause 5.4.5, the handset and loudspeaker volume shall be capable of automatic adjustment based on the measured or predicted ambient cab noise. The volume shall also be manually adjustable by the Train Captain.

Rationale: *Train Captains will have preferences over volume levels. The ambient noise in the cab is likely to vary considerably between low speed and very high speed in tunnels.*

Cross reference: *See also Section 9.7.4 (Train Captain settings)*

8.10.4 TTS-2517 - Recording of GSM-R Coverage Loss

The loss and re-establishment of GSM-R coverage shall be recorded.

8.10.5 TTS-3021 - GSM-R to Authorised Person

It shall be possible to undertake two-way communication between an Authorised Person at the public address handset adjacent to the Evacuation Door and the NICC on the Wayside, via the GSM-R voice radio system.

Rationale: *This is necessary to support communication during an Evacuation if the Train Captain has left the cab or is otherwise not able to communicate. The full GSM-R voice radio functionality is not required at the public address handset, only the ability to make this particular call.*

8.11 Other protection systems

8.11.1 A Driver's Reminder Appliances (DRA), as defined by GM/RT2491[94], is required by the current list of notified national technical rules.

Rationale: ***CRN interface -*** *A DRA device is deemed to be required for operation on the CRN*

8.11.2 TTS-486 - Driver's Reminder Appliance (DRA) Functionality

When the DRA is reset, there shall be a warning to the Train Captain in the form of a recorded voice message "DRA off – Driver check signal."

Rationale: *This functionality is intended to assist the Train Captain in ensuring it is safe to proceed.*

8.11.3 TTS-488 - Vigilance - Driving Modes

With reference to LOC&PAS TSI[4] Section 4.2.9.3.1, the 'driver's activity control' (vigilance) function shall be configurable to :

- operate at all times as specified in the LOC&PAS TSI;
- monitor activity at all times, but not make an emergency brake application when the ATO On-board is Engaged (EG); and
- operate only when ATO is not Engaged (EG).

Rationale: *Whilst this functionality currently contravenes the LOC&PAS TSI[4], the capability to change to this functionality, when permitted, will improve operation of the railway by the ability to take alternative action if a Train Captain has become incapacitated when operating under ATO, e.g. by moving the Train to a specific point of safety before stopping.*

8.11.4 TTS-1760 - Vigilance - Communicate to Wayside

A lack of driver's activity and the failure of the Train Captain to cancel the warning shall be communicated to the Wayside, whether or not a brake application is made.

8.11.5 TTS-1761 - Vigilance - Adjust X Value

With reference to LOC&PAS TSI[4] Clause 4.2.9.3.1 (2) ¶3, it shall be possible to set a separate value of X (the time before an activity is required) for when ATO On-board is Engaged (EG) and when it is not Engaged.
The value of X for when ATO On-board is Engaged shall be capable of being greater than 60 seconds.
Values of X shall be set as Operator Settings.

Rationale: *It may be determined that when ATO is Engaged, activity monitoring is required, but at a less frequent interval.*

8.11.6 TTS-3383 - Vigilance - Variable X Value

When ATO On-board is Engaged (EG), the value of X (the time before an activity is required) shall be capable of being set to a randomly changing value between two limits.
The limit values of X shall be set as Operator Settings.

Rationale: *A constant value of X would mean the Train Captain would have a very repetitive interaction while ATO is engaged. A variable value of X may lead to better engagement*

8.11.7 Human factors assessment will be required to determine how best to apply the 'driver's activity control' function while ATO On-board is active. Implementation in any way other than that specified in the LOC&PAS TSI will be subject to updates to the TSIs to permit this functionality or other regulatory approval that enables this. The above requirements specify the capability to change the function, but such changes would not be implemented without the necessary approvals. Refer to Appendix O.

9 Functionality and systems

9.0.1 The functionality of the Unit, its interactions with Passengers, the Train Captain and other Train Crew, and its integration with the Wayside will be developed by the TMM in partnership with the Purchaser, the HS2 Train Operator and other stakeholders in the HS2 project according to the functional integration process described in MSA Schedule 11.

9.0.2 The TTS defines the high-level functions to be achieved. The TMM will develop the detailed functionality that achieves these functions and integrates all systems.

9.0.3 The majority of functionality requirements apply to the Unit as an operational Train, which may comprise one Unit or two coupled Units. Requirements refer to 'Unit' or 'Train' accordingly. Where requirements refer to the Unit or Train, this includes On-board CCS and Rolling Stock subsystems.

9.0.4 This section first sets out common train controls functions and principles, which are used for most systems. It then defines requirements for driving the Train, followed by requirements for each area of functionality.

9.1 Operator Settings and Software Updates

9.1.1 The functionality described in this TTS must be developed prior to Acceptance. However, it is envisaged that some systems will need to permit changes to settings after Acceptance without the need for formal modification. Such changes would be implemented by the Operator to affect how the Unit interacts with Passengers, the Train Captain and Train Crew. These are referred to as **Operator Settings**. Requirements through this section make reference to functions being adjustable as an Operator Setting. The following general requirements exist for Operator Settings where they are specified:

9.1.2 TTS-494 - Set Operational Vehicle Type

It shall be possible for Vehicles within a Unit to have different Operator Settings from each other.

Rationale: *This permits different vehicles to be allocated to different types of on-board service.*

9.1.3 TTS-1362 - Update Operator Settings 1

It shall be possible to update Operator Settings from the Wayside.

Rationale: *This is to prevent the need to visit each Unit to update it.*

9.1.4 TTS-1361 - Update Operator Settings 2

It shall be possible to update Operator Settings on a single Unit, the Fleet or a number of Units within the Fleet.

Rationale: *It is envisaged that new settings may be trialled on a single Unit prior to roll-out across the Fleet. In some cases this could introduce undesirable situations, and so all Units must be updated together. These Operator Settings will need to be restricted to fleet-only so that all Units must be updated together.*

9.1.5 TTS-2079 - Temporary Operator Settings

It shall be possible to temporarily update Operator Settings for a particular Vehicle. The updated settings would be set at Crew Control Points or received from the Wayside. The updated settings shall reset at the end of the current Service.

Rationale: *This would give the flexibility for some passenger-facing settings (HVAC set-point and lighting levels are the most likely changes) to be adjusted either mid-journey or for a particular journey.*

9.1.6 There are further settings for which it would not be suitable to make changes without suitable review, assurance and control. However, it is still required that these changes can be made through changes to software alone. These are referred to as **Software Updates** - see Section 9.29.

9.2 Diagram allocation

9.2.1 This section describes functionality required to permit individual Units to be allocated to specific **Operational Diagrams** - the sequence of Services that a Unit will undertake in a given day, including empty coaching stock (ECS) moves. Each **Service** is a journey between two points with a number of intermediate stops. This functionality will need to be developed with any traffic management systems that are implemented on the HS2 Network and the CRN.

Rationale: *The functionality in this section is defined to simplify the process of the Train Captain and Train Crew setting up a Unit. This will speed-up departure and should minimise the chance that services leave with incorrect or missing passenger information. This functionality will also enable Units to automatically prepare themselves for service, pre-heating and pre-cooling only when required and minimise the overall energy consumption.*

9.2.2 TTS-1392 - Operational Diagram Allocation

It shall be possible to allocate a Unit to a specific Operational Diagram on a specific date, and time as required.

9.2.3 TTS-1564 - ODA - Multiple Unit Operation

Operational Diagram Allocation shall include multiple-unit operation, in which the order of Units shall be planned and monitored.

Rationale: *Certain services will be operated as two Units. The Units will need to configure themselves for this arrangement, including opening and closing coupler covers at the appropriate points.*

9.2.4 TTS-1395 - ODA - Control

A Unit shall receive its allocation to an Operational Diagram from the Wayside, and shall store this on the Unit.

Rationale: *This Unit should not be dependent on the connection to the Wayside to maintain this functionality.*

9.2.5 TTS-1393 - ODA - Time in Advance

It shall be possible to allocate Units to Operational Diagrams up to three months in advance.

9.2.6 TTS-1394 - ODA Changes - Wayside

It shall be possible to change the allocation of a Unit to an Operational Diagram from the Wayside in advance, between services or during a Service.
If the Unit is in a driving mode (i.e. it has an Active Cab) at the time of the change, the change shall be displayed to the Train Captain and at any Crew Control Point.

Rationale: *Changes to the planned diagram or route of Train may be made by the traffic management system.*

9.2.7 TTS-1396 - ODA Changes - On-board

It shall be possible for the Train Captain to change the allocation of a Unit to an Operational Diagram.
If a change is made, this shall be communicated to the Wayside.

9.2.8 TTS-1397 - ODA - On-board Check

It shall be possible for the Train Captain and Train Crew to check which Operational Diagram and Services a Unit has been allocated to, and which Service it is currently operating.

9.2.9 TTS-3380 - ODA - On-board Check Information

For each Service which the Train Captain can check (TTS-1397), the Train Captain shall be able to see at least the:
- origin;
- destination;
- stopping points;
- coupling/uncoupling locations;
- preceding Service; and
- following Service.

9.2.10 TTS-1400 - ODA Auto Login

The Unit shall automatically provide mandatory data to on-board systems, e.g. ETCS, ATO, DAS and GSM-R voice radio based on its Operational Diagram allocation and the Service it is operating.
The Train Captain shall be required to confirm this data.

9.2.11 TTS-1996 - ODA Crew Log

It shall be possible to add names or IDs of Train Captain and Train Crew for a particular Service to an Operational Diagram.
It shall be possible to compare this data to crew logins.

9.3 On-board controls

9.3.1 This section sets out controls to be provided for the Train Captain and Train Crew. The functionality of these controls is defined in other sections of the TTS.

9.3.2 TTS-1593 - Train Captain Controls

All controls for the Train Captain to operate the Train shall be included in the Cab.

9.3.3 TTS-1454 - Crew Control Point - Mandatory

The Unit shall have a Crew Control Point positioned close to the mid-point of the Unit.
The Crew Control Point shall include a colour touch screen for accessing a limited set of information and controls, and a communications handset.

Rationale: *It is assumed that the Cab will provide means to access train control systems. To enable a faster response to issues that may arise on-board, access is required to some systems without Train Crew needing to walk to a Cab at the far end of the Unit.*

9.3.4 TTS-1594 - Crew Controls in Cab

Train Crew shall be able to use a subset of controls and equipment in an Inactive Cab to access information from on-board systems.

9.3.5 TTS-1595 - Public Address Point

The Unit shall have public address points with a communications handset in Vestibules arranged such that:
- at least one public address point is provided in each Vehicle;
- in Vehicles with Evacuation Doors, the handset shall be provided in the same Vestibule as the Evacuation Doors; and
- there is at least one public address point every 25m along the Unit.

Public address points shall not be accessible to the public.

Rationale: *Train Crew will need to be able to make announcements and respond to calls throughout the Unit.*

9.3.6 TTS-1330 - Train Crew Door Control at Doorways

Three sets of controls for Train-wide door control, including a signal buzzer for communication with the Train Captain, shall be provided for use by Train Crew.
Train-wide door controls shall be distributed at approximately 50m intervals throughout the Unit.
Train-wide door controls shall be installed adjacent to Exterior Doorways inside the Vestibule on both sides of the Vehicle.
Train-wide door controls shall not be accessible to the public.

Rationale: *This is in addition to door controls in the Cab, for use by the Train Captain. Controls would be approximately 50m, 100m and 150m along the Unit. The controls are required to support specific train dispatch concepts.*

9.3.7 TTS-2173 - Controls' Human Factors

The design of all controls, including the presentation of information and soft controls on train control screens shall consider the human factors of the user of the controls.

Rationale: *This high-level requirement is included to highlight that human factors needs to be considered as part of the development of train controls.*

9.4 Train to Wayside and passenger communications

9.4.0.1 This section contains requirements for three systems to enable non-critical and passenger communications between the Unit and the Wayside. Whilst the functionality is split in to three systems it is not required that they are physically separated and may share common elements to allow optimisation of the overall design.

9.4.1 Non-Passenger communications

9.4.1.1 Non-passenger communications covered by this section are intended to include communication required for all data related to the Wayside Data System including for example, diagnostic data, CCTV data, Operator Settings, etc.

9.4.1.2 TTS-3304 - Train to Wayside Communications Interface

All non-safety critical, operational communication between the Unit and the Wayside and Wayside Data System shall be capable of being transmitted via both:
- WiFi when the Unit is within range of a suitable WiFi system (e.g. depot or station); and
- public mobile networks.

Rationale: *It is expected that the most accessible communications channel available to the Units will be public mobile networks, including in HS2 tunnels, however WiFi may also be used for certain bulk download activities at stations and/or depots.*

9.4.1.3 TTS-3306 - Mobile Network Future Compatibility

Provision shall be made for Train to Wayside communications to be compatible with future 5G networks.
This provision shall as a minimum include suitable antennas and cabling to cover the current range of frequencies anticipated for UK mobile operations in the range from 700MHz to 5GHz.

Rationale: *The Units should be prepared as much as possible for future mobile network upgrades.*

9.4.2 Passenger mobile communications

9.4.2.1 TTS-3308 - Digital On-board Repeater (D-OBR) - Mandatory

The Unit shall be fitted with a system capable of repeating and boosting mobile network signals from outside the Unit to all areas of the Unit - a Digital On-board Repeater (D-OBR). Any signal boosting capability shall include tuneable gain and filtering, echo cancellation channel switching and noise cancellation appropriate to each band and configurable by Location (Line & Distance).

9.4.2.2 TTS-3309 - D-OBR Coverage

The D-OBR shall be designed to ensure that there is sufficient coverage for the 1SL seating capacity.

9.4.2.3 TTS-3310 - D-OBR Compatibility

The D-OBR shall be multiband compatible and capable of repeating and enhancing signals in all bands and across all cellular standards for voice and data communications used by UK public mobile operators.

Rationale: *Passengers and Train Crew should have the ability to remain connected to high quality public mobile network signals for as much of the journey as possible.*

9.4.2.4 TTS-3311 - D-OBR Future Compatibility

Provision shall be made for the D-OBR to be compatible with future 5G networks.
This provision shall as a minimum include suitable antennas and cabling to cover the current range of frequencies anticipated for UK mobile operations in the range from 700MHz to 5GHz.

Rationale: *The Units should be prepared as much as possible for future mobile network upgrades.*

9.4.3 Passenger WiFi communications

9.4.3.1 TTS-3313 - Public WiFi Network - Mandatory

Units shall be fitted with a system to provide WiFi to all passenger and staff areas within the Unit - a Public WiFi Network.

Rationale: *Passengers and Train Crew should have the option to use a public WiFi network to enable communications via personal computers, smart phones, tablet computers or equivalents.*

9.4.3.2 TTS-3305 - Mobile Network Compatibility

The Public WiFi Network shall communicate with public mobile networks and shall be 2G, 3G and 4G compatible and support the following:

- LTE Carrier Aggregation;
- Multiple-in / Multiple Out antennas for train to mobile network connectivity;
- GNSS positioning; and
- bonding of multiple connections.

Rationale: *The Public WiFi Network should be able to maximise available bandwidth.*

9.4.3.3 TTS-3314 - Public WiFi Network Capacity

The Public WiFi network shall be designed to ensure that, assuming the 1SL seating capacity, all passengers can be connected to the system simultaneously and that the bandwidth available to each user is maximised.

Rationale: *Passengers and Train Crew should have the ability to continue to use their devices when on-board. It is acknowledged that the final available bandwidth will be dependent on the network coverage.*

9.4.3.4 TTS-3324 - Future Flexibility - Public WiFi Network Expansion

The on-board network provided to support the Public WiFi Network systems shall be capable of supporting a minimum of 10Gb/s. This shall include all cabling, switches and gateway units.

Rationale: *There should be scope for scaling of the system based on technology and equipment available during the lifetime of the Units.*

9.4.3.5 TTS-3315 - Public WiFi Network Mobile Network Future Compatibility

Provision shall be made for the Public WiFi Network to be compatible with future 5G networks for transmission to the Wayside.
This provision shall as a minimum include suitable antennas and cabling to cover the current range of frequencies anticipated for UK mobile operations in the range from 700MHz to 5GHz.

Rationale: *The Units should be as prepared as possible for future mobile network upgrades.*

9.4.3.6 TTS-3316 - Public WiFi Network Access Point Functionality

WiFi access points shall conform to IEEE 802.11 using the following protocols:
- IEEE 802.11a (5.0 GHz);
- IEEE 802.11b (2.4 GHz);
- IEEE 802.11g (2.4 GHz);
- IEEE 802.11n (2.4 GHz);
- IEEE 802.11n (5.0 GHz); and
- IEEE 802.11ac (5.0 GHz).

WiFi access points shall be able to dynamically allocate channels to minimise interference.

9.4.3.7 TTS-3317 - Public WiFi Network Access Point Upgradeability

The WiFi access point shall be flexible/expandable to support any future WiFi protocols.

Rationale: *The Units should be as prepared as possible for future WiFi upgrades.*

9.4.3.8 TTS-3320 - Public WiFi Network Content Server

An on-board content server shall be provided which shall interface with the Public WiFi Network.
The content server should be able to host various content like video, audio and interactive games and services.

Rationale: *The Units should support a wide range of future operating scenarios.*

9.4.4 Additional Data Communications System Provision

9.4.4.1 TTS-3318 - Provision for Additional Data Communications Systems - Mandatory

The Unit shall include provision for the fitment of an additional data communications system. This provision shall be in the form of locations and interfaces to install one system with the following characteristics in each of the leading Vehicles (i.e. two systems per Unit):
- space allocation in the form of a 19" rack mount which is at least 4U high and a minimum depth of 400mm. It shall be assumed that the equipment to be fitted will have a maximum mass of 10kg;
- the provision of a power supply of up to 3A at 110V DC;
- physical interfaces and cabling to allow this additional system to be connected to the Public WiFi Network;
- physical interfaces and cabling to allow this additional system to be used for non-passenger communications; and
- accessible cable route to a location suitable for the future fitment of a roof mounted antenna that has a line of sight in front of the leading Cab.

Rationale: *The Units should be as prepared as possible for future technology changes. The HS2 Network or CRN may be fitted with a dedicated wireless communications system to enable high-bandwidth communication with the Units. Such a system may require additional equipment to be fitted to the Units. Passenger communications (using the Public WiFi Network on the Units) and non-passenger communication (Section 9.4.1) would be expected to utilise the dedicated wireless communication system at all locations where it is fitted, but would need to revert to infrastructure-fitted WiFi or to public mobile networks elsewhere.*

9.5 Monitoring and recording

9.5.1 Events

9.5.1.1 TTS-498 - Record Events - Mandatory

The Train shall record an Event whenever
• there is a failure of any system or function that can reasonably be recorded; *and/or*
• specific conditions or actions occur on the Train.

9.5.1.2 The list of Events to be recorded, and their priority, will be developed by the TMM in collaboration with HS2 Ltd as part of the functional integration described in MSA Schedule 11.

9.5.1.3 TTS-2918 - Event Location

Events shall be recorded on the Unit on which the Event occurs.
On a 400m Train Events shall be accessible from the other Unit from that in which the Event occurred.

Rationale: *If an Event occurs in the rear Unit of a 400m Train, it may be necessary to alert the Train Captain. With less urgent events, Train Crew in one Unit may want to investigate events in the other Unit.*

9.5.1.4 TTS-2187 - Prioritisation of Events

Each Event shall be prioritised depending on
• the most appropriate person to respond - Train Captain, Train Crew or Maintenance Technician;
• the priority of this response; and
• the Location (Line & Distance) of the Train.

Rationale: *It is necessary to prioritise events to prevent overloading staff with information and to provide information to the right staff. Changes in priority due to location are necessary to account for the different operation on the HS2 Network and the CRN. In addition, changes in priority may be necessary when approaching and traversing long tunnels.*

9.5.1.5 TTS-1374 - Event Metadata

All Events shall be recorded with relevant metadata about the condition and location of the Unit.

Rationale: *This data should help explain the nature and the timing of the Event, and assist with defining the cause of the Event.*

9.5.1.6 TTS-1463 - Event Presentation - Train Captain

Warnings and information for the Train Captain due to an Event shall be presented in the Active Cab with an appropriate alert depending on the priority.

9.5.1.7 TTS-1464 - Event Presentation - Train Crew

Warnings and information for Train Crew due to an Event shall be accessible in any Inactive Cab or a Crew Control Point following log-in.

9.5.1.8 TTS-2188 - Event Alert - Train Crew

It shall be possible to broadcast an audible alert to Train Crew when certain Events take place.
It shall be possible to configure which Events cause the alert and the volume of this alert as an Operator Setting.

Rationale: *An audible alert may be useful operationally to alert Train Crew. However, these can become annoying for Passengers.*

9.5.1.9 TTS-1465 - Event Presentation - Maintainer

A list of all Events and all data associated with the Events shall be accessible to a Maintenance Technician both on-board or on the Wayside.

9.5.1.10 TTS-1377 - Event Messages

It shall be possible to edit the Event messages displayed to the Train Captain or Train Crew as an Operator Setting.

9.5.1.11 TTS-1466 - Event Transmission to Wayside

The Unit shall communicate Events to the Wayside at appropriate intervals based on the priority of the Event and the actions required to respond to the Event.

Rationale: *High priority Events will need to be communicated as soon as possible to the Wayside, whereas low priority Events can be downloaded at regular intervals.*

9.5.1.12 TTS-3250 - Time to Transmit

For the highest priority Events, the Unit shall take no more than 5 seconds from the source of the Event occurring to the Event being transmitted to and received by the Wayside, assuming mobile data communications or WiFi connectivity with the Wayside are available.

Rationale: *This is specified to ensure that transmission of high priority Events is not delayed by other on-board systems. A transmission rate is specified since the method of transmission is still to be defined.*

9.5.1.13 TTS-1999 - Manual Event

The Train Captain and Train Crew shall be able to manually record Events, such as failures of on-board equipment, faults or other information to be reported to a Maintenance Technician. This shall be possible in a Cab or at a Crew Control Point either by picking from pre-defined lists or by entering text.

9.5.2 Data recording

9.5.2.1 TTS-500 - Data Recording - Systems / Performance

The Unit shall record Train Data about all on-board systems to record the performance of the system and how the Unit has been operated.

9.5.2.2 The TTS does not define the individual items of Train Data to be recorded. The TMM shall develop this list of items as part of the functional integration process defined in Schedule 11.

9.5.2.3 TTS-2526 - Data Recording - Time and Location

Recorded Train Data shall be synchronised with time and location data for the Unit.

Rationale: *This is necessary to understand data in the context of other events on the Train and on the Wayside.*

Cross reference: *See also Section 9.36 (Clocks / time)*

9.5.2.4 TTS-1763 - Data Recording - Train Captain

The Unit shall record Train Data about the Train Captain's actions, both normal and abnormal, and in particular those that are safety-related.

9.5.2.5 TTS-1764 - Report Abnormal Actions

All abnormal Train Captain's actions shall be immediately reported to the Wayside.

Rationale: *The definition of what will be considered 'abnormal' will be agreed with the TMM as part of the functional integration process described in MSA Schedule 11. Examples are isolating systems and unexpectedly leaving a Cab.*

9.5.2.6 TTS-2021 - Data Recording - Journey Time

The Unit shall record Train Data about the journey time achieved on each Service, including
- wheel-start and wheel-stop times at each station;
- speed / time profile; and
- any unplanned stops.

9.5.2.7 TTS-2497 - Data Recording - Delay

When the Train is delayed compared to planned journey times for a Service, the Unit shall record Train Data about the cause of the delay, whether it is:
- train regulation by the Train Captain, ATO or signalling system;
- passenger interaction (e.g. passenger alarm); and
- failure of an on-board system or function.

9.5.2.8 TTS-1713 - Data Recording - Passenger Interface

The Unit shall record Train Data about on-board systems such that defects that could lead to the Unit being withdrawn from service are detected.

Rationale: *Exactly which defects will lead to the HS2 Train Operator withdrawing a service is not defined. With some exceptions listed in the TSA, the HS2 Train Operator could choose to withdraw the Unit for most failures. Failures of safety-related systems would lead to a high-priority Event. The purpose of this requirement is to record data about whether systems such as lighting, HVAC, passenger information, WiFi are functioning correctly to give clear data to support the TSA. The scope and level of monitoring will be developed through the design phase such that the widest scope of systems are monitored without negatively affecting reliability.*

9.5.2.9 TTS-499 - Data Download - Regular

The Unit shall communicate recorded Train Data to the Wayside at appropriate intervals, or following particular Events.
This shall include Train Data on the train data recorder / juridical recorder unit and Train Data recorded in other monitoring systems.

9.5.2.10 TTS-1822 - Data Download - Triggered

It shall be possible to trigger the download of specific Train Data from the train data recorder / juridical recorder unit and other monitoring systems from the Wayside.
It shall be possible to select Train Data for any time period stored on the Unit.

9.5.2.11 TTS-1470 - Data Review On-board

It shall be possible for a Maintenance Technician to access recorded Train Data on-board the Unit, including Train Data stored on the data recorder / juridical recorder.

9.5.2.12 TTS-2261 - Future Flexibility - Data Capacity

The data recorder / juridical recorder shall have at least 20% spare recording channels over-and-above those necessary to meet this specification and Mandatory Standards.

Rationale: *This requirement ensures flexibility to include additional on-board monitoring and recording.*

9.5.3 Data recording for testing

9.5.3.1 To support testing and systems integration, particularly of the CCS, additional data recording is required over and above the normal data recording that would continue for the Unit's life.

9.5.3.2 TTS-2528 - Data Recording - Enhanced Temporary Cab Diagnostics

It shall be possible to temporarily configure the Unit to synchronously record the status of cab controls and all images shown and inputs to control screens in the Active Cab.
Storage shall be provided for up to 24 hours of operation.

Rationale: *This function is to support testing, particularly of the on-board CCS and achieve enhanced diagnostics.*

9.5.3.3 TTS-2292 - Data Recording - Enhanced CCS Monitoring

It shall be possible to temporarily configure the Unit to record all messages received and sent by the On-board CCS.
On an IM Unit, this data shall be synchronised with the GSM-R quality of service monitoring data.

Rationale: *This requirement supports testing activities for ETCS, C-DAS and ATO.*

Cross reference: *See also Requirement TTS-619 (GSM-R Transmission Quality Monitoring) in Section 9.27.5 (Signalling and Radio Frequency Monitoring System)*

9.5.4 Reset and isolation

9.5.4.1 TTS-490 - Automatic Recovery from Failure

Where possible and appropriate, the Unit shall automatically respond to Events and data about the status and failure of functions and systems. This response may include a limited number of resets or isolation of the function or system.

9.5.4.2 TTS-491 - Remote Recovery from Failure

Where possible and appropriate, the Unit shall enable functions and systems to be reset and isolated from the Cab and/or from the Wayside.

9.5.4.3 TTS-492 - Isolation Control On-board

Where functions or systems require reset and isolation on the Unit local to the component, the Unit shall provide clear instructions to the Train Captain and Train Crew as appropriate.

9.6 Location-based functions

9.6.1 A number of functions defined in this Section 9 of the TTS relate to the location of the Unit. Depending on the function, it may be necessary to determine:

- whether the Unit is on the HS2 Network or the CRN;
- the line of the network (as identified by the 'Engineer's Line Reference' codes on Network Rail infrastructure and the equivalent codes on HS2 Network), and the distance along that line from a datum; and
- the specific track that the Unit is on - e.g. Up Fast.

9.6.2 Requirements for the Train to establish its location are specified below. Functions based on location refer to one of these levels of accuracy.

9.6.3 It is envisaged that the Train will be able to establish its location using at least:

- GNSS;
- Eurobalises, where fitted; and/or
- distance travelled since last confirmed position.

9.6.4 TTS-1706 - Location (Network)

The Train shall be able to establish whether it is operating on the HS2 Network or CRN - its **Location (Network)**.

Rationale: *Some functions will need to know which network the Train is operating on. Depending on the Unit design, some functions may need to know this with a high level of integrity to ensure that the Unit is operating in a suitable state for the Network it is operating on.*

9.6.5 TTS-1707 - Location (Line & Distance)

The Train shall be able to establish its location with respect to the line it is operating on and the distance along this line from the line's datum, with an accuracy of ±10m - its **Location (Line & Distance)**.

Rationale: *The majority of functions requiring location data will need know an approximate geographical location of the Unit. This will not require a high level of integrity and a GNSS should suffice.*

9.6.6 TTS-1825 - Location Reporting

The Unit shall report its Location (Line & Distance) and current speed to the Wayside every 15 seconds, provided a connection to the Wayside is available.

Rationale: *This functionality is specified to provide location information on the CRN without having to rely on trackside CRN systems. On the HS2 Network, other systems will be available to report the position of the Units, but Unit should continue to report its location.*

9.6.7 TTS-1398 - ODA Deviation

The Unit shall monitor its Location (Line & Distance) against the time and location expected for an Operational Diagram.

Rationale: *This data may be used to provide live updates to passengers. A similar function is required using ATO - TTS-2354.*

9.6.8 TTS-3230 - Report Orientation

The orientation of each Unit in the Train shall be reported to the Wayside at regular intervals.

Rationale: *The HS2 operation will lead to Units frequently changing orientation. Accurate information must be provided to staff and information systems at stations to help Passengers wait in the correct location.*

9.7 Login, states and activation times

9.7.1 Log-in and security

9.7.1.1 TTS-1451 - On-board Log-in

The Unit shall require the Train Captain, Train Crew or Maintenance Technicians to log-in with a unique ID before accessing train control functions.

Rationale: *This log-in is required to restrict access to train control functions.*

9.7.1.2 TTS-3436 - Log-in for Presence

The Unit shall enable all members of Train Crew to log-in to the Unit independently from accessing train control functions (TTS-1451).

Rationale: *This log-in is required to check the presence of certain Train Crew on the Train.*

9.7.1.3 TTS-1605 - Contactless Login

The Train Captain, Train Crew and Maintenance Technicians shall be able to log in using contactless technology.
Facilities for log-in shall be provided in Cabs and at the Crew Control Point.
The unique cards, or similar devices, issued to each member of the HS2 Train Operator's staff will be Special Operator Equipment.

Rationale: *This reduces the risk that unique IDs are shared or misused.*

9.7.1.4 TTS-1604 - Record Login

The Unit shall record which Train Captains, Train Crew and Maintenance Technicians have logged into the Unit and when this occurred.
This data shall be transmitted to the Wayside.

9.7.1.5 TTS-3437 - Report Log-ins

The Unit shall report to the Wayside when the planned Train Captain and all planned Train Crew have logged in to the Unit.

Rationale: *A service should not depart until all necessary Train Crew are on-board.*

Cross reference: *See also Requirement TTS-1996 (ODA Crew Log) in Section 9.2 (Diagram allocation)*

9.7.1.6 TTS-412 - On-board Mode Selection - Train Captain

Only a Train Captain shall have access to driving modes to move the Unit.

9.7.1.7 TTS-1369 - Secure Mode

The Unit shall enable the Train Captain to leave the Cab and secure the Unit without exiting a driving mode or de-activating the Cab.
The Unit shall be unmoveable until the Train Captain returns to the same Cab.
All Passenger-facing systems shall retain full functionality and performance while the Train Captain is away.

Rationale: *This state permits the Train Captain to leave the Cab (e.g. to go to a signal telephone) without needing to de-activate and then re-start the Train.*

9.7.1.8 TTS-1606 - Changeover

The Unit shall enable Train Captains to change over, including logging in and logging out and the removal of any personally-issued equipment, such as keys, without deactivating the Cab or affecting Passenger-facing systems.

Rationale: *This is necessary to ensure that changeover of the Train Captain does not delay the service.*

9.7.2 Operational states

9.7.2.1 TTS-1598 - On-board States

The Unit shall have a number of on-board States relating to the status and operation of on-board systems.

9.7.2.2 Requirements of this TTS assume at least the following States

- **Passenger Service State** - all systems operational and fully functioning
- **Standby State** - systems running at reduced output to limit energy consumption; limited functionality considering no passengers on-board; Train may be stationary or running empty coaching stock
- **Limited Heat Release State** - systems configured to minimise heat output from the Unit while providing the best on-board environment possible.

- **Servicing State** - systems running at settings to permit cleaning, maintenance or service preparation
- **Shut-down State** - the Unit is not connected to the 25kV power supply; all systems except Wayside communication are switched off
- **Full Shut-down State** - the Unit is not connected to the 25kV power supply; all systems are switched off so no power is consumed

9.7.2.3 The following table shows the anticipated operational States for each driving mode described in Section 8.

	ATO	Manual	Back-up	Shunting / Reverse	No driving / Active Cab
Passenger Service	✓	✓	✓		✓
Standby	✓ (1)	✓	✓	✓	✓
Limited Heat Release	✓	✓			
Servicing					✓
Shut-down					✓
Full Shut-down					✓

(1) ATO will be used for empty stock moves

9.7.2.4 TTS-1371 - Automatic State Switching - Operational Diagram

The Unit shall automatically switch between Standby State and Passenger Service State based on the allocated Operational Diagram and the next Service that Unit will operate.
It shall be possible to adjust the timings of switches between States as Operator Settings.

9.7.2.5 TTS-1016 - On-board State Selection - Train Crew

It shall be possible for Train Crew to override the automatic State-switching (TTS-1371) and switch the Unit between different States from any Inactive Cab or Crew Control Point.

Rationale: *It should be possible for Train Crew to manually select a different state at a different time to automatic switching (e.g. if cleaning is completed more quickly than expected).*

9.7.2.6 TTS-421 - Selection of Train State from the Wayside

It shall be possible to identify the State of a specific Unit and switch its State from the Wayside.

9.7.2.7 TTS-1370 - On-board State Selection - Maintenance / Servicing

It shall be possible for cleaners to switch a Unit into Servicing State using a single control on-board the Unit and without having to log in.
This control shall be inaccessible or inoperable when the Unit is in Passenger Service State.

Rationale: *Cleaners will only need access to the Unit, and will not need to control the Unit in any way except that lighting, Interior Doors etc. should be operational.*

9.7.2.8 TTS-2174 - Switch Out of Maintenance State

The Unit shall switch back from Servicing State to Standby State, by activating the control (TTS-1370) again, or after a defined time period, which shall be an Operator Setting.

9.7.2.9 TTS-840 - Management of Power Supply Interruption - Standby

If a Unit in Standby State loses 25kV power supply whilst stationary, the Unit shall, after a defined time period, automatically drop its pantograph, switch to Shut-down State and report this change to the Wayside.
The time period shall be an Operator Setting.

Rationale: *Dropping the pantograph saves on-board energy and gives a visual indication to depot staff that power has been lost.*

9.7.2.10 TTS-1602 - Maintain Communication in Shut-down

When in Shut-down State, the Unit shall maintain communication with the Wayside while auxiliary power is available.

Rationale: *This enables the Unit to be remotely switched back on.*

9.7.2.11 TTS-2477 - Full Shut-down

When in Shut-down State, the Unit shall switch to a Full Shut-down State at a defined low battery level.

Rationale: *A minimum level of battery capacity and voltage must be protected such that the Unit can raise its pantograph when 25kV is available.*

9.7.2.12 The exact list of driving modes and operational States will be developed by the TMM as part of the functional integration process described in MSA Schedule 11.

9.7.3 Activation times

9.7.3.1 TTS-428 - Start Up Time from Standby

The Unit shall start-up from standby in no more than 90 seconds. This shall be measured from the Unit being in Standby State to the Unit being in Passenger Service State and ready to depart on a service, excluding:

- time between request for and receipt of an ETCS MA; and
- time to pre-heat / pre-cool the interior.

This shall include a reasonable period for the Train Captain to enter any mandatory data, unless this is automatically set.

9.7.3.2 TTS-2735 - Start-up Time from Shut-down

The Unit shall start-up from shut-down in no more than 180 seconds. This shall be measured from the Unit being in Shut-down State to the Unit being in Passenger Service State and ready to depart on a Service, excluding:
- time between request for and receipt of an ETCS MA; and
- time to pre-heat / pre-cool the interior.

The time to charge air-supplies is not included in this time. This start-up time shall include a reasonable period for the Train Captain to enter any mandatory data, unless this is automatically set.

Rationale: *Although it is envisaged that Units will rarely be in the Shut-down State immediately prior to a Service, the Unit may be restarted to clear faults (even if this is not the correct course of action to resolve the fault), and the time taken to restart becomes critical to the length of the delay.*

Cross reference: *See also Requirement TTS-2309 (ETCS Power-up Time) in Section 8.3.2 (ETCS performance)*

9.7.3.3 TTS-1373 - Stand-by Time

The Unit shall change from Passenger Service State to Standby State in no more than 30 seconds. This shall be measured from the point that the Unit comes to a halt at the end of a Service to the point it is in a Standby State with no Train Captain logged in.

9.7.3.4 TTS-2040 - Train Captain Changeover Time

The Unit shall facilitate a changeover of Train Captains (TTS-1606) within a two-minute Dwell Time. In this time period there shall be time for the exiting Train Captain to:
- release and open Exterior Doors;
- log out of the Cab; and
- exit the Cab and Unit.

In this time period there shall be time for the entering Train Captain to:
- enter the Unit and Cab;
- log in to the Cab;
- adjust Cab setting to the Train Captain's personal preferences; and
- fulfil the Train Captain's role in closing doors, which does not include checking the PTI.

9.7.4 Train Captain settings

9.7.4.1 TTS-2044 - Train Captain Settings

The Train Captain shall be able to save their settings for all electronically adjustable systems in the Cab.
The Train Captain shall be able to restore a Cab to these saved settings.

Rationale: *Saved settings will prevent Train Captains having to remember their preferred settings and re-adjust the cab every time they enter a new cab.*

9.7.4.2 The following list of systems are envisaged as being part of the saved settings (depending on the design of these systems):

- cab seat position;

- 'driver's safety device' footpedal height;
- cab radio volume; and
- Cab HVAC settings.

9.7.4.3 TTS-2047 - Train Captain Settings - Wayside Synchronisation

When the Train Captain saves their settings, these shall be synchronised with a database of settings on the Wayside.

Rationale: *This functionality should work between different Units.*

9.7.4.4 TTS-2048 - Train Captain Settings - Automatic Adjustment

When the Train Captain logs in to a Cab, the Cab shall automatically adjust to their last-saved settings, as recorded in a database on the Wayside Data System.

Rationale: *This reduces the time taken for a Train Captain to get the cab to their liking.*

9.8 Interworking and coupling

9.8.1 Interworking and rescue

9.8.1.1 Interworking

9.8.1.1.1 TTS-249 - Interworking Function (PQTS-89) - Mandatory

The Unit shall enable coupling to, and interworking with, another Unit of the same type, regardless of its orientation.
All functions that are available on a single Unit shall be available on a coupled Train of two Units.

9.8.1.1.2 There are no requirements for compatibility with rolling stock that may be procured with later phases of the High Speed 2 Project, other than the rescue requirements in Section 9.8.1.2, below.

Rationale: *Achieving interworking between Phase 1 and Phase 2 rolling stock (which may be supplied by different manufacturers) is considered too complex given the complexity of train control required.*

9.8.1.1.3 TTS-1426 - Propelling Mode

A 400m Train shall be able to switch to a propelling mode. In this mode, one Unit lowers its pantograph while the Train is in motion.
The Unit with the raised pantograph shall supply all tractive effort for the Train.
The Unit with the lowered pantograph shall supply full auxiliary loads regenerated from its traction system.
Both Units shall provide full functionality and performance (except journey time performance) as if fully powered.

Rationale: *This is a mode that will potentially be used on the CRN if it is not possible to operate with two pantographs raised at high speeds - see requirements in section 7.5.2. It is assumed that full auxiliary power could be re-generated from the traction system when the Unit is moving at higher speed. When stationary or at low speeds, the second Unit would need to raise its pantograph. Note that the journey time and traction requirements to not apply to this mode.*

9.8.1.1.4 TTS-1590 - Propelling Mode Pantograph Control

When in propelling mode, the Unit not providing tractive effort shall automatically raise its pantograph at low speed and lower the pantograph as speed increases.

9.8.1.2 Rescue

9.8.1.2.1 The following definitions are made for this section:

- **Unit -** an HS2 conventional-compatible Unit as defined by this TTS;
- **unit** - any unit including a Unit (as above), or another unit or locomotive that a Unit could encounter;
- **rescuing unit -** the unit undertaking the rescue that is fully powered and operational;
- **failed unit -** the unit that requires rescue and has somehow failed; and
- **rescue Train -** the formation of one or more rescuing Units and one or more failed Units.

9.8.1.2.2 TTS-820, TTS-432 and TTS-1626 apply to rescue scenarios where one of the units may not be a 'Unit', as defined by this TTS. TTS-3415 and TTS-3419 only apply to scenarios where both units are 'Units'.

9.8.1.2.3 TTS-820 - Brake Control when Failed

It shall be possible to control a failed Unit's braking from a rescuing unit via the UIC brake system (brake pipe as braking control command line).

Rationale: *The LOC&PAS TSI[4] requires rescue by a Vehicle equipped with a UIC brake system. This could be complied with via a simple on/off brake control. Full control provided by the UIC brake system is required for rescue scenarios. Note that TTS-2612 requires 5 hours' auxiliary supply to support brake control on the failed Unit.*

Cross reference: *See also Requirement TTS-220 (Rescue Performance) in Section 7.2 (Traction)*

9.8.1.2.4 TTS-432 - Brake Control when Rescuing

A rescuing Unit shall be able to control a failed unit's braking via the UIC brake system (brake pipe as braking control command line), provided that the failed unit has a compatible brake system.

Rationale: *This is the equivalent requirement to TTS-820 for the rescuing Unit.*

9.8.1.2.5 TTS-3415 - Train Control when Failed

It shall be possible to control the traction of the rescuing Unit and the braking of the rescue Train from the Cab of the failed Unit, provided that auxiliary power is available on all Units and there are no faults preventing this.

Rationale: *It may only possible to rescue a failed Unit from the rear and not possible to reverse direction. Therefore, it will be necessary to control the rescue Train from the leading Cab of the failed*

Unit. It is assumed that the failure on the failed Unit does not inhibit this operation. Note that TTS-2612 requires 5 hours' auxiliary supply to support this operation.

9.8.1.2.6 TTS-1626 - Auxiliary Supply during Rescue

When the rescue Train is in motion, it shall be possible for the failed Unit to provide full auxiliary power to systems on the failed Unit, generated from the traction system on the failed Unit, provided the relevant systems are still operational.

Rationale: *This will support longer rescue periods and provision of more facilities to Passengers (e.g. HVAC).*

9.8.1.2.7 TTS-3419 - Auxiliary Supply via Jumper

It shall be possible to make a connection between two Units' Auxiliary Power Systems via a jumper such that the rescuing Unit can supply auxiliary power to the failed Unit. This jumper will be Special Operator Equipment.

Rationale: *This would allow limited transfer of power if a failed Unit lost all stored energy.*

9.8.1.3 Rescue couplers

9.8.1.3.1 TTS-375 - Rescue Coupler - Compatibility

The Fleet shall be supplied with rescue couplers and pneumatic hoses for rescue compatibility with:
- units with a Dellner 12 couplers at 1025mm above rail level;
- units with a Dellner 12 couplers at 925mm above rail level; and
- draw hook.

These rescue couplers will be Special Operator Equipment.

Rationale: *This should enable coupling to most rolling stock on the WCML and ECML. Dellner 12 (or compatible Voith type 136) couplers at 925mm are becoming a UK standard for multiple units. However, Class 390 and 22x units have a different height and compatibility with these units is also required. See RSSB research report T1003[109] for more detailed information.*

Cross reference: *See also Requirement TTS-1181 (Rescue Coupler Storage) in Section 10.11 (Equipment and storage)*

9.8.2 Coupling process

9.8.2.1 Coupling / uncoupling process

9.8.2.1.1 TTS-250 - No Impacts from Coupling / Uncoupling (PQTS-152)

When coupling or uncoupling, Passenger-facing functions of the stationary Unit, including Exterior Door control, shall be unaffected.

Rationale: *Some 400m Trains will need to split and join mid-journey. To minimise the impact on journey time, the Unit will need to be able undertake normal station operations during this time. It may be decided, operationally, to close doors during the coupling process, but the Unit design should not require this.*

9.8.2.1.2 TTS-1627 - Forces during Coupling

When coupling, the maximum jerk and acceleration experienced on either Unit shall be low enough for Passengers to be able to board and alight the stationary Unit during the process.

Rationale: *This requirement complements TTS-250. As well as being able to functionally couple with doors open, the motion of the two Units must support Passengers boarding and alighting during the couple. This may be achieved through energy absorbing couplers or other means.*

9.8.2.1.3 TTS-251 - Maximum Couple Time (PQTS-151)

The time to couple two Units shall not exceed 120 seconds. This is measured from the time when the second Unit contacts and mechanically couples with the stationary Unit until the combined Train is ready to depart. It includes:

- the time to make an electrical connection and re-configure systems into a single operational Train;
- the time for normal dwell activities (e.g. close Exterior Doors), which may overlap coupling and reconfiguration; and
- the time for the combined Train to request an ETCS MA.

Rationale: *Achievement of this time is necessary to support the planned train service.*

9.8.2.1.4 TTS-252 - Maximum Uncouple Time (PQTS-235)

The time to uncouple two Units shall not exceed 120 seconds. This is measured from when the two coupled Units come to a stop until one of the Units is ready to depart. It includes:

- the time to separate mechanical and electrical connections;
- the time to retract couplers and close coupler covers if this must happen while stationary (see TTS-1624);
- the time for both Units to reconfigure into single Units; and
- the time for normal dwell activities (e.g. close Exterior Doors), which may overlap coupling and reconfiguration.

Rationale: *The 120 second duration supports completion of uncoupling in a standard station Dwell Time.*

9.8.2.1.5 TTS-1624 - Single Stop Uncoupling (PQTS-235)

When two Units arrive at a station, uncouple and depart, both Units shall come to a stop only once in the process. The Units shall either:

- be able to retract couplers and close coupler covers while stationary; or
- be able to close coupler covers while in motion without affecting the acceleration of the Train.

Rationale: *A second stop at the station would lengthen the uncoupling process and confuse passengers.*

9.8.2.1.6 TTS-1735 - Uncoupling from Lead Cab

It shall be possible to uncouple two Units from a Cab remote from the coupling.

Rationale: *When a Train splits in a station, the Train Captain in the leading Unit should be able to uncouple the trailing Unit without leaving the Cab at the front of the formation. It should not be* *necessary to activate either of the Cabs adjacent to the coupler between the two Units in order to uncouple. This would require extra staff, and creates a risk of delay.*

9.8.2.1.7 TTS-2090 - Uncoupling from Centre Cab

It shall be possible to uncouple two Units from only one of the Cabs adjacent to the coupler.

Rationale: *If a 400m Train is split into two Units in a depot or at a terminal station, the Train Captain or other Authorised Person may be closer to the centre of the Train.*

9.8.2.1.8 TTS-434 - Manual Coupling

The Unit shall include controls in the Cab and/or functionality for the Train Captain to couple and uncouple two Units, including: • controls to enable a slow-speed approach; • controls to open and close coupler covers at either end of the Train Captain's Unit and deploy / retract the coupler (if required); • equipment to enable a check that the coupler covers on both units are open and couplers deployed (if required); • engagement of the electrical heads at the Train Captain's discretion; and • controls to enable a pull-away test, if required.

Cross reference: *See also Requirement TTS-596 (FFRF Auto-coupler View) in Section 9.26.2 (FFRF CCTV)*
See also Requirement TTS-3441 (FFRF Short Range View) in Section 9.26.2 (FFRF CCTV)

9.8.2.1.9 TTS-1614 - No Electrical Connection

When coupled, it shall be possible to disengage the electrical connection between Units while remaining mechanically coupled.

Rationale: *This will enable the two Units to switch from an interworking functionality to a rescue / recovery formation if one Unit has a failure.*

9.8.2.2 Automation for coupling

9.8.2.2.1 TTS-3429 - Minimisation of Coupling Steps

The number of inputs, checks and acknowledgements by the Train Captain during the coupling process shall be minimised.

Rationale: *The more complex the coupling process, the greater variation in coupling time will occur, and the greater chance the Train Captain will make a mistake.*

9.8.2.2.2 TTS-3430 - Coupling Speed Limit

During coupling, the Train Captain shall be able to select a speed limit set at a value suitable for coupling.

Rationale: *This will ensure the Unit is travelling at the correct speed for coupling. When combined with TTS-3429, the goal is a single 'couple' pushbutton controlling approach speed and coupling.*

Cross reference: *See also Requirement TTS-2177 (Speed Control) in Section 8.7 (Manual driving (GoA1))*
See also Requirement TTS-3428 (Speed Limiter) in Section 8.7 (Manual driving (GoA1))

9.8.2.2.3 TTS-1620 - Automatic Coupling - Open Cover

Prior to coupling, both the stationary and moving Unit shall automatically open their coupler covers and deploy their couplers (if necessary) at the locations where the Units will couple.

Rationale: *Automatic coupling should not rely on the Train Captains to remember to prepare their Units for coupling. The Unit can use the Operational Diagram allocation to identify that it is planned to couple at a forthcoming station. The stationary Unit can use its Operational Diagram allocation to open covers close to the time that coupling should occur.*

9.8.2.2.4 TTS-2092 - Control Coupler Covers

The Unit shall prevent the Train Captain from attempting to couple to another Unit with the coupler cover of either Unit closed.

Rationale: *The Train Captain may not have visibility of the coupler cover. It is recognised that it may not be possible to prevent incorrect operation regarding the coupler cover in all scenarios, but the Unit should automatically manage the covers in normal operation.*

9.8.2.2.5 TTS-3439 - Coupler Cover Speed Interlock

The Unit shall be able to prevent the Train Captain driving the Train at more than 50km/h with the coupler cover open.
It shall be possible to isolate this function.

Rationale: *Driving the Train with the coupler cover open will expose the coupler to damage and affect noise and energy consumption. However, the scenario where a coupler cover fails must be manageable.*

9.8.2.2.6 TTS-1625 - Reconfigure Train Automatically

Following coupling, the two Units shall automatically reconfigure themselves into a single Train using data from the Operational Diagram allocation. This shall commence when the two Units have confirmed successful coupling.

Rationale: *This will save time of the Train Captain in the stationary Unit waiting for confirmation of coupling and then re-configuring the Units.*

9.8.2.2.7 TTS-436 - Enable Uncoupling - Automatic

When a 400m Train arrives at station where it is due to uncouple, it shall automatically uncouple and reconfigure the two Units into two Trains, based on the Operational Diagram allocation.

Rationale: *This will save time of waiting for the second Train Captain entering the second Unit, uncoupling and then reconfiguring their Unit.*

9.8.2.2.8 TTS-1622 - Automatic Uncoupling - Close Covers

Following separation after automatic uncoupling, the two Units shall close their coupler covers and retract couplers (if necessary) automatically and as soon as possible.

Rationale: *It is assumed that coupler covers can only close after the Units have moved apart. Alternatively the couplers could retract so that covers could close while the Units are stationary.*

9.9 Traction control

See also LOC&PAS TSI[4] §4.2.8.2 and GM/RT2111[84]

9.9.1 TTS-939 - Acceleration Limit

It shall be possible to implement acceleration limits on the CRN based on the Location (Line & Distance) of the Unit.

Rationale: ***CRN interface -** Certain parts of the CRN have an assumed maximum acceleration or 'attainable speed' in the design of their CCS systems. New rolling stock may exceed this assumed acceleration and therefore not be compatible with existing equipment without operational controls. Such controls should be implemented automatically.*

9.9.2 TTS-1351 - Tractive Effort Limit

It shall be possible to limit the maximum tractive effort by Location (Line & Distance), time of year and alternatively a command from the Wayside.

Rationale: *This is to prevent damage to the track where wheelspin frequently occurs. Limits could be applied during seasons or could be activated from the NICC at times of known low adhesion.*

9.9.3 TTS-959 - Traction-Braking Controller Orientation

With reference to LOC&PAS TSI[4] Clauses 4.2.9.1.6 (4) and 7.3.2.19, the orientation of traction/braking controls shall follow UK conventions: • the 'tractive effort' shall increase by drawing the lever towards the Train Captain; and • the 'braking effort' shall increase by pushing the lever away from the Train Captain.

Rationale: *Clarification of options in LOC&PAS TSI.*

Cross reference: *See also Requirement TTS-2139 (Cab Desk and Control Layout) in Section 10.9.1 (Cab design)*

9.9.4 TTS-1444 - Traction Control Gradation for Manual Driving

In manual driving, the Unit shall have continuously variable traction control with a clear detent for no traction / coasting.

Rationale: *Continuously variable control is considered to the best method of control, based on feedback from fleets where this has been implemented. It is recognised a variable control position may be encoded into discrete traction demands, while still giving the impression of continuous variability. The no traction / coast detent will be used when ATO is Engaged.*

Cross reference: *See also Requirement TTS-2139 (Cab Desk and Control Layout) in Section 10.9.1 (Cab design)*

9.10 Brake control

See also LOC&PAS TSI[4] §4.2.4 and GM/RT2045[82]

9.10.1 TTS-259 - Holding Brake (PQTS-416)

The Unit shall have a holding brake function that automatically prevents any roll-back when the Unit comes to a halt or starts moving when the Unit is on a 35 ‰ gradient.

Rationale: ***HS2 and CRN interface -*** *This supports the adoption of a 4.2m overhang on the CRN, and ensures a Unit cannot roll-back after coming to a stop. It is considered important functionality even with a shorter nose as it is necessary to hold the train when ATO disengages when coming to a stop.*

9.10.2 TTS-937 - Regen Isolation

With reference to LOC&PAS TSI[4] Clause 4.2.8.2.3 (2), it shall be possible for a Maintenance Technician to isolate the regenerative brake. It shall not be possible for a Train Captain to isolate the regenerative brake.

Rationale: *This function is considered to satisfy Clause 4.2.8.2.3 (2) of the LOC&PAS TSI. This function should not be provided to the Train Captain to avoid regenerative braking being incorrectly isolated on-board.*

9.10.3 TTS-938 - Braking Status Display

The status of the braking system shall be displayed to the Train Captain, considering: • the rate of braking applied by the Train Captain using the controls; • the brake force or deceleration currently being achieved; • split between different braking systems; • isolation of any parts of the braking system, including sanding; and • energy available to braking systems.

Rationale: *The Purchaser does not have a firm view of the braking information to be provided to the Train Captain. However, air pressure gauges and warnings of isolation are unlikely to be sufficient. In particular feedback to the Train Captain of the applied* or *achieved brake rate is likely to be required. This status display will need to be developed via the functional integration process defined in Schedule 11.*

9.10.4 TTS-953 - Brake Control Gradation for Manual Driving

In manual driving, the Unit shall have continuously variable brake application with clear detents for emergency brake and coast / no braking.

Rationale: *The seven-step brake application is as specified by the LOC&PAS TSI[4]. A continuously variable brake application has been considered compliant with the LOC&PAS TSI on other projects. The emergency brake position should be distinguishable from service braking. The no-braking 'coast' will be used in when ATO is Engaged.*

Cross reference: *See also Requirement TTS-2139 (Cab Desk and Control Layout) in Section 10.9.1 (Cab design)*

9.10.5 TTS-2176 - Emergency Brake Control

With reference to LOC&PAS TSI[4] Clause 4.2.4.4.1 (2), at least one of the independent emergency brake command devices shall be available in an inactive cab (i.e. it can be used in a rear or middle cab of a Train).

Rationale: *UK convention is that the emergency stop plunger / pushbutton in all cabs can be used at all times.*

9.10.6 TTS-926 - Brake Release for Recovery

It shall be possible to release holding and parking brake applications in any vehicle condition with the Unit at a HS2 Platform or CRN platform.

Rationale: *It must be possible to recover a stalled Unit, considering all possible conditions for that unit, including loss of air supply. With reference to releasing the brakes, a Unit located at a platform is considered the worst location due to the restricted access to the underframe, which may require internal isolation cocks.*

9.10.7 TTS-927 - Parking Brake Automatic Application

With reference to LOC&PAS TSI[4] Section 4.2.4.4, the parking brake shall automatically be applied following a loss of main braking energy (e.g. main reservoir pressure) such that the Unit does not move during the transition.

Rationale: *HS2 requires an automatic parking brake function as envisaged, but not mandated in LOC&PAS TSI Section 4.2.4.4.5.*

Cross reference: *See also Requirement TTS-927 (Parking Brake Automatic Application) in Section 9.10 (Brake control)*

9.10.8 TTS-2039 - Report WSP

Activation of the wheel slide protection system shall be immediately reported to the Wayside, with details of:
- the Train Location (Line & Distance);
- the direction of travel;
- whether the ATO On-board is Engaged (EG) or not; and
- the level of traction or braking demand when spin or slide was detected.

Rationale: *This will support collation of data about sites with low adhesion so that preventative measures can be taken - e.g. more defensive driving.*

9.10.9 TTS-3144 - Report WSP in Automatic Mode

When ATO On-board is in Engaged (EG) state, activation of the wheel slide protection system, together with the currently-applied ATO brake and acceleration rates, shall be sent by the ATO On-board to the ATO Trackside within 5 seconds.

Rationale: *This requirement expands on ATO over ETCS SRS[19] Clause 7.6.1.2 by additionally requiring brake and acceleration rates. Such information is commonly used in other ATO systems to inform the required response.*

9.11 Jerk rate

9.11.1 TTS-409 - Jerk Rate and Adjustment

The Unit shall control the longitudinal jerk rate to not exceed $0.5 m/s^3$ with the following exceptions:
- loss or substantial instantaneous reduction of traction power supply for any unplanned reason (i.e. excluding neutral sections);
- during the loss of regenerative braking for any irregular reason; and
- during the application of the emergency brake.

Rationale: *Maintaining an acceptable jerk rate is important to Passenger comfort.*

9.11.2 TTS-410 - Jerk Rate Adjustment

It shall be possible to adjust the jerk rate limit between 0.25m/s³ and 0.75m/s³ via a Software Update.

Rationale: *This requirement is to allow the flexibility to change jerk rate at a later date, if required. Compliance with journey time, acceleration and energy consumption requirements is only required with a 0.5m/s³ jerk rate.*

9.12 Sanding and adhesion control

See also GM/RT2461[93]

9.12.1 TTS-824 - Sanding Equipment - Mandatory

The Unit shall have sanding equipment for use in traction and braking during low adhesion conditions.

Rationale: ***CRN interface -*** *The TSIs and NNTRs cover the performance and functionality of sanding equipment, but not the need for sanding. A sanding system is necessary for compatibility with the CRN and may be required for operation on the HS2 Network.*

9.12.2 TTS-946 - Automatic Sanding Activation

When On-board ATO is Engaged (EG), sanding shall be automatic in both traction and braking.

9.12.3 TTS-947 - Automatic Sanding Activation (Braking)

When the Train is being manually driven, sanding shall be automatic in braking.

9.12.4 TTS-948 - Manual Traction Sanding Activation

When the Train is being manually driven, sanding in traction shall be manually activated by the Train Captain. The Train Captain shall receive an indication that wheel spin has occurred and shall then be able to select whether to actuate sanding.

9.12.5 TTS-940 - Automatic Sanding Variation and Inhibition

It shall be possible, in braking and traction, to inhibit or vary the rate of sanding based on the Unit's Location (Line & Distance). Variable sanding shall have at least two rates available.

Rationale: *Inhibition of sanding will prevent sand being deposited in tunnels or over switches and crossings. Variability of sanding rates will allow usage of sand to be optimised. It will also permit different sanding rates for the CRN and HS2 Network. Whereas the CRN has often suffered from low adhesion, the HS2 Infrastructure Manager intends to manage the HS2 Network to minimise low adhesion, and would like to minimise contamination of the railway with sand as far as possible.*

9.12.6 TTS-2178 - Sand Usage Monitoring

The Unit shall monitor the estimated usage of sand and alert the Wayside when sand is likely to need to be topped up.

Rationale: *Incidents have occurred in the UK where trains have operated without sufficient sand. This requirement mitigates the risk of this happening, by triggering an Event for the need for more sand.*

Cross reference: *See also Requirement TTS-1543 (Monitoring of Consumables / Tanks) in Section 9.29.2 (Consumable / waste monitoring)*

9.12.7 TTS-1700 - Sand Level Monitoring

The Unit shall monitor the level of sand on the Unit and alert the Train Captain and the Wayside when sand is below a defined level.

Rationale: *This requirement, together with TTS-1701 provides a 'last resort' in case sand is not topped up in response to TTS-2178.*

9.12.8 TTS-1701 - Limit Sanding in Low Sand Level

The Unit shall restrict sanding to either braking only or emergency braking only, configurable as a Software Update, when the sand level is below the defined level specified in TTS-1700.

9.13 Power supply control

See also LOC&PAS TSI[4] §4.2.8.2 and GM/RT2111[84]

9.13.1 TTS-1489 - Power Supply Transition Trigger

With reference to LOC&PAS TSI[4] Section 4.2.8.2.9.8, the Unit shall automatically transition through neutral sections and the HS2-CRN transition:
- on the HS2 Network, on which ETCS will be installed; and
- on the CRN, where ETCS is not currently installed, but Eurobalises are installed for this purpose.

Rationale: *On the HS2 Network, power supply commands will be received via ETCS as envisaged in the TSIs. On the CRN, HS2 Ltd intends to install Eurobalises to provide instructions for neutral sections and for the CRN-HS2 transition. The Unit will need to receive messages from the Eurobalises when operating in Level NTC.*

9.13.2 TTS-393 - Neutral Section Transition

With reference to LOC&PAS TSI[4] Clauses 4.2.8.2.9.8 (4) and (5), the Unit shall automatically remove and restore traction demand such that jerk limits are met.

Rationale: *This expands the TSI by requiring traction to be removed in a controlled way.*

Cross reference: *See also Requirement TTS-409 (Jerk Rate and Adjustment) in Section 9.11 (Jerk rate)*

9.13.3 TTS-1500 - APC Magnet

The Unit shall be capable of being fitted with equipment to enable compatibility with automatic power control magnets for neutral section transitions on the CRN, in compliance with GM/RT2111[84] Section 4.11.

Rationale: ***CRN interface -*** *This is a fall-back option for compatibility with the CRN. HS2 Ltd is seeking to implement Eurobalises for power supply transitions on the CRN, but it may not be possible to achieve this.*

9.13.4 Non-fitment of an automatic power control receiver would require a deviation to GM/RT2111 Section 4.11. This would be supported by the Purchaser.

9.13.5 TTS-256 - HS2-CRN Power Supply Transition (PQTS-194)

The Unit shall transition between the HS2 Network power supply and the CRN power supply, and vice versa, without any interaction from the Train Captain and without the Train needing to stop. This shall include:

- automatically removing and restoring traction demand such that jerk limits are met;
- automatically lowering and raising the HS2 Pantograph and CRN Pantograph (if required); and
- adjusting power supply compatibility limits.

Rationale: *Trains should be able to move between the CRN and HS2 networks seamlessly and reliably to ensure trains run on time. It is expected that two different types of pantograph would be required, but if a single pantograph can be provided it can retain contact with the OCS/OLE.*

Cross reference: *See also Requirement TTS-409 (Jerk Rate and Adjustment) in Section 9.11 (Jerk rate)*

9.13.6 TTS-257 - Variable Current Limit (PQTS-229)

The maximum line current drawn by the Unit shall be capable of being automatically varied due to:

- the Location (Network) and Location (Line & Distance) of the Unit;
- messages received from Eurobalises compliant with RIS-0784-CCS[80];
- whether the Unit is operating as a 200m Train or 400m Train; and
- whether the other Unit in a 400m Train has its pantograph raised.

These current limits for different locations / conditions shall be adjustable as a Software Update.

Rationale: ***HS2 and CRN interface -** As a minimum, the Units will operate with separate current limits for the HS2 Network and the CRN. Studies are being undertaken to further optimise allowable train current limits on both the HS2 Network and CRN. This could include varying current limit at different locations on the networks.*
It is currently anticipated that a 300A limit will apply to all operation on the CRN at the introduction of the Units, but could later be increased. At the moment, the 300A limit applies to the whole train, so a two-Unit train would be at 150A / Unit.

Cross reference: *See also Requirement TTS-1426 (Propelling Mode) in Section 9.8.1.1 (Interworking)*

9.13.7 TTS-1490 - Dynamic Current Limit (PQTS-229)

The maximum line current drawn by a Unit shall be capable of being adjusted temporarily from the Wayside, for all or part of the Fleet. On the HS2 Network the current limit will be set using ETCS track condition data sent via balise or data radio.

Rationale: *In considering how to optimise the allowable train current and managed service perturbations, altering current limits in particular scenarios is being considered, for either the whole fleet or certain units.*

9.13.8 TTS-1003 - Dynamic Regenerative Current Limit

The maximum current returned from the Unit during regenerative braking shall be capable of being adjusted, independently from current drawn in traction:
- due to the Location (Line & Distance) of the Unit (as per TTS-257);
- due to messages received from Eurobalises (as per TTS-257); and
- as a temporary limit (as per TTS-1490).

This adjustment shall have no impact on the achieved brake rate.

9.13.9 TTS-3405 - Maximum Regen Voltage

With reference to GM/RT2111[84] Clause 3.6.1.c, while the Train is operating on the CRN, regeneration shall not be initiated or continue when the OLE voltage at the pantograph is above a predetermined value within the range of 27kV to 29 kV.
This setting shall be selectable in a maximum of 500V steps.
The setting shall be capable of being varied automatically based on the Location (Line & Distance) of the Train.

Rationale: ***CRN interface -*** *Network Rail have advised that a maximum limit of 27kV must be adhered to where Class 92 locomotives operate - currently the WCML. This is 500V below the limit set in GM/RT2111.*

9.13.10 TTS-814 - MCB Re-close Strategy

Following an unplanned power supply outage individual Units shall automatically close main circuit breakers at different times such that two Units in the Fleet will not re-close their main circuit breakers within 20ms of each other within a single electrical section.

Rationale: ***CRN interface -*** *This function is to manage the loading on the power supply.*

9.13.11 TTS-2478 - Shore Supply Interlock

It shall not be possible for a Unit to be moved while it is connected to any shore supply.

9.14 Energy metering

See also LOC&PAS TSI[4] §4.2.8.2.8 and GM/RT2132[87]

9.14.1 TTS-828 - Energy Metering System - Mandatory

The Unit shall include an Energy Metering System.

Rationale: *These requirements for an energy metering system are specified to deliver energy data to the Train Operator. Requirements are set about how the data is recorded to enable potential future analysis of this data.*

9.14.2 TTS-829 - Energy Metering - Traction / Regen / Auxiliary

The Energy Metering System shall measure energy separately for:
- traction;
- regenerated energy; and
- non-traction auxiliary loads.

9.14.3 TTS-3188 - Energy Metering - Depot

The Energy Metering System shall measure energy separately for when the Unit is in Washwood Heath depot or any other depot.

Rationale: *This enables energy usage during stabling and maintenance to be separately calculated, which leads to incentivisation to minimise energy consumption when stabled.*

9.14.4 TTS-2034 - Energy Metering Data Processing

The Energy Metering System shall enable energy to be measured in configurable blocks of time or distance. For each block, the following shall be recorded:
- energy consumed (as per TTS-829);
- start time and start Location (Line & Distance);
- end time and end Location (Line & Distance); and
- other on-board data that could affect energy consumption (e.g. payload).

It shall be possible to adjust, as an Operator Setting, whether blocks are time-based or location-based, and what the start and finish points are in each case.

Rationale: *This functionality is to provide data at a level of granularity to allow energy to be summed for each network, in and out of passenger service, or for other comparative analysis. The configurable blocks would be set to initial values (e.g. HS2 Network and CRN), but could later be adjusted if more detailed information is required. Alternatively energy could be recorded in different time periods to align with different energy prices.*

9.15 Pantograph control

9.15.1 TTS-406 - Actions on ADD

Activation of the pantograph Automatic Dropping Device (ADD) shall:
- be reported to the Train Captain;
- provide Pantograph CCTV images from a defined period of time before the ADD activated;
- provide Pantograph CCTV images of the affected pantograph in the stowed position to the Train Captain; and
- be reported to Wayside with location and speed data.

Rationale: *Images from before the ADD may allow the Train Captain to see the cause of the ADD activation. Images of the stowed pantograph are necessary to inspect the pantograph following an ADD activation, to determine if the pantograph should be re-raised.*

9.15.2 TTS-1048 - Reset & Isolate ADD

It shall be possible to isolate the ADD from within the Unit.
Isolation of the ADD shall be recorded, indicated to the Train Captain and communicated to the Wayside.

Rationale: *It should not be necessary to leave the vehicle or access the roof to isolate the ADD.*

9.15.3 TTS-1639 - Lower Pantograph to Reduce Noise

It shall be possible to automatically lower and raise the Train's pantograph(s) at defined Locations (Line & Distance) at any speed up to 360km/h.
It shall be possible to change the locations for lowering and raising the pantographs as a Software Update.

Rationale: *This is required as a potential mitigation of excessive noise in particular locations, in addition to the acoustic requirements in section 7.18. If the overall noise of the railway cannot be mitigated by other means, pantographs may be lowered. Journey times would be adjusted accordingly. Auxiliary power may be regenerated by the traction system or supplied by on-board batteries.*

9.15.4 TTS-3189 - Switch Pantographs during Wash

The Unit shall automatically switch pantographs when it is traversing a train-wash.

Rationale: *The train wash at the Washwood Heath depot should wash as high up the bodyside as possible, and the pantograph will need to be lowered as the Unit passes through the wash.*

9.15.5 The method of train control through the train-wash at Washwood Heath depot is not yet finalised. Trains could be under ATO or manual control.

Cross reference: *See also Requirement TTS-2177 (Speed Control) in Section 8.7 (Manual driving (GoA1))*

9.16 Running Gear monitoring

9.16.1 TTS-2622 - Running Gear Hunting Detection

The Running Gear shall be monitored for vibrations indicative of hunting.
If hunting is detected, the Train shall make an automatic service brake application until hunting has stopped.
The Train Captain and the Wayside shall be informed that hunting has been detected.

Rationale: *Hunting has been witnessed on other rolling stock designed to operate on two different networks.*

9.16.2 TTS-2623 - Running Gear Derailment Detection

The Running Gear shall be monitored for indications that it has derailed.
If derailment is detected, the Train shall automatically make an emergency brake application to stop the Train.
The Train Captain and the Wayside shall immediately be informed that derailment has been detected.

Rationale: *This function helps to mitigate hazards associated with derailments. There have been incidents where derailment has not been reacted to quickly enough.*

9.16.3 TTS-3184 - Deflated Suspension Monitoring

If there are any operational limitations on the Train when the secondary suspension is deflated:
- the Train Captain shall be informed of the deflation; and
- any necessary speed restriction shall be automatically implemented with removal of traction and a service brake application if the Train is travelling above the speed restriction.

Rationale: *Deflated suspension is a rare occurrence and hence design for full performance in this condition may lead to over-design of systems. Limitations in deflated condition are permissible, but need to be managed as part of operation of the Train.*

9.17 Payload management

9.17.1 TTS-1582 - Payload Information

The Train Captain, Train Crew and the Wayside shall be able to view
- the measured payload of each Vehicle in the Train;
- whether a Vehicle is exceeding the Exceptional Payload (HDL); and
- a time history of the Payload information.

Rationale: *This information allows operational staff to understand the loading of the Unit, and take decisions about operation of the Unit.*

9.18 Exterior Doors

See also LOC&PAS TSI[4] §4.2.5.5 and GM/RT2473[95]. Note that GM/RT2473 is notified but superseded by RIS-2747-RST[98]

9.18.0.1 The requirements of this section apply to all Exterior Doors - i.e. all doors between the inside of the Unit and the exterior except for dedicated Cab Doors (if provided). Doors may be configured as crew-only doors (see TTS-2928), but all Exterior Doors must be capable of meeting the requirements of this section.

9.18.1 Standards

9.18.1.1 TTS-1276 - Compliance with EN 14752

All Exterior Doors and Moveable Steps shall be compliant with the requirements of EN 14752[40] except where clarified or superseded by the requirements of this specification.

Rationale: *HS2 considers this standard to provide good practice requirements. Where necessary, clarifications are made through TTS requirements.*

9.18.2 Train-wide door control

9.18.2.1 For each station on the CRN and HS2 Network there will be a 'door control strategy', i.e. an approach to releasing, opening and closing the doors at the station and who is responsible for each step. This section lists requirements to enable each of these strategies.

9.18.2.2 TTS-1232 - Configuration of Door Control Strategies

It shall be possible, as an Operator Setting, to configure a door control strategy for each station based on the time of day, including:
- how a door release command will be given to the Train and by whom;
- how Exterior Doors will be opened and by whom;
- whether auto-close time (TTS-307) differs from its default value or is inhibited;
- how the PTI will be checked and by whom; and
- how a Train-wide door close command is given and by whom.

Rationale: *The door control mode may need to be changed based on the station and the time of day to reflect the expected passenger flows and other considerations such as noise experienced by neighbours or control of heat exchange with external air.*

9.18.2.3 TTS-1281 - Display of Door Control Strategy to Train Captain

The door control strategy for the next / current station (TTS-1232) shall be displayed to the Train Captain and at the Crew Control Point on approach to the station and during the station stop.

Rationale: *The Train Captain should be made aware of the planned door control strategy to reduce the chances of errors on arrival at a station. This should allow the Train Captain to understand who has responsibility for releasing, opening and closing doors at the next station.*

9.18.2.4 The door control strategy may be made up of a combination of the following requirements.

9.18.2.5 TTS-315 - Train Captain Door Control

The Exterior Doors and Moveable Steps shall allow control by the Train Captain including the following operations:
- Train Captain commanded release and open of all available doors and steps on one side of the Train;
- Train Captain commanded release of all available doors and steps on one side of the Train, to allow Passengers to open individual doors using the local door controls; and
- Train Captain commanded close of all doors (when it has been confirmed to the Train Captain that it is safe to close doors).

Rationale: *These door control modes are required to support the HS2 Operational Concept. Note there is no requirement for the Train Captain to be able to assess the PTI from Cab e.g. via on-board cameras.*

9.18.2.6 TTS-318 - Automatic Door Control

The Exterior Doors and Moveable Steps shall allow control by the ATO On-board; including the following automatic operations:
- automatic release and open of all available doors and steps on one side of the Train, when the Train stops at a station; and
- automatic release of all available doors and steps on one side of the Train when the Train stops at a station, to allow Passengers to open individual doors using the local door controls.

The Train Captain shall be able override automatic operations.

Rationale: *These door control modes are required to support the HS2 Operational Concept. Note that when the Unit is being driven by ATO On-board, these are not the only door control strategies. Train Captain or Train Crew control of doors may be used with ATO On-board just controlling driving.*

9.18.2.7 TTS-2828 - Automatic Door Release and Accuracy

During automatic door operation (TTS-318) door release shall only be requested when the Train has confirmed it has stopped within the required stopping accuracy (TTS-100).

Cross reference: *See also Requirement TTS-100 (ATO Stopping Accuracy) in Section 8.6.4 (ATO stopping accuracy)*

9.18.2.8 TTS-316 - Train Crew Door Control

The Exterior Doors and Moveable Steps shall allow control by the Train Crew from a door control point or an Inactive Cab, including the following operations:
- Train Crew commanded release and open of all available doors and steps on one side of the Train;
- Train Crew commanded release of all available doors and steps on one side of the Train, to allow Passengers to open individual doors using the local door controls;
- Train Crew commanded close of all doors and steps on the Train; and
- Train Crew commanded close of the doors and steps of the Unit where the Train Crew is located.

Rationale: *These door control modes are required to support the HS2 Operational Concept. For 400m Trains, if Train Crew are responsible for checking the PTI and closing doors it is considered that two Train Crew may be required, each taking responsibility for a Unit. This could vary between stations depending on the characteristics of the platform.*

9.18.2.9 TTS-302 - Pre-arm Doors

When the door control strategy for the next station (TTS-1232) indicates that Exterior Doors are to be opened by Passengers using local door controls, pressing a local door open button up to 60 seconds before a door release command is received shall cause the Exterior Door to open as soon as they are released (and the Moveable Step is deployed). If the button is being held at the point when the door release command is received the Exterior Door shall still open without the button needing to be released and pressed again.

Rationale: *This is intended to both reduce confusion for Passengers and also to ensure doors are opened as quickly as possible when under Passenger control. On arrival at stations, the time taken for deployment of the Moveable Step may create confusion and frustration for Passengers trying to open the doors.*

9.18.2.10 TTS-312 - Evacuation Door Control

The Unit shall enable both the Train Captain and the Train Crew to release any subset of Exterior Doors in the Train while all other Exterior Doors remain closed and locked and temporarily unresponsive to Emergency Egress Devices.
It shall be possible to implement this function from both a Cab and the Crew Control Point.

Rationale: *This is to support the tunnel evacuation strategy. Ideally, the ATO On-board will stop Trains with the designated Evacuation Door adjacent to a cross-passage. Passengers need to be managed to only evacuate through the specified door. In some scenarios, it may be necessary to evacuate through another Exterior Door instead of the designated Evacuation Doors. It is recognised* *that this function could be deemed non-compliant to the LOC&PAS TSI[4] Clause 4.2.5.5.9 (1), but this functionality is required, subject to agreement of the evacuation process. A safety analysis will be required to show that the Exteriors Doors cannot fail in a locked-out condition.*

Cross reference: *See also Requirement TTS-165 (Evacuation Door Position) in Section 7.15.7 (Evacuation)*
See also Requirement TTS-2035 (Temporary Isolation of Emergency Open Device) in Section 9.18.8 (Emergency Egress Device)

9.18.2.11 TTS-314 - Terminal Station Mode

The Train shall have a terminal station door control mode that leaves Exterior Doors released but closed, and prevents Exterior Doors from being operated by local external controls.
In this mode:
- the Moveable Step shall remain deployed;
- internal controls for Exterior Doors shall remain active; and
- Exterior Doors shall be closed by auto-close functionality or local door controls.

Rationale: *This function is intended to support railway operations at terminal stations where Trains may be prepared to turn around or prepared for an empty stock move.*

9.18.2.12 TTS-1294 - Authorised Access in Terminal Station Mode

A means shall be provided, at each Exterior Doorway, to allow Authorised Persons to access the Unit when the Unit is in terminal station mode (TTS-314).

Rationale: *This function is required to allow staff to access catering facilities whilst Units are at stations in order to carry out tasks such as re-stocking. It should be possible to ensure the Units is still secured from unauthorised access.*

9.18.2.13 TTS-2835 - Door Release in Standby

It shall be possible for the Unit to retain an active door release command while the Unit is in Standby State.
In this mode, external door controls shall not be active as per the terminal station mode (TTS-314).

Rationale: *When Units are between services or stabled, it will be necessary to provide access for servicing and maintenance. For access, the Moveable Steps will need to be deployed; it is expected that this means the doors must be released.*

9.18.2.14 TTS-317 - Selective Re-open Control

Following a Train-wide door close command it shall be possible to fully re-open and re-close only those doors not proved closed.

Rationale: *This functionality is required to allow issues at stations to be resolved as quickly as possible to facilitate HS2's Dwell Time aspirations.*

9.18.2.15 TTS-1437 - Selective Door Inhibit

The Unit shall include functionality to allow individual doors to be inhibited from opening at specific stations based on commands from the Train Captain or from the Wayside.

Rationale: *This functionality is intended to allow for resolution of incidents in service where station operations require certain doors not to open. This is in addition to the selective door operation functionality.*

9.18.2.16 TTS-1438 - Selective Door Inhibit PIS Interface

The PIS shall be capable of automatically providing audio or visual information to Passengers related to the operation of the selective door inhibit functionality (TTS-1437). The messages shall be broadcast in the affected Vestibule and any adjacent Saloons.

Rationale: *Passengers should be made aware of situations where doors will not be opened at the next station.*

9.18.2.17 TTS-3247 - Emergency Ventilation

The Unit shall permit Exterior Doors to be opened in an emergency to provide ventilation. For this operation:

- the operation can be initiated and cancelled from a Cab or Crew Control Point;
- when initiated, all Exterior Doors on one side or both sides, selectable by Train Crew, shall release and open a small amount;
- when initiated, all Interior Doors between the Saloon and Vestibule shall fully open and remain open; and
- when cancelled, all doors shall close and return to their original state.

Rationale: *The purpose of this function is to provide a means of ventilation when there is no more on-board power to supply HVAC modules. This would also be used with the higher ventilation rate specified in TTS-3269 if this increases airflow.*

9.18.3 Automatic Selective Door Operation (ASDO)

9.18.3.1 TTS-313 - Automatic Selective Door Operation (ASDO) - Mandatory

The Unit shall be provided with an ASDO system / function that:

- is operable on both the HS2 Network and the CRN; and
- only permits Exterior Doors and Moveable Steps adjacent to a platform to be released and opened.

Rationale: *ASDO is required to allow Trains to stop at stations with different platform lengths.*

9.18.3.2 The ASDO only needs to work with Eurobalises (as required by TTS-3028) for both the HS2 Network and CRN. Alternative methods of defining the Train's location (e.g. GNSS, other proprietary beacon systems) are not required.

9.18.3.3 TTS-3028 - ASDO Eurobalise Message

The ASDO system shall be capable of controlling Exterior Door and Moveable Step release in accordance with:

- CCS TSI[5] when operating under ETCS; and
- messages received from Eurobalises compliant with RIS-0784-CCS[80].

9.18.3.4 TTS-1609 - Correct Side Door Enable (CSDE) Functionality

The ASDO shall include Correct Side Door Enable (CSDE) functionality on both the HS2 Network (via ETCS) and CRN (via Eurobalise).
CSDE functionality shall only permit Exterior Doors and Moveable Steps to be released on the side of the Train adjacent to a platform.

Rationale: *This system is intended to improve safety by ensuring only the doors on the correct side of the train can be released.*

9.18.3.5 TTS-1610 - Correct Stopping Position

When the Train has been manually stopped at a station (i.e. the ATO On-board has not controlled the stopping), the ASDO shall ensure the Train is at the correct stopping position before permitting Exterior Doors and Moveable Steps to be released.

Rationale: *This system is intended to improve safety by ensuring that the door release pattern is correct for the stopping location.*

Cross reference: *See also Requirement TTS-2828 (Automatic Door Release and Accuracy) in Section 9.18.2 (Train-wide door control)*

9.18.3.6 TTS-1223 - ASDO Function during Train State Change

The ASDO system shall remain effective in inhibiting the appropriate doors even when the Train:
- changes State;
- changes direction (e.g. at a terminus); and
- is coupled to or uncoupled from another Unit.

Rationale: *This functionality is intended to eliminate a risk that a Unit is activated and doors not adjacent to a platform can be released.*

Cross reference: *See also Section 9.7.2 (Operational states)*

9.18.3.7 TTS-2933 - ASDO on Shut-down

If restarting the Unit clears ASDO information, only the Train Captain shall be able to release Exterior Doors and Moveable Steps, and the Train Captain shall be provided with a warning that ASDO is not active prior to release of doors and steps.

Rationale: *Restarting the Train should not allow the Train Captain or Train Crew to accidentally release more doors that were previously permitted by the ASDO. Only the Train Captain can establish the position of the Unit.*

9.18.3.8 TTS-1303 - ASDO Override

The Train Captain shall be able to override the ASDO and CSDE system and select which Exterior Doors and Moveable Steps will be released or inhibited.
This override shall be recorded and shall be communicated to the Wayside.

Rationale: *The Train Captain should be able to manually override the ASDO system on a Train, Unit, Vehicle or Exterior Door basis for situations such as emergency evacuation, ASDO system failure, normal stopping point not available, etc. This function is only available to the Train Captain as only the Train Captain can establish the position of the Unit.*

9.18.4 Exterior Door system

9.18.4.1 TTS-3272 - Vehicle Overturning Load Case

With reference to EN 14752[40] Clause 4.2.1.4, Exterior Doors shall be assessed for the optional vehicle overturning load case.

Rationale: *This requirement provides clarification that compliance with this optional requirement should be provided.*

9.18.4.2 TTS-3285 - Emergency Access Device Colour

With reference to EN 14752[40] Clause 4.3.3.3, emergency access devices shall be the same colour as the surrounding area in which they are mounted.

Rationale: *This requirement provides clarification that ensures consistency with common practice in the UK to minimise misuse of the access devices.*

9.18.4.3 TTS-3286 - Local Door Controls - Door Open Control Availability

The local Exterior Door open controls shall be deactivated when a Train-wide door close command is initiated and remain deactivated throughout the door closing process.

Rationale: *This requirement is included for clarity and as a result of learning point 4 in the RAIB report on West Wickham.*

9.18.4.4 TTS-303 - Local Door Controls - Door Close

All Exterior Doors shall be provided with internal door close pushbuttons compliant with EN 14752[40] Section 4.3.

Rationale: *This permits Passengers and Train Crew to close doors to manage internal climate.*

9.18.4.5 TTS-1271 - Door Out-of-Service Indicator

In addition to the requirements of EN 14752[40] Section 4.3 a separate door out-of-service indication shall be provided internally and externally at all Exterior Doors.

Rationale: *It is considered that a clear separate indicator should be provided to Passengers over and above indication on the door open/close buttons. This could be on the door or adjacent to controls.*

9.18.4.6 TTS-1272 - Door Closing Force

The closing force of all Exterior Doors shall be compliant with force level (1) in EN 14752[40] Clause 5.2.1.4.2.2.

Rationale: *It is considered that the higher force level is not applicable.*

9.18.4.7 TTS-1273 - Door Closing Kinetic Energy

The kinetic energy contained by Exterior Doors throughout their travel on closing shall not exceed 20 J when calculated according to EN 14752[40] Clause 5.2.1.4.2.3.

Rationale: *It is considered that the kinetic energy of the Exterior Doors should be limited to minimise the risk of injury to Passengers.*

9.18.4.8 TTS-304 - Door Audible Warnings

The timings of audible alerts for operation of Exterior Doors shall be adjustable as a Software Update.

Rationale: *The HS2 Train Operator will want to retain the ability to optimise the timings of door operations whilst still complying with the requirements of the PRM TSI.*

9.18.4.9 TTS-2928 - Crew-only Door

It shall be possible to configure any Exterior Door as a Train Crew-only door via a Software Update. When configured in this way, • it shall only be controllable by Authorised Persons and auto-close shall be inhibited; and • all controls for Passengers shall not illuminate.

Rationale: *This is a change that would be made during reconfiguration or refurbishment. The door may be repainted so as not to contrast with the bodyside so it is clearly not a door for Passengers.*

9.18.5 Auto-close

9.18.5.1 TTS-307 - Door Auto-close

Exterior Doors shall automatically close after a defined amount of time. The amount of time shall be an Operator Setting.

Rationale: *Doors should close automatically after a fixed period of time to limit ingress of cold air or rain water.*

Cross reference: *See also Requirement TTS-1654 (Moveable Step Retraction) in Section 9.18.9 (Moveable Step)*

9.18.5.2 TTS-1283 - Door Auto-close Inhibit during Boarding/Alighting

The auto-close command shall not close the Exterior Door while Passengers are boarding or alighting through that doorway, or if Passengers are partially obstructing the doorway. Detection of Passengers boarding or alighting shall reset the auto-close timer.

Rationale: *If a Passenger passes through the door it should not close or not continue to close as part of the auto-close function. Passengers may attempt to cancel auto-close by placing their arm or leg in the doorway expecting this to stop the motion of the door. The auto-close detection should pick up the widest range of obstructions.*

9.18.5.3 TTS-1651 - Local Auto-close Inhibit

It shall be possible for Train Crew or the Train Captain to inhibit auto-close at a particular Exterior Door for the remainder of a station stop. It shall be possible to activate this command local to the Exterior Door, or from a Cab or Crew Control Point.

Rationale: *It should be possible for staff to locally inhibit the auto-close function to allow the use of equipment such as manual On-board Ramps. This function may be combined with controls of the Moveable Step at the same doorway (TTS-1640). Unlike retracting the step, this function does not affect safety, so achieving this function using existing controls (e.g. holding the 'open' pushbutton for two seconds) would be suitable.*

Cross reference: *See also Requirement TTS-1640 (Retract Step) in Section 9.18.9 (Moveable Step)*

9.18.5.4 TTS-1302 - Door Controls During Auto-close

During or following auto-close of Exterior Doors the local door open controls shall remain active. Activating a control shall cause the Exterior Door to re-open.

Rationale: *Passengers should be able to stop the doors from closing or re-open the doors as long as a close command has not been received.*

9.18.6 Door obstacle detection

See also LOC&PAS TSI[4] §4.2.5.5.3 (5)

9.18.6.1 TTS-306 - Obstacle Management

The Exterior Door obstacle detection sequence shall allow the following parameters to be adjusted as Software Updates: • door re-opening distance; • number of obstacle detections prior to complete door re-open; and • triggers for information and CCTV images provided to the Train Captain.

Rationale: *The HS2 Train Operator will want the ability to adjust the parameters related to obstacle detection to optimise the performance of the system.*

9.18.6.2 TTS-1687 - Automatic Obstacle Detection PIS Messages

The PIS shall be capable of automatically providing audio announcements that are triggered as part of the Exterior Door obstacle detection sequence. This message shall be audibly broadcast in the affected Vestibule and shown on the PIS screens adjacent to the Exterior Door.

Rationale: *The HS2 Train Operator will want to retain the ability to determine the most appropriate way to deal operationally with obstructed doors. This is envisaged as an automated "Please stand clear of the doors" message.*

Cross reference: *See also Requirement TTS-1383 (External Display) in Section 9.25.1 (Visual displays)*
See also Requirement TTS-2488 (Visual Displays in Vestibules) in Section 9.25.1 (Visual displays)

9.18.6.3 TTS-3298 - Obstacle Warning Announcements

The PIS shall be capable of automatically providing audio announcements (e.g. "Stand clear!") if the Exterior Door's auto-close sensor detects an obstacle close to the Exterior Door during the door close cycle.

9.18.6.4 TTS-1688 - Obstacle Detection PA Announcements

The PIS shall allow the Train Captain to make public address announcements at an individual Vestibule when an Exterior Door has failed to close due to obstacle detection.

Rationale: *The HS2 Train Operator will want to retain the ability to determine the most appropriate way to deal operationally with obstructed doors. It may be considered that more personal announcements are more effective.*

9.18.7 Door status

9.18.7.1 TTS-2736 - Bodyside Indicator Light

Each Vehicle shall have at least one bodyside indicator light that illuminates when any Exterior Door or Moveable Step on that Vehicle is not closed and locked.
The light shall be amber, and shall maximise visibility within the constraints of gauging and aerodynamics.
If more than one indicator is provided on each side of the vehicle, the indicator shall be directly associated with the door it is indicating.

Rationale: *An external light is required for compatibility with normal UK operations. It is envisaged that the light would be recessed into the carbody with a lens to give a spread of light, or lights could be provided on the vehicle ends, adjacent to the Gangway*

9.18.7.2 TTS-1293 - Door status display to Train Captain

The operational status of each Exterior Door shall be reported to the Train Captain and Crew Control Point.

Rationale: *The Train Captain must be made aware of the status of each door to assist in resolving issues at stations and to mitigate the impact of failures.*

9.18.7.3 TTS-1436 - Door status display to Wayside

The current operational status of each Exterior Door shall be reported to the Wayside throughout a station dwell.

Rationale: *This is to facilitate train dispatch and incident resolution in stations. Authorised Persons on the station should be able to immediately identify the status of all door systems. This gives an alternative option to the use of bodyside indicator lights.*

9.18.7.4 TTS-1686 - External Door Status Indicator

If an Exterior Door is locked out of service or does not operate correctly, the Unit shall provide visual information to Passengers and platform staff via the local PIS displays.

Rationale: *This is to provide clearer information than a small 'out of service' indicator. It will help platform staff diagnose faults when trying to dispatch a Train.*

Cross reference: *See also Requirement TTS-1383 (External Display) in Section 9.25.1 (Visual displays)*
See also Requirement TTS-2488 (Visual Displays in Vestibules) in Section 9.25.1 (Visual displays)

9.18.8 Emergency Egress Device

9.18.8.1 TTS-3284 - Emergency Egress Device Colour

With respect to EN 14752[40] Clause 4.3.2.3, Emergency Egress Devices shall be green according to ISO 3864-4[27].

Rationale: *This requirement clarifies the requirement included in EN 14752[40] to provide consistency with other Emergency Egress Devices in use in the UK.*

9.18.8.2 TTS-1304 - Emergency Egress Device in Station

Operation of an Emergency Egress Device when the Train is stopped at a platform or departing from a platform shall lead to an emergency brake application, resulting in a complete stop.
When the Train has come to a complete stop, the Train Captain shall be able to cancel the brake application.

Rationale: *This functionality is intended to mimic the functionality of a passenger alarm in LOC&PAS TSI[4] Clause 4.2.5.3.3 (1). This is intended to manage a situation where a Passenger uses the 'wrong' emergency device to alert the Train Captain.*

9.18.8.3 TTS-1439 - Emergency Egress Device at Speed

With reference to LOC&PAS TSI[4] Clauses 4.2.5.5.9 (1) and (2), operation of an Emergency Egress Device shall not allow the Exterior Door to be opened while the Unit is moving above 10km/h.

Rationale: *This clarifies which of the two options in LOC&PAS TSI[4] Clause 4.2.5.5.9 (1) and (2) will be acceptable.*

9.18.8.4 TTS-1657 - Emergency Egress Device & Traction Interlock

Operation of an Emergency Egress Device while not in a platform and above 10km/h shall not unlock the Exterior Door and shall not break the door-traction interlock.
Feedback shall be provided to the person that operated the device that the Train has recognised operation of the device.

Rationale: *Breaking the interlock would require a loss of traction (LOC&PAS TSI[4] Clause 4.2.5.5.7 (1)) and an emergency brake application (GM/RT2473[95] Clause B.6 / RIS-2747-RST[98] Clause 2.5.4.1). In the majority of scenarios, stopping the Train when an emergency opening device is activated would not be the best course of action.*

9.18.8.5 TTS-1286 - Reporting of Emergency Egress Devices

The operation of an Emergency Egress Device and its location on the Train shall be reported to the Train Captain and Wayside.

Rationale: *The Train Captain should be made aware of the operation of an Emergency Egress Device in order to take appropriate action.*

9.18.8.6 TTS-1287 - CCTV Following Emergency Opening Device Operation

The operation of an Emergency Egress Device shall cause live CCTV images of the area around the emergency open device to be made available to the Train Captain and at the Crew Control Point.

Rationale: *The Train Captain should be able to view local CCTV in order to determine appropriate action.*

9.18.8.7 TTS-2035 - Temporary Isolation of Emergency Open Device

It shall be possible to temporarily prevent the Emergency Egress Device from opening the Exterior Door when the speed is below 10km/h. It shall be possible to activate this function for all Emergency Egress Devices on the Train from both the Cab and a Crew Control Point. The function shall be time-limited.

Rationale: *This function is to support management of Trains stalled in tunnels and evacuation. The function prevents Passengers trying to leave the train at the wrong location. A time-limit is required to prevent the Train being left in this condition. It is anticipated that the Train Captain / Train Crew would need to re-apply this function, for example, every 10 minutes. A failure analysis will be needed to show that an Emergency Egress Device cannot fail in this locked-out condition.*

Cross reference: *See also Requirement TTS-312 (Evacuation Door Control) in Section 9.18.2 (Train-wide door control)*

9.18.9 Moveable Step

9.18.9.1 TTS-263 - Moveable Step Deployment

The Moveable Step shall deploy when a Train-wide door release command is received, regardless of whether the door has received a local or Train-wide 'open' command.

Rationale: *Deploying the Moveable Step immediately reduces the time for Passengers to open the door if they approach the door some time after the doors are released.*

9.18.9.2 TTS-1654 - Moveable Step Retraction

The Movable Step shall remain deployed until a Train-wide door close command has been received (i.e. removing the release command). The Movable Step shall not retract due to auto-close or local door controls or the terminal station mode.

Rationale: *This is to ensure that if an Exterior Door closes but remains released the step does not retract to ensure that if the door is reopened, this is not delayed by the step cycle time.*

Cross reference: *See also Requirement TTS-314 (Terminal Station Mode) in Section 9.18.2 (Train-wide door control)*

9.18.9.3 TTS-3192 - Moveable Step / Door Interaction

Contrary to clause 5.2.2.2 of EN 14752[40], the Exterior Doors shall not open more than 50mm until the Moveable Step is fully deployed.

Rationale: *The 400mm distance specified in the EN is considered too large given the large gap between the Unit and the platform. A small overlap enables the door to unlock and unplug as the step finishes its deployment*

9.18.9.4 TTS-3283 - Lock-out of Moveable Step

With respect to clause 5.1.6.2 of EN 14752[40], it shall be possible to lock a Moveable Step out-of-service from inside the Vehicle. A single device shall be provided to lock-out both the Movable Step and associated Exterior Door simultaneously.

Rationale: *This requirement is intended to clarify the open point in this clause within the standard. While the step and door may fail separately, no scenario where the doorway can operate safely with* *the step isolated has been identified. A single isolation switch ensures one element is not accidentally isolated.*

9.18.9.5 TTS-2469 - Moveable Step Deployment Distance - HS2

On the HS2 Network, the distance of deployment of the Moveable Step shall adjust to the platform offset at the doorway.

Rationale: *The HS2 Platforms will be at a consistent height, but will have small changes in offset due curvature of 1000m minimum track radius at some stations. For the HS2 Network, the Moveable Step may sense or physically contact the platform.*

9.18.9.6 TTS-3340 - Moveable Step - Contact Platform

If the Moveable Step contacts the platform to detect the platform offset, the control and contract surface of the Moveable Step shall be compatible with the platform edge.

Rationale: ***HS2 interface -*** *The Trains will stop at a consistent location at each station stop. Therefore, if the step contacts the platform, there will be repeated contact at the same point on the platform. The materials on the end of the step and the platform edge will need to be selected to manage this repeated contact.*

9.18.9.7 TTS-159 - Moveable Step Deployment Distance - CRN (PQTS-408)

On the CRN, the distance of deployment of the Moveable Step shall be individually configurable at each Exterior Doorway, for each platform, including no deployment if required.
Updates to the configuration shall be possible as a Software Update.

Rationale: *CRN platforms have a range of heights and offsets and some are positioned on very small radius curves. Some platforms have variable height and offset along their length. HS2's proposal is that the preferred condition is for the step to fully deploy and oversail CRN platforms. However where this is not possible, it may be necessary to determine how best to deploy the step to minimise the gap seen by Passengers. Sensing the edge of the platform is not considered a suitable solution because it would prevent oversailing and lead to short deployments in some cases, giving a small stepping surface.*

9.18.9.8 TTS-1635 - Prevent Step Deployment

It shall be possible for Train Crew to inhibit the deployment of a Moveable Step for when a door release command is next received.
The associated Exterior Door shall then only be openable, when released, by an Authorised Person.

Rationale: *It is envisaged that the Moveable Step will not be used when a manual On-board Ramp is used to enable wheelchairs or catering trolleys to board the Unit. This option would be used if a member of Train Crew is able to supervise the PTI at a particular door. The Movable Step may also not be used during certain evacuation scenarios.*

9.18.9.9 TTS-1640 - Retract Step

It shall be possible for an Authorised Person, using controls local to the Exterior Doorway, to retract and deploy the Movable Step without changing the position of the Exterior Door.
This function shall be possible during normal door release scenarios and when an Evacuation Door is opened.

Rationale: *This would permit a member of staff to deploy an On-board Ramp during the station stop without pre-planning this.*

9.18.9.10 TTS-2461 - No Retraction in Use

The Moveable Step shall not retract while Passengers are standing on the step. It shall be possible to inhibit this function as a Software Update.

Rationale: *When fully deployed, it is anticipated that the Moveable Step will be large enough for a Passenger to comfortably stand with both feet on the step, and so it is considered possible that Passengers could still be standing on the step at the point it starts to retract. Reliably sensing Passengers standing on the step may be difficult, so it may be chosen to inhibit this function if service experience shows this function is not necessary.*

9.18.9.11 TTS-3299 - Automatic PIS on Passenger Detection

The PIS shall be capable of automatically providing audio announcements if the Moveable Step detects there are Passengers standing on the step.

9.19 PEP system

9.19.0.1 Implementation of a platform edge protection (PEP) system at HS2 stations is still being considered. The most likely solution is some form of platform door, aligned with the Exterior Door positions, but other concepts are being investigated. To support this, the Unit will need to include a system to communicate with the PEP system on the particular platform that the Unit has stopped at. The scope of the TMM is to select a suitable means of communication and provide equipment mounted to the Unit. All equipment mounted on the platform is not in the TMM's scope (i.e. the boundary is the 'air gap'). The TMM's responsibilities with regard to interfacing with platform equipment are defined in MSA Schedule 11.

9.19.1 PEP-to-Unit Communication

9.19.1.1 TTS-309 - PEP System Functional Integration - Mandatory

The Unit shall include a system to wirelessly communicate with the PEP system on a platform where the Unit has stopped.

Rationale: *The TMM will be the Lead Integrator with respect to the PEP system as defined in MSA Schedule 11. Therefore, the TMM will need to select a suitable system and include the on-board elements in the Unit design.*

9.19.1.2 TTS-2490 - System Integrity

The Unit-to-PEP interface shall have sufficient integrity to support protection of the platform edge and dispatch of the Unit.

Rationale: *It is envisaged that the Unit-to-PEP communication system will need a high level of integrity. There are a number of hazards such as PEP opening when Moveable Steps are not deployed and Train departing with PEP open that will need to be managed.*

9.19.1.3 TTS-2470 - PEP Communications Protocol

The Unit-to-PEP communication system shall use a non-proprietary communications protocol.

Rationale: *HS2 Ltd will separately procure wayside elements of the PEP system. To support open tendering for this system, the communications protocol should not restrict the range of suppliers.*

9.19.2 Door and PEP control

9.19.2.1 TTS-1289 - Door Control Functions with PEP System

Where stations are fitted with PEPS, the control of Exterior Door and Moveable Steps shall be available in accordance with TTS-315, TTS-318 and TTS-316.

9.19.2.2 TTS-2491 - PEP / Door Release

When the Unit stops at a PEP-equipped platform, the Unit shall command the PEP to release when:

- Exterior Doors have been released; and
- Moveable Steps have deployed.

Rationale: *The PEP must not open until Moveable Steps are in place. If TTS-2473 cannot be achieved, it is likely that the PEP would open at every Exterior Doorway, following a train-wide door release.*

9.19.2.3 TTS-2494 - PEP / Door Close

When the Unit is ready to depart a PEP-equipped platform, the Unit shall command the PEP to close when:

- a Train-wide door close command is issued (which may originate from the platform - see TTS-2474);
- all Exterior Doors have closed; and
- all Moveable Steps have retracted.

Rationale: *Because the Moveable Step presents a large enough space for passengers to stand between the platform and the Unit, the PEP must not close until the Moveable Step has retracted. A Passenger on the step could then step back on to the platform.*

9.19.2.4 TTS-2474 - TC-Platform Communication

The Unit and the Unit-to-PEP communication system shall enable the Train Captain and platform-based staff to send train dispatch commands and responses to each other, at least:

- signal from platform-based staff to Train Captain to close doors;
- signal from Train Captain to platform-based staff that interlock is made; and
- 'Right Away' signal from platform-based staff to Train Captain for the Train to depart.

Rationale: *Whether or not a PEP system is implemented, dispatch of the Train will likely require communication of 'close doors' and 'right away' instructions from platform staff to the Train Captain or direct to the ATO On-board. The Unit-to-PEP communication system can enable this function.*

9.19.2.5 TTS-3275 - Close Doors from Platform

The Unit and Unit-to-PEP communication system shall enable the close sequence of Exterior Doors and the PEP to be triggered from:
- on-board the Unit (as per section 9.18.2); and
- platform-based staff communicating via the Unit-to-PEP communication system.

Rationale: *The Unit-to-PEP communication system could also be used to send a 'doors close' signal from the platform to the Train, if platform-based staff have full responsibility for dispatch.*

9.19.2.6 TTS-2472 - PEP System Interlock

When the Unit is ready to depart a PEP-equipped platform, the Unit shall require interlock of the PEP system, communicated via the Unit-to-PEP communication system, prior to:
- the Train Captain being able to take traction; or
- the ATO On-board becoming Available (AV).

Rationale: *This interlock is envisaged to include closure of doors and a check of the space between PEP and Train.*

9.19.2.7 TTS-3300 - Report On-board Obstacles to Platform

The Unit and Unit-to-PEP communication system shall enable the Unit to report the location of:
- Exterior Doors / Moveable Steps that have not closed and locked following the closing sequence;
- Exterior Doors that have activated their obstacle detection sequence;
- Exterior Doors that have detected an obstacle near the door when closing (TTS-3298); and
- Moveable Steps that have detected a Passenger standing on the step during the closing sequence.

Rationale: *The purpose of this function is to make platform staff aware of any issues that will or may affect dispatch so they can investigate. Relying on bodyside indicator lights would not support short dwell times, and is not suitable if a PEP system is fitted.*

9.19.2.8 TTS-2473 - Door/PEP Synchronisation - Doorway

When the Unit is at a PEP-equipped platform, it shall be possible to synchronise the opening and closing of an individual Exterior Door with the adjacent element (e.g. door) of the PEP, such that opening either will open the other within one second.

Rationale: *This would facilitate opening and closing of individual doors during longer dwells.*

9.19.2.9 TTS-2495 - Train Door or PEP Locked-out

When the Unit is at a PEP-equipped platform, it shall be possible to synchronise Exterior Doors and the adjacent PEP element to not open when either reports it is locked out of service, or a Moveable Step fails to deploy.

Rationale: *If any element of the PTI does not operate, all elements should not operate so that Passengers cannot get part way across the interface.*

9.19.2.10 TTS-1290 - Train Door Inhibit Based on PEP

The Train shall allow specific Exterior Doors to be inhibited for a station stop based on the status of the PEP at the relevant platform.
Door inhibit shall be communicated audibly and visually in the Vestibule concerned and any adjacent Saloons.
Door inhibit information for forthcoming stations shall be available to the Train Captain and Train Crew.
The status of the PEP at each platform will be communicated to the Train from the Wayside.

Rationale: *As well as synchronising at a platform, information can be provided ahead of arrival to forewarn Passengers on-board.*

9.19.2.11 TTS-1291 - PEP Inhibit Based on Train Door

The Train shall provide data to the Wayside on the operational status of Exterior Doors and Moveable Steps to allow PEP systems at stations on the Train's journey to adjust accordingly.

Rationale: *As well as synchronising at a platform, information can be provided ahead of arrival to forewarn Passengers at the platform.*

9.20 HVAC

9.20.1 Definitions in this section are taken from on EN 13129[32] and EN 14813[41].

9.20.1 HVAC control

9.20.1.1 TTS-385 - Temperature Regulation

The Passenger HVAC system shall regulate the target internal temperature, T_{ic}, of each saloon, with respect to:
- the State that the Train is in;
- external mean temperature T_{em} as measured by the Unit;
- external temperature data provided from the Wayside;
- Location (Line & Distance) of the Train;
- the Service the Unit is on (direction, stopping pattern);
- time of day; and
- time of year.

It shall be possible change the temperature regulation as an Operator Setting per vehicle.

Rationale: *The temperature regulation curve in EN 13129 is too simple for HS2 operation - e.g. it could cause a cool train to turn on heating as it entered a hot tunnel. The Passenger HVAC will need to recognise that an increase in external temperature has been caused by the entry into the tunnel and that Passengers will not expect a change of interior temperature. Separate regulation curves are envisaged for when the Unit is out of service and when it is stabled. In addition, it is necessary to have modes to limit heat output in certain locations. This range of options should permit the necessary degree of control. It may not be necessary to use all variables. Different settings between Vehicles permit different settings for different types of service offering*

Cross reference: *See also Section 9.7.2 (Operational states)*

9.20.1.2 TTS-1087 - Fresh Air Regulation

The Passenger HVAC system shall regulate the rate of fresh air into the Saloon with respect to:
- the State that the Train is in;
- measured CO_2 levels in the Saloon;
- measured payload for the Vehicle;
- external mean temperature T_{em} as measured by the Unit;
- Location (Line & Distance) of the Train;
- the Service the Unit is on (direction, stopping pattern)
- time of day; and
- time of year.

It shall be possible to change the fresh air regulation as an Operator Setting per Vehicle.

Rationale: *Fresh air flow rates need to be controllable to get the best interior environment while minimising energy consumption. Additionally, it is considered likely that fresh air rates will need to be increased prior to entering long tunnels, since it may be necessary to close-off fresh air in the tunnel to avoid pressure pulses. It may also be necessary to increase the permitted the CO_2 level in the tunnel or at Euston or Old Oak Common station to manage heat output from the Unit in the summer. When the Unit is out of service or stabled, more relaxed settings are envisaged to save energy.*

Cross reference: *See also Section 9.7.2 (Operational states)*

9.20.1.3 TTS-1313 - Automatic Pre-heat / Pre-cool

The Unit shall be able to estimate the time to revert the internal temperature, T_{im}, of the Cab and Saloon from Standby State to a Passenger Service State and automatically start heating or cooling to make the Unit ready for the next Service at the time defined by the Operational Diagram that the Unit is allocated to.

Rationale: *Rather than specify a pre-heating / pre-cooling time, it is proposed that the Unit automatically monitors external conditions and prepares itself for service. This means that heating and cooling systems will only need to be sized to meet the design conditions specified in section 7.16. It is assumed that pre-heating / pre-cooling would take place while the Unit is connected to the 25kV overhead supply.*

9.20.1.4 TTS-3270 - Emergency High Ventilation Mode

Following loss of the 25kV power supply, the Unit shall automatically switch to emergency ventilation (TTS-388).
The Train Captain and Train Crew shall be provided with external temperature information and shall be able to select a higher rate of emergency ventilation (TTS-3269).
It shall be possible to select the higher rate of emergency ventilation locally in each Vehicle following a loss of train control.

Rationale: *See also paragraph 7.16.1.11. A higher rate of ventilation is specified for emergency ventilation in very hot weather.*

9.20.1.5 TTS-1138 - Cab Temperature Control

The Unit shall allow the Train Captain to vary the cab interior temperature setting (T_{ic}) between +18°C and +26°C with 1°C steps.

Rationale: *It is envisaged that Train Captains will want to set temperature to their preferred level and so this setting should be readily accessible.*

9.20.1.6 TTS-3197 - Inactive Cab Temperature Setting

The cab interior temperature setting (T_{ic}) of Inactive Cabs shall be set to the same value as the T_{ic} of the nearest Saloon.

Rationale: *Inactive Cabs may be used by Train Crew as staff accommodation, so should be controlled to a normal temperature when the Unit is in service.*

9.20.1.7 TTS-1144 - Cab Fresh Air Regulation

The Cab HVAC shall regulate the rate of fresh air into the Cab with respect to:
- whether the Cab is an Active Cab or Inactive Cab;
- whether the Cab is otherwise indicated as occupied (e.g. lights switched on in an Inactive Cab);
- CO_2 level measured in the Cab; and
- Location (Line & Distance) of the Train.

9.20.1.8 TTS-1166 - Cab Air Speed

The Unit shall allow the Train Captain to alter the air speed of Cab HVAC vents by at least five steps.

Rationale: *The Train Captain should be able to adjust the feel of the air-flow in the Cab, but should not be able to switch the Cab HVAC into a state where there is insufficient fresh air.*

9.20.1.9 TTS-1170 - Cab HVAC Vent Adjustment

The Unit shall enable the Train Captain to adjust the direction of the of the air flow towards and away from the Train Captain's seat.

9.21 Heat management

9.21.1 TTS-1460 - Limited Heat Release State

The Train shall be able to switch to a Limited Heat Release State. In this state:
- cooling systems shall run at reduced output; and
- affected systems may operate at reduced performance.

The level of reduction shall be a Software Update per system.

Rationale: *This function has been specified to manage heat output from the Unit in tunnels and enclosed stations (Euston and Old Oak Common). At these locations, in some conditions, it will be necessary to restrict the performance of the Unit to manage the ambient temperature. While some performance requirements can be specified - section 7.17 - it is expected that systems will need to be adjusted following testing to get the optimal performance of the Unit and ventilation systems.*

9.21.2 TTS-1587 - LHRS Automatic Operation

The Unit shall switch to the Limited Heat Release State automatically and back to Passenger Service State, due to:
- the Unit's Location (Line & Distance);
- the external temperature measured by the Unit; and
- a signal from the Wayside.

The locations and temperatures at which a switch occurs shall be adjustable as Software Updates.

9.22 Fire and smoke detection

See also LOC&PAS TSI[4] §4.2.10

9.22.1 Internal fire detection

9.22.1.1 TTS-325 - On-board Fire Detection Systems

With reference to LOC&PAS TSI[4] Section 4.2.10.3.2, the Unit shall include fire detection systems in at least the following areas:
- Saloons and Vestibules;
- Toilets;
- Cab;
- Catering Areas; and
- technical cabinets containing traction equipment (as defined by EN 45545-6[56] Table 1, Section 5.2).

Rationale: *LOC&PAS TSI Section 4.2.10.3.2 gives general requirements for fire detection, but not specific requirements. EN 45545-6[56] is considered to be an acceptable solution. EN 45545-6[56] Table 1, Section 5.2 makes detectors in passenger areas and toilets recommended, but not mandatory. These are required. As part of the safety assessment of the Unit (see MSA Schedule 10), it is expected that a review of fire hazards and detector provision will be undertaken, which may identify the need for more detectors.*

9.22.1.2 TTS-2937 - Future Flexibility - Additional Fire Detectors

It shall be possible to add at least two additional fire detectors to each Vehicle if different interior equipment is added during refurbishment (e.g. unattended baggage area).

9.22.1.3 TTS-2869 - Fire Detection Type

Fire detection systems shall be suitable for the location they are monitoring and the type of fires that could develop.

Rationale: *Depending on the location, it may be necessary to monitor heat or smoke or both. EN 45545-6[56] also identifies detection of flames as an option.*

9.22.1.4 TTS-2850 - Manual Fire Detection

It shall be possible for both the Train Captain and Train Crew to manually record that a fire has been detected by Train Crew or Passengers and
- the location on the Train of the fire; and
- the source of the fire - luggage, part of the Unit or some other source.

The design of this input shall be suitable for a high-stress situation.

Rationale: *Train Crew or Passengers may identify fires which are not detected by the detection systems. Either may contact the Train Captain via communications handset or passenger emergency alarm respectively. Alternatively, Train Crew may record the fire themselves if they are in the vicinity of the Crew Control Point or an Inactive Cab. Once identified, the response to the fire would be the same as if automatically detected. A location of the fire needs to be recorded so that the impact can be judged on the Wayside. It needs to be possible to quickly record the approximate position of the fire and the type of fire.*

9.22.1.5 TTS-1832 - Traction Equipment Isolation on Fire Detection

Upon detection of a fire in a technical cabinet containing traction equipment, the power supply to that equipment shall be shut down.

Rationale: *Implementation of EN 45545-6*[56]

9.22.1.6 TTS-1833 - Internal Fire Ventilation Shut-down

Upon detection of a fire inside the Vehicle, including manual detection, any ventilation and cooling for that Vehicle shall be shut down, but other Vehicles of the Train shall be unaffected.

Rationale: *Implementation of EN 45545-6*[56]

9.22.1.7 TTS-1838 - Internal Fire Train Captain Alert

Upon any detection of fire, an audible and visual indication shall be provided to the Train Captain until acknowledged.
The location of the fire detection shall be identified to the Train Captain.
This requirement does not apply to fires that the Train Captain manually records.

Rationale: *Implementation of EN 45545-6*[56]

9.22.1.8 TTS-2849 - Present Advice to Train Captain

The Unit shall provide advice to the Train Captain on the recommended course of action following the fire detection. This advice shall depend on the:
- Location (Line & Distance) of the Train;
- direction of travel; and
- speed of the Train.

Rationale: *The response to the fire may vary depending on these factors to minimise the risk of the Train becoming stalled in a tunnel or other location where it could be difficult to evacuate. This information needs to support efficient decision making by the Train Captain.*

9.22.1.9 TTS-1834 - Internal Fire Train-Crew Alert

Upon detection of an internal fire, including manual detection, the Unit shall be capable of providing a time-limited audible alarm at the Crew Control Point and/or throughout the Train.
It shall be possible to both vary the timing and disable these alerts as an Operator Setting.

9.22.1.10 TTS-2848 - Fire Detection Wayside Alert

Detection of a fire shall be communicated to the Wayside. The communication shall identify the:
- location on the Train of the fire detection;
- Location (Line & Distance) of the Train;
- direction of travel of the Train; and
- speed of the Train.

Rationale: *Providing information to the Wayside about the fire is necessary to make decisions about how to manage the fire.*

9.22.1.11 TTS-1300 - Fire Detection Internal CCTV

Upon detection of an internal fire, including manual detection, the most appropriate CCTV images shall be made available to both the Train Captain and the Wayside.
These CCTV images shall also be flagged for later review.

9.22.1.12 TTS-1839 - Fire Detection Automated Passenger Information

Upon detection of a fire, and confirmation from Train Crew or the Train Captain, the Unit shall be capable of broadcasting a visual and audio message to the Vehicle where the fire was detected, communicated via the PIS.
These messages shall direct Passengers in both directions or in a single direction depending on the location of the fire on the Train.
It shall be possible to configure, as an Operator Setting, whether the alarm message occurs automatically or whether the alarm requires confirmation from Train Crew prior to broadcast.

9.22.1.13 TTS-1835 - Fire Detection Interior Doors Close

Upon detection of an internal fire, including manual detection, Interior Doors either side of the fire, up to and including the next fire barrier, shall close, if open.
The Interior Doors shall no longer respond to Passenger door controls on the outside of the area containing a fire.
The Interior Doors shall continue to respond to Passenger door controls inside the area containing the fire.

Rationale: *Passengers must be able to leave the area containing the fire, but should not be able to re-enter the area.*

Cross reference: *See also Requirement TTS-1814 (Interior Doors Evacuation Requirements 1) in Section 9.34 (Interior Doors)*

9.22.1.14 TTS-1837 - Fire Detection Interior Doors Photoelectric Response

Upon detection of an internal fire, including manual detection, the Interior Doors shall no longer respond to photoelectric inputs, if these are used to manage automatic control.

Rationale: *Smoke from fires can interfere with photoelectric inputs.*

9.22.1.15 TTS-1841 - Fire Detection Remote Reset

It shall be possible to reset the fire detection remotely from an Active Cab, an Inactive Cab or a Crew Control Point.

9.22.1.16 TTS-1840 - Fire Detection Active Time

All automatic responses to a detected fire shall remain active until the alarm has been reset by Train Crew or the Train Captain.

9.22.2 External smoke control

9.22.2.1 TTS-1117 - Automatic Response to Fresh Air Smoke

The Unit shall automatically detect external smoke at each fresh air intake.
Upon detection, fresh air intake from that location shall be stopped for a minimum of 10 minutes and until smoke is no longer detected.
It shall be possible to change the minimum duration as an Operator Setting.

Rationale: *An automatic response is required because the Train Captain and Train Crew will not be able to reliably 'detect' external smoke, and may have other priorities.*

9.22.2.2 TTS-1842 - Inform Train Captain of Fresh Air Smoke

The Train Captain shall be informed of automatic fresh air smoke detection and resets (TTS-1117) and the location of these along the Train.

Rationale: *This will provide information to enable the Train Captain to close Train-level ventilation.*

9.22.2.3 TTS-1845 - Reset Fresh Air Smoke Detection

It shall be possible for the Train Captain to remotely reset and remotely isolate the fresh air smoke detection at an intake.

Rationale: *This would enable fresh-air to be restarted if a detector failed.*

9.22.2.4 TTS-1844 - Adjust Detection Thresholds

It shall be possible to individually change the detection threshold and the 'no smoke' threshold of the fresh air smoke detection as an Operator Setting.

Rationale: *It is likely that the detectors will need adjustment to achieve optimum performance.*

9.22.2.5 TTS-1118 - Manual Response to External Smoke

With reference to LOC&PAS TSI[4] Clause 4.2.10.4.2 (2), both the Train Captain and Train Crew, at the Crew Control Point, shall be able to manually prevent fresh air intake to the Train for a fixed period of time.
Fresh air shall restart after this period.
The period shall be adjustable as an Operator Setting.

Rationale: *This is a slight clarification of the TSI, which doesn't specify who is responsible for switching off the fresh air intake, and does not cover how a restart will occur.*

9.23 Security

9.23.1 Physical security

9.23.1.1 TTS-2829 - General Access Security

When the Unit is not in passenger service, access to the Unit shall be restricted to Authorised Persons.

9.23.1.2 TTS-3003 - Cab Back Wall Resistance to Forced Entry

The internal cab entry door shall be protected against unauthorised access to 'Security Rating 2' according to LPS1175[114].

9.23.1.3 TTS-2223 - Recording of Entry in to Cab

Entry in to the Cab shall be recorded by the Unit as an Event.
It shall be possible to define alerts and alarms on-board the Unit and on the Wayside in response to entry into the Cab.

Cross reference: *See also Section 9.5.1 (Events)*

9.23.1.4 TTS-2221 - Train Crew Areas Resistance to Forced Entry

Entry in to any area intended for Train Crew only, including crew-only parts of Catering Areas, shall be protected against unauthorised access to Security Rating 2 according to LPS1175[114].

9.23.1.5 TTS-2222 - Recording of Entry in to Train Crew Areas

Entry in to any area intended for Train Crew only, including crew-only parts of Catering Areas, shall be recorded by the Unit as an Event.
It shall be possible to define alerts and alarms on-board the Unit and on the Wayside in response to crew-only areas.

9.23.1.6 TTS-3425 - Cubicle Security

Cupboards and cubicles containing operational and train control equipment shall be protected against unauthorised access to Security Rating 2 according to LPS1175[114].

9.23.1.7 TTS-3426 - Cubicle Access Differentiation

Security for cupboards and cubicles where access is only necessary for maintenance shall be different (e.g. by a separate key) from security for cupboards and cubicles that Train Captain or Train Crew need to access.

Rationale: *This enables access to certain parts of the Unit to be restricted from Train Crew and Train Captain, if required.*

9.23.1.8 All keys to support the above physical security requirements will be Special Operator Equipment. Quantities are specified in MSA Schedule 14.

9.23.2 Cyber security

9.23.2.1 Requirements for cyber security are included in an Appendix to MSA Schedule 9.

9.24 Passenger Alarms and Call For Aids

Cross reference: *See also Requirement TTS-1408 (Audio System Priorities) in Section 9.25.2 (Audio information)*

9.24.0.1 With reference to LOC&PAS TSI Section 4.2.5.4, separate communications devices are not required; it is considered that the Passenger Alarm fulfils this purpose.

9.24.1 Passenger Alarms

See also to LOC&PAS TSI §4.2.5.3.

9.24.1.1 TTS-3301 - Passenger Alarm Provision - Mandatory

With reference to LOC&PAS TSI[4] Clause 4.2.5.3.2 (1), the Unit shall have a Passenger Alarm:

- in each Saloon; and
- adjacent to each Exterior Door, i.e. two per Vestibule.

All Passenger Alarms shall be accessible by the User Population.

Rationale: *A Passenger Alarm at each Doorway is considered essential to allow Passengers to raise an alarm if something is caught in a door. Since this will be a high-stress situation Passengers will need to be able to intuitively raise an alarm. Alarms must be positioned for the whole User Population, and not placed at a high level as on some designs.*

9.24.1.2 TTS-510 - Alarm Indication - Train Crew

When a Passenger Alarm is triggered it shall be possible to provide an audible indication at the Crew Control Point and/or throughout the Train in addition to indication in the Active Cab.
It shall be possible to activate/deactivate these audible indications as an Operator Setting.

Rationale: *The alert warns Train Crew of the alarm, but too many audible alerts would become confusing for Train Crew and annoying for Passengers.*

9.24.1.3 TTS-1417 - Alarm CCTV

When a Passenger Alarm is triggered, CCTV images of the location of the alarm shall be available in the Active Cab, all Inactive Cabs and all Crew Control Points in the Train.

9.24.1.4 TTS-1414 - Alarm Response

Following activation of a Passenger Alarm, it shall be possible to establish a voice communications link to the passenger alarm from the Active Cab, an Inactive Cab or a Crew Control Point.

9.24.1.5 TTS-2532 - Alarm Response - Selection

Where multiple Passenger Alarms have been activated these shall be presented for selection in the Active Cab, an Inactive Cab and the Crew Control Points.
Selection of an active alarm shall present relevant CCTV and establish communications with the appropriate alarm location.

9.24.1.6 TTS-509 - Alarm Reset

It shall be possible to reset Passenger Alarms devices remotely from the Active Cab, an Inactive Cab or a Crew Control Point.

9.24.1.7 TTS-1416 - Alarm Indication - Wayside

When a Passenger Alarm is triggered it shall be communicated to the Wayside.
Live CCTV of the location of the alarm shall be broadcast to the Wayside.
It shall be possible to communicate with the Passenger Alarm from the Wayside.

Rationale: *It is envisaged that as well as managing alarms on the wayside, information may be communicated from the Wayside back to a mobile device held by Train Crew. This communication would be outside the TMM's scope.*

9.24.1.8 TTS-1415 - PEA Brake Application Hold-off

With reference to LOC&PAS TSI[4] Clause 4.2.5.3.3 (2), the Train Captain shall only need to make a single acknowledgement (within 10±1 seconds) of the Passenger Alarm and shall not need to maintain this acknowledgement.
The Train Captain shall be provided with a permanent visual reminder that a Passenger Alarm is active.

Rationale: *On the HS2 Network, stopping Trains in tunnels will be avoided where possible. Depending on the cause of the alarm, the Train Captain may continue to the next Safe Location or to the next station. The Train Captain should not need to permanently hold off the alarm.*

Cross reference: *See also Requirement TTS-2356 (ATO Stopping) in Section 8.6.2 (ATO Stop and Safe Location)*

9.24.1.9 Note that the requirement of LOC&PAS TSI[4] Clause 4.2.5.3.3 (1) to automatically stop if the Train is within the station applies whether ATO On-board is Engaged (EG) or not.

9.24.2 Call For Aid

See also PRM TSI[6] (various clauses)

9.24.2.1 TTS-3259 - Call For Aid Provision

The Unit shall have Call For Aids:
- at each wheelchair spaces *in accordance with PRM TSI[6] clause 4.2.2.2 (11)*;
- in the Universal Toilet *in accordance with PRM TSI clauses 5.3.2.4 (11)-(15)*;
- in the Standard Toilet, positioned on a vertical surface not less than 800 mm and not more than 1 100 mm above the floor, measured vertically to the centre of the control; and
- in each Vestibule, separately located from the Passenger Alarm.

Rationale: *The Call For Aid at the Exterior Doorway is to enable Passengers to request help for access and egress e.g. if an On-board Ramp is required, or the Passenger does not feel comfortable traversing the Moveable Step.*

9.24.2.2 TTS-3260 - Call For Aid Design

The Call For Aids shall all be of the same design and shall comply with 5.3.7 of EN 16584-2[49].

Rationale: *It is important that Call For Aids are distinguishable from Passenger Alarms and that Passengers have a common interface through the Unit.*

9.24.2.3 TTS-3261 - Call For Aid Response

When a Call For Aid is triggered
- an audible indication shall be sounded throughout the Train; and
- an Event shall be raised.

Rationale: *It is anticipated that Call For Aids will be addressed by Train Crew, rather than the Train Captain. The Train Captain will be alerted via the Event, and an appropriate prioritisation will be required.*

9.24.2.4 TTS-3264 - Call For Aid CCTV

When a Call For Aid is triggered, CCTV images of the location of the Call For Aid shall be available in all Inactive Cabs, all Crew Control Points or the Active Cab.

9.24.2.5 TTS-3262 - Call For Aid Voice Communications

Following activation of a Call For Aid, it shall be possible to establish a voice communications link to the Call For Aid from an Inactive Cab, a Crew Control Point or the Active Cab

Rationale: *Train Crew will want to communicate with the Passenger prior to, if necessary, going to the Call For Aid location.*

9.24.2.6 TTS-3263 - Call For Aid - Selection

Where multiple Call For Aids have been activated these shall be presented for selection in an Inactive Cab, a Crew Control Point or the Active Cab.
Selection of a Call For Aid shall present relevant CCTV and establish communications with the appropriate alarm location.

9.24.2.7 TTS-3265 - Call For Aid Reset

It shall be possible to reset Call For Aid devices remotely from an Inactive Cab, a Crew Control Point or the Active Cab.

9.24.2.8 TTS-3266 - Call For Aid - Wayside Response

When a Call For Aid is triggered it shall be communicated to the Wayside.
Live CCTV of the location of the alarm shall be broadcast to the Wayside.
It shall be possible to communicate with the Call For Aid from the Wayside.

9.24.2.9 TTS-3267 - Call For Aid Exterior Doorway

When a Call For Aid at an Exterior Door is triggered and the Train is at a station:
- the auto-close function of the adjacent Exterior Door shall be inhibited;
- the Event raised (TTS-3261) shall be high priority to alert the Train Captain;
- external visual indication shall be given.

Rationale: *Passengers may use the Call For Aid at an Exterior Doorway if there is an issue leaving the Train. In this scenario, the Exterior Door should not close on the Passenger (which would increase their alarm), the Train Captain should be warned not to try and depart until the issue is resolved and platform staff should be alerted.*

9.25 Passenger Information System (PIS)

9.25.1 Visual displays

9.25.1.1 TTS-1380 - Saloon Display Quantity - Mandatory

The Unit shall have a minimum number of colour displays in each Saloon:

Length of Saloon, m	Minimum PIS Displays
0 - 9.9	2
10 - 14.9	3
> 15	4

Rationale: *Detailed and dynamic Passenger information should be available throughout the Unit and visible to all Passengers. Displays/m is specified instead of a higher-level requirement for information to be readable, because the content of the displays is to be developed at a later date, and the size of text is not inherent in the display design as was the case for LED dot matrix displays.*

Cross reference: *See also Requirement TTS-1388 (Screen Position) in Section 11.1.7 (PIS display position)*

9.25.1.2 TTS-2939 - Future Flexibility - Additional Saloon Display

It shall be possible to add at least one colour display to the Saloon of each Vehicle.

Rationale: *During refurbishment, the Saloon may be enlarged, or it may be decided to provide more displays.*

9.25.1.3 TTS-1410 - Colour Display Size

Each colour display in the Saloon shall have a minimum size:
- width of 600mm and 1920 pixels; and
- height of 130mm.

Rationale: *Passenger information should be visible to all Passengers. A thin, wide display is specified to enable it to be installed in the centre-ceiling.*

9.25.1.4 TTS-1861 - Visual Displays in Toilets

The PIS shall have one colour display in each Toilet.
These displays shall have a minimum diagonal size of 250mm.

Rationale: *Important information should be provided to reassure Passengers when using Toilets, for example the name of and expected time until arrival at the next station.*

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9.25.1.5 TTS-2488 - Visual Displays in Vestibules

The PIS shall have two colour displays in each Vestibule.
These displays shall have a minimum size of 500mm diagonal.

Rationale: *Important route and journey information should be provided within the Vestibules to allow Passengers to continue to receive information whilst waiting to disembark or whilst moving through the Unit. These displays can also provide detailed door opening information specific to the Exterior Doorway.*

9.25.1.6 TTS-1381 - Vehicle ID Displays Location

The PIS shall display a Vehicle ID at the following locations:
- at each end of each Saloon, on a separate display to the colour display; and
- if one Vestibule serves two Saloons, in the Vestibule at the entrance to the Saloon.

Rationale: *It should be made as clear as possible to Passengers which Vehicle they are in, e.g. "Coach G". It is anticipated that the main colour displays will be switched off between stations, and hence this information needs to be on separate displays. In addition, vehicle information should not be replaced by other information during parts of the journey.*

9.25.1.7 TTS-2940 - Vehicle ID Display Design

The Vehicle ID display shall:
- be visible at all times the Unit is in service;
- be of suitable size to be readable from the centre of the Saloon;
- display up to two alpha-numeric characters to indicate the Vehicle ID; and
- allow the Vehicle ID to change between Services.

Rationale: *The Vehicle ID will only change between services. Therefore, the display should be suitable for showing this type of semi-static information. Static information (e.g. "Coach") could be displayed by label.*

9.25.1.8 TTS-1383 - External Display

The PIS shall have an external display on or adjacent to each Exterior Door that:
- can statically display text or simple images;
- has a minimum size of 250mm diagonal;
- can display in at least four colours; and
- is readable in the full range of lighting conditions, including bright sunlight.

Rationale: *The external display is required so that wayfinding is facilitated by clear information provided to Passengers before boarding to help with Dwell Time performance. Some stations will see a large number of services, and so Passengers will need to be able to quickly confirm which service they are boarding at the doorway. Scrolling displays can be slow to read so it should be possible to display the destination and stopping points statically. The range of lighting conditions may mean that a different screen technology is required to that used inside the Vehicle. It is recognised that alternative technologies have a more limited colour range. A dot matrix display would not be suitable, because it may be necessary to show simple graphics or pictograms to indicate class of travel or type of service offering.*

9.25.1.9 TTS-1404 - Display Illumination

Illuminated displays shall adjust their brightness automatically to suit the ambient conditions.
Non-illuminated displays shall be visible in all conditions the display will encounter.

Rationale: *Visual information should be available to Passengers regardless of ambient conditions.*

9.25.2 Audio information

9.25.2.1 TTS-1402 - Audio System - Passenger Information

The PIS shall include an audio system that permits:
- the Train Captain;
- Train Crew in an Inactive Cab;
- Train Crew at a public address point;
- Train Crew at the Crew Control Point; and
- Wayside (via the GSM-R voice radio)

to address Passengers on the Train.

9.25.2.2 TTS-3382 - Audio System - Crew Communication

The PIS shall include an audio system that permits two-way communication between any pair of:
- the Train Captain;
- Train Crew in an Inactive Cab;
- Train Crew at a public address point; and
- Train Crew at the Crew Control Point,

each at any point in the Train.

Rationale: *The system shall facilitate audio communication for operational purposes between staff on the Train and on the Wayside and with Passengers. Note that Passenger communication back to the Train Captain or Train Crew is covered by the passenger alarm (section 9.23).*

Cross reference: *See also Requirement TTS-3021 (GSM-R to Authorised Person) in Section 8.10 (Voice radio)*

9.25.2.3 TTS-1408 - Audio System Priorities

The PIS shall have pre-set priorities between different types of communication including response to alarms.
Communication that does not affect Passengers shall be possible in parallel with automatic announcements.

9.25.2.4 TTS-1405 - Volume Adjustment

The PIS shall adjust the volume of its output at all locations to account for background noise levels.

Rationale: *The audibility of the audio announcements should be maintained at a suitable level. The volume required in tunnels is likely to be too loud for when the Train is in a station.*

Cross reference: *See also Requirement TTS-871 (STI PA Level) in Section 7.18.5 (Communication audibility)*

9.25.3 Automatic Information Programme (AIP)

9.25.3.1 TTS-1384 - Automatic Information Programme (AIP)

The PIS shall present an Automatic Information Programme (AIP) combining
• Service information;
• journey time updates;
• real-time travel information; and
• other on-board information.
This AIP shall be in the format of:
• a combination of static text / images and short videos / animations on the colour displays; and
• audio announcements (typically a subset of the visual information).

Rationale: *HS2 intends to provide dynamic content to passengers that delivers real-time useful information.*

9.25.3.2 The detailed content to be used in the Automatic Information Programme will be developed as part of the functional integration process defined in MSA Schedule 11. This section sets out the capability of the programme.

9.25.3.3 TTS-1401 - AIP Setup

The AIP shall be automatically selected for the Service from the Operational Diagram that the Unit is allocated to.

Rationale: *Information presented to passengers should always be relevant to their journey. Automating this set-up prevents Train Crew needing to manually set-up the programme.*

9.25.3.4 TTS-2878 - AIP Through Journey

The AIP shall present information at appropriate points of the Service, based on
• the Train's Location (Line & Distance); and
• input from the ATO On-board.

Cross reference: *See also Requirement TTS-2354 (Expected Arrival Time Information) in Section 8.6.5 (Other ATO functions)*

9.25.3.5 TTS-1601 - AIP Start / Stop

The AIP shall not be interrupted by a Train Captain activating a Cab or changing driving modes.

9.25.3.6 TTS-1412 - AIP Service Information

The Service information element of the AIP shall include:
• mandatory information about the destination and next station as required by the PRM TSI[6];
• supplementary information about the next station e.g. platform side, station information; and
• restrictions on door opening due to platform length, door failure or PEP failure, or other factors.

Rationale: *Passengers should be made aware of important information so that they can make decisions about their journey, e.g. when to get ready to disembark.*

9.25.3.7 TTS-2942 - AIP Journey Time Update

The journey time updates element of the AIP shall provide passengers with the
- location of the Unit; and
- estimated arrival time at subsequent stations.

The data for this shall be provided by the ATO On-board, C-DAS or other Wayside data sources; or estimated from Location (Line & Distance) of the Train compared with the timetable for the Service if these sources are not available.

9.25.3.8 TTS-2943 - AIP Real-time Travel Information

The real-time travel information element of the AIP shall provide status of other HS2 services and other networks at the destination of the Service (e.g. West Midlands Metro, Manchester Metrolink). This will be provided from the Wayside.

9.25.3.9 TTS-1409 - AIP Service Information

The on-board information element of the AIP shall include:
- status of toilets throughout the Unit;
- catering that is available (if applicable); and
- any out-of-service systems which directly affect the Passengers (e.g. Exterior Doors)

9.25.3.10 TTS-1385 - AIP Vehicle Differentiation

The AIP shall be capable of providing different visual and audio information in each Saloon.

Rationale: *This is to ensure information is relevant to the Passenger's specific location within the Train.*

9.25.3.11 TTS-1457 - AIP Vestibule Differentiation

The AIP shall be capable of providing different visual and audio information in each Vestibule.

Rationale: *This is intended to allow localised announcements, for example, related to Exterior Doors that will not open.*

9.25.3.12 TTS-1386 - AIP Screen Differentiation

Within a Vehicle, the AIP shall permit the visual information on the colour displays to have variations depending on the location and orientation of the screen within the Vehicle.

Rationale: *Variations could include indicating which side of the Train doors will open, which would vary depending on the orientation of the display. Alternatively this could be used to support segmentation of the Vehicle using partitions.*

9.25.3.13 TTS-1407 - AIP Screen Switch Off

When the AIP does not require any information to be displayed, the colour displays shall be switched off, with appropriate transitions between on and off and vice-versa.

Rationale: *It is proposed that screens will be blank for large parts of the journey to avoid annoying passengers. This will also highlight when important information is displayed. The transitions should appear to be intentional and should not show any visible image tearing, flickering, etc.*

9.25.3.14 TTS-1389 - AIP Staff Interface

It shall be possible for the Train Captain, Train Crew or staff on the Wayside to:

- view the current AIP;
- suspend or cancel the AIP;
- skip elements of the AIP;
- select another AIP;
- display pre-composed messages with pre-composed audio announcements; and
- compose and display text messages.

Rationale: *It may be necessary to take control of the system or to provide bespoke messages for operational reasons.*

9.25.3.15 TTS-1413 - Wayside Messages

It shall be possible for an Authorised Person on the Wayside to send a text message to be shown on the colour displays of all active Units in the Fleet or a defined subset of Units (e.g. all Units travelling south to London).

Rationale: *It may be necessary to take control of the system or to provide bespoke messages for operational reasons.*

9.25.3.16 TTS-3140 - AIP Emergency & Evacuation

The AIP shall allow pre-programmed emergency audio and visual announcements that can be triggered for different scenarios.
The emergency announcements shall apply to a Vehicle, a Unit or the whole Train.
The emergency announcement shall override other automated messages.

Rationale: *For example, messages could be displayed during evacuation of a Train or after a fire has been detected in a Vehicle.*

9.25.3.17 TTS-1390 - AIP Update

It shall be possible to update the AIP as an Operator Setting.

Rationale: *The HS2 Train Operator will need to be able to update the content of the AIP to ensure they remain relevant and in keeping with their visual identity.*

9.25.4 Wayfinding beacon system

9.25.4.1 The intention of this section is to provide requirements for a system of beacons that could be used to provide wayfinding within the trains. The primary use case for this system would be for partially sighted Passengers using audio instructions on a portable device, such as a mobile phone, however the system could provide information to all Passengers.

9.25.4.2 TTS-545 - Provision of Wayfinding Beacons

The Unit shall be fitted with a system of Bluetooth Low Energy or similar beacons at key locations within the interior to provide location information to a Passenger's wayfinding system.

Rationale: *This system provides a wayfinding system for all Passengers including those with visual impairments. It is anticipated that these beacons would be used to allow devices to provide audio and or visual guidance through the Unit.*

9.25.4.3 TTS-546 - Locations of Wayfinding Beacons

Beacons shall be installed at all key navigation points, including:
- either side of Exterior Doors;
- either side of Interior Doors;
- either side of Toilet doors;
- Gangways; and
- Catering Areas.

Rationale: *It shall be possible to locate beacons to allow provision of instructions at a suitable level of detail.*

9.25.4.4 The final location of beacons will be agreed through the interiors collaboration process defined in MSA Schedule 9, Appendix 1.

9.25.4.5 TTS-547 - Wayfinding Beacon Protocol

The beacons shall be compatible with a protocol that supports proximity detection and the provision of status information, e.g. battery level.

Rationale: *The functionality of the system should be maximised to allow its use to be developed over time.*

9.25.5 Reservation and occupancy detection

9.25.5.1 TTS-1771 - Seat Reservation System

The Unit shall have a system that shows the reservation information for each
- Seating Position;
- bike space; and
- Multi-Purpose Area.

Rationale: *The Seat Reservation System is intended to be used to provide dynamic information regarding the booking status and availability of each seat.*

9.25.5.2 TTS-2747 - Seat Reservation Display Content

The reservation system shall be able to show text information for each reservable location defined in TTS-1771.

9.25.5.3 TTS-531 - Configurability of Seat Reservation Display

The content and presentation of text on the reservation displays shall be editable as an Operator Setting.

Rationale: *It will be necessary to update presentation of information to react to passenger feedback and add new functionality.*

9.25.5.4 TTS-528 - Location of Seat Reservation Display

The reservation information for each Passenger Seat shall be displayed on or adjacent to that Passenger Seat in a way that makes clear which Passenger Seat is which.
If the associated seat is reconfigured during the life of the Unit, this facility shall be moveable with the seat to any position within the Saloon.

9.25.5.5 TTS-529 - Location of Wheelchair Space Display

The reservation information for Wheelchair Spaces shall be displayed at a height visible to a Passenger in a wheelchair.
It shall be possible to move this display without requiring new interior panelling.

Rationale: *The interior layout of the Unit must be flexible and must not be constrained by systems provided at each Seating Position.*

9.25.5.6 TTS-2969 - Location of Bike Space Displays

The reservation information for each bike space shall be positioned close to the bike space, but clear of any likely contact with the bike.
It shall be possible to move this display without requiring new interior panelling.

9.25.5.7 TTS-2981 - Multi-use Area Display

The reservation information for each Multi-Purpose Area shall be positioned close to the folding table.
It shall be possible to move this display with the table.

Rationale: *The display for the Multi-Purpose Area needs to be associated with the area in its multi-use mode.*

9.25.5.8 TTS-2945 - Automatic Reservation Set-up

The Unit shall automatically populate seat reservation displays based on the Service in the Operational Diagram.
Reservation information shall be downloaded from the Wayside.

Rationale: *Automatic set-up is considered the best way to ensure reservations are correctly loaded.*

9.25.5.9 TTS-2946 - Manual Reservation Set-up

Train Crew shall be able manually load reservation information from the Wayside without affecting the Service the Unit is allocated to.

Rationale: *The provision to manually load reservations should also be available if the automatic loading does not work or the allocation of a Unit is changed.*

9.25.5.10 TTS-527 - Live update of Seat Reservation System

The seat reservation system shall enable booking and re-booking of seats throughout the Service.
On-board displays shall update within 10 seconds of a change being made at the Wayside, provided Train to Wayside communications are available.
The Train shall confirm to the Wayside when a display has been updated.

Rationale: *Live update of reservations has become increasingly common on UK rail services.*

9.25.5.11 TTS-2204 - Seat Occupancy Detection

All Seating Positions shall be fitted with a system capable of detecting whether or not the Seating Position is occupied.
If the associated Seating Position is reconfigured during the life of the Unit, this facility shall be movable with the Seating Position to any position within the Saloon.

9.25.5.12 TTS-3369 - Seat Occupancy Functions

The data from the seat occupancy detection system shall be made available to the Train Crew and to the Wayside in real time.
It shall be possible to apply logic to the detection of occupancy based on time delays and location to allow for temporary changes in occupancy status (e.g. passengers going to a toilet).

Rationale: *This system is intended to allow reporting to the ticketing/reservation system regarding the rate of occupancy of Seating Positions and also to allow Train Crew to monitor any use of seats in segregated areas. Train Crew can confirm that booked Seating Positions are not occupied and hence release them for use, later in the Service. 'Seating Positions' is specified because it is not necessary for the same type of detection systems to be used on Passenger Seats and Wheelchair Areas, but occupancy of each is required.*

9.26 On-board CCTV

9.26.1 Requirements applicable to all CCTV Systems

9.26.1.1 TTS-1347 - Provision of CCTV System - Mandatory

The Unit shall have a CCTV System that includes:
- Forward Facing/Rear Facing (FFRF) CCTV System;
- Pantograph CCTV System;
- Interior CCTV System; and
- Cab CCTV System.

9.26.1.2 Together, these functions are referred to as CCTV Systems. It is not necessary for each function to be delivered by independent equipment.

9.26.1.3 TTS-553 - Recorded CCTV Transmission

Recordings from the CCTV Systems shall be made available to the Wayside for remote retrieval of the data at any time.
It shall be possible to select recordings from specific cameras and/or specific times for download.

9.26.1.4 TTS-552 - Live CCTV Transmission

The CCTV Systems shall allow Restricted Persons on the Wayside to view live images in real time either by selecting individual camera locations on a Train or scrolling automatically through all camera locations.

Rationale: *The HS2 Train Operator will need to be able to monitor Units remotely to assist in the response to incidents.*

9.26.1.5 TTS-554 - On-board Viewing of Live Images

The CCTV Systems shall allow Authorised Persons on-board the Train to view live images in real time either by selecting individual camera locations on a Train or scrolling automatically through all camera locations.

Rationale: *Train Crew may need to be able to access images as appropriate to carry out their duties.*

9.26.1.6 TTS-555 - On-board Viewing of Recorded Images

The CCTV Systems shall allow Restricted Persons to select and view recorded images on board the Train.

Rationale: *Train Crew may need to be able to access images as appropriate to carry out their duties.*

9.26.1.7 TTS-557 - Retrieval of Recordings On-board Using Laptop

Recordings from the CCTV Systems shall be able to be manually retrieved by a Restricted Person by connecting a laptop at any one of the maintenance ports on the Train, via a standard interface.

9.26.1.8 TTS-558 - Retrieval of Storage Media from Unit

CCTV storage media shall be manually removable from the Unit by Restricted Persons. The removable storage media will be an item of Special Operator Equipment.

9.26.1.9 TTS-559 - Viewings do not Interrupt Recording

Monitoring / viewing of live and recorded images from the CCTV Systems shall not interfere with the continuous recording of images by any of the CCTV Systems.

9.26.1.10 TTS-561 - Metadata Encoding

All CCTV images shall include metadata to allow the Unit number/ID, camera location, Unit Location (Line & Distance), time and date to be determined.

Rationale: *It should be possible to ascertain the key information related to that recording when reviewing images, or to search for images based on known metadata.*

9.26.1.11 TTS-562 - Frame Rate

All CCTV images shall be recorded at a frame rate suitable for their use. This shall not be less than 25 frames per second.

9.26.1.12 TTS-563 - Image Quality

The CCTV Systems shall be capable of capturing, live streaming, displaying and recording images at FHD resolution (1920 × 1080 progressive) or better.
The frame rate and resolution of live images streamed to the Wayside shall be adapted to the available bandwidth.

Rationale: *Recordings need to be of sufficient quality to be fit for purpose.*

9.26.1.13 TTS-1345 - Reproduction of Still Images

The images recorded by the CCTV Systems should be capable of being reproduced as still images.

Rationale: *This is one of the preferred means of presenting evidence during investigation or inquiries.*

9.26.1.14 TTS-573 - Confirm Live Images

Images from all CCTV Systems shall include a 'heart beat' / 'life sign' visual indication that is generated at the camera and visible when viewing the image.

Rationale: *The presence of frozen images must be obvious to the user, so that the user can confirm the images are in real time.*

9.26.1.15 TTS-564 - Time for Storage if Images

All CCTV images shall be stored for a minimum of 28 days.

9.26.1.16 TTS-1741 - Display of CCTV Images on PIS Displays

It shall be possible to display images from the CCTV Systems on internal PIS displays.
It shall be possible to display these images with a time delay which can be configured as an Operator Setting.

Rationale: *For example this capability could be used to provide comfort that luggage is safe when left in luggage stacks or a view from the Forward Facing CCTV cameras*

9.26.1.17 TTS-1743 - Impact of Camera Failure

Failures of or damage to any camera shall not impact the operation of any other camera.

Rationale: *It should not be possible for a failure of a camera or malicious damage to a camera to prevent other cameras from operating.*

9.26.1.18 TTS-567 - Evidential Continuity

Recording and retrieval of CCTV recordings shall provide a secure and auditable trail of evidence that satisfies the requirements of evidential continuity to prove that the data has not been tampered with in any way.

Rationale: *It must be possible to provide images to support investigations by police and security services.*

9.26.1.19 TTS-1198 - Resistance to Tampering

All CCTV camera installations shall be resistant to tampering and vandalism.

9.26.2 FFRF CCTV

Cross reference: *See also Requirement TTS-1579 (Reverse Driving CCTV) in Section 8.8 (Shunting)*

9.26.2.1 TTS-1343 - Performance in All Lighting Conditions

The FFRF CCTV System shall operate in, and automatically compensate for, all lighting conditions, day or night, including rapid changes associated with high speed operation.

9.26.2.2 TTS-595 - FFRF Long Range Coverage

The FFRF CCTV System cameras shall be capable of recording images of track, signals, overhead catenary, and the lineside. As a minimum this should encompass the view seen by the Train Captain.

9.26.2.3 TTS-596 - FFRF Auto-coupler View

The FFRF CCTV System shall provide images that include a view of the auto-coupler of the Unit.

9.26.2.4 TTS-3441 - FFRF Short Range View

The FFRF CCTV System shall provide images that include a view of the area up to 5m in front of the auto-coupler plane.

Rationale: *This supports manual coupling. It is assumed a separate camera would be required for this function.*

9.26.2.5 TTS-593 - When Images are Recorded - FFRF

The FFRF CCTV System shall be active and shall record images from the front and rear of the Train at all times when the Units are not in a Shut-down State.

9.26.2.6 TTS-597 - Keep FFRF Cameras Clear

A means shall be provided to automatically keep all FFRF CCTV camera views clear and free from obstructions such as water, snow, ice, plant detritus and insects.

9.26.2.7 TTS-1197 - Train Captain Marker (FFRF)

The FFRF CCTV System shall include functionality to allow the Train Captain to electronically mark the recording to note a feature for further investigation.
The recording of this marker shall be reported to the Wayside.

9.26.3 Pantograph CCTV

9.26.3.1 TTS-601 - View of Raised Pantograph

The Pantograph CCTV System shall provide images showing the full width of each pantograph and its interaction with the overhead contact wire.

9.26.3.2 TTS-602 - View of Stowed Pantograph

The Pantograph CCTV System shall provide images showing each pantograph in the stowed position.

9.26.3.3 The images described in TTS-601 and TTS-602 do not need to be recorded by the same camera.

9.26.3.4 TTS-1419 - Performance in All Lighting Conditions

The Pantograph CCTV System shall operate in, and automatically compensate for, all lighting conditions, day or night, including rapid changes associated with high speed operation.

9.26.3.5 TTS-3067 - Pantograph Light Configuration

It shall be possible to configure, via a Software Update, the operation of lights provided for Pantograph CCTV cameras to account for:
- time of day; and
- whether or not the pantograph is raised.

Rationale: *If a Unit has four pantographs, there could be a significant amount of light on the roof which could be distracting for other railway users or neighbours of the railway or wildlife.*

9.26.3.6 TTS-603 - When Images are Recorded - Pantograph

The Pantograph CCTV System shall be active and shall record at all times when the Unit is not in a Shut-down State.

9.26.3.7 TTS-1420 - Train Captain Marker (Pantograph)

The Pantograph CCTV System shall include functionality to allow the Train Captain to electronically mark the recording to note a feature for further investigation.
The recording of this marker shall be reported to the Wayside.

9.26.4 Interior CCTV

9.26.4.1 TTS-609 - When images are recorded - Saloon

The Interior CCTV System shall be active and shall record at all times when the Unit is not in a Shut-down State.

9.26.4.2 TTS-2502 - Interior CCTV - Light Adjustment

The Interior CCTV shall operate in, and automatically compensate for all lighting conditions including the range of internal lighting defined in this TTS and the range of ambient daylight.

9.26.4.3 The following coverage requirements do not require separate cameras for each requirement - a single camera may satisfy multiple requirements depending on the layout.

9.26.4.4 TTS-608 - Interior CCTV Coverage - Saloon

The Interior CCTV System shall provide an overall coverage of at least 90% of the Saloon area.

9.26.4.5 TTS-605 - Interior CCTV Coverage - Exterior Doors

The Interior CCTV System shall provide a clear unobscured interior view of each Exterior Doorway and the area around it.

Rationale: *Note that this view is not intended to be used to dispatch the Train. It may be used if an Exterior Door fails to shut or if an Emergency Egress Device is activated.*

9.26.4.6 TTS-607 - Interior CCTV Coverage - Gangway

The Interior CCTV System shall provide a clear unobscured view to observe activity in the Gangway.

9.26.4.7 TTS-3203 - Interior CCTV Coverage - Bulk Luggage Storage

The Interior CCTV System shall provide a clear unobscured view to observe activity around the Bulk Luggage Storage Areas.

9.26.4.8 TTS-606 - Interior CCTV Coverage - Alarms

The Interior CCTV System shall provide a clear unobscured view of the area around all Passenger Alarms and Call For Aids, except Call For Aids in Toilets, to observe activity in that area.

9.26.4.9 TTS-2218 - Interior CCTV Coverage - Toilet Doors

The Interior CCTV System shall provide a clear unobscured view of each Toilet door to allow people to be identified entering or leaving the Toilet.

9.26.4.10 TTS-2219 - Interior CCTV Coverage - Catering Areas

The Interior CCTV System shall provide an overall coverage of 80% of any Catering Areas.

9.26.4.11 TTS-2231 - Interior CCTV - Viewing Resolution

The Interior CCTV System shall support the following viewing resolutions:

Location	Resolution - Live	Resolution - Forensic
Vestibules and Gangways	Observe	Identify
Passenger Doors	Recognise	Identify
Toilet doors	Observe	Identify
Saloon	Observe	Observe
Catering Areas	Recognise	Identify

'Resolution - Live' indicates the image size provided to a security control room operator monitoring the images live, measured in %Rotakin. The standard Rotakin values are utilised:

- Identify – 100%
- Recognise – 50%
- Observe – 25%
- Detect – 10%
- Monitor – 5%

'Resolution - Forensic' indicates the image sized provided to an operator monitoring the images forensically where higher resolution pictures can be zoomed in to to get the full resolution of the image. The following values are utilised:

- Identify - >4mm per pixel
- Recognise - >8mm per pixel
- Observe - >16mm per pixel
- Detect - >40mm per pixel
- Monitor - >80mm per pixel

Rationale: *This requirement is intended to define the minimum resolutions of images for both the Live viewing, i.e. full camera image shown on screen and Forensic viewing, i.e. when the image has been zoomed in on a specific area.*

9.26.4.12 TTS-1186 - Future Flexibility - Interior CCTV Coverage - Movable Cameras

The Interior CCTV System shall include a minimum of two additional cameras per Vehicle that can be positioned and moved to a number of locations within the Saloon.
The repositioning of these cameras shall be possible in the depot environment.

Rationale: *The CCTV System must be able to account for changes in the Saloon layout through the life of the Units. For example if extra luggage stacks are added, it may be necessary to place cameras adjacent to these stacks.*

9.26.5 Cab CCTV

9.26.5.1 TTS-2012 - When Images are Recorded - Cab

The Cab CCTV System shall record at all times when the Unit is not in a Shut-Down State. It shall be possible, as an Operator Setting, to configure the Cab CCTV System to record based on whether the Cab is an Active Cab or Inactive Cab.

Rationale: *The provision and use of this CCTV system would be quite novel and will need agreement on exactly how it is used and at what times.*

9.26.5.2 TTS-2013 - Cab CCTV Coverage

The Cab CCTV System shall provide a view of the cab desk and controls, and the Train Captain's seated position.

Rationale: *The goal of this requirement is to be able to see how the Train Captain uses the cab controls.*

9.27 Infrastructure Monitoring

9.27.1 Monitoring equipment to be fitted to all Units

9.27.1.1 TTS-2837 - Fitment of Accelerometers

A minimum of one Vehicle on all Units shall be fitted with accelerometers for detection of poor track geometry (and therefore ride comfort) and track quality issues.

Rationale: *This system is intended to provide early warning of issues on the infrastructure and to allow investigation of passenger comfort issues.*

9.27.1.2 TTS-2838 - Location of Accelerometers

On the Vehicle fitted with accelerometers (TTS-2837), at least one set of Running Gear and the Carbody shall be instrumented for measurements.

Rationale: *This is intended to allow for complete investigation of accelerations experienced by axles, primary and secondary sprung structures.*

9.27.1.3 TTS-2839 - Running Gear Accelerometers - Axle Box Fitment

The instrumented Running Gear shall include a vertical accelerometer on each end of the axle for one pair of wheels and a lateral accelerometer at one end of each axle for a pair of wheels, all mounted on the axle boxes.

9.27.1.4 TTS-2840 - Bogie Accelerometers - Bogie Frame Fitment

If the Running Gear is a bogie, a tri-axial accelerometer shall be fitted near to both the leading and trailing extremities of the bogie, one on each side, diagonally opposite each other on the bogie structure.

9.27.1.5 TTS-2845 - Carbody Accelerometers

Tri-axial accelerometers shall be fitted at both ends of the Carbody, level with the top of Passenger Seat bases, diagonally opposite each other.

9.27.1.6 TTS-1976 - Axle Box Accelerometer Accuracy

Axle box-mounted accelerometers shall measure inputs with a minimum frequency range of 0.2Hz to 10000Hz and a minimum dynamic range of ±1000m/s^2.

9.27.1.7 TTS-3159 - Bogie Frame Accelerometer Accuracy

Bogie frame-mounted accelerometers shall measure inputs with a minimum frequency range of 0Hz to 1000Hz and a minimum dynamic range of ±50m/s^2.

9.27.1.8 TTS-3158 - Carbody Accelerometer Accuracy

Carbody-mounted accelerometers shall measure inputs with a minimum frequency range of 0Hz to 250Hz and a minimum dynamic range of ±10m/s^2.

9.27.1.9 TTS-2842 - Accelerometer Data Processing

Data from the accelerometers shall be conditioned, filtered and processed on-board the Unit.

Rationale: *The data needs to be processed to allow the end user to be able to make decisions. Therefore processing is likely to include, for example, low and high-pass filtering, removal of spurious and incomplete data, conversion to displacement information before being transferred to the Wayside for more in depth analysis, such as trending and prediction.*

9.27.1.10 TTS-2843 - Accelerometer Alert Reporting

When the accelerometer data presents parameters which are outside defined threshold levels, notifications shall be sent to the Wayside.
The thresholds shall be configurable as Operator Settings.

Rationale: *This is intended to allow investigations to commence as soon as possible.*

9.27.1.11 TTS-2841 - Accelerometer Data Metadata

Data recorded by the accelerometers shall include the following metadata:
- Unit ID;
- Unit Location (Line & Distance);
- Unit speed;
- direction of travel;
- the routes travelled against the Operational Diagram; and
- date and time.

Rationale: *This data is intended to assist in the review of downloaded data.*

9.27.2 Equipment fitted to IM Units

9.27.2.1 A proportion of the Units will have Infrastructure Monitoring (IM) equipment fitted, i.e. the **IM Units**.

9.27.2.2 TTS-3152 - Equipment Fitted to IM Unit - Mandatory

The IM Unit shall include the following additional systems:
- Unattended Geometry Measurement System (UGMS);
- Unattended Overhead Measurement System (UOMS); and
- Signalling and Radio Frequency Monitoring System.

9.27.2.3 TTS-2505 - Provision for IM Fitment

All Units other than the IM Units shall have provision for the fitment of all IM systems. This provision shall include all mounting locations and cabling required to allow the IM systems to be fitted in the depot environment.

Rationale: *The HS2 Infrastructure Manager wishes to retain the flexibility to increase the number of IM Units (via the Purchaser) at a later date.*

9.27.2.4 TTS-2504 - IM Self Calibration

The infrastructure monitoring system shall be self-calibrating. Cyclical compliance checks to ensure calibration shall be carried out using run-on-run comparisons.

9.27.2.5 TTS-3302 - IM No On-board Control

The infrastructure monitoring system shall not require any control by the Train Captain or Train Crew.

9.27.2.6 TTS-611 - IM Self Maintenance

The infrastructure monitoring system shall not require maintenance attention other than within the regular maintenance cycles of the Unit.

9.27.2.7 TTS-612 - IM Data Recording

The IM Unit shall be capable of storing all IM Train Data for a minimum of 30 days' continuous recording of all parameters during normal operations.

Rationale: *Recordings should be retained for a sufficient period to allow for any issues with data download to the Wayside.*

9.27.2.8 TTS-2520 - IM Data Download - Regular

The IM Unit shall automatically communicate recorded IM Train Data to the Wayside at appropriate intervals.

Rationale: *IM Train Data should be regularly made available to the Wayside to enable maintenance interventions where necessary.*

9.27.2.9 TTS-2521 - IM Data Download - Triggered

It shall be possible for a download of IM Train Data on an individual IM Unit or all IM Units to be triggered from the Wayside.

Rationale: *Maintenance investigations may require the most up to date data to be downloaded when necessary.*

9.27.2.10 TTS-2507 - IM Data Metadata

IM Train Data recorded by the IM Unit shall include the following metadata:
- Unit ID;
- Unit Location (Line & Distance); direction of travel;
- Unit speed;
- the routes travelled against the train diagram; and
- date and time.

Rationale: *This data is intended to assist in the review of downloaded data.*

9.27.2.11 TTS-2508 - IM Data Collection Speed

It shall be possible to collect all IM Train Data at any speed up to Maximum Line Speed.

Rationale: *Monitoring should be possible at all times by the IM Units.*

9.27.3 Unattended Geometry Measurement System (UGMS)

9.27.3.1 TTS-2509 - UGMS Parameters

The UGMS shall be capable of measuring the following parameters:

Track Geometry Parameter	Repeatability of Geometry Signal	Resolution of data
3m Tw3m (track twist)	± 1mm	0.1mm
10m Vertical Alignment (left and right rail)	± 1mm	0.1mm
35m Vertical Alignment (left and right rail)	± 1mm	0.1mm
70m Vertical Alignment (mean)	± 2mm	0.1mm
120m Vertical Alignment (mean)	± 2mm	0.1mm
10m Horizontal Alignment (left and right rail)	± 1mm	0.1mm
35m Horizontal Alignment (left and right rail)	± 1mm	0.1mm
70m Horizontal Alignment (mean)	± 2mm	0.1mm
120m Horizontal Alignment (mean)	± 2mm	0.1mm
Gauge (track)	± 1mm	n/a
Cross-level	± 1mm	0.1mm
Cant Deviation	± 1mm	0.1mm
Curvature/Versine	± 1mm	0.1mm

9.27.3.2 TTS-1977 - UGMS Data Spacing

Data shall be processed on-board the IM Unit and track geometry information shall be provided at 0.2m spacing.

9.27.3.3 TTS-1974 - UGMS Alert Reporting

When an IM Unit detects track geometry parameters which are outside defined threshold levels, notifications shall be sent to the Wayside.
The thresholds shall be configurable as Operator Settings.

Rationale: *This is intended to allow investigations to commence as soon as possible.*

9.27.4 Unattended Overhead Measurement System (UOMS)

9.27.4.1 TTS-3335 - UOMS Fitment

All pantographs on the IM Unit shall be fitted with an Unattended Overhead Measurement System (UOMS).

9.27.4.2 TTS-616 - UOMS Contact Quality Measurement

The UOMS shall monitor the overhead line contact quality in accordance with EN 50317[62].

9.27.4.2 Note that all Units will have CCTV cameras monitoring the pantograph.

Cross reference: *See also Section 9.26.3 (Pantograph CCTV)*

9.27.4.4 TTS-2524 - UOMS Parameters

The UOMS shall be capable of measuring the following parameters:

UOMS parameter	Accuracy	Recording frequency
Vertical contact wire position	±10mm	20Hz
Horizontal contact wire position	±5mm	20Hz

9.27.4.5 TTS-2525 - UOMS Data Correction

The UOMS shall be capable of correcting data for the aerodynamic and inertial impact of the measuring equipment.

9.27.4.6 TTS-3155 - UOMS Alert Reporting

When an IM Unit detects overhead parameters which are outside defined threshold levels, notifications shall be sent to the Wayside.
The thresholds shall be configurable as Operator Settings.

Rationale: *This is intended to allow investigations to commence as soon as possible.*

9.27.5 Signalling and Radio Frequency Monitoring System

9.27.5.1 TTS-619 - GSM-R Transmission Quality Monitoring

The Signalling and Radio Frequency Monitoring System shall conduct a continuous diagnostic evaluation of the quality of data and voice transmission of the GSM-R system.
When an IM Unit detects issues, notifications shall be sent to the Wayside, including location data.
The thresholds shall be configurable as Operator Settings.

9.27.5.2 TTS-2280 - Eurobalise Health Monitoring

The Signalling and Radio Frequency Monitoring System shall monitor the Eurobalise status of the CCS trackside equipment and detect faults related to transmission of data or issues with the data transmitted to Units.
When an IM Unit detects issues, notifications shall be sent to the Wayside, including location data.
The thresholds shall be configurable as Operator Settings.

Rationale: *This requirement contributes to the overall target for HS2 reliability and availability. Diagnostic information may include Eurobalise 'health' status as well as radio status on both the HS2 Network and CRN.*

9.27.5.3 TTS-2514 - TPWS Equipment Monitoring

The Signalling and Radio Frequency Monitoring System shall record the frequency and signal strength being transmitted from TPWS standard loops and TPWS miniature loops fitted in the track.
When an IM Unit detects issues, notifications shall be sent to the Wayside, including location data.
The thresholds shall be configurable as Operator Settings.

9.27.5.4 TTS-2516 - AWS Equipment Monitoring

The Signalling and Radio Frequency Monitoring System shall record the magnetic field strength and polarities created by the AWS equipment.
When an IM Unit detects issues, notifications shall be sent to the Wayside, including location data.
The thresholds shall be configurable as Operator Settings.

9.28 Automatic vehicle identification tag

9.28.1 TTS-1043 - AVI Tags

The Unit shall be fitted with AVI tags in accordance with HS2-NRL-RR-SPE-000-000002[119].

Rationale: ***CRN interface -*** *This is necessary for compatibility with infrastructure-based monitoring systems.*

9.29 Maintenance and servicing

9.29.1 Train preparation

9.29.1.1 TTS-2041 - Automated Fit for Service Check

The Unit shall be capable of undertaking an automated check that confirms the Unit is Fit for Service.
The Unit shall check all aspects of the Unit that can reasonably be checked automatically.
It shall be possible to initiate this check automatically at a specific time, on-board, or from the Wayside.

Rationale: *This check is intended to allow the Operator and/or Train Captain confirm that the requirements of TSA Schedule 5, Appendix 3 'Meaning of Fit for Service' have been met before a Train enters service.*

9.29.1.2 TTS-1824 - Fit for Service Certificate Review

The Unit shall record a Fit for Service 'certificate'.
The certificate shall include a timestamp and shall expire after a configurable amount of time.
When a Train Captain logs in to a Train, the current Fit for Service certificates of all Units in the Train shall be displayed to the Train Captain.

Rationale: *This is intended to allow a Train Captain taking over a Train to confirm (if necessary) that the Units within a Train were Fit for Service.*

9.29.2 Consumable / waste monitoring

9.29.2.1 TTS-1543 - Monitoring of Consumables / Tanks

The Unit shall monitor the levels of all consumables that are replenished as part of servicing (e.g. windscreen washer fluid or fresh water) and levels of grey water / solid waste tanks that require emptying.
This information shall be reported by the Unit to the Wayside.

9.29.2.2 TTS-2182 - External Tank Level Indication

When the Unit is in Servicing State, each Vehicle shall display on its external PIS displays information about the levels of all tanks / containers containing consumables or grey water / solid waste.

Rationale: ***Depot interface -** During servicing, consumables will need to be refilled and waste tanks emptied. It will assist staff if they can see whether a tank needs filling / emptying on a display local to the tank itself. Given the aerodynamic skirts and covers, it is unlikely that displays on tanks themselves will be visible on the exterior of the Unit. Therefore, use of external PIS displays is proposed as a way of presenting this information. The information would need to be readable from track level so would need to be simple and clear, probably just identifying which tanks need attention.*

9.29.3 Software update

9.29.3.1 TTS-2482 - Update Software for Fleet

It shall be possible to make a Software Update to the Fleet from the Wayside for all non-safety critical application software.

Rationale: *Software Updates may be made to individual Units for the purpose of testing, but should then be implemented across the Fleet.*

9.29.3.2 TTS-3069 - Update Software from Wayside

Access to upload software to Units shall be controlled to ensure that appropriate configuration control is maintained for each software element.

Rationale: *This is in addition to the configurable 'Operator Settings'. It must be possible to update software versions without having to take a laptop to each Unit, or each controller on a Unit. This is* *necessary to ensure timely updates and to manage configuration across the fleet. It is recognised that some elements of software on the Unit can only be updated locally.*

9.29.4 Maintenance laptop access

9.29.4.1 TTS-2533 - Train Control Maintenance Ports

The Unit shall include a minimum of four maintenance ports, of which one shall be in each Cab. These ports shall allow a Maintenance Technician to connect a laptop for the purposes of diagnostic investigations, data downloads, software uploads, etc. It shall be possible to connect to all systems on the Unit from any maintenance port, except where it can be demonstrated that there are safety or security justifications for limiting this functionality.

Rationale: *This is intended to allow local connection to the Unit or its systems to allow maintenance, testing or configuration changes to be carried out without having to move to multiple locations within the Unit.*

9.29.4.2 TTS-2210 - Train-Computer Hardware Interfaces

The maintenance ports to allow connection of computers to the Unit shall be directly compatible with an industry standard laptop PC so that bespoke interfacing hardware such as special leads, interface boxes and dongles shall not be required between them.

Rationale: *This requirement intends to mitigate the risk of needing to maintain a store of legacy computer equipment.*

9.29.4.3 TTS-2209 - Train-Computer Software Interfaces

Software used to interact with the Unit and any of its subsystems shall operate using a standard, commercially available operating system and shall allow for computers used by staff to be upgraded to future operating systems.

Rationale: *This requirement intends to mitigate the risk of needing to maintain a store of legacy computer equipment. It is envisaged that this could be achieved using interfaces based on web browser accessible applications.*

9.30 Horns

See also LOC&PAS TSI[4] §4.2.7.2 and GM/RT2131[86]

9.30.1 TTS-628 - Horn

With reference to LOC&PAS TSI[4] Section 4.2.7.2.2, the horn shall have two volumes: • a 'loud' horn compliant with EN 15132-2[42] Clause 5.2.2; and • a 'soft' horn compliant with EN 15132-2 Appendix D.

Rationale: *The UK specific case of a lower horn volume is not suitable for high speed operation. However, the loud horn volume is potentially too loud for some operation on the CRN. This is implementing GM/RT2131[86] Clause 2.2.1.*

9.30.2 TTS-1778 - Automatic Volume Varying

The horn volume shall automatically switch between loud and soft based on the speed the Train is travelling.
It shall be possible to change the speed of transition as Software Update.

Rationale: *This requirement is mandating GM/RT2131[86] Clause 2.2.2.*

9.30.3 TTS-630 - Depot Warning Device

The Unit shall have a warning device of suitable volume for use in the depot.

Rationale: *Normal horns are too loud to be used in the depot environment. The Train Captain can select the appropriate warning device depending on the Unit's location.*

9.30.4 TTS-1784 - Warning in Reverse

When the Train is being reversed, and only when it is being reversed, it shall be possible to sound the horn and/or depot warning device at the rear of the Train from the front Cab.

9.31 Exterior lights

See also LOC&PAS TSI[4] §4.2.7.1 and GM/RT2131[86]

9.31.1 TTS-631 - Automatic Lights

The Unit shall enable head, marker and tail lights to be automatically set based on the Active Cab location and Train formation.

9.31.2 TTS-1780 - Automatic Day / Night Headlights

The Unit shall automatically switch between day-time and night-time headlights based on ambient light levels.

9.31.3 TTS-1779 - Manual Lighting Control

The Unit shall enable the Train Captain to switch off automatic control of the exterior lights and manually set the lights.
The Unit shall revert to automatic control of lights when the Train Captain logs out of the Unit.

9.31.4 TTS-1783 - Reverse Lighting

When the Unit is moved in the reverse direction, it shall display head and tail lights in a non-standard pattern.

Rationale: *This is to highlight that the Train is moving in an unusual way, and that the Train Captain does not have full visibility. The exact arrangement will be agreed during design but may include flashing.*

9.32 Toilets and Sanitary Systems

See also section 9.16 for toilet design requirements

9.32.1 TTS-1064 - Availability Status of Toilets - on Module

The availability status of the Toilet:
- available;
- occupied; or
- out-of-service,

shall be displayed on the outside of each Toilet, close to the door, in both text and pictograms.
Availability status shall be visible on approach to the Toilet in any direction.

Rationale: *This is to provide clarity to the full range of users as to whether the Toilet is available. Users complain that they cannot determine whether Toilets are out of use or occupied and that indications are not in an appropriate location. Availability should be visible on approach from any direction which may require more than one indicator to be used.*

9.32.2 TTS-693 - Availability Status of Toilets - in Saloon

The availability status (available, occupied or out-of-service) of the next Toilet along the Unit shall be displayed at each end of each Saloon.

Rationale: *This is to provide clarity whilst still in the Saloon as to the location of the nearest Toilet and whether the Toilet is available.*

9.32.3 TTS-2503 - Audible Status Announcement

When a passenger presses external access controls of an occupied or out-of-service Toilet, an audible message confirming the Toilet is unavailable shall be played in the vicinity of the toilet module.

Rationale: *This is to provide information for visually-impaired passengers. It is assumed that only Universal Access Toilets will have powered doors with controls, but powered doors may be provided for Standard Toilets as well.*

9.32.4 TTS-2157 - Availability Status of Toilets - through Unit

It shall be possible to display availability of all Toilets (free, occupied or out-of-service) in the Unit on the colour displays.

Rationale: *This enables passengers to better see where an available toilet is located.*

9.32.5 TTS-1068 - Occupation Timer

If a toilet module has remained occupied for more than a configurable amount of time, an Event shall be raised for Train Crew and an indication shall be provided on the exterior of the toilet to alert a member of staff.
This time shall be an Operator Setting.

Rationale: *This function is to alert Train Crew to Passengers that may need assistance or to possible fare evasion. The alert does not need to be a dedicated warning indicator but could be a combination of other indicators.*

9.32.6 TTS-2641 - Grey Water Release

The Unit shall only release 'grey' water when the Unit is stationary and the Unit is at defined Locations (Line & Distance).

Rationale: ***HS2 interface*** *- 'Grey' water released from bio-reactor Sanitary Systems cannot be dropped while the Unit is in motion as the sprayed water may cause corrosion. The water can only be dropped at 'tanked' locations where the water will enter a sewer and not the environment.*

Cross reference: *See also Requirement TTS-3342 (Drain Grey Water) in Section 7.23.3 (Access for servicing tasks)*

9.33 Interior lighting

Cross reference: *See also Section 10.20 (Interior lighting)*

9.33.1 Lighting states and levels

Cross reference: *See also Section 9.7.2 (Operational states)*

9.33.1.1 TTS-2050 - Passenger Service Lighting

When the Unit is in Passenger Service State, lighting shall be provided to meet the requirements of section 10.20 of this TTS and all reading lights shall be available.

9.33.1.2 TTS-1097 - Servicing State Lighting

When the Unit is in Servicing State, maximum lighting shall be provided from all luminaires in all parts of the Unit.

Rationale: *Maximum lighting levels are required for cleaning and maintenance tasks.*

9.33.1.3 TTS-1111 - Stand-By State Lighting

When the Unit is in Standby State, a reduced level of lighting shall be provided.
The lighting levels and time period shall be Operator Settings.

Rationale: *This is intended to reduce energy consumption and improve luminaire lifetimes by reducing lighting when not required.*

9.33.1.4 TTS-1035 - Shut-down State Lighting

When the Unit is in Shut-down State, all lighting shall be switched off.

Rationale: *This is intended to reduce energy consumption and improve luminaire lifetimes by reducing lighting when not required.*

9.33.1.5 TTS-1089 - Interior Lighting Zones

The interior lighting in passenger areas shall be divided in to zones allowing the lighting performance to be configured separately in each zone.
The zones shall be as follows:

- at Seating Positions - split into two half-Saloons;
- low-level lighting below Seats;
- along the aisle of the Saloon - split into two half-Saloons;
- ceilings in the Saloon - split into two half-Saloons;
- Vestibules;
- Toilets;
- Gangways; and
- Catering Areas.

Rationale: *The lighting concept should improve the Passenger experience and allow different areas of the Unit to be differentiated. This may be in response to the Vehicle designation, geographic location of the Unit or other inputs.*

9.33.1.6 TTS-1462 - Switch Off lighting

It shall be possible for Train Crew or the Wayside to switch off lighting in any zone on a per-Vehicle basis.

Rationale: *This functionality is intended to be used if for any reason a particular Vehicle is not in use.*

9.33.1.7 TTS-753 - Seating Position Lighting Illuminance Adjustment

It shall be possible to vary the nominal illuminance level at Seating Positions between 100 lux and 250 lux on a half-Saloon basis, as an Operator Setting. It shall be possible to adjust each zone as a temporary Operator Setting received from the Wayside or from Train Crew. This shall revert to the standard setting at the end of the Service.

9.33.1.8 TTS-1103 - Aisle Lighting Illuminance Adjustment

It shall be possible to vary the nominal lighting illuminance along the Saloon aisle at floor level between 50 lux and 200 lux on a half-Saloon basis, as an Operator Setting. It shall be possible to adjust each zone as a temporary Operator Setting received from the Wayside or from Train Crew. This shall revert to the standard setting at the end of the Service.

9.33.1.9 TTS-3146 - Future Flexibility - Aisle Lighting Seating Adjustment

It shall be possible to adjust the lighting in the aisle zone to account for changes between HS2 Seats and Premium Seats.

Rationale: *Seating may be configured in a '2+2' or '2+1' configuration which will adjust the position of the aisle. Control is required to allow the lighting illuminance to account for this change.*

9.33.1.10 TTS-757 - Toilet Lighting Illuminance

It shall be possible to vary the nominal lighting illuminance in Toilets on a per-Toilet basis, between 150 lux and 250 lux, as an Operator Setting.

Rationale: *It should be possible to tune the lighting experience to provide the best possible passenger experience.*

9.33.1.11 TTS-759 - Vestibule Lighting Illuminance

It shall be possible to vary the nominal lighting illuminance in Vestibules between 75 lux and 250 lux on a per-Vestibule basis, as an Operator Setting.

Rationale: *The lighting concept should improve the Passenger experience and different areas of the Unit to be differentiated. This may be in response to the Vehicle designation, geographic location of the Unit or other inputs.*

9.33.1.12 TTS-1855 - Lighting Arrangement in Saloon - Low Level Lighting

It shall be possible to vary the nominal lighting illuminance of low-level lighting between 0 lux (i.e. off) and 50 lux on a half-Saloon basis, as an Operator Setting.

Rationale: *This lighting is intended to be used to reduce shadowing below seats and create more complex lighting scenes that, for example, use different colour temperatures at low level to increase the feeling of vertical space within the saloon.*

9.33.1.13 TTS-2965 - Illuminance Variation by Location

It shall be possible to vary the illuminance of lighting across all zones due to the Location (Line & Distance) of the Train.

Rationale: *This would permit lighting to be adjusted on the approach to stations - e.g. low level lighting may be enhanced at these points to remind Passengers not to leave belongings behind.*

9.33.1.14 TTS-754 - Adjustment of Lighting Colour Temperature

It shall be possible to vary the lighting correlated colour temperature between 2700 K and 6500 K in each lighting zone (TTS-1089) of each Vehicle, except ceiling (see TTS-756), as an Operator Setting.
It shall be possible to adjust each zone as a temporary Operator Setting received from the Wayside or from Train Crew.
This shall revert to the standard setting at the end of the Service.

9.33.1.15 TTS-756 - Ceiling Lighting - Colour Adjustment

It shall be possible to vary the colour of each ceiling zone of each half-Saloon in an RGBW spectrum, as an Operator Setting.
It shall be possible to adjust each zone as a temporary Operator Setting received from the Wayside or from Train Crew.
This shall revert to the standard setting at the end of the Service.

Rationale: *The ceiling lighting is intended to illuminate and accent any key parts of the ceiling rather than provide lighting for Passengers to read, work etc. Changing the colour will allow a different 'feel' to be achieved in different parts of the Unit.*

9.33.1.16 TTS-2464 - Ceiling Lighting - Response

It shall be possible to set the ceiling lighting to change colour or illuminance in response to:
- the Location (Line & Distance) of the Train; and
- certain Events on-board.

Rationale: *For example, the ceiling lighting could be used to indicate when the Train is approaching a station or change of time of day.*

9.33.1.17 TTS-752 - Adjustment of Lighting Level Based on Ambient Light Level

The lighting in each zone shall automatically adjust based on the ambient lighting conditions. The automatic adjustment of lighting shall be designed to take in to account the rapid changes between tunnel operation and surface operation.
This adjustment shall be separately configurable for each zone via Operator Settings.
It shall be possible to disable this feature on a per Vehicle basis via Operator Settings.

Rationale: *The desired lighting level should be maintained as far as possible within the changing ambient lighting levels expected to be experienced.*

9.33.1.18 TTS-1853 - Transitions Between Lighting Levels

When lighting illuminance or colour temperature are adjusted it shall be possible to configure the transition to allow for sudden or gradual changes between the levels.

Rationale: *Transitions between lighting levels and colour should not be noticeable, to present a calm and comfortable environment to Passengers. This may require transitions to take place over a number of minutes, except in instances where a quicker response may be required, such as entering tunnels during the day (when the ambient conditions present a sudden change) or an immediate response, such as emergency situations.*

9.33.1.19 TTS-1499 - Loadshed Lighting

When lighting is reduced following the loss of 25kV supply, the lighting shall transition between different levels such that there are no instantaneous, significant reductions in lighting.

Cross reference: *See also Requirement TTS-1176 (180-Minute Auxiliary Supply) in Section 7.7 (Auxiliary Power Supply)*
See also Requirement TTS-1726 (10-Minute Auxiliary Supply) in Section 7.7 (Auxiliary Power Supply)

9.33.2 Reading lights

9.33.2.1 TTS-1809 - Reading Lights - Passenger Controls

Passengers shall be able to turn their reading light on or off and adjust the brightness of the lighting to at least three levels using controls available at the Seating Position.

Cross reference: *See also Requirement TTS-1847 (Saloon Lighting Illuminance - At Seat Reading Lights) in Section 10.20.3 (Illuminance levels)*

9.33.2.2 TTS-1810 - Reading Lights - Remote Control

It shall be possible for Train Crew or the Wayside to switch all at seat reading lights on or off on a per-Vehicle or per-Unit basis.
When reading lights are controlled in this way they shall default to a common brightness level.

Rationale: *This functionality is envisaged for resetting the lighting at the end of a journey or for testing/inspection purposes.*

9.33.2.3 TTS-2104 - Reading Lights and States

It shall be possible to assign a reading light status to each State such that switching states switches all reading lights on or off as appropriate.

Rationale: *This will reset all lights when the Unit cycles through different states.*

9.33.3 Cab lighting control

9.33.3.1 TTS-2052 - Train Captain Cab Lighting On/Off

The Train Captain shall be able to switch all cab lighting on or off from the cab desk or when entering a Cab.

9.33.3.2 TTS-2053 - Train Captain Cab Lighting Adjust

The Train Captain shall be able to adjust the level of the Cab lighting from the cab desk. Cab lighting illuminance, measured at the desk, shall be adjustable between 'off' and 250 lux with a minimum of five intermediate steps (i.e. seven total steps).

Cross reference: *See also Section 9.7.4 (Train Captain settings)*

9.33.3.3 TTS-2054 - Train Crew Cab Lighting

Train Crew entering an Inactive Cab shall be able to switch the cab lights on or off at a default level.
This lighting level shall be adjustable as an Operator Setting.

9.33.3.4 TTS-2055 - Cab Lighting Auto-off

Cab lighting in Inactive Cabs shall switch off after a defined period of time.
This time period shall be an Operator Setting.
It shall be possible to disable this function as an Operator Setting.

9.34 Interior Doors

Cross reference: *See also Requirement TTS-3247 (Emergency Ventilation) in Section 9.18.2 (Train-wide door control)*

9.34.1 This section contains the requirements for Interior Doors. Interior Doors include (where included in the Unit design) vestibule doors, partition doors and gangway doors. Requirements for other doors included in the interior of Units, e.g. toilet doors are covered separately.

9.34.2 TTS-720 - Interior Door Operation

All Interior Doors shall be power operated.

9.34.3 TTS-3022 - Glazed Interior Doors

The majority of each Interior Door leaf shall be glazed.

Rationale: *Glazed doors provide a more welcoming environment and are also necessary for fire situations.*

9.34.4 TTS-719 - Manage Unit on Canted Track

All Interior Doors shall be operable in the full range of Normal Operation including the full range of cant deficiencies.

Rationale: *It is not acceptable for interior doors to fail to open, close or remain closed due to the track cant or the dynamic movement of the Vehicles.*

9.34.5 TTS-1041 - Interior Door Controls 1

It shall be possible to configure, as an Operator Setting, all Interior Doors such that in Normal Operation, they can be opened by:
- a push button;
- a sensor; or
- a combination of both.

Rationale: *The HS2 Train Operator will want to retain the flexibility to optimise the operation of Interior Doors based on User needs.*

9.34.6 TTS-1536 - Interior Door Controls 2

The controls used for operation of Interior Doors and their positioning shall be consistent across all Interior Doors.

Rationale: *It is considered important to ensure passenger controls are consistent to allow Units to be used intuitively. If doors between Saloons and Vestibules have different controls to those at Gangways, this can be confusing walking through the Unit.*

9.34.7 TTS-729 - Auto-Close of Interior Doors

After a configurable period, Interior Doors shall close automatically.
This time shall be separately configurable as Operator Settings for different types of Interior Doors.

Rationale: *Interior Doors must close to provide the appropriate ambience within the Saloon and provide a fire barrier. However, the HS2 Train Operator will want to retain the flexibility to optimise the operation of Interior Doors.*

9.34.8 TTS-730 - Interior Door Close Check

Interior doors shall include functionality to ensure they do not initiate closing if a Passenger is positioned within an area the full width of the door clearway and extending 200mm from either face of the door.
It shall be possible to configure this function on and off as an Operator Setting.

Rationale: *This requirement is intended to avoid issues seen on some current Units where doors close on Passengers waiting to disembark. It is desirable that the door is not prevented from closing if a bag is left adjacent to the door.*

9.34.9 TTS-721 - Configurable Operation of Interior Doors

The opening and closing speeds of Interior Doors as well as any delays used in their operation shall be configurable as an Operator Setting.

Rationale: *The HS2 Train Operator will want to retain the ability to optimise the operation of Interior Doors.*

9.34.10 TTS-722 - Interior Door Obstacle Detection

All Interior Doors shall include an obstacle detection function that shall cause the door to re-open.
The parameters for obstacle detection in Interior Doors shall be configurable as Software Updates.

Rationale: *The Interior Doors should not close and trap passengers as occurs on some current UK rolling stock.*

9.34.11 TTS-1814 - Interior Doors Evacuation Requirements 1

It shall be possible for the full User Population to manually open Interior Doors from either side.
There shall be clearly identifiable handholds for this purpose.

Rationale: *This is to ensure that interior doors can be used in an emergency scenario, either because power to the Interior Doors has failed or the Interior Doors are not responding to commands due to fire detection (TTS-1835)*

9.34.12 TTS-1047 - Interior Doors Evacuation Requirements 2

If single-leaf Interior Doors are fitted at a location, Interior Doors at opposite ends of the Vehicle shall open in opposite directions.

Rationale: *This is to ensure that if the Vehicle overturns, Passengers can escape from the Vehicle in at least one direction. This is not applicable to bi-parting doors.*

9.34.13 TTS-2531 - Interior Doors Evacuation Requirements 3

Interior Doors shall be fitted with glazing that includes a mechanism to allow it to be removed in an emergency.

Rationale: *This requirement is intended to allow for situations where it is no longer possible to open an interior door due to deformation of the door or frame.*

9.34.14 TTS-3016 - Lock-out Interior Doors

It shall be possible mechanically lock-out Interior Doors, such they do not respond to commands and cannot be manually opened.

Rationale: *This may be necessary operationally (e.g. if a Vehicle is damaged).*

9.34.15 TTS-1813 - Automatic Interior Door Opening - Stations

Interior Doors on a normal route from Seating Positions to the platform shall automatically open when the Train is approaching a platform, and shall remain open until the Train has departed the platform and no Passengers are detected.
It shall be possible to inhibit / enable this function for different stations and different times of year as an Operator Setting.

Rationale: *The need to open Interior Doors (and them automatically re-closing on some existing rolling stock) causes delay to Dwell Times. The Interior Doors to be opened will depend on the layout of Vehicles and their vestibules.*

9.34.16 TTS-2175 - Automatic Interior Door Opening - Maintenance / Servicing State

It shall be possible to configure all Interior Doors to open and stay open while a Unit is in Servicing State.

Rationale: *This would ease cleaning and maintainers who may need to walk through the whole Unit.*

9.34.17 TTS-1178 - Synchronisation of Gangway Doors

With reference to PRM TSI[6] Clause 4.2.2.3.3 (5), where consecutive Interior Doors are fitted either side of a Gangway, both doors shall open synchronously as a pair.

Rationale: *This is to clarify the optional functionality described in PRM TSI Clause 4.2.2.3.3(5).*

9.34.18 TTS-2872 - Temporary Interior Door Inhibit

If an internal clearway of the gangway is not sufficient to permit a wheelchair to move between Vehicles on curved track, as defined in EN 16286-1[48] in any operational situation, it shall be possible to configure, as an Operator Setting, Interior Doors adjacent to Gangways close to Wheelchair Spaces such that they do not respond to passenger controls at certain Locations (Line & Distance).

Rationale: *It is unlikely this function would be enabled at Acceptance. If additional Wheelchair Spaces are later fitted to the Unit, the preference is to use the existing Universal Toilets accessed via the Gangway. It is unlikely that an 800mm clearway through the gangway can be achieved over the full range of curves and reverse curves, but it should be possible over the significant majority of the route. Therefore, temporarily inhibiting the doors at locations with tight curvature may be a solution to mitigate this issue. Such a solution would only be implemented following a review of the safety of such a function.*

9.35 Cleaning sockets

9.35.1 TTS-880 - Cleaners Sockets

A 13A, RCD-protected, 3-pin Socket shall be provided in each vehicle for cleaning equipment in or close to each vestibule.

9.35.2 TTS-1992 - Automatic Socket Switch-off

The sockets for cleaning shall automatically be switched on when the Unit is in Servicing State and switched off when the Unit is in Passenger Service State.

9.36 Clocks / time

9.36.1 TTS-438 - Time Synchronisation

The internal clocks of all on-board systems shall be synchronised with an external source to maintain time to an accuracy of better than ±1s per day.

Rationale: *This is intended to ensure that on-board and trackside systems are synchronised as well as ensuring that any data downloads are accurately timestamped to allow accurate investigation.*

9.36.2 TTS-2264 - Timestamping

All data timestamping shall record the time
- in seconds; and
- in UTC and British Summer Time (UTC +1) when applicable.

Rationale: *In particular, UTC is required for all on-board and trackside CCS systems to enable synchronisation of data exchanges between sub-systems.*

9.37 Staff communication

9.37.1 TTS-3403 - Written Orders

It shall be possible for traffic management controllers at the NICC to send written orders to a particular Unit. The written order shall be displayed to the Train Captain and stored on-board the Unit.

Rationale: *A written order would normally be written by a driver to record an instruction received from a signaller in an abnormal situation. The goal of this requirement is for traffic management controllers to be able to transmit this message to the Unit so that Train Captain does not need to write this down and there is less risk of the message being corrupted.*

9.37.2 TTS-3434 - Train Crew Communication

It shall be possible to send messages from the Wayside to Train Crew on-board to be viewed via the Crew Control Point.

Rationale: *Wayside staff may need to provide information to Train Crew for issues such as providing assistance to Passengers at a particular station. Some messages could be automatically generated on the Wayside.*

9.37.3 TTS-3435 - Not to be Moved Message

It shall be possible to display a 'Not to be moved' message on screens in the Cab, at Crew Control Points and on external passenger information displays.
It shall be possible to trigger this message on the Unit or from the Wayside.

Rationale: *This would be used if a Unit was undergoing maintenance, cleaning or some other intervention. It may supplement or replace a physical sign.*

10 Interior Design and Components

10.0.1 This section gives requirements for the interior components and their general integration into the interior of the Unit. These components are used to define the interior layouts defined in Section 11.

10.0.2 The requirements of this section are all subject to development via the interiors collaboration process described in MSA Schedule 9, Appendix 1.

10.1 Human factors

10.1.1 This section gives some human factors requirements for the rolling stock. This set of requirements is not exhaustive and the TMM is required to develop and implement a human factors plan as detailed in MSA Schedule 9, Appendix 3.

10.1.2 TTS-291 - User Population (PQTS-352)

The Unit shall be suitable for a population spanning the 5th-percentile female to the 95th-percentile male. The PeopleSize dataset[110] shall be used for any anthropometric measurements, adjusted for predicted secular growth over the life of the Unit and taking into account allowances for typical clothing (including protective equipment) worn by the user groups.

Rationale: *This is HS2's preferred dataset. This requirement is in addition to the requirements concerning anthropometric measurements in the LOC&PAS TSI[4].*

10.1.3 The population described in TTS-291 is defined as the **User Population**.

10.1.4 TTS-1920 - Crew and Captain Usability of Design

The Unit shall enable the Train Captain and Train Crew, with appropriate training, to operate the Train in a safe, reliable and efficient manner.

10.1.5 TTS-1919 - Passenger Usability of Design

The Unit and its systems shall be safe, easy and intuitive for Passengers to use and interact with.

10.1.6 TTS-2588 - Passenger Impairments

The design of the Unit shall take account of any permanent or temporary physical, mental, intellectual or sensory impairments that Passengers may have.

Rationale: *The design of the Unit needs to consider the full range of people with disabilities and people with reduced mobility, which is defined in the PRM TSI[6] as any person who has a permanent or temporary physical, mental, intellectual or sensory impairment which, in interaction with various barriers, may hinder their full and effective use of transport on an equal basis with other passengers or whose mobility when using transport is reduced due to age.*

10.1.7 TTS-2206 - Elimination of Cross System Errors

Where Passengers, the Train Captain, Train Crew and Maintenance Technicians interact across multiple on-board systems, the designs shall be consistent, and not generate cross system errors.

Rationale: *This is intended to remove instances where users' knowledge of one system can influence how they use another e.g. blue means 'ok' on one system and cancel on another. Users will see the Unit as a single system despite it being it being assembled from multiple suppliers.*

10.1.8 TTS-2208 - Ambiguity of Controls

All controls should be uniquely identifiable and unambiguous.

10.1.9 TTS-2268 - Control Visibility

All Cab controls and indications shall be clearly legible from the Train Captain's position over the full range of ambient lighting levels and incidence angles.

Rationale: *The Train Captain's controls and indications should be arranged to provide clarity of the displays when taking into account the cab environment, including screen position, sources of sunlight, the position of the Train Captain (including viewing angles), cab lighting levels, maximum night-time cab illumination levels, reflections of reflective clothing, etc.*

10.1.10 TTS-2875 - Musculoskeletal Disorders

Train Captain, Train Crew and Maintenance Technician's facilities and interfaces shall be designed to ensure users are protected from developing musculoskeletal disorders.

Rationale: *Facilities and interfaces should be designed to allow repeated and continuous use if necessary without causing harm to users.*

10.1.11 TTS-790 - Lack of finger traps

There shall be no accessible holes or gaps between fixed or moveable panels, fixtures, components or equipment that could cause injury by trapping fingers, hands or any other body parts. A finger trap shall be as defined in EN 1176-1[30] Section 4.2.7.

10.1.12 TTS-2847 - Design for PRM Use

The Unit shall be designed for PRM use and shall be compliant with the rolling stock requirements of EN 16584-1[49], EN 16584-2[50] and EN 16584-3[51].

10.2 Industrial design

10.2.1 This section gives some very high-level requirements to guide the industrial design of the Unit. The design of the interior will be developed through the interiors collaboration process defined in MSA Schedule 9, Appendix 1.

10.2.2 TTS-1916 - Passenger-facing Appearance

Interfaces between Passengers and the Unit shall have a modern, uncluttered appearance that embodies the values set out in the HS2 Design Vision[127].

10.2.3 TTS-1917 - Consistent Design Theme

Passengers shall be presented with a consistent design theme throughout their interactions with the Unit, including consistent controls and visual themes.

10.2.4 TTS-1918 - Material Finish

Materials and finishes on the interior shall give Passengers the impression of a high quality service, while also meeting requirements for robustness, cleanability, graffiti-resistance, etc.

10.2.5 TTS-3442 - Material Aesthetic Finish Duration

Materials and finishes on interior trim and luggage storage areas shall maintain Minimum Aesthetic Standards for:
• 4 years for locations that are likely to be in contact with bicycles, luggage and catering trolleys; and
• 8 years for all other interior trim, grab-handles, seat backs and tables

Rationale: *This requirement aligns with rules on developing the Maintenance Plan in MSA Paragraph 4.9.*

10.3 Passenger Seats

See also GM/RT2100[83] section 6.2.

10.3.0.1 Requirements in this section are listed in the following sections:

- **10.3.1 - General seat design** - which applies to all types of Passenger Seat;
- **10.3.2 - HS2 Seat** - which applies to the 'HS2 Seat' that will provide 2+2 seating in at least the majority of the Unit; these requirements also apply to the Tip-up Seat;

- **10.3.3 - Tip-up Seat** - which applies to the Tip-up Seat only, a sub-type of HS2 Seat that can be raised to provide a clear area;
- **10.3.4 - Premium Seat** - which applies to the 'Premium Seat' that may be used to provide 2+1 seating in some vehicles, depending the final layout decisions;
- **10.3.5 - At-seat facilities** - which defines facilities that apply to all 'Seating Positions'; and
- **10.3.6 - Vestibule Seats -** which applies to provision for seating to be provided in the vestibules.

10.3.1 General seat design

10.3.1.1 TTS-1801 - Seat Comfort

Passenger Seats shall be comfortable for the User Population, for the range of journey lengths that are possible on HS2 services and whilst completing tasks likely to be undertaken by Passengers.

Rationale: *The comfort of seat should not only consider Passengers seated in an ideal position, since Passengers may not adopt this position. For example, Passengers may spend the journey resting, reading, working on a laptop or watching a video on a phone or tablet.*

10.3.1.2 TTS-654 - Seat Functionality - Recline

It shall be possible to recline Passenger Seats (except Tip-up Seats) to allow for at least two distinct seating positions.
The action of reclining a seat shall not affect the space available to the Passenger behind.

Rationale: *This is considered to be important to providing comfort to Passengers and the 'tasks' they may undertake while seated.*

10.3.1.3 TTS-1683 - No Under-Seat Obstructions

Passenger Seats shall have no obstruction under the seat in an area:
- ±200mm from the centre-line of the seat;
- 300mm up from the floor; and
- 400mm forward from the rearmost part of the seat

Rationale: *There should be no intrusions under seats that may reduce the comfort of Passengers seated in the seat behind, or prevent luggage being stowed at floor level. This requirement applies to the Passenger Seat, which includes its mountings to the wall and vertical legs. Wall-mounted heaters that may also encroach into this space are managed by requirement TTS-633.*

Cross reference: *See also Requirement TTS-1662 (Under-Seat Storage Provision) in Section 10.3.5 (At-seat facilities)*

10.3.1.4 TTS-655 - Display of Seat Numbers

Two-digit seat numbers shall be displayed on each Passenger Seat such that they can be clearly read by the full User Population from the aisle in any position within 1m of the seat.
The seat number shall remain visible when the seat is occupied.

Rationale: *It should be easy for Passengers moving through the Saloon to locate the correct seat. This supports minimisation of dwell time. Note that identification will be required for Wheelchair Spaces, but this is assumed to be achieved via labelling.*

10.3.1.5 TTS-1510 - Prevention of Pick-pocketing

Passenger Seats shall be designed to help prevent pick pocketing from behind the seats.

Rationale: *Passengers should be able to relax when travelling and feel that they and their belongings are secure.*

10.3.1.6 TTS-329 - Future Flexibility - Move seats

Passenger Seats and their interface to the Unit shall enable the position of seats to be moved without affecting floor coverings or interior panelling, except for cover-strips on mechanical fixtures and electrical / data connections.

Rationale: *It should be possible for the interior layouts of the Units to be easily reconfigured to take in to account changes in demand and Passenger needs over the life of the Units.*

10.3.1.7 TTS-2060 - Future Flexibility - Re-use seats

It shall be possible to re-use the majority of a single Passenger Seat in another position in the Saloon.
The main structure of individual seats shall not be handed so that they can only be fitted to one side of the Vehicle.

Rationale: *To enable future re-configuration, it should be possible to move and re-use seats. This includes removing a pair of seats from its mounting and re-using the two individual seats at another location.*

10.3.1.8 TTS-3443 - Minimum Aesthetic Passenger Seat Characteristics

Passenger Seats coverings and cushions shall maintain Minimum Aesthetic Standards for 8 years, provided that seat covers are deep cleaned, away from the Unit, every 2 years.

Rationale: *This requirement aligns with rules on developing the Maintenance Plan in MSA Paragraph 4.9.*

10.3.2 HS2 Seats

10.3.2.1 TTS-639 - Minimum Seat Width - HS2 Seat - Mandatory

The width of the cushioned area of each HS2 Seat, and the space between the armrests, shall be shall not be less than 450mm.

10.3.2.2 TTS-1981 - Seat Clearance - HS2 Seat

The installation of HS2 Seats shall ensure, as a minimum:
- airline seating - 150mm horizontal clearance between the front of a 95th-percentile male knee and any part of the seat in front within a vertical zone between the top and bottom of the thigh; and
- bay seating - 300mm horizontal clearance between the knees of two 95th-percentile males sitting opposite each other.

In both cases, measurements shall be based on the normal expected seating position for the chosen seat with no recline.

Rationale: *These definitions have been developed to ensure a good level of comfort when seated. The space available for each passenger needs to take in to account the space required for the seats to deliver the appropriate facilities and comfort to each Passenger. This requirement needs to be complied with in combination with the seat pitch dimensions specified as part of the layouts in Section 11.*

Cross reference: *See also Requirement TTS-2239 (Seat Pitch) in Section 11.1.1 (Passenger Seats)*
See also Requirement TTS-2654 (Seat Pitch - HS2) in Section 13.3.7 (Passenger Seats)

10.3.2.3 TTS-646 - Provision of Armrests - HS2 Seat - Mandatory

All HS2 Seats shall be fitted with moveable armrests on both sides.
A single armrest may be fitted between two HS2 Seats.

10.3.2.4 TTS-3151 - Armrest Rotation - HS2 Seat

Armrests on HS2 Seats shall be capable of rotating to a position in line with the seat back cushion.
The armrest closest to the sidewall may be restricted from moving.

Rationale: *Moveable armrests are required to allow easier access to all seats, not just those designated as priority seats. The armrest adjacent to the sidewall could cause a finger trap if it moved.*

10.3.2.5 TTS-647 - Armrest Width - HS2 Seat - Mandatory

Armrests fitted to HS2 Seats shall have a width of no less than 50mm.

10.3.2.6 TTS-651 - Seat Materials - HS2 Seat

The material to be used to finish the HS2 Seats shall be a moquette type fabric which shall be demonstrated to have sufficient abrasion resistance and burst strength to be fit for purpose.

10.3.3 Tip-up Seats

10.3.3.1 Tip-up Seats are used for the Multi-Purpose Area described in Section 10.5. They are arranged in transverse positions. They are a sub-type of the HS2 Seat and all requirements applicable to the HS2 Seat, except recline (TTS-654) also apply to these seats.

10.3.3.2 TTS-972 - Use of Tip-Up Seats

Tip-up Seats shall only be used in the Saloon
- in a transverse configuration; and
- as part of the Multi-Purpose Areas.

Rationale: *All passengers should be provided with a consistent level of experience and as such, longitudinal tip-up seats are not considered acceptable.*

10.3.3.3 TTS-970 - Tip-Up Seat Lock Up and Down

Tip-up Seats shall provide facilities to enable them to be locked in the up or down position by an Authorised Person.

Rationale: *This is to provide operational flexibility in the use of Multi-Purpose Areas.*

10.3.3.4 TTS-971 - Tip-Up Seat Mechanism

Tip-up Seats shall return to a vertical position when not in use and not locked in the down position.

Rationale: *This is to allow seats to be used in a tip-up configuration to improve access.*

10.3.3.5 TTS-966 - Tip-Up Seat Structural Design

Tip-up Seats and supporting structures shall withstand proof and fatigue loads applied to the seat throughout its lifetime, including a vertical proof load of 2000N applied vertically downwards at any position on the front edge of a deployed seat.

Rationale: *If Tip-Up seats are used in Multi-Purpose Areas then they need to be assured to deliver reliable performance over their full life.*

10.3.4 Premium Seats

10.3.4.1 TTS-640 - Minimum Seat Width - Premium

The width of the cushioned area of a Premium Seat, and the space between the armrests, shall not be less than 500mm.

10.3.4.2 TTS-2599 - Seat Clearance - Premium Seat

The installation of Premium Seats shall ensure, as a minimum:
- airline seating - 150mm horizontal clearance between the front of a 95^{th}-percentile male knee and any part of the seat in front within a vertical zone between the top and bottom of the thigh; and
- bay seating - 300mm horizontal clearance between the knees of two 95^{th}-percentile males sitting opposite each other.

In both cases, measurements shall be based on the normal expected seating position for the chosen seat with no recline.

Rationale: *These definitions have been developed to ensure a good level of comfort when seated. The space available for each Passenger needs to take in to account the space required for the seats to deliver the appropriate facilities and comfort to each Passenger. This requirement needs to be complied with in combination with the seat pitch dimensions specified as part of the layouts in Section 11.*

10.3.4.3 TTS-648 - Armrest Width - Premium

Armrests fitted to Premium Seats shall have a width of no less than 80mm.

10.3.4.4 TTS-1868 - Provision of Armrests - Premium

All Premium Seats shall be fitted with movable armrests on both sides.
A single armrest of double width (i.e. 160mm) may be fitted between two Premium Seats.

Rationale: *A single central arm-rest removes the risks of trapping fingers between two adjacent arm-rests. Two armrests would need a separation to prevent this.*

10.3.4.5 TTS-3177 - Armrest Rotation - Premium

Armrests fitted to Premium Seats shall be capable of rotating to a position in line with the seat back cushion.
The armrest closest to the sidewall may be restricted from moving.

Rationale: *Moveable armrests are required to allow easier access to all seats, not just those designated as priority seats. The armrest at the sidewall can create a risk of trapping if it moves, but the seat may be moved to a different position in the future so the restriction should be temporary.*

10.3.4.6 TTS-652 - Seat Materials - Premium

The material to be used to finish the Premium Seats shall be a leather-like fabric which shall be demonstrated to have sufficient abrasion resistance and burst strength to be fit for purpose.

10.3.5 At-seat facilities

10.3.5.1 The requirements in this section apply to each Seating Position, which includes Wheelchair Spaces and seats in the Multi-Purpose Area when configured as seats. Note that requirements for facilities to move with the seat only apply to Passenger Seats and not to the Wheelchair Spaces.

10.3.5.2 TTS-662 - At-Seat Power - 3-Pin Socket

A 3A 230V 3-pin Socket shall be provided for each Seating Position, i.e. one socket per Seating Position.
For Passenger Seats, if the associated seat is reconfigured during the life of the Unit, this facility shall be moveable with the seat to any position within the Saloon.

Rationale: *All Passengers should have access to power for laptops or other electrical devices for which a USB provides insufficient power, or the passenger does not have the correct adaptor.*

Cross reference: *See also Requirement TTS-333 (Wheelchair Charging) in Section 10.7 (Wheelchair Spaces)*

10.3.5.3 TTS-663 - At-Seat Power - Low Voltage

A USB Type A power socket shall be provided for each Seating Position. Connectors shall be designed to be upgraded and easily replaced in the event of damage.
For Passenger Seats, if the associated seat is reconfigured during the life of the Unit, this facility shall be moveable with the seat to any position within the Saloon.

Rationale: *All Passengers should have access to power for mobile phones, tablets, etc.*

10.3.5.4 TTS-2062 - Future Flexibility - Replacement Low Voltage

It shall be possible to replace the USB Type A socket (TTS-663) with a USB Type C or other low voltage socket without moving the seat or other internal equipment.

Rationale: *It is considered likely that USB Type A will no longer be the 'standard' connector either during the design / manufacture of the vehicles, or shortly after introduction.*

10.3.5.5 TTS-2032 - Positioning of Power Sockets

Both 230V (TTS-662) and low voltage (TTS-663) sockets shall be positioned so as:
- to be visible to seated Passengers;
- to not require Passengers to reach across each other to use them; and
- minimise the risk of accidental damage or contact with fluids.

Rationale: *All Passengers should have easy access to power for their devices.*

10.3.5.6 TTS-664 - Coat Hook

A coat hook shall be provided at each Seating Position.
This facility shall be moveable with the seat to any position within the Saloon.

Rationale: *This is to ensure that Passengers can keep their belongings close by if they wish.*

10.3.5.7 TTS-665 - Reading Light Provision

A reading light shall be provided at each Seating Position.
This facility shall be moveable with the seat to any position within the Saloon.

Rationale: *This is to provide a level of control over the lighting level at a Seating Position.*

Cross reference: *See also Requirement TTS-1847 (Saloon Lighting Illuminance - At Seat Reading Lights) in Section 10.20.3 (Illuminance levels)*

10.3.5.8 TTS-660 - Cup Holder Provision

A cup holder shall be provided at each Seating Position.
The cup holder should enable either a bottle of up to 75mm diameter and a minimum height of 200mm or a cup with a base diameter of 55mm and a top diameter of 75mm and a height of 95mm to be secured.
The use of the cup holder shall not preclude the use of a laptop on the table provided at that seat.
For Passenger Seats, if the associated seat is reconfigured during the life of the Unit, this facility shall be moveable with the seat to any position within the Saloon.

Rationale: *Passengers are likely to bring drinks with them, or buy drinks on-board. The cup-holder should hold the widest range of drinks containers.*

Cross reference: *See also Section 10.4 (Tables)*

10.3.5.9 TTS-2468 - Small Item Storage

Storage for small items, such as a mobile phone, shall be provided at each Seating Position. The use of this storage shall not preclude the use of a laptop on the table provided at that seat.
For Passenger Seats, if the associated seat is reconfigured during the life of the Unit, this facility shall be moveable with the seat to any position within the saloon.

Rationale: *This feature is to provide the ability for Passengers to keep important items close at hand.*

10.3.5.10 TTS-1662 - Under-Seat Storage Provision

Passenger Seats in airline arrangement shall include features that allow bags to be stored under the seat in front of where a Passenger is sitting.
These features shall prevent bags moving forward in to the space provided for the Passenger in front.
This facility shall be moveable with the seat to any position within the Saloon.

Rationale: *If passengers decide to use the under seat space for storing their bags they should be confident that it will not slide forward or be taken by the passenger in front.*

Cross reference: *See also Requirement TTS-1683 (No Under-Seat Obstructions) in Section 10.3.1 (General seat design)*

10.3.5.11 TTS-2211 - Fitment of Hearing Aid Induction Loops to Priority Seats

All Seating Positions designated as priority seats shall be covered by induction loops, compliant with the requirements of BS 7594[26] and EN 60118-4[66], for relaying PIS audio messages to Passengers with hearing aids.
This facility shall be movable with the seat to any position within the Saloon.

Rationale: *This is intended to ensure that Passengers with hearing impairments can receive PIS audio messages clearly.*

10.3.5.12 TTS-2212 - Future Flexibility - Provision for Induction Loops

All Seating Positions shall be provisioned for coverage by induction loops for relaying PIS audio messages to Passengers with hearing aids.
This provision shall include all mountings, power and data connections required to allow fitment of the devices in a depot.

Rationale: *This is intended to provide flexibility to increase the number of induction loops fitted during the lifetime of the Units.*

10.3.6 Vestibule Seat

10.3.6.1 Vestibule Seats, if fitted, will be primarily used by staff to support specific duties related to the fire and evacuation strategy. The seats may also be used by Passengers in specific scenarios. There is no requirement to provide the Vestibule Seats at this stage, however provision for their fitment should be included in the design.

Note: Vestibule Seats will not be considered as Seating Positions.

10.3.6.2 TTS-3294 - Future Flexibility - Vestibule seat provision

All Vestibules shall be capable of accommodating a minimum of one Vestibule Seat. This provision shall assume a suitable seat that can be folded away when not in use and can be used by the full User Population. The provision shall at least include the structural elements to mount the Vestibule Seat.

10.4 Tables

See also GM/RT2100[83] Section 6.3

10.4.1 Bay tables

10.4.1.1 TTS-670 - Provision of Tables in Bays

Fixed tables shall be fitted in all bay seating positions, except Multi-Purpose Areas.

10.4.1.2 TTS-1007 - Provision of Fold-Away Tables in Multi-Purpose Areas

Multi-Purpose Areas shall be fitted with a table capable of being folded away to leave the floor areas between the seats clear for other uses.

Rationale: *It is key to maximise the floor area left free when the fold-away table is in the stowed position to allow Multi-Purpose Areas to be used for storage of items such as luggage or pushchairs.*

10.4.1.3 TTS-1495 - Size of Fixed Tables

Fixed and fold-away tables shall be sized to ensure that they can accommodate and support a reference laptop for each passenger in the bay, whilst in use, with 15.1" display and a footprint of 350mm × 250mm. It shall be possible for the User Population to type on the laptop and angle the screen for reading when the Passenger's seat recline is in the upright position.

Rationale: *All Passengers should be provided with sufficient space to use their devices and work if necessary.*

10.4.1.4 TTS-1147 - Fold-Away Table Lock Up and Down

Fold-away tables shall provide a facility that enables them to be locked in the up or down position by an Authorised Person.

Rationale: *This is to provide operational flexibility in the use of multi-purpose areas*

10.4.1.5 TTS-2167 - Future Flexibility - Table Flexibility

Fixed and fold-away tables and their interface to the Unit shall enable the position of tables to be moved without affecting floor coverings or interior panelling, except for cover-strips on mounting points and electrical connections.

Rationale: *It should be possible for the interior layouts of the Units to be easily reconfigured to take in to account changes in demand and user needs over the life of the Units.*

10.4.2 Seat back tables

10.4.2.1 TTS-658 - Provision of Seat-Back Tables

All Passenger Seats arranged in an airline configuration shall be provided with a Seat-back Table mounted to the seat in front or other structure if there is no seat in front.

Rationale: *All passengers should have access to a table. If seats face a partition, they should be provided with a table fitted to the partition.*

10.4.2.2 TTS-659 - Size of Seat-Back Table

All Seat-back Tables shall be capable of fully accommodating and supporting a reference laptop whilst in use, with 15.1" display and a footprint of 350 × 250mm. It shall be possible for the User Population to type on the laptop and angle the screen for reading when their seat recline is in the upright position.

Rationale: *The experience at Passenger Seats in airline configuration should, as far as possible, match bay seats. The design should ensure that seat-back tables allow comfortable use of a laptop computer by the full range of Passengers. A pull-out extension to the table may be necessary to support the laptop*

10.4.2.3 TTS-1494 - Tablet/Phone Holder Built in to Seat-Back Table

Seat-back Tables, or other features on the seat, shall allow a mobile phone or tablet computer to be held in a standing position suitable for viewing the screen. The features should account for a range of sizes of device.

Rationale: *The design of airline seats should ensure that Passengers are able to make best use of their devices.*

10.4.2.4 TTS-1234 - Future Flexibility - Provision to Add Seat-Back Tables

All Passenger Seats shall be capable of providing a Seat-back table to a Seating Position behind. When the seat is positioned so that the table is not usable (e.g. when the seat back is against a luggage stack), the table shall either be removed or be protected from damage. The changes required shall be possible in the depot.

Rationale: *It should be possible to reconfigure the Saloon, re-using existing components as far as possible. As such, it may be necessary to add or remove seat-back tables to seats depending on whether they are in an airline or back-to-back configuration.*

10.5 Multi-Purpose Areas

10.5.1 TTS-975 - Multi-Purpose Areas - Contents

Multi-Purpose Areas shall contain four Tip-up Seats and a fold-away bay table.

Rationale: *Multi-Purpose areas are intended to allow flexibility to provide features such as additional luggage storage, buggy storage, etc. and as such require the ability to create additional floor space.*

Cross reference: *See also Section 10.3.3 (Tip-up Seats)*

10.5.2 TTS-1539 - Multi-Purpose Areas - Definition

Multi-Purpose Areas shall normally operate as a seating bay, including a table.
It shall be possible for one Authorised Person to reconfigure the Multi-Purpose Area to provide empty floor space to be used for storage of luggage or other items such as push-chairs.
It shall be possible to lock the furniture in either state.

Rationale: *Multi-Purpose areas are intended to allow flexibility to provide features such as additional luggage storage, buggy storage, etc. and as such require the ability to create additional floor space.*

10.6 Luggage storage

See also GM/RT2100[83] section 6.8.

10.6.0.1 "**Large Bags**" shall be defined as having dimensions of 800 × 570 × 300mm

10.6.0.2 "**Small Bags**" shall be defined as having dimensions of 560 × 450 × 250mm

10.6.0.3 A "**Bicycle**" shall be defined as a bicycle with 740mm wheels, a 580mm frame (i.e. seat tube measurement), 1050mm wheelbase and 460mm width handlebars

10.6.1 Overhead luggage racks

10.6.1.1 TTS-1023 - Use of Overhead Racks for Small Bags

The design of the overhead luggage rack shall ensure that a Small Bag can be securely stowed.

Rationale: *Passengers' expectations for overhead luggage racks is that they can store a reasonably size bag close to their seat.*

Cross reference: *See also Information TTS-673 (Definition of Luggage Types - Small Bag) in Section 10.6 (Luggage storage)*

10.6.1.2 TTS-679 - Visibility of Luggage in Overhead Racks from Below

Luggage stowed in the overhead luggage rack shall be visible from Seating Positions directly below.

10.6.1.3 TTS-680 - Visibility of Luggage in Overhead Racks from the Aisle

Luggage stowed in the overhead luggage rack shall be visible by the User Population walking through the Saloon.

Rationale: *Train Crew should be able to identify luggage that is suspicious or that has been left behind by Passengers.*

10.6.1.4 TTS-681 - Visibility of Luggage in Overhead Racks on CCTV

Luggage stowed in the overhead luggage rack shall be visible by the Interior CCTV System within the Saloon.

Rationale: *This is required for incident management.*

Commercial in Confidence

10.6.1.5 TTS-1026 - Retention by Overhead Racks in Normal Operation

Overhead luggage racks shall be designed to ensure the retention of all stowed luggage during normal Vehicle movements.

Rationale: *In the interests of passenger safety the risk of luggage falling from the overhead racks must be minimised. Luggage may be of a variety of size, not just the dimensions of a Small Bag. Note that GM/RT2100[6] requires dividers every 3m, which supports this.*

10.6.2 Luggage stacks

10.6.2.1 The need for luggage stacks is defined by the layout requirements in section 11. Luggage stacks will be required to store Large Bags inside the Saloon. There are no specific design requirements for the shape or design of luggage stacks, but the interior collaboration process described in MSA Schedule 9, Appendix 1 will consider how usable the luggage stacks are by the User Population.

10.6.2.2 TTS-1020 - Visibility of Luggage in Stacks on CCTV

Luggage stowed in luggage stacks shall be visible by the Interior CCTV System within the Saloon.

Rationale: *Passengers have anxiety about leaving luggage in a luggage stack that is remote from a Seating Position, and the CCTV can give some confidence that bags are being monitored.*

10.6.2.3 TTS-2169 - Future Flexibility - Luggage Stack Flexibility

Luggage stacks and their interface to the Unit shall enable the position of stacks to be moved without affecting floor coverings or interior panelling, except for cover-strips on mounting points and electrical connections.

Rationale: *It should be possible for the interior layouts of the Units to be easily reconfigured to take in to account changes in demand and User Needs over the life of the Units.*

10.6.3 Bulk Luggage Storage Area

10.6.3.1 The Bulk Luggage Storage Area is intended to provide flexible storage to allow Large Bags, bulky items and/or Bicycles to be stored.

10.6.3.2 TTS-682 - Bulk Luggage Storage Area - Capacity - Mandatory

A Bulk Luggage Storage Area shall be capable of accommodating:
- two Bicycles; and alternatively
- luggage up to a minimum total volume of $2m^3$, with intermediate shelves.

It shall be reconfigurable between these uses.

10.6.3.3 TTS-1968 - Bulk Luggage Storage Area - Reconfiguration

It shall be possible for a single member of Train Crew to reconfigure an empty Bulk Luggage Storage Area between bicycle storage and luggage storage within five minutes.

10.6.3.4 TTS-3086 - Bulk Luggage Storage Area - Power

A 13A 230V 3-pin Socket shall be provided at each location within the Bulk Storage Area where a bicycle could be stored.

Rationale: *This is to facilitate the charging of electric bicycles.*

10.6.3.5 TTS-1970 - Future Flexibility - Bulk Luggage Storage Area

All Vehicles shall be capable of accommodating a Bulk Luggage Storage Area.

10.6.3.6 TTS-1971 - Future Flexibility - Reconfiguration of Bulk Luggage Storage Area

It shall be possible to remove Bulk Luggage Storage Areas from Vehicles and fit other interior features, such as seating.

10.7 Wheelchair Spaces

10.7.1 TTS-1990 - Integration of Wheelchair Spaces

Wheelchair Spaces shall be integrated into the Saloon and Passengers using the spaces shall not feel isolated from other Passengers.

Rationale: *A high quality, inclusive experience should be delivered for all Passengers.*

10.7.2 TTS-333 - Wheelchair Charging

A 13A 230V 3-pin Socket shall be provided at each Wheelchair Space. (This is in addition to TTS-662.)

Rationale: *This is to enable charging of the wheelchair.*

10.7.3 TTS-1056 - Table in Wheelchair Space

Fold-away tables shall be provided for the use of the occupants of the Wheelchair Space, including at companion seats.

Rationale: *Wheelchair users should be provided with similar facilities to those using other seating options. It may be necessary to fold the table away for larger wheelchairs to occupy the Wheelchair Space.*

10.7.4 TTS-1675 - Future Flexibility - Flexibility in Number of Wheelchair Spaces - Mandatory

The Unit shall allow the number of Wheelchair Spaces to be increased up to a maximum of eight.
This modification shall be possible within the depot environment.

Rationale: *The Unit needs to be able to adapt to future changes in the passenger population.*

10.8 Catering

10.8.0.1 This section contains requirements for each of the catering options that may be used in the layout of the interior. See Section 11 for specification or which catering, if any, is required.

10.8.1 Catering Trolley Stowage Point

10.8.1.1 A Catering Trolley Stowage Point provides facilities to store and restock a trolley with hot and cold beverages as well as refrigerated and un-refrigerated snacks. Provision of the trolley itself is not within the scope of the contract.

10.8.1.2 TTS-2124 - Trolley Space - Mandatory

A Catering Trolley Stowage Point shall have space to store a catering trolley measuring 1550 × 380 × 950mm (height x width x length).

10.8.1.3 TTS-3030 - Trolley Retention Device

Catering Trolley Stowage Points shall include a device to retain the trolley in position when stowed.
A visual indication shall be provided that the device has been engaged.

10.8.1.4 TTS-2123 - Trolley Power

Two 13A 230V 3-pin Socket shall be provided in a Catering Trolley Stowage Point.

10.8.1.5 TTS-2125 - Trolley Water Provision

A Catering Trolley Stowage Point shall include facilities to store and dispense 100 litres of hot (boiling) water.
Water shall be UV-sterilised before dispensing.

10.8.1.6 TTS-2126 - Trolley Refrigerated Storage

A Catering Trolley Stowage Point shall include a fridge with 150 litres storage capacity.

10.8.1.7 TTS-2128 - Trolley Un-refrigerated Storage

A Catering Trolley Storage Point shall have space to store 1m³ of un-refrigerated food, drink and catering supplies, with shelves and dividers.
The storage shall be designed to retain the items and any cupboards or drawers shall latch closed to ensure secure storage.

10.8.2 Catering Café-Shop

10.8.2.1 A Catering Café-Shop will provide facilities for the sale of hot and cold drinks and snacks. The facility includes an area where refrigerated and un-refrigerated produce can be selected by Passengers and a counter with facilities behind for Catering Staff to provide additional services.

10.8.2.2 TTS-2730 - Café-Shop Produce Selection Area - Unrefrigerated Storage

A Catering Café-Shop shall include configurable shelving for the display of un-refrigerated snack items, such as chocolate bars and bagged sweets.
It shall be possible to configure both shelving and pegs for the display of different items.
Shelving shall be angled to aid display of items.
The minimum depth for shelves and pegs shall be 350mm.

Rationale: *This area is intended to allow passengers to select produce to be taken to the counter for sale.*

10.8.2.3 TTS-2732 - Café-Shop Produce Selection Area - Refrigerated Storage

A Catering Café-Shop shall include a refrigerated display unit for drinks and refrigerated food.
The contents shall be visible and accessible to Passengers at all times.
The refrigerated display shall have a minimum capacity of 300 litres and it shall maintain a temperature between +2°C / +5°C.

Rationale: *This area is intended to allow passengers to select produce to be taken to the counter for sale.*

10.8.2.4 TTS-2733 - Café-Shop - Counter Area

A Catering Café-Shop shall have a serving counter of at least 400 × 1000mm. The serving counter shall be accessible to the full User Population.

Rationale: *A counter should be provided to divide the area accessible to Passengers from the area accessible to Catering Staff only and to allow Catering Staff to serve Passengers.*

10.8.2.5 TTS-3032 - Café-Shop - Counter Area Hearing Aid Induction Loop

The Catering Café-Shop serving counter shall be fitted with induction loops, compliant with the requirements of BS 7594[26] and EN 60118-4[66], for relaying speech from behind the counter to Passengers using hearing aids standing in front of the counter.

10.8.2.6 TTS-2728 - Café-Shop - Behind Counter Facilities

A Catering Café-Shop shall accommodate the following facilities for Catering Staff access only, behind the counter:

- a convection microwave oven;
- refrigerated storage of 300 litres (separate from the display unit in TTS-2732);
- a working surface (separate from the counter) of at least 400 × 600mm;
- space to store 1m³ of un-refrigerated food and drink to allow restocking of passenger display area;
- handwashing facilities;
- a rubbish bin or bins with a minimum capacity of 60 litres;
- UV-sterilised, chilled potable water; and
- a hot drinks machine that is able to prepare bean-to-cup coffee, a range of teas and chocolate drinks, including those with foamed milk.

Rationale: *These facilities are intended to allow restocking of the shop and simple food preparation activities.*

10.8.2.7 TTS-3033 - Café-Shop Produce Selection Area - Heated Storage

A Catering Café-Shop service counter shall include a heated storage/ display cabinet of 100 litres, for the temperature-controlled storage of hot food.
The heated display cabinet shall be accessible from behind the counter only and incorporate transparent front, side and top panels.

10.8.2.8 TTS-2742 - Café-Shop - Hot Drinks Capacity

The hot drinks machine in the Café-Shop shall be designed to provide a minimum of 50 drinks per hour and include capacity for consumables, such as coffee beans, sufficient for a minimum of 100 drinks.

10.8.2.9 TTS-2743 - Café-Shop - Water Provision

The water supply provided for the handwashing, potable water and coffee making facilities in the Café-Shop shall have a minimum capacity of 500 litres.

10.8.2.10 TTS-2726 - Café-Shop - EPOS

Provision shall be made in the Café-Shop for an electronic point of sale system in the form of a 13A 230v 3-Pin Socket power supply, cabling and mounting points to connect a unit on the counter.

Rationale: *This is to allow a till system to be in place to take payments from Passengers.*

10.8.3 Catering Kiosk

10.8.3.1 A Catering Kiosk provides self-service facilities of both hot and cold beverages and snacks.

10.8.3.2 TTS-2739 - Catering Kiosk - Facilities

A Catering Kiosk shall accommodate a self-service machine or machines capable of selling:

- 'bean-to-cup' coffee , teas and chocolate drinks, including those with foamed milk;
- chilled confectionary and snacks;
- chilled drinks in cans and/or bottles; and
- UV-sterilised, chilled potable water (to be dispensed free of charge).

The machine or machines are part of the scope of supply.

Rationale: *The self-service machines must be incorporated in the scope of supply since they will need to be integrated into the Unit, and meet all applicable structural and materials requirements*

10.8.3.3 TTS-3204 - Catering Kiosk - Payments

A Catering Kiosk shall include the ability to pay with cash, credit/debit cards and contactless payments.

10.8.3.4 TTS-2744 - Catering Kiosk - Hot Drinks Capacity

The hot drinks machine in the Catering Kiosk shall include capacity for consumables, such as coffee beans and cups, sufficient for a minimum of 100 drinks.

10.8.3.5 TTS-2741 - Catering Kiosk - Chilled Capacity

A Catering Kiosk shall have capacity for a minimum of 20 different items of chilled confectionary or drinks and a minimum stock of six of each of those items.

10.8.3.6 TTS-3206 - Catering Kiosk - Stock Level Reporting

A Catering Kiosk shall be capable of reporting the stock levels of all items and consumables to the Wayside.

10.8.3.7 TTS-2740 - Catering Kiosk - Water Provision

The water supply provided in the Catering Kiosk shall have a minimum capacity of 200 litres.

10.8.3.8 TTS-3034 - Catering Kiosk - Waste Management

The Catering Kiosk shall include two integrated Litter Bins.

Cross reference: *See also Section 10.17 (Litter collection)*

10.8.4 Catering flexibility

10.8.4.1 TTS-2738 - Future Flexibility - Reconfiguration of Catering Areas

It shall be possible to remove any of the types of catering and fit other interior features, such as seating.
Replacement of catering facilities may include addition or removal of other interior fixtures depending on their relative sizes.

10.8.4.2 TTS-3085 - Future Flexibility - Location of Catering Trolley Stowage Point

A minimum of two Vehicles shall be capable of accommodating a Catering Trolley Stowage Point.

10.8.4.3 TTS-3083 - Future Flexibility - Location of Catering Kiosks

A minimum of four Vehicles shall be capable of accommodating a Catering Kiosk.

10.8.4.4 TTS-3084 - Future Flexibility - Location of Catering Café-Shop

A minimum of two Vehicles shall be capable of accommodating a Catering Café-Shop.

Rationale: *This flexibility permits catering options to be changed during the interiors collaboration process (MSA Schedule 9, Appendix 1) or later in the Unit's life.*

10.9 Train Captain and Train Crew facilities

10.9.1 Cab design

See also LOC&PAS TSI[4] Section 4.2.9 and GM/RT2161[90] Section 6.1.1

10.9.1.1 TTS-771 - Cab Accommodation

Each Cab shall have suitable facilities for a Train Captain and an Instructor.

10.9.1.2 TTS-2534 - Cab-Saloon Door

Each Cab shall include an access route to and from the nearest Saloon that does not require the Train Captain to exit the Unit.

10.9.1.3 TTS-2139 - Cab Desk and Control Layout

The cab desk and controls shall be arranged, such that:
• a combined traction/brake controller is provided to the left of the driving seat;
• a 'driver's safety device' footpedal is provided under the desk for controlling the 'driver's activity control' (vigilance) function; and
• there is no permanent flat desk area in front of the Train Captain.

Rationale: *This layout of cab controls and desk is specified for consistency with existing rolling stock operated on the CRN routes. Cab desks with a flat area in front of the Train Captain, as commonly found on trains in mainland Europe, have caused complaints because of access into and out of the driving position.*

10.9.1.4 TTS-2056 - Electrically Adjustable Train Captain's Seat

The Train Captain's seat shall be electrically adjustable.

Cross reference: *See also Section 9.7.4 (Train Captain settings)*

10.9.1.5 TTS-3233 - Electrically Adjustable Footpedal

If the 'driver's safety device' footpedal is adjustable, it shall be electrically adjustable.

Rationale: *For the User Population to operate the Unit, it is likely that the footpedal will need to adjust to ensure smaller Train Captains are not seated too low. A manual adjustment is not considered suitable given the location of the footpedal.*

Cross reference: *See also Section 9.7.4 (Train Captain settings)*

10.9.1.6 TTS-3007 - Instructor's Seat

The Instructor shall be provided with a seat suitable for providing instruction or observation of a Train Captain.

10.9.1.7 TTS-2138 - Standing at Driving Position

It shall be possible for the Train Captain to quickly stand at the driving position when the Unit is stationary, e.g. at a station.

Rationale: *The ability of the Train Captain to stand supports regular movement. It may be necessary to push back the Train Captain's seat to achieve this, which should be a simple movement to enable the Train Captain to be able to stand quickly.*

10.9.1.8 TTS-2751 - Standing in ATO

It shall be possible for the Train Captain to operate the Train while ATO On-board is Engaged (EG) from a standing position.
An additional control to input into the 'driver activity control' (vigilance) system from standing positions in the Cab shall be provided.

Rationale: *During ATO, the ability to stand will assist the Train Captain with regular movement and help ensure the Train Captain remains alert.*

10.9.1.9 TTS-2870 - Tablet Storage

The cab desk shall include a space to securely hold a large tablet (up to 310 × 230 × 10 mm) such that it can be read from the driving position. The cab desk shall include USB Type A power socket positioned to provide power to this tablet. The socket shall be designed to be upgraded (e.g. to USB Type C).

Rationale: *This tablet would contain reference information for the Train Captain - e.g. copy of the Rule Book, daily instructions.*

10.9.1.10 TTS-2007 - Storage for Train Crew Belongings

With reference to clause LOC&PAS TSI[4] *4.2.9.5 (1),* each Cab shall be equipped with: • two hooks for clothing or a niche with a clothes beam; and • a free space for storing two suitcases or bags of size 300 × 400 × 400 mm.

Rationale: *Additional storage is required compared to the LOC&PAS TSI.*

10.9.1.11 TTS-3452 - Emergency Equipment Cupboard

Each Cab shall include a storage cupboard with minimum internal dimensions of 300 × 300 × 300 mm. The storage cupboard shall include a 3A 230V 3-pin Socket and a USB Type A power socket. The USB socket shall be designed to be upgraded (e.g. to USB Type C).

Rationale: *This cupboard is to store emergency equipment in the cab (TTS-3444), equipment provided by the HS2 Train Operator (at least a torch and smoke hood).*

10.9.1.12 TTS-773 - Power Sockets in Cab

Two 3A 230V 3-pin Sockets shall be provided in each Cab.

Rationale: *This is to provide power to the Train Captain's mobile phone or tablet that will be provided for their use undertaking their role.*

10.9.1.13 TTS-2240 - Low Voltage Power in Cab

Two USB Type A power sockets shall be provided in each Cab (in addition to TTS-2870). Sockets shall be designed to be upgraded (e.g. to USB Type C) and easily replaced in the event of damage.

Rationale: *This is to provide power to the Train Captain's mobile phone or other device that will be provided for their use undertaking their role.*

10.9.1.14 TTS-1151 - Prevent Inadvertent Operation

Equipment and controls within the Cab shall be designed and installed to avoid inadvertent damage or activation whilst occupying, entering, leaving or moving about in the Cab.

Rationale: *Emergency stop buttons have sometimes been positioned where they can be caught by bags, which then delays the Train.*

10.9.1.15 TTS-1154 - Resist Malicious Damage

The components within the Cab shall resist damage from robust usage, vandalism and deliberate attempts to misuse.

10.9.1.16 TTS-2217 - Cab Back Wall Resistance to Forced Entry

The door in the cab back wall shall be capable of withstanding the following loading, applied separately:
- 2kN over any area measuring 50mm by 50mm; and
- 7kN over the whole area of the door.

Rationale: *This requirement is specified to define a level of protection for the Cab. The loadcase has been used on other UK rolling stock projects.*

10.9.1.17 TTS-3006 - Instructor Emergency Stop

An emergency stop control shall be provided in each Cab which can be operated by an Instructor from their seated position.

Rationale: *This facilitates an Instructor being able to make an emergency brake application when a trainee is under instruction / observation*

10.9.1.18 TTS-625 - Windscreen Standard

With reference to LOC&PAS TSI[4] Clause 4.2.9.2, the windscreen shall additionally comply with EN 15152[43] Section 4.2.12 - resistance to repeated impact from small particles (gravelling).

Rationale: ***HS2 interface -*** *The addition of tests related to gravelling are required to manage an interface with the HS2 civils design.*

10.9.2 Cab sightlines

10.9.2.1 TTS-772 - Sightlines

With reference to LOC&PAS TSI[4] Clause 4.2.9.1.3.1 (1), sightlines from the Train Captain's seat shall comply with both this clause of the LOC&PAS TSI and UK specific case, GM/RT2161[90] Section 6.1.1, referenced from LOC&PAS TSI Clause 7.3.2.18.
With reference to GM/RT2161 Clause 6.1.1.a, visibility of the track at 10m is required.

Rationale: ***HS2 and CRN interface -*** *Visibility should be provided for compatibility with both HS2 Network and CRN. Complying with this requirement should support this goal.*

10.9.2.2 TTS-287 - Cab Side Visibility (PQTS-437)

The Cab shall include side windows that allow a seated Train Captain to have a view of the platform and signage.

Rationale: *The side window will support the Train Captain to stop the Train accurately, using stop-car markers on the platform. Ideally, existing markers will be used, so some flexibility in the position of the window would be beneficial.*

10.9.2.3 TTS-1148 - Instructor Visibility - Sightlines

The Instructor shall be able to see the sightlines as per TTS-772. The Instructor may stand to see the lowest, closest positions.

10.9.2.4 TTS-2027 - Instructor Visibility - ETCS DMI

The Instructor shall be able to see and read the ETCS DMI.

Rationale: *This is necessary to support training.*

10.9.3 Train Crew facilities

10.9.3.1 TTS-776 - Storage for Train Crew Belongings

The Unit shall provide secure storage for four coats and four bags of minimum size 300 × 400 × 400 mm for members of Train Crew, not including the Train Captain. This storage is in addition to TTS-2007 and shall not be located in the cabs.

10.10 Evacuation equipment

10.10.1 In order to support evacuation scenarios, the Unit will need to carry Evacuation Devices and Evacuation Wheelchairs - see TTS-2802 and TTS-2973 (Section 10.11) and MSA Schedule 14 for quantities.

10.10.2 TTS-2975 - Evacuation Device Deployment

It shall be possible for no more than two Train Crew to deploy the Evacuation Device at any Exterior Doorway.

Rationale: *Ideally, the designated Evacuation Doors will be used for evacuation, but it may be necessary to evacuate through another doorway. It is to be assumed that no more than two Train Crew are available to support the evacuation process.*

10.10.3 The following four requirements set out scenarios for which the Evacuation Device should be designed. It is not mandated that a single device be capable of delivering all scenarios. If multiple devices or components are required, the complete set of equipment will make up the Evacuation Device.

10.10.4 TTS-168 - Evacuation Device - Unit to Unit (PQTS-184)

The Evacuation Device, and its integration with the Unit, shall enable the User Population to evacuate to another Unit on an adjacent track:
- for any track cant up to 180mm, assuming the same cant angle and direction on each track; and
- for any track separation from 3500mm to 5000mm between track centres.

Rationale: ***HS2 interface -*** *This requirement is intended to cover the scenarios related to evacuation of passengers from one Unit to another. Detraining Passengers from one Unit directly to another Unit is the preferred evacuation route.*

10.10.5 TTS-3131 - Evacuation Device - Escape Walkway Tunnel (PQTS-184)

The Evacuation Device, and its integration with the Unit, shall enable the User Population to evacuate to any location, relative to level track, between:

- +700mm and +850mm vertically, relative to rail level; and
- 1700mm and 2200mm horizontally from the track centre-line.

Rationale: ***HS2 interface -*** *In tunnels, there will be a walkway positioned 760mm perpendicular to the track plane. Track may be canted at up to 160mm, and the walkway will move up or down to account for this. The walkway itself will be level. The offset of the walkway will vary depending on the tunnel size.*

10.10.6 TTS-3344 - Evacuation Device - Escape Walkway Viaduct (PQTS-184)

The Evacuation Device, and its integration with the Unit, shall enable the User Population to evacuate to any location, relative to level track, between:

- -250mm and +550mm vertically, relative to rail level; and
- 2400mm and 2800mm horizontally from the track centre-line.

Rationale: ***HS2 interface -*** *On viaducts, the walkway will be positioned 100-200mm above the rail level and approximately 2500mm from track centre. However, the height will not be adjusted for track cant and so the walkway may be lower or higher relative to the track plane.*

10.10.7 TTS-3130 - Evacuation Device - Ground Level (PQTS-184)

The Evacuation Device shall include features to enable free end to be securely located on uneven terrain.

Rationale: ***HS2 interface -*** *In the event that evacuation is required to a location other than another Unit or a walkway, the Evacuation Device could still be used. No dimensional requirements are specified since there are a wide range of potential scenarios. The 'landing' site for the Evacuation Device may be ballast or part of slab track and so each foot of the device may be at a different height.*

10.10.8 TTS-330 - Evacuation Wheelchair

Evacuation Wheelchairs shall be suitable for transferring any person within the User Population over all floor surfaces within the Unit (including through Gangways and along a 450mm-wide aisle) and on a concrete or tarmac walkway under the assistance of one member of Train Crew.

Rationale: *In some evacuation scenarios, it might be necessary to move a wheelchair user through the Unit to a different Evacuation Door and for relatively long distances along trackside/tunnel walkways.*

10.10.9 TTS-2974 - Evacuation Wheelchair Usage

For all Evacuation Device positions in TTS-168, TTS-3131 and TTS-3344, it shall be possible for a Passenger in an Evacuation Wheelchair to be evacuated from the Unit assisted by no more than two Train Crew.

Rationale: *A means is required to evacuate people from the Unit in an Evacuation Wheelchair. It is anticipated that the Evacuation Device (or if necessary, an alternative device) would be compatible with the Evacuation Wheelchairs in order to enable such evacuation.*

10.10.10 TTS-2989 - Evacuation in Own Wheelchair - to Unit

For evacuation to another Unit, as defined in TTS-168, it shall be possible for a Passenger in their own wheelchair to be evacuated from the Unit assisted by no more than two Train Crew.

Rationale: *It will be preferable for a Passenger to remain in their own wheelchair rather than have to move to an Evacuation Wheelchair. Unit-to-Unit evacuation is considered achievable in this scenario.*

10.10.11 TTS-2990 - Evacuation in Own Wheelchair - to Track / Walkway

For evacuation to track level or to an escape walkway, as defined in TTS-3130, TTS-3131 and TTS-3344 respectively, the range of scenarios in which a Passenger in their own wheelchair can be evacuated with the assistance of no more than two Train Crew shall be maximised.

Rationale: *Evacuation in a Passenger's wheelchair to track level or to the escape walkway is recognised as more difficult, because steps are likely to need to be negotiated. The design of the Evacuation Device will need to be developed with the Purchaser as part of the interior collaboration process described in MSA Schedule 9, Appendix 1.*

10.11 Equipment and storage

10.11.1 TTS-1677 - Operator-specific Cupboard

Each non-driving Vehicle shall include a storage cupboard with minimum internal dimensions of 300 × 300 × 300 mm.
The storage cupboard shall include a 3A 230V 3-pin Socket and a USB Type A power socket. The USB socket shall be designed to be upgraded (e.g. to USB Type C).

Rationale: *This is to permit storage of operator-specific equipment, such as emergency provisions or Train Crew equipment. This is in addition to the similar cab cupboard (TTS-3452).*

10.11.2 TTS-268 - On-board Ramp Storage

The Unit shall include a manually-deployed On-board Ramp, and an enclosed storage cupboard for this ramp, in each Vehicle that contains Wheelchair Spaces. The On-board Ramp will be Special Operator Equipment.

Rationale: *An On-board Ramp is required if the Train stops at a station with no available ramp, or PRMs need to disembark from two Vehicles simultaneously. The ramp cupboard needs to keep the ramp clear of Passengers when not in use.*

10.11.3 TTS-2802 - Evacuation Equipment Cupboard

The Unit shall include cupboards adjacent to each Evacuation Door Vestibule for storing the following evacuation equipment:
- one Evacuation Device;
- two Evacuation Wheelchairs; and
- a 500 × 500 × 500 mm area with an intermediate shelf for smaller items (torches, smoke hoods, etc.).

The cupboard shall have a 3A 230V 3-pin Socket.
The Evacuation Device and Evacuation Wheelchairs shall be provided with each Unit and will be Special Operator Equipment.

Rationale: *This equipment is to facilitate different evacuation scenarios. Storage space could be provided in several cupboards or in a single cupboard, provided all are near the Vestibule. Equipment other than the Evacuation Device and Wheelchairs will be provided by the HS2 Train Operator. The socket is to allow charging of the torch or other equipment.*

Cross reference: *See also Requirement TTS-168 (Evacuation Device - Unit to Unit) in Section 10.10 (Evacuation equipment)*
See also Requirement TTS-2975 (Evacuation Device Deployment) in Section 10.10 (Evacuation equipment)

10.11.4 TTS-3444 - GM/RT2130 Equipment

With reference to GM/RT2130[85] Section 5.1, the Unit shall be provided with and have storage for:

- two sets of track circuit operating clips per Cab;
- one red flag per Cab; and
- one ladder or step ladder made from non-conducting material per Unit.

Cab equipment may be located in the storage cupboard (TTS-3452).
This equipment will be Special Operator Equipment.

Rationale: *Of the equipment listed in GM/RT2130 Section 5, this is the equipment that is applicable to the Unit. The ladder is in addition to the Evacuation Device and may be used in addition or as an alternative.*

10.11.5 TTS-2973 - Future Flexibility - Extra Emergency Equipment

The Unit shall allow for the fitment of an additional emergency equipment cupboard (with content as per TTS-2802) to be installed if the number of Wheelchair Spaces is increased.

Rationale: *Depending on the location of additional Wheelchair Spaces, and the access from these extra spaces to the Evacuation Door, an alternative evacuation route may be required. Depending on the final design of the interior layout the required content of this cupboard may be reduced during the project.*

Cross reference: *See also Requirement TTS-1675 (Future Flexibility - Flexibility in Number of Wheelchair Spaces) in Section 10.7 (Wheelchair Spaces)*

10.11.6 TTS-3337 - Door Barrier

The Unit shall include barriers that can be positioned across an open Exterior Doorway to provide a physical barrier to Passengers exiting the Unit. The Unit shall include one door barrier per Vestibule, and storage for these on-board. The door barriers will be Special Operator Equipment.

Rationale: *The door barriers are intended to be used when the doors are opened to provide additional ventilation when a Train has become stranded.*

10.11.7 TTS-1181 - Rescue Coupler Storage

With reference to LOC&PAS TSI[4] Clause 4.2.2.2.4 (3), a location shall be identified that could be used for temporary storage of rescue couplers.

Rationale: *Rescue couplers are not required to be stored on board. The LOC&PAS TSI requires that that the Unit has a location to store rescue couplers, but this location does not need to be retained exclusively for rescue couplers.*

10.12 Gangway

10.12.1 TTS-1136 - Inter-Vehicle Gangway - Mandatory

Gangways shall be fitted between all Vehicles making up the Unit.

Rationale: *Passengers and Train Crew should be able to move freely between Vehicles on a Unit.*

10.12.2 TTS-1146 - Inter-Vehicle Gangway - Structural Requirements

Gangways shall be compliant with the requirements of GM/RT2100[83] Section 5.6.

Rationale: *These requirements are considered to provide good practice.*

10.12.3 TTS-900 - Inter-Vehicle Gangway Clearway - Minimum (PQTS-444)

Gangways on the Unit, and the layout of adjacent areas, shall permit a Passenger in a wheelchair to move between Vehicles as defined in EN 16286-1[48] Clause 7.3 3, but for straight track only.

Rationale: *Access between Vehicles supports inter-Vehicle evacuation beyond a fire barrier (TTS-321) and permits Universal Toilets to be used by wheelchairs users in an adjacent Vehicle.*

Cross reference: *See also Requirement TTS-321 (Cross-section Fire Barriers) in Section 7.21 (Fire)*

10.12.4 TTS-2078 - Inter-Vehicle Gangway Clearway - Maximisation

The capability of the Unit to permit a wheelchair to move between Vehicles on curved track, as defined in EN 16286-1[48], including both single and reverse curves, shall be maximised, considering curvature down to that specified in TTS-1541.

Rationale: *It is recognised that achievement of this requirement across the full range of curves and reverse curves may not be possible, so maximisation of the width is required.*

10.12.5 TTS-1133 - Inter-Vehicle Gangway Vertical Clearway

Gangways on the Unit, and the layout of adjacent areas, shall have a vertical clearway as defined in EN 16286-1[48] Clauses 7.3.2 and 7.3 3.

10.12.6 TTS-3198 - Inter-Vehicle Gangway Vertical Height Changes

The route through the gangway shall:
- have no steps greater than 15mm in height; and
- have no ramps steeper than specified in PRM TSI[6] Table 6.

Rationale: *These limits are specified to permit wheelchair users to pass through the gangway (subject to suitable clearway). This supports evacuation beyond a fire barrier (TTS-321) and permits Universal Toilets to be used by wheelchair users in an adjacent Vehicle*

10.13 Interior panelling and glazing

10.13.1 TTS-1518 - Protective Films for Glazing

All glazed surfaces accessible to Passengers shall incorporate replaceable protective films to mitigate damage as a result of vandalism by etching or scratching.

Rationale: *It must be possible to ensure the Units can be presented in a good condition for every journey.*

10.13.2 TTS-3385 - Window Blinds

The Unit shall have blinds for all Windows, which:
- when deployed, cover at least 80% of the Window; and
- when stowed, cover no clear part of the Window.

10.13.3 TTS-1514 - Interior Panelling - Resistance to Damage

All interior surfaces, including walls, partitions, bodyside panels and ceiling panels shall be hard wearing, resistant to physical damage by vandalism, fading, scouring, acid etching or graffiti, and shall be easy to clean and maintain.

Rationale: *The interiors of the Units shall be designed to enable them to be presented in good condition for every journey.*

10.13.4 TTS-1515 - Interior Panelling - Visible Fixtures

Visible fixings within the Saloon, Vestibule and Toilets shall be avoided where possible. Where fastenings are visible, they shall be tamper resistant, aesthetically consistent with the interior design, whilst being robust enough to be undamaged during maintenance activities.

Rationale: *Opportunities for tampering and vandalism should be minimised.*

10.13.5 TTS-1516 - Interior Panelling - Panel Gaps

Gaps between adjacent internal panels shall be minimised. Joints shall present a consistent appearance, both edges being parallel and panel surfaces being level with each other.

Rationale: *Panels should be finished and installed to a consistently high standard.*

10.13.6 TTS-1678 - Panel Gaps - No Slots

The joins and junctions between interior panels, fixtures and fittings shall not allow paper, such as travel tickets, to be inserted through gaps and junctions.

Rationale: *The inserted paper or card could become a fire hazard or could be difficult to extract to make the Unit presentable.*

10.13.7 TTS-2149 - Future Flexibility - Additional Panelling

It shall be possible to fit additional interior panelling to locations where Toilets, Catering Areas and Bulk Luggage Storage Areas are initially installed.

10.14 Interior partitions

10.14.1 Full-width Partitions

10.14.1.1 TTS-2142 - Full-width Partition

Full-width Partitions shall fully separate two sections of Vehicle, such that there are no gaps in the partition.

Rationale: *Such a partition provides thermal and acoustic insulation.*

10.14.1.2 It is envisaged that, depending on the final layout requirements, there will be single-sided Full-width Partitions fitted at the end of each Saloon. Double-sided (i.e. with two Passenger-facing surfaces) Full-width Partitions may be fitted part-way along the Saloon, e.g. if there are two separate classes of travel in a Vehicle.

10.14.1.3 TTS-2147 - Full-width Partition Door

Full-width Partitions shall include an Interior Door to enable Passengers to pass through.

10.14.1.4 TTS-2151 - Future Flexibility - Add Full-width Partition

It shall be possible to install a double-sided, Full-width Partition near the centre of each Vehicle.

Rationale: *A full-width partition at this location would enable a Saloon to be split into two classes or service-offerings.*

10.14.1.5 TTS-2152 - Future Flexibility - Move Full-width Partition

It shall be possible to move a double-sided, Full-width Partition from one Vehicle to another, with only new fixings required.

10.14.1.6 TTS-2148 - Future Flexibility - Move End Full-width Partition

It shall be possible to move a single-sided, Full-width Partition to a different position in the Vehicle without moving HVAC ducting or significant changes to wiring.

Rationale: *It would be necessary to move the Full-width Partitions at the ends of Vehicles if a Toilet or Bulk Luggage Storage Area was added or removed, or if it was decided to have these facilities within the Saloon.*

10.14.2 Partial Partitions

10.14.2.1 Partial Partitions are designed to provide a visual break to long sections of passenger seating.

10.14.2.2 TTS-2145 - Partial Partition Throughway

Partial Partitions shall maintain a clear aisle throughway at their centre that is wide enough for both 2+2 and 2+1 seating arrangements.

10.14.2.3 TTS-2146 - Future Flexibility - Move Partial Partition

It shall be possible to move Partial Partitions to any position along the length of the saloon, or to another saloon, without affecting the ceiling, flooring or luggage racks.

Rationale: *This type of partition should be easily moved with a seating layout change. This could enable short-term reconfiguration of a Saloon, e.g. for school holidays.*

10.14.2.4 TTS-2868 - Move Partition in Service

It shall be possible for two Authorised Persons to move a Partial Partition to a different position in the Vehicle in 10 minutes.

Rationale: *This will enable changes to service offerings between Services.*

10.15 Interior flooring

10.15.1 TTS-1107 - Saloon Floor Covering

The floor covering in the Saloon shall be a hard-wearing carpet-like material.

10.15.2 TTS-1106 - Aisle Floor Covering

The floor covering used in the Saloon aisles shall be replaceable without the need to remove any other interior equipment, in particular Passenger Seats.

10.15.3 TTS-1108 - Vestibule Floor Covering

The floor covering in the Vestibule shall be hard wearing carpet-like material suitable for wet and dry conditions and designed to minimise the amount of dirt and water carried through to the Saloon.

10.15.4 TTS-2832 - Vestibule Floor Barrier Mat

The Vestibule floor shall be designed to include a barrier mat in the immediate vicinity of the door which can be removed and replaced separately from the main floor.

10.16 Toilets

10.16.1 General Toilet requirements

10.16.1.1 TTS-1060 - Future Flexibility - Standard Toilets

All Vehicles shall be capable of accommodating one Standard Toilet.

10.16.1.2 TTS-2750 - Future Flexibility - Universal Toilets

All Vehicles with Wheelchair Spaces, or where additional Wheelchair Spaces could be fitted (TTS-1675) shall be capable of accommodating a Universal Toilet.

10.16.1.3 TTS-1878 - Future Flexibility - Reconfiguration of Toilets

It shall be possible to add or remove Toilets and install other interior features, such as seating, in their place.

10.16.1.4 TTS-907 - Compliance with EN 16585-1

Toilets shall comply with EN 16585-1[52].

Rationale: *HS2 feels that this standard provides good practice requirements for the design and layout of toilets.*

10.16.1.5 TTS-694 - Toilet Cleanability

Toilets and Sanitary Systems shall be designed to ensure ease of cleaning.

Rationale: *To ensure the best possible passenger experience, it must be possible to keep toilets clean throughout the day with limited time between services.*

10.16.1.6 TTS-2480 - Minimisation of Standing Water - Sink Area

The sink in the Toilet shall be designed to minimise the occurrence of standing water both in the sink and on any surfaces surrounding it, including the floor.

Rationale: *To ensure the best possible passenger experience the risk of water being standing on surfaces within the Toilet should be limited, both at floor level and above, e.g. around the sink.*

10.16.1.7 TTS-699 - Prevention of Fluid Leakage

The Toilet shall incorporate appropriate features to prevent fluid leaking or pooling in the Toilet, Saloon, Vestibule or vehicle underframe.

Rationale: *In order to ensure the Units can be kept clean it is important to prevent any fluids from leaving the toilet modules*

10.16.1.8 TTS-2243 - Toilet Door Threshold

With reference to PRM TSI[6] clause 4.2.2.8 (6), a door threshold strip (if installed) in any Toilet shall not exceed 15 mm in height.

Rationale: *This requirement is intended to minimise the possibility of having an obstacle at toilet doors that presents a trip hazard or an impediment to wheelchair users or ambulatory aids.*

10.16.2 Toilet Facilities

10.16.2.1 TTS-704 - Definition of Standard Toilet Facilities

In addition to any mandatory equipment, the Standard Toilets shall be fitted with the following:
- a device to freshen the air by the addition of a pleasant or odour neutralising fragrance;
- a sink and a tap that provides warm water at a temperature suitable for hand washing;
- a warm air hand drying facility that effectively dries hands within 15 seconds whilst containing water from hands within the sink;
- a mirror with tamper proof fixings and integrated lighting;
- a soap dispenser;
- a toilet paper dispenser;
- a bin for disposal of sanitary products;
- two hooks for coats and bags;
- a shelf or horizontal surface for the placement of small items, e.g. handbag;
- a Litter Bin;
- a visual display (see TTS-1861); and
- a speaker for PIS audio messages;

Rationale: *These are considered to be the minimum features required by Passengers within the Standard Toilet.*

Cross reference: *See also Requirement TTS-1861 (Visual Displays in Toilets) in Section 9.25.1 (Visual displays)*

10.16.2.2 TTS-2539 - Accessibility of Standard Toilet

The Standard Toilet shall have an area of floor 500 × 500 mm that is clear up to a height of 1950mm, when a 95^{th}-percentile male is seated on the toilet, assuming that the toddler seat (TTS-2539) and bag shelf (TTS-2749) are not in use.
This space shall remain clear in the full opening range of the toilet door.

Rationale: *This space is intended to improve use by Passengers with mobility aids, such as walking frames, and also those with assistance dogs.*

10.16.2.3 TTS-2540 - Standard Toilet - Toddler Seat

The Standard Toilet shall include a fold down seat suitable for a child up to a 95^{th}-percentile, two year old male to be used whilst the toilet is in use by an adult.

Rationale: *This is intended to allow parents to more easily use the Standard Toilet if they are accompanied by young children.*

10.16.2.4 TTS-2749 - Standard Toilet - Bag Shelf

The Standard Toilet shall include a fold down shelf suitable for placing a Small Bag whilst using the toilet. The shelf shall keep the bag at least 150mm from the floor.

Rationale: *This is intended to improve the experience of Passengers that want to bring a bag in to the Toilet for security, but do not want to leave it on the floor.*

10.16.2.5 TTS-705 - Definition of Universal Toilet Facilities

In addition to any mandatory equipment, the Universal Toilets shall be fitted with the following:

- a device to freshen the air by the addition of a pleasant or odour neutralising fragrance;
- a sink and a tap that provides warm water at a temperature suitable for hand washing;
- a warm air hand drying facility that effectively dries hands within 15 seconds whilst containing water from hands within the sink;
- a mirror with tamper proof fixings and integrated lighting;
- a soap dispenser;
- a toilet paper dispenser;
- a bin for disposal of sanitary products that is not operated by the use of a foot;
- two hooks for coats and bags;
- a shelf or horizontal surface for the placement of small items, e.g. handbag;
- a Litter Bin that is not operated by the use of a foot;
- a visual display (see TTS-1861);
- a speaker for PIS audio messages; and
- a location for the temporary placement of colostomy bags.

Rationale: *These are considered to be the minimum features required by passengers within the Universal Toilet.*

Cross reference: *See also Requirement TTS-1861 (Visual Displays in Toilets) in Section 9.25.1 (Visual displays)*

10.16.2.6 TTS-2833 - Universal Toilet - Toddler Seat

The Universal Toilet shall include a fold down seat suitable for a child up to a 95th-percentile, two year old male to be used whilst the toilet is in use by an adult, including an adult using a wheelchair.

Rationale: *This is intended to allow parents to more easily use the Universal Toilet if they are accompanied by young children.*

10.16.2.7 TTS-2834 - Universal Toilet - Bag Shelf

The Universal Toilet shall include a fold down shelf suitable for placing a Small Bag whilst an adult is using the toilet, including an adult using a wheelchair.
The shelf shall keep the bag at least 150mm from the floor.

Rationale: *This is intended to improve the experience of Passengers that want to bring a bag in to the Toilet for security.*

10.16.2.8 TTS-1072 - Retention of Toilet Lids and Seats in the Up Position

When left in an open / up position, toilet bowl lids and seats shall remain in the open / up position for the full range of normal Vehicle movements.

Rationale: *This is required to ensure usability of the Sanitary Systems.*

10.16.2.9 TTS-708 - Baby Changing Facilities 1

The Standard Toilet and the Universal Toilet shall be designed to allow baby changing, including the fitment of a baby changing table compliant to EN 16585-1[52].
Passengers using the baby changing facilities shall have access to the sink and bins.

Rationale: *Baby changing facilities are required in all toilets to ensure that facilities are available close to all Passengers and that reliance on the Universal Toilets for baby changing is reduced.*

10.16.2.10 TTS-3073 - Baby Change Facilities 2

The Standard Toilet and Universal Toilet shall be fitted with dispensers for:
- disposable changing mats; and
- bags for the disposal of nappies.

These dispensers shall be accessible when the baby changing table is deployed.

Rationale: *HS2 is keen to ensure that baby changing facilities can be available and sanitary at all times.*

10.16.2.11 TTS-2214 - Fitment of Hearing Aid Induction Loops in Toilets

Toilets shall be fitted with induction loops, compliant with the requirements of BS 7594[26] and EN 60118-4[66], for relaying PIS audio messages to Passengers with hearing aids.

Rationale: *This is intended to ensure that Passengers with hearing impairments can continue to receive PIS audio messages whilst in the Toilets.*

10.16.3 Toilet Controls

10.16.3.1 TTS-710 - Commonality of Toilet Controls

The toilet controls in the Universal Toilet and the Standard Toilet shall be consistent in terms of appearance and user operation.

Rationale: *Consistency of controls will assist Passengers in understanding how to use the Toilet and Sanitary Systems.*

10.16.3.2 TTS-711 - Door Lock Control

All Toilet doors shall be locked by the movement of a mechanical device inside the Toilet. This is regardless of whether the lock itself is electronic.

Rationale: *Passengers are not confident that electrical push-button locks do actually lock the door, even if electronic visual and audible messages are provided.*

10.16.3.3 TTS-712 - Operation of Door Locks

All Toilet door controls shall be operable by Passengers with limited dexterity and additionally shall be operable using an elbow as well as a hand.

Rationale: *All Passengers should be able to operate the door controls, including without having to use their hands.*

10.16.3.4 TTS-713 - Sound Associated with Door Locks

Operation of the Toilet door lock shall be accompanied by an audible sound that gives comfort that a lock has engaged and a visual indication that the door is locked.

Rationale: *Passengers require reassurance that the toilet door is locked, and pushbuttons and illuminations alone have been shown to be insufficient. The sound will be selected as part of the interiors collaboration process described in MSA Schedule 9, Appendix 1.*

10.16.3.5 TTS-1067 - Controls Outside Toilet

Where Toilets have powered doors, controls outside the Toilet shall be positioned as close as possible to the opening side of the door.

Rationale: *Controls and their location should be designed to make them as intuitive as possible.*

10.16.3.6 TTS-3004 - Closing Toilet Door

Where Toilets have powered doors, controls shall be provided to close the door from both the inside and outside. The door shall automatically close after a defined period.

10.16.3.7 TTS-714 - Unlocking from Outside the Toilet

All Toilet doors shall incorporate a device to allow the door to be overridden and opened by Train Crew when 'locked', including when a person has fallen behind the door.
It shall not be possible for Passengers to operate this device.

Rationale: *This is to ensure that Train Crew can enter the Toilet to provide assistance to Passengers.*

10.16.3.8 TTS-1063 - Lock Toilet Out-of-Use

The Toilet shall incorporate a means for Train Crew to lock the door out-of-use.

10.16.3.9 TTS-715 - Flush Availability

Flush controls for the Sanitary System shall be available whether the toilet seat or lid is up or down.

Rationale: *Passengers should not have to touch the toilet lid.*

10.16.3.10 TTS-717 - Hands-Free Activation of Hand Wash Facilities

The Sanitary System shall use non-contact sensors for dispensing of soap, water and operation of the hand-dryer.
Sensors shall be activated in a consistent way.
The location of these sensors should be clearly visible when using the facilities.

Rationale: *This is to reduce physical contact with controls but to ensure that they are still user-friendly.*

10.16.3.11 TTS-707 - Location of Hand Wash Facilities

If the soap and water dispensers and hand-dryer are combined in to a single unit, soap dispensers shall be positioned such that they are furthest away from the user, followed by water and then hand-dryer.

Rationale: *This requirement is intended to limit inadvertent dispensing of soap or water.*

10.17 Litter collection

10.17.1 TTS-739 - Litter Bin Capacity

Each Litter Bin shall have a capacity of at least 30 litres.

10.17.2 TTS-740 - Litter Bin Emptying

It shall be possible to remove the bin liner and its contents without the use of special tools other than a standard key provided to cleaners. This key will be Special Operator Equipment.

10.17.3 TTS-2026 - Litter Bin - Functionality - Self Closing Lids

Litter Bins shall have self-closing lids.

10.17.4 TTS-741 - Litter Bin Functionality - Containment

Litter Bins shall ensure their contents are securely contained, preventing escape of odours into the surrounding areas.

10.17.5 TTS-1040 - Litter Bin Functionality - Fire Containment

Litter Bins shall achieve 10 minutes integrity when tested to EN 1364-1[28].

10.18 Colours and signage

See also PRM TSI[6]

10.18.1 The colours and signage of the Unit will be developed as part of the collaboration process defined in MSA Schedule 9, Appendix 1. No requirements for the overall colour scheme are specified, and no colour scheme will be included in the TMM Train Proposal. The colour scheme will be selected and agreed during the Design Phase.

10.18.2 For the purpose of production of a tender and initial project phases, a default colour scheme is presented in Appendix M. This is not a requirement, and any deviation from this colour scheme will not be considered a Change.

10.18.3 TTS-2912 - Contrast

With reference to PRM TSI[6] contrast between adjacent surfaces, where required, shall be in accordance with EN 16584-1[49].

Rationale: *Although the HS2 Train Operator and other stakeholders will have a significant input into the final design, responsibility for compliance with the PRM TSI remains with the TMM, and the TMM will need to inform the Purchaser if proposed colours do not achieve sufficient contrast. The definition of contrast in in the referenced EuroNorm is to be used to be consistent with current UK practice.*

10.18.4 TTS-994 - Orange Line

With reference to GM/RT2111[84] Clause 2.3, the warning line for the overhead contact line shall be orange.

Rationale: *The colour of the warning line is no longer mandated by standards. HS2 does not have a requirement for the precise shade of orange.*

10.18.5 TTS-743 - Emergency Signage

Emergency and safety signs shall be provided and shall comply with ITL/GN001[105].

Rationale: *This document gives standardised ways of presenting emergency information that is used across UK railways to provide consistent information to passengers.*

10.18.6 TTS-1160 - Display of Vehicle Numbers

Vehicle and Unit numbers shall be displayed internally and externally in accordance with RIS-2453-RST[92].

10.18.7 TTS-746 - Signage Removal

It shall be possible to remove labels without damage to panels / substrate.

10.18.8 TTS-1161 - Display of Door Numbers

Exterior Doors and Interior Doors shall be numbered sequentially and fitted with discreet labelling indicating this.

10.19 PIS display integration

10.19.1 TTS-1403 - Display Glare

The installation and integration of the colour displays shall minimise reflections from the lighting for seated Passengers and standing Passengers. It can be assumed that a white background will be used for displayed messages.

10.19.2 TTS-3346 - Display Integration

The installation and integration of the colour displays shall protect the displays from accidental damage, vandalism and cleaning processes.

Rationale: *In particular, displays in the vestibules are likely to be vulnerable to vandalism or accidental damage from luggage, due to their location. Displays in toilets will need to enable the toilet to be effectively cleaned.*

10.20 Interior lighting

10.20.1 Lighting standards

10.20.1.1 TTS-748 - Interior Lighting - Compliance to EN 13272

The interior lighting shall comply with the applicable requirements of EN 13272[33] for 'high speed trains', considering both 'passenger areas' (Saloon, Vestibule, Gangway, Catering Area, Toilet) and 'service areas' (Cab), except where clarified by the requirements of this TTS.

Rationale: *HS2 believes that this standard provides good practice requirements for the general specification of interior lighting systems.*

10.20.2 Luminaire specification and design

10.20.2.1 TTS-1092 - Light Fixtures Design Requirements

Lighting enclosures shall be tamper resistant and be sealed to a level suitable to their location within the Vehicle.

Rationale: *This is intended to ensure that light fixtures remain operational in service and are also resistant to weather and activities such as cleaning.*

10.20.2.2 TTS-1850 - Luminaire Design - Temperature Protection

All luminaires and/or associated driver(s) shall have a means of thermal protection in the form of an automatic dimming or stepping/holding down the output where temperature exceeds operational limits. Thermal cut-out devices that turn the fixture completely off shall only be used as a last resort based on safety assessment.

Rationale: *Where elements of the lighting system are required to protect themselves from excessive temperatures, this should not be at the expense of lighting required by Passengers or Train Crew.*

10.20.2.3 TTS-2087 - Luminaire Design - Short Wavelength Light Output

Light output power at 400nm and below shall be 0.

10.20.2.4 TTS-1859 - Luminaire Design - Colour Temperature Variation

The maximum colour temperature variation between luminaires within any Vehicle shall be 3-step MacAdam ellipse.
This variation shall be maintained throughout the lifetime of the lighting installations and shall be accounted for when replacing light sources.

Rationale: *It is important to HS2 to create a high quality and consistent ambience within each zone.*

10.20.2.5 TTS-750 - General - Colour Rendering

The Colour Rendering Index *R*a of the light sources shall be ≥ 90.

Rationale: *This is intended to update requirement 4.1.5 of EN 13272[33] to improve the quality of the interior experience.*

10.20.2.6 TTS-1851 - Luminaire Audible Noise

There shall be no audible noise from any luminaire and/or driver when at any output level.

Rationale: *As part of the HS2 ambiance, the lighting system should not create any irritation for Passengers, the Train Captain and Train Crew.*

10.20.2.7 TTS-1852 - Luminaire Flicker

There shall be no visible flicker, blinking or strobing when at any output level. For LED based systems this shall include compliance with the recommendations of IEEE 1789[76].

Rationale: *As part of the HS2 ambiance, the lighting system should not create any irritation for Passengers and Train Crew.*

10.20.2.8 TTS-1854 - Luminaire Lifetime Adjustment

The lighting control system shall provide constant light output throughout the luminaires' lifetime, compensating for the depreciation of luminous flux.

10.20.3 Illuminance levels

See LOC&PAS TSI[4] §4.2.9.1.8

10.20.3.1 The interior lighting is conceived around a number of zones defined in TTS-1089. Luminaires need to be installed around the Vehicle to provide lighting in each of these zones. The requirements of this section provide performance requirements for the lighting when it is at its maximum settings. Requirements in section 9.33 allow lighting levels to be varied from these maximum levels.

10.20.3.2 TTS-1860 - General - Visibility of Light Sources

The interior lighting system shall be designed to ensure that there is no direct view of any lamps or light sources in the normal field of view of Passengers using the Unit.

Rationale: *This requirement is intended to reduce the instances of significant glare being experienced when using or moving through the Unit.*

10.20.3.3 TTS-1102 - Lighting Arrangement in Saloon - Shadowing

The interior lighting arrangement shall be designed, along with the interior panelling and equipment, to eliminate shadowing in areas above seat level that are visible to seated Passengers, particularly on ceiling panels and below luggage racks.

Rationale: *The design should avoid unwanted shadows on panelling that can create unwanted ambiance effects, such as a feeling of reduced size of the interior.*

10.20.3.4 TTS-2961 - Saloon Lighting Illuminance - At Seating Positions

The interior lighting in the Saloon shall be capable of achieving an illuminance of 250 lux at Seating Positions. This performance shall be achieved with reading lights switched off.

Cross reference: *See also Requirement TTS-753 (Seating Position Lighting Illuminance Adjustment) in Section 9.33.1 (Lighting states and levels)*

10.20.3.5 TTS-1856 - Saloon Lighting Uniformity - At Seats

The illuminance uniformity between Seating Positions shall be between 0.8 and 1.2.

Rationale: *It is important to HS2 to create a high-quality and consistent ambience within each zone.*

10.20.3.6 TTS-1847 - Saloon Lighting Illuminance - At Seat Reading Lights

At-seat reading lights shall provide sufficient supplementary illumination to achieve 300 lux in the reading zone, as defined in EN 13272[33], when at the maximum setting.

Rationale: *Passengers should have the ability to adjust the level of light available to allow them customise their experience.*

Cross reference: *See also Requirement TTS-665 (Reading Light Provision) in Section 10.3.5 (At-seat facilities)*
See also Requirement TTS-1809 (Reading Lights - Passenger Controls) in Section 9.33.2 (Reading lights)

10.20.3.7 TTS-2228 - Saloon Lighting Illuminance - At Seat Reading Lights and Adjacent Seats

At seat reading lights shall provide localised illumination only and not cast unwanted spill light into the adjacent seating.

Rationale: *The use of a reading light should not infringe on the experience for Passengers seated nearby.*

10.20.3.8 TTS-2962 - Saloon Lighting Illuminance - In Aisle

The interior lighting in the Saloon shall be capable of achieving an illuminance of 200 lux along the centre-line of the aisle, at floor level. This performance shall be achieved assuming the 1SL with reading lights switched off.

Cross reference: *See also Requirement TTS-1103 (Aisle Lighting Illuminance Adjustment) in Section 9.33.1 (Lighting states and levels)*

10.20.3.9 TTS-1857 - Saloon Lighting Uniformity - In Aisle

The illuminance uniformity in the aisle zone shall be between 0.8 and 1.2.

Rationale: *It is important to HS2 to create a high quality and consistent ambience within each zone.*

10.20.3.10 TTS-2963 - Toilet Lighting Illuminance

The interior lighting in the Toilets shall be capable of achieving an illuminance of 250 lux across the Toilet floor and at all controls and signage.

Cross reference: *See also Requirement TTS-757 (Toilet Lighting Illuminance) in Section 9.33.1 (Lighting states and levels)*

10.20.3.11 TTS-2964 - Vestibule Lighting Illuminance

The interior lighting in the Vestibule shall be capable of achieving an illuminance of 250 lux, measured in accordance with EN 13272[33] and additionally at all controls, handrails and signage.

Cross reference: *See also Requirement TTS-759 (Vestibule Lighting Illuminance) in Section 9.33.1 (Lighting states and levels)*

10.20.3.12 TTS-761 - Gangway Lighting Illuminance

With the Interior Doors at the Gangway (if fitted) open, the lighting illuminance in the Gangways shall be no less than 75 lux.

Rationale: *The Gangways should provide safe passage between Vehicles.*

10.20.3.13 TTS-2966 - Low-level Lighting Illuminance

The low-level lighting beneath Seat shall be capable of achieving an illuminance of 50 lux at floor level below the centre of each seat base.

10.20.3.14 TTS-3176 - Cab Lighting Illuminance

The cab lighting shall be able to achieve up to 250 lux:
- across the whole of the desk;
- at any controls and switches;
- on all handrails;
- on internal and external (if applicable) door thresholds; and
- at the Instructor's seat.

Rationale: *This lighting level is to allow occupants to see any controls and to be able to safely move around the cab. The lighting should allow an Instructor to read and write. This is in addition to mandatory standards*

10.20.3.15 TTS-1090 - Future Flexibility - Lighting Arrangement in Saloon - Task Lights

The lighting arrangement in the Saloon shall enable the fitting of localised task lights to be directed at focus points such as luggage stacks.
The task lights shall be designed to provide up to 200 lux across a vertical plane at the front edge of a luggage stack.
This lighting shall be flexible to reconfiguration of the Saloon and relocation of focus points. If the reconfiguration of task lights requires reconfiguration of hardware this shall be possible by one person in a depot environment.

Rationale: *It should be possible to arrange lighting around key passenger facing features. The design of the lighting system needs to take in to account the desire for re-configurability of the Saloon.*

10.20.4 Reduced lighting

10.20.4.1 Reduced lighting is provided for 60 minutes following a loss of 25kV power supply.

Cross reference: *See also Requirement TTS-3248 (60-Minute Auxiliary Supply) in Section 7.7 (Auxiliary Power Supply)*

10.20.4.2 TTS-3254 - Reduced Lighting Levels

The reduced lighting shall provide the following minimum lighting levels:
- aisles, at floor level - 50 lux;
- seating areas - 100 lux;
- Vestibules - 100 lux; and

• Toilets - 75 lux.

Rationale: *These levels are a slight reduction on levels specified in EN 13272 to provide Passengers with a reasonably comfortable environment.*

10.20.4.3 TTS-3255 - Reduced Lighting Uniformity

The illuminance uniformity of the reduced lighting in the Saloon and Vestibules shall be between 0.7 and 1.6.

Rationale: *Research has shown that a good uniformity is important to help persuade Passengers to remain seated and avoid attracting Passengers to brighter areas (e.g. Vestibules).*

10.20.4.4 The above lighting levels may be provided using any luminaires in any of the lighting zones described in Paragraph TTS-1089. Luminaires that do not contribute to the above lighting levels may be switched off.

10.20.5 Emergency lighting

See also LOC&PAS TSI §4.2.10.4.1

10.20.5.1 The requirements of this section are based on the key points of GM/RT2130[85] but updated to consider more recent developments of lighting technology and the lighting requirements otherwise specified in this TTS.

10.20.5.2 TTS-3011 - Emergency Lighting Local Battery Supplies

The emergency lighting shall have its own battery supplies in addition to the Auxiliary Power Supply, which shall be installed locally to the luminaires.

Rationale: *This provides additional redundancy if Vehicles are separated in an incident.*

10.20.5.3 TTS-3013 - Emergency Lighting Shock Resistance

The emergency lighting system, including the local batteries and all associated equipment required for continued operation, shall continue to function after being subjected to two successive shock pulses in accordance with the pulse defined in GM/RT2100[83] Appendix E Dynamic Test Procedures when mounted in a manner representative of its installation in the Vehicle.

Rationale: *This is intended to ensure that emergency lighting should remain functional in the event of a serious incident or collision.*

10.20.5.4 TTS-3014 - Emergency Lighting Levels and Uniformity

The emergency lighting shall provide a minimum of 15 lux: • at each Seating Position; • along the aisle of the Saloon at floor level; • in the Toilets at floor level and at controls; • in the Vestibules at floor level and at controls; and • at any emergency equipment facilities or equipment cupboards. The uniformity between any of these points shall be between 0.5 and 2.0.

Rationale: *One of the key findings of the research that informed GM/RT2130[85] was that lighting should be uniform along the Vehicle and that bright spots should not be created in vestibules or other areas, which might attract Passengers.*

10.20.5.5 TTS-3015 - Emergency Lighting of Evacuation

When an Evacuation Door is opened, lighting in the Vestibule shall provide illumination of at least 40 lux: • in all parts of the Vestibule adjacent to the Evacuation Door; • over all parts of the Evacuation Device, when it is installed in any configuration; and • over an area at track-level extending at least 1m from the base of the Evacuation Device when deployed to track level. The area where the Evacuation Device fits to the Unit shall be illuminated to at least 100 lux.

Rationale: *If an Evacuation Device is deployed when it is dark outside the Unit, the Unit will need to provide sufficient lighting of the environment around the device to enable the device to be fitted to the Unit and Passengers to evacuate.*

10.21 Fire extinguishers

10.21.1 TTS-3132 - Fire Extinguisher Location - Saloon

Each Vehicle shall have a location for storage of a 2 litre fire extinguisher such that there is an extinguisher location within 15m of all parts of each Saloon.

Rationale: *This is based on the requirements of EN 45545-6. It is up to the future operator to decide how many extinguishers to carry and whether these are available to Passengers.*

10.21.2 TTS-1307 - Saloon Fire Extinguisher Installation

It shall be possible configure the Saloon fire extinguisher location such that: • the extinguisher is visible and available to Passengers; and alternatively • the extinguisher is behind a locked cover and only accessible to Train Crew.

Rationale: *It is up to the HS2 Train Operator to decide how many extinguishers to carry and whether these are available to Passengers.*

10.21.3 TTS-1309 - Fire Extinguisher Location - Cab

The Cab shall include a 2 litre fire extinguisher.

10.21.4 TTS-3134 - Fire Extinguisher Location - Catering

Any Catering Area shall include a 2 litre fire extinguisher.

Cross reference: *See also Section 10.8 (Catering)*

11 Interior Layout

11.0.1 This section contains requirements on the layout of the interior components described above in section 10.

11.0.2 Section 11.1 contains the requirements for the One Space Layout (1SL) to be provided with the Tender. The number of seats that are provided with the 1SL will form part of Stage 5 of the Tender Evaluation. Appendix R contains a set of changes to the requirements in Section 11.1 to produce the Two Space Layout (2SL). This is an alternative layout for costing purposes. The costs of both the 1SL and 2SL will be factored into Stage 5 of the Tender Evaluation.

11.0.3 Prior to contract award, it is anticipated that either the 1SL or the 2SL will be chosen as the base layout for the contract. The layout may then be changed through the interiors collaboration process described in MSA Schedule 9, Appendix 1. Requirements in section 11.1 will be updated to align with any agreed layout changes.

11.0.4 In order to ensure that flexibility of the seating layout and interior features is maintained throughout the course of the contract Section 11.3 contains a requirement for a minimum internal area, the "Contractually Protected Area" that must be free of permanent obstructions. This will be derived from the 1SL.

11.0.5 In order to ensure that the Unit technically has the capability to accept a range of interior layouts, a High Density Layout is defined in section 11.4, which represents the maximum payload capacity of the Unit.

11.1 One-Space Layout

11.1.1 Passenger Seats

11.1.1.1 TTS-1979 - Number of Seats

There shall be [●] Passenger Seats in the One-Space Layout.

11.1.1.2 ***Update for contract -*** *It is anticipated that TTS-1979 will not be included in the contracted TTS, because seat numbers will be recorded in layouts in the Train Proposal and Design Documentation. The requirement to maintain the Contractually Protected Layout will be maintained in place of TTS-1979*

11.1.1.3 TTS-2239 - Seat Pitch - Mandatory

The One-Space Layout shall provide the following seat pitches, i.e. the distance from the rearmost point of one seat to the rearmost point of the next seat:
- airline seating - 895mm; and
- bay seating - 2030mm.

Nominal seat pitches shall not be greater or less than these values.

Rationale: *These definitions have been developed to ensure a good level of comfort when seated and an consistent evaluation of the furnishable space provided in the interior layout. The integration of the specific seat design proposed will be evaluated separately. Seat pitches cannot exceed these values as the integration of tables and seats will be based on this value. Any space that cannot be filled with a whole row of seats should be filled with a luggage stack or left empty.*

11.1.1.4 TTS-1980 - Seat Arrangement - Mandatory

The One-Space Layout shall include HS2 Seats that shall be arranged transversely so that there are no more than two seats adjacent to each other (commonly referred to as 2+2 seating).

Rationale: *This layout provides all Passengers with the same space at all Passenger Seats (although depending on the specific seat design, priority seats may affect this slightly).*

11.1.1.5 TTS-734 - Aisle Clearway - Mandatory

With reference to PRM TSI[6] Clauses 4.2.2.6 and 7.3.2.4, the aisle between Passenger Seats shall provide a minimum horizontal clearway of 450mm at all points of the Saloon.

Rationale: *This is intended to clarify that HS2 does not consider that the special case provided in PRM TSI[6] Clause 7.3.2.4 provides adequate passenger experience and the Unit should be designed to deliver compliance horizontally with Clause 4.2.2.6.*

11.1.1.6 TTS-2710 - Longitudinal Seating - Mandatory

The One-Space Layout shall have no longitudinal Passenger Seats.

11.1.1.7 TTS-2015 - Bay/Airline Seating Arrangement - Mandatory

The One-Space Layout shall include seat bays (including Multi-Purpose Areas) as follows:
- a minimum of 32 Full Seat Bays per Unit; and
- a minimum of 2 Full Seat Bays per Vehicle.

Rationale: *HS2 wants to ensure that seat bays are available to passengers with a preference to use them.*

11.1.1.8 TTS-2004 - Multi-Purpose Areas - Mandatory

All Vehicles within the One-Space Layout that do not contain Wheelchair Spaces shall have one Multi-Purpose Area.

11.1.1.9 TTS-2005 - Multi-Purpose Areas - Location - Mandatory

Multi-Purpose Areas shall be located at the end of a Saloon such that there are no other seats between the Multi-Purpose Area and the nearest Exterior Door.

Rationale: *This is intended to ensure that if the Multi-Purpose Area is being used to store large luggage items or pushchairs the area is as accessible as possible.*

11.1.1.10 TTS-2075 - Distance from Seats to Doors - Mandatory

All Seat Positions shall be no more than 12m from an Exterior Door, measured along the centre-line of the Vehicle from the mid-point of the Seating Position to the centre-line of the Exterior Doorway, as shown in Figure Q1 in Appendix Q.

Rationale: *This is to ensure that all passengers are close to a doorway to maximise dwell time performance.*

11.1.2 Wheelchair Spaces

11.1.2.1 TTS-1982 - Number of Wheelchair Spaces per Unit - Mandatory

The One-Space Layout shall have four Wheelchair Spaces.

Rationale: *This level of Wheelchair Space provision is seen as sufficient for the start of operation. Provision for additional Wheelchair Spaces is also specified.*

Cross reference: *See also Requirement TTS-1675 (Future Flexibility - Flexibility in Number of Wheelchair Spaces) in Section 10.7 (Wheelchair Spaces)*

11.1.2.2 TTS-2009 - Number of Wheelchair Spaces per Vehicle - Mandatory

The One-Space Layout shall have no more than two Wheelchair Spaces in any Vehicle.

11.1.2.3 TTS-1502 - Positioning of Wheelchair Spaces - Mandatory

With reference to PRM TSI[6] Clause 4.2.2.3.2 (4), the closest doorway to the Wheelchair Spaces shall be an Evacuation Door, which shall be positioned to comply with TTS-165.

Rationale: *The opportunities for wheelchair users to be evacuated without the need for them to leave their own wheelchair should be maximised. For this requirement, it cannot be assumed that access through the Gangway is possible unless this can be demonstrated for all curves defined in TTS-1541.*

Cross reference: *See also Requirement TTS-165 (Evacuation Door Position) in Section 7.15.7 (Evacuation)*

11.1.2.4 TTS-1051 - Companion Seats - Mandatory

With reference to PRM TSI[6] Clause 4.2.2.2 (9), companion seats shall be provided for all Wheelchair Spaces. These seats shall not be positioned on the opposing side of the aisle.

Rationale: *It should be ensured that wheelchair users can sit with other Passengers with whom they are travelling.*

11.1.2.5 TTS-1054 - Wheelchair Spaces - Access - Mandatory

Where two Wheelchair Spaces are positioned in the same Vehicle they shall be configured to ensure that if one space is occupied this shall not prevent access or egress by a wheelchair from the other Wheelchair Space.

Rationale: *Accessibility of the wheelchair facilities should always be maintained.*

11.1.3 Window size and alignment

11.1.3.1 Additional explanation and figures for the following requirements are provided in Appendix Q, Section Q.2. Note that the Window size and position is part of the Interiors Collaboration process as defined in MSA Schedule 9, Appendix 1 and 2.

11.1.3.2 TTS-2634 - Area with Windows

All parts of the Saloon and areas that could be converted to Saloon shall have apertures for Windows.
The maximum longitudinal distance from the start of the Saloon to the first Window aperture shall be 1000mm.
If these apertures are not adjacent to Seating Positions in the 1SL or 2SL the Window shall be obscured as part of that layout.

Rationale: *Provision of windows throughout the Saloon ensures all Passengers have some view. Obscured windows enable Toilets and Bulk Luggage Storage Areas to be removed and replaced by seating later in the Unit's life, without major changes to the Carbody.*

11.1.3.3 TTS-3392 - Window Pitch

For all Windows on a Vehicle, except those at the end of each Vehicle, the longitudinal distance between the start of one Window and the start of the next shall be 1790mm.

Rationale: *The alignment of seats with windows is important for Passenger experience. The Window pitch is specified to be two times the pitch of HS2 Seats in airline configuration. The majority of seats will be in airline configuration, and this Window pitch ensures consistent alignment of seats and windows can be achieved.*

11.1.3.4 TTS-3202 - Number of Window Types

There shall be no more than two sizes of Window used on the Unit.

Rationale: *The number of window sizes used should be minimised in order to manage spares provision for damage and vandalism. This does not include windows used in doors or in cabs.*

11.1.3.5 TTS-1213 - Minimise Deadlight Area

The size of the deadlight, measured between adjacent sections of un-obscured glass over 80% of the height of the Window (see Figure Q5), shall not exceed:

Preferred 1: The deadlight shall not exceed 300mm.
Preferred 2: The deadlight shall not exceed 350mm.
Preferred 3: The deadlight shall not exceed 400mm.
Preferred 4: The deadlight shall not exceed 450mm.
Preferred 5: The deadlight shall not exceed 500mm.

Rationale: *Minimisation of the deadlight size will ensure all Passengers have a reasonable view from the Unit.*

11.1.3.6 TTS-2633 - Window Height

The height of the Windows shall enable the User Population to see a point at track level, 10m laterally from the Unit, while:
- seated in any Passenger Seat;
- seated in a Wheelchair; and
- standing in the centre of the aisle in the Saloon.

Rationale: *This ensures all Passengers can see outside to avoid motion sickness, and improves the experience of travelling.*

11.1.3.7 TTS-1219 - Minimum Size - Door Windows

The lower edge of the transparent section of Exterior Door windows shall be not more than 1200mm above floor level and the upper edge shall be at least 1700mm above floor level. The minimum horizontal width of the Exterior Door windows shall be 300mm.

Rationale: *This is specified to ensure adequate visibility to standing passengers when the Unit is in a station.*

11.1.4 Toilets

11.1.4.1 TTS-1983 - Number of Toilets - Mandatory

The One-Space Layout shall include at least eight Toilets.
At least two of these Toilets shall be Universal Toilets.

Rationale: *This level of Toilet provision is seen to give an appropriate ratio of Passengers to toilets.*

11.1.4.2 TTS-691 - Distance from Seats to Toilets - Mandatory

The mid-point of all Seating Positions shall be no more than 25m from the nearest Toilet, measured along the centre-line of the Unit to the nearest point of the Toilet door.

Rationale: *Passengers should not need to have to walk far in any direction to reach Toilet facilities.*

11.1.4.3 TTS-2227 - Doors between Saloons and Toilets - Mandatory

Including the toilet door, there shall be at least two doors between any Seating Position and any Toilet.

11.1.4.4 TTS-2236 - Doors between Toilets and Catering Facilities - Mandatory

Including the toilet door, there shall be at least two doors between any Catering Area and any Toilet.

11.1.4.5 TTS-3354 - Toilet Position

All Toilets shall be positioned adjacent to a Saloon such that they could be converted to part of that Saloon (as shown in Appendix N, Figure N2).

Rationale: *This ensures maximum flexibility is achieved.*

11.1.5 Luggage

11.1.5.1 TTS-678 - Visibility of Luggage - Mandatory

All luggage storage, except that stored in the Bulk Luggage Storage Area, shall be contained within and be accessible from the Saloon

11.1.5.2 TTS-3351 - Minimum Luggage Stack Provision - Mandatory

Each Vehicle shall have at least the following number of luggage stacks, based on the number of Seating Positions:

Seating Positions	Minimum Luggage Stacks
0 – 24	1
25 – 48	2
49 – 72	3
73 +	4

Each such luggage stack shall have a minimum longitudinal length of 620mm as shown in Appendix Q, Figure Q5.
Each luggage stack shall be separate from other luggage stacks as shown in Appendix Q, Figure Q6.

Rationale: *This is specified to give a minimum level of luggage storage.*

11.1.5.3 TTS-676 - Luggage per Passenger - Small Bag

Each Vehicle shall have sufficient luggage capacity for 50% of Passengers, spread evenly through the Saloon, to bring a Small Bag.
Each Passenger's Small Bag shall be within 3m of their Seating Position.
Luggage stacks, luggage racks and space between back-to-back Passenger Seat may be used for this purpose. Other under-seat storage and Bulk Luggage Storage Areas shall not be used for this storage of Small Bags.

11.1.5.4 TTS-677 - Luggage per Passenger - Large Bag

Each Vehicle shall have sufficient luggage capacity for 25% of Passengers, spread evenly through the Saloon, to bring one Large Bag.
Each Passenger's Large Bag shall be stored between a Passenger's Seating Position and the nearest Exterior Doorway.
Luggage stacks and space between back-to-back Passenger Seat may be used for this purpose. Other under-seat storage and Bulk Luggage Storage Areas shall not be used for this storage of Large Bags.

Rationale: *This ensures that luggage storage is provided throughout the Saloon, close to all seats.*

11.1.5.5 TTS-284 - Bulk Luggage Storage (PQTS-370) - Mandatory

The One-Space Layout shall include two Bulk Luggage Storage Areas per Unit.

Rationale: *This will give a capacity for four Bicycles.*

11.1.5.6 TTS-2014 - Bulk Luggage Storage Location 1 - Mandatory

The Bulk Luggage Storage Area shall be positioned adjacent to a Vestibule.
Passengers shall not have to return to the platform between placing items in the storage and finding their seat.

Rationale: *Retrieving luggage from a remote bulk storage area could extend the Dwell Time.*

11.1.5.7 TTS-3352 - Bulk Luggage Storage Location 2

The Bulk Luggage Storage Area shall be positioned adjacent to a Saloon such that it can be converted to part of that Saloon (as shown in Appendix N, Figure N2).

Rationale: *This ensures maximum flexibility is achieved.*

11.1.6 Catering

11.1.6.1 TTS-1911 - Catering - Mandatory

The 1SL shall include two Catering Trolley Storage Points.
Each Catering Trolley Storage Point shall be located in different halves of the Unit.

11.1.6.2 TTS-3353 - Catering Position

The Catering Trolley Storage Points shall be positioned adjacent to a Saloon such that it can be converted to part of that Saloon (as shown in Appendix N, Figure N2).

Rationale: *This ensures maximum flexibility is achieved.*

11.1.7 PIS display position

11.1.7.1 TTS-1388 - Screen Position

The main colour PIS displays in the Saloon shall be positioned such that all Seating Positions in the 1SL are facing a screen not more than 12m away.

Cross reference: *See also Requirement TTS-1380 (Saloon Display Quantity) in Section 9.25.1 (Visual displays)*

11.1.8 Other equipment

11.1.8.1 TTS-3076 - Litter Bins - Mandatory

The One-Space Layout shall include two Litter Bins in each Vestibule.

11.1.8.2 TTS-3077 - Ramp and Evacuation Equipment - Mandatory

The One-Space Layout shall include for each Vehicle that contains Wheelchair Spaces:
- one On-board Ramp;
- one Evacuation Device; and
- two Evacuation Wheelchairs;

and storage cupboards to store this equipment

11.2 Two-Space Layout

11.2.1 TTS-3364 - 2SL changes from 1SL - Mandatory

The 2SL shall be the same as the 1SL except for changes necessary to meet the changed requirements in Appendix R.

11.3 Contractually Protected Area

11.3.1 The **Contractually Protected Area** is the area available within each Vehicle that can be used flexibly for the fitment of interior equipment. This space shall allow both the One-Space Layout and the Two-Space Layout to be accommodated individually without structural changes to any of the Vehicles. Items such as electrical equipment cubicles are excluded from the Contractually Protected Area.

11.3.2 TTS-1924 - Retain Contractually Protected Area - Mandatory

Each Vehicle shall provide the Contractually Protected Area defined by Figure N3 to [●] in Appendix N. These areas shall:
- be free from permanent fixtures, electrical equipment cubicles, structural partitions or other restrictions that prevent the reconfiguration of the Saloon; and
- maintain the minimum cross-sectional area (TTS-633) assuming typical interior panels.

Rationale: *The ability to reconfigure the interior layout is key to providing the ability for the rolling stock to adapt to future changes in User Population demographics and service offering.*

11.4 High Density Layout

11.4.1 The purpose of the High Density Layout (HDL) is to define the maximum payload capability of the Unit. This informs HS2 Ltd, the Purchaser and the HS2 Train Operator how the Unit can be operated and how the interior layout could be reconfigured in the future. The higher the normal payload and exceptional payload that the Unit can operate with, the more flexibility there is for future interior layout changes and operational flexibility.

11.4.2 For the Tender, a higher normal payload and/or exceptional payload will score more TTS compliance marks.

11.4.3 The HDL shall be developed from the 1SL. The HDL is only required to be developed as a layout diagram and payload calculation. Detailed design of the interior for the HDL is not required.

11.4.4 TTS-1818 - HDL Seat Type - Mandatory

In the HDL, the HS2 Seats in the 1SL shall be replaced by HDL Seats

11.4.5 The HDL Seat shall be a typical Intercity seat that has been used on another Intercity vehicle. The ergonomics of the typical intercity seat do not need to be considered; only the mass of the seat needs to be considered.

11.4.6 TTS-3361 - HDL Luggage Stacks - Mandatory

Luggage stacks shall be removed and/or reduced in size so that there are only two luggage stacks, each of which shall be 620mm measured along the centre-line of the Vehicle as shown in Appendix Q, Figure Q5.

11.4.7 TTS-3360 - HDL Bulk Luggage Storage - Mandatory

If, in the 1SL, the Bulk Luggage Storage Area can be converted into part of Saloon, it shall be replaced by HDL Seats in the HDL.

Cross reference: *See also Requirement TTS-3352 (Bulk Luggage Storage Location 2) in Section 11.1.5 (Luggage)*

11.4.8 TTS-3359 - HDL Catering - Mandatory

If, in the 1SL, the Catering Trolley Storage Points can be converted into part of the Saloon, it shall be replaced by HDL Seats in the HDL.

Cross reference: *See also Requirement TTS-3353 (Catering Position) in Section 11.1.6 (Catering)*

11.4.9 TTS-3207 - HDL Seat Arrangement - Mandatory

The HDL Seats shall be arranged in 2+2 formation.

11.4.10 TTS-3210 - HDL Seat Orientation - Mandatory

All HDL Seats shall be in an airline configuration except for a single bay near the centre of each Vehicle on either side of the aisle.

11.4.11 The seat pitches shall be selected to maximise the number of seats (see TTS-3217) while managing the Normal Payload (HDL) such that all relevant requirements of this TTS (as listed in Appendix B) can be complied with in this condition. The seat pitches shall comply with the following requirements:

11.4.12 TTS-3212 - HDL Priority Seats - Mandatory

Each Vehicle shall have at least 10% of its airline HDL Seats designated as priority seats. The seat pitch of these priority HDL Seats shall comply with the dimensions in PRM TSI[6] Appendix H.

11.4.13 TTS-3213 - HDL Common Airline Seat Pitch - Mandatory

All airline HDL Seats that are not priority seats shall be arranged such that they have the same seat pitch throughout the Unit.

11.4.14 TTS-3211 - HDL Minimum Airline Seat Pitch - Mandatory

The minimum seat pitch for HDL Seats in airline arrangement shall be 705mm.

11.4.15 TTS-3214 - HDL Common Bay Seat Pitch - Mandatory

All bay HDL Seats shall be arranged such that they have the same seat pitch throughout the Unit.

11.4.16 TTS-3215 - HDL Minimum Bay Seat Pitch - Mandatory

The minimum seat pitch for HDL Seats in bay arrangement shall be 1650mm.

11.4.17 The number of seats in the HDL should be evaluated against the following requirement:

11.4.18 TTS-3217 - HDL Seating Capacity

The HDL shall have a seated capacity in the Normal Payload (HDL) condition of:

Preferred 1: The HDL shall have 700 seats or greater.
Preferred 2: The HDL shall have 650 seats or greater.
Preferred 3: The HDL shall have 600 seats or greater.
Preferred 4: The HDL shall have 550 seats or greater.
Preferred 5: The HDL shall have 500 seats or greater.

11.4.19 The standing density (i.e. value for "[●]" in the Exceptional Payload (HDL) definition, in kg/m²) should be varied such that all requirements of the TTS referencing the Exceptional Payload (HDL) and all requirements in Mandatory Standards that apply to the exceptional payload (see definitions in Section 2.4) can be achieved. The total capacity of the Unit should be evaluated against the following requirement:

11.4.20 TTS-3224 - HDL Total Capacity

Considering a mass per standing passenger of 80kg, the HDL shall have a total seated and standing capacity in the Exceptional Payload (HDL) condition of:

Preferred 1: The HDL shall have a total capacity of 950 Passengers or greater.
Preferred 2: The HDL shall have a total capacity of 850 Passengers or greater.
Preferred 3: The HDL shall have a total capacity of 750 Passengers or greater.
Preferred 4: The HDL shall have a total capacity of 650 Passengers or greater.
Preferred 5: The HDL shall have a total capacity of 550 Passengers or greater.

12 Wayside Data System

12.0.1 The Wayside Data System is a software solution to be provided by the TMM to allow:

- data to be sent to, requested from and received from Units; and

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- data downloaded from the Unit to be reviewed, interrogated and manipulated.

12.1 Requirements

12.1.1 TTS-3093 - Wayside Data System - Interface

The Wayside Data System shall be available to Wayside Staff via both
• a web browser-based interface; and
• phone / tablet applications to be provided by the TMM.
The web browser interface shall be compatible with commonly used browsers at the time of Acceptance.
The phone/tablet-compatible applications shall be compatible with commonly used mobile operating systems at the time of Acceptance.

12.1.2 TTS-3199 - Wayside Data System - Data Retrieval by Other Applications

The Wayside Data System shall include interfaces to allow exchange of Train Data with other 3rd party applications. The interface with such systems is to be agreed with the Purchaser and may be defined by the Purchaser.

12.1.3 TTS-3242 - Wayside Data System - Core Functions - Wayside Functions

The Wayside Data System shall:
• enable Wayside Staff to update Operator Settings;
• enable Wayside Staff to update current and tractive effort limits;
• facilitate creation, testing and upload of any new databases for the PIS Automatic Information Programme, including audio and video files;
• facilitate sending software updates to the Unit; and
• enable transfer of data related to Diagram Allocation as described elsewhere in this specification.

Cross reference: *See also Requirement TTS-159 (Moveable Step Deployment Distance - CRN) in Section 9.18.9 (Moveable Step)*
See also Requirement TTS-307 (Door Auto-close) in Section 9.18.5 (Auto-close)
See also Requirement TTS-415 (Reverse Driving) in Section 8.8 (Shunting)
See also Requirement TTS-494 (Set Operational Vehicle Type) in Section 9.1 (Operator Settings and Software Updates)
See also Requirement TTS-510 (Alarm Indication - Train Crew) in Section 9.24.1 (Passenger Alarms)
See also Requirement TTS-531 (Configurability of Seat Reservation Display) in Section 9.25.5 (Reservation and occupancy detection)
See also Requirement TTS-721 (Configurable Operation of Interior Doors) in Section 9.34 (Interior Doors)
See also Requirement TTS-729 (Auto-Close of Interior Doors) in Section 9.34 (Interior Doors)
See also Requirement TTS-730 (Interior Door Close Check) in Section 9.34 (Interior Doors)
See also Requirement TTS-752 (Adjustment of Lighting Level Based on Ambient Light Level) in Section 9.33.1 (Lighting states and levels)
See also Requirement TTS-753 (Seating Position Lighting Illuminance Adjustment) in Section 9.33.1 (Lighting states and levels)
See also Requirement TTS-754 (Adjustment of Lighting Colour Temperature) in Section 9.33.1 (Lighting states and levels)
See also Requirement TTS-756 (Ceiling Lighting - Colour Adjustment) in Section 9.33.1 (Lighting states and levels)

See also Requirement TTS-757 (Toilet Lighting Illuminance) in Section 9.33.1 (Lighting states and levels)
See also Requirement TTS-759 (Vestibule Lighting Illuminance) in Section 9.33.1 (Lighting states and levels)
See also Requirement TTS-1041 (Interior Door Controls 1) in Section 9.34 (Interior Doors)
See also Requirement TTS-1068 (Occupation Timer) in Section 9.32 (Toilets and Sanitary Systems)
See also Requirement TTS-1087 (Fresh Air Regulation) in Section 9.20.1 (HVAC control)
See also Requirement TTS-1103 (Aisle Lighting Illuminance Adjustment) in Section 9.33.1 (Lighting states and levels)
See also Requirement TTS-1111 (Stand-By State Lighting) in Section 9.33.1 (Lighting states and levels)
See also Requirement TTS-1117 (Automatic Response to Fresh Air Smoke) in Section 9.22.2 (External smoke control)
See also Requirement TTS-1118 (Manual Response to External Smoke) in Section 9.22.2 (External smoke control)
See also Requirement TTS-1232 (Configuration of Door Control Strategies) in Section 9.18.2 (Train-wide door control)
See also Requirement TTS-1361 (Update Operator Settings 2) in Section 9.1 (Operator Settings and Software Updates)
See also Requirement TTS-1362 (Update Operator Settings 1) in Section 9.1 (Operator Settings and Software Updates)
See also Requirement TTS-1371 (Automatic State Switching - Operational Diagram) in Section 9.7.2 (Operational states)
See also Requirement TTS-1377 (Event Messages) in Section 9.5.1 (Events)
See also Requirement TTS-1390 (AIP Update) in Section 9.25.3 (Automatic Information Programme (AIP))
See also Requirement TTS-1394 (ODA Changes - Wayside) in Section 9.2 (Diagram allocation)
See also Requirement TTS-1395 (ODA - Control) in Section 9.2 (Diagram allocation)
See also Requirement TTS-1396 (ODA Changes - On-board) in Section 9.2 (Diagram allocation)
See also Requirement TTS-1460 (Limited Heat Release State) in Section 9.21 (Heat management)
See also Requirement TTS-1575 (Slow Speed Adjustment) in Section 8.8 (Shunting)
See also Requirement TTS-1741 (Display of CCTV Images on PIS Displays) in Section 9.26.1 (Requirements applicable to all CCTV Systems)
See also Requirement TTS-1761 (Vigilance - Adjust X Value) in Section 8.11 (Other protection systems)
See also Requirement TTS-1813 (Automatic Interior Door Opening - Stations) in Section 9.34 (Interior Doors)
See also Requirement TTS-1834 (Internal Fire Train-Crew Alert) in Section 9.22.1 (Internal fire detection)
See also Requirement TTS-1844 (Adjust Detection Thresholds) in Section 9.22.2 (External smoke control)
See also Requirement TTS-1855 (Lighting Arrangement in Saloon - Low Level Lighting) in Section 9.33.1 (Lighting states and levels)
See also Requirement TTS-2012 (When Images are Recorded - Cab) in Section 9.26.5 (Cab CCTV)
See also Requirement TTS-2034 (Energy Metering Data Processing) in Section 9.14 (Energy metering)
See also Requirement TTS-2054 (Train Crew Cab Lighting) in Section 9.33.3 (Cab lighting control)
See also Requirement TTS-2055 (Cab Lighting Auto-off) in Section 9.33.3 (Cab lighting control)
See also Requirement TTS-2079 (Temporary Operator Settings) in Section 9.1 (Operator Settings and Software Updates)
See also Requirement TTS-2174 (Switch Out of Maintenance State) in Section 9.7.2 (Operational states)
See also Requirement TTS-2188 (Event Alert - Train Crew) in Section 9.5.1 (Events)
See also Requirement TTS-2482 (Update Software for Fleet) in Section 9.29.3 (Software update)
See also Requirement TTS-2872 (Temporary Interior Door Inhibit) in Section 9.34 (Interior Doors)
See also Requirement TTS-2942 (AIP Journey Time Update) in Section 9.25.3 (Automatic Information Programme (AIP))
See also Requirement TTS-3069 (Update Software from Wayside) in Section 9.29.3 (Software update)

12.1.4 TTS-3243 - Wayside Data System - Core Functions - Diagnostic Data

The Wayside Data System shall:
- enable Wayside Staff to conduct analysis related to failures of the Unit including: trend analysis, post-failure interventions and service performance analysis;
- enable Wayside Staff to carry out and request upload and download of Train Data stated elsewhere in this specification;
- initiate, collate and report on fitness to run assessments; and
- facilitate access to infrastructure monitoring Train Data and creation of related alerts.

Cross reference: *See also Requirement TTS-499 (Data Download - Regular) in Section 9.5.2 (Data recording)*
See also Requirement TTS-840 (Management of Power Supply Interruption - Standby) in Section 9.7.2 (Operational states)
See also Requirement TTS-1048 (Reset & Isolate ADD) in Section 9.15 (Pantograph control)
See also Requirement TTS-1303 (ASDO Override) in Section 9.18.3 (Automatic Selective Door Operation (ASDO))
See also Requirement TTS-1465 (Event Presentation - Maintainer) in Section 9.5.1 (Events)
See also Requirement TTS-1466 (Event Transmission to Wayside) in Section 9.5.1 (Events)
See also Requirement TTS-1543 (Monitoring of Consumables / Tanks) in Section 9.29.2 (Consumable / waste monitoring)
See also Requirement TTS-1604 (Record Login) in Section 9.7.1 (Log-in and security)
See also Requirement TTS-1700 (Sand Level Monitoring) in Section 9.12 (Sanding and adhesion control)
See also Requirement TTS-1822 (Data Download - Triggered) in Section 9.5.2 (Data recording)
See also Requirement TTS-1974 (UGMS Alert Reporting) in Section 9.27.3 (Unattended Geometry Measurement System (UGMS))
See also Requirement TTS-2041 (Automated Fit for Service Check) in Section 9.29.1 (Train preparation)
See also Requirement TTS-2047 (Train Captain Settings - Wayside Synchronisation) in Section 9.7.4 (Train Captain settings)
See also Requirement TTS-2178 (Sand Usage Monitoring) in Section 9.12 (Sanding and adhesion control)
See also Requirement TTS-2222 (Recording of Entry in to Train Crew Areas) in Section 9.23.1 (Physical security)
See also Requirement TTS-2223 (Recording of Entry in to Cab) in Section 9.23.1 (Physical security)
See also Requirement TTS-2520 (IM Data Download - Regular) in Section 9.27.2 (Equipment fitted to IM Units)
See also Requirement TTS-2521 (IM Data Download - Triggered) in Section 9.27.2 (Equipment fitted to IM Units)
See also Requirement TTS-2843 (Accelerometer Alert Reporting) in Section 9.27.1 (Monitoring equipment to be fitted to all Units)
See also Requirement TTS-3206 (Catering Kiosk - Stock Level Reporting) in Section 10.8.3 (Catering Kiosk)

12.1.5 TTS-3246 - Wayside Data System - Core Functions - Real Time Diagnostic and Unit Data

The Wayside Data System shall:
- inform Wayside Staff and other interfacing systems of specific diagnostic and operating Events on Trains in real time to allow them to manage Trains whilst they are operating in service;
- provide Train Data about Train status to allow monitoring of Units;

• facilitate sending and receiving of door status information to allow for failures on Units and on PEP installations to be accounted for in service;
• facilitate sending and receiving of live information to support the AIP and seat reservation functionality; and
• report changes made to settings by staff on the Unit where required by this specification.

Cross reference: *See also Requirement TTS-385 (Temperature Regulation) in Section 9.20.1 (HVAC control)*
See also Requirement TTS-406 (Actions on ADD) in Section 9.15 (Pantograph control)
See also Requirement TTS-527 (Live update of Seat Reservation System) in Section 9.25.5 (Reservation and occupancy detection)
See also Requirement TTS-1286 (Reporting of Emergency Egress Devices) in Section 9.18.8 (Emergency Egress Device)
See also Requirement TTS-1290 (Train Door Inhibit Based on PEP) in Section 9.19.2 (Door and PEP control)
See also Requirement TTS-1291 (PEP Inhibit Based on Train Door) in Section 9.19.2 (Door and PEP control)
See also Requirement TTS-1389 (AIP Staff Interface) in Section 9.25.3 (Automatic Information Programme (AIP))
See also Requirement TTS-1413 (Wayside Messages) in Section 9.25.3 (Automatic Information Programme (AIP))
See also Requirement TTS-1416 (Alarm Indication - Wayside) in Section 9.24.1 (Passenger Alarms)
See also Requirement TTS-1436 (Door status display to Wayside) in Section 9.18.7 (Door status)
See also Requirement TTS-1582 (Payload Information) in Section 9.17 (Payload management)
See also Requirement TTS-1764 (Report Abnormal Actions) in Section 9.5.2 (Data recording)
See also Requirement TTS-1825 (Location Reporting) in Section 9.6 (Location-based functions)
See also Requirement TTS-2039 (Report WSP) in Section 9.10 (Brake control)
See also Requirement TTS-2204 (Seat Occupancy Detection) in Section 9.25.5 (Reservation and occupancy detection)
See also Requirement TTS-2622 (Running Gear Hunting Detection) in Section 9.16 (Running Gear monitoring)
See also Requirement TTS-2623 (Running Gear Derailment Detection) in Section 9.16 (Running Gear monitoring)
See also Requirement TTS-2848 (Fire Detection Wayside Alert) in Section 9.22.1 (Internal fire detection)
See also Requirement TTS-2943 (AIP Real-time Travel Information) in Section 9.25.3 (Automatic Information Programme (AIP))
See also Requirement TTS-2945 (Automatic Reservation Set-up) in Section 9.25.5 (Reservation and occupancy detection)
See also Requirement TTS-2946 (Manual Reservation Set-up) in Section 9.25.5 (Reservation and occupancy detection)

12.1.6 TTS-3244 - Wayside Data System - Core Functions - Remote Control

The Wayside Data System shall:
• enable Wayside Staff and other interfacing systems to control the turning on and off of consumers on Units, so as to and maximise energy efficiency (for example during extended dwells);
• allow Wayside Staff and other interfacing systems to interrogate and change states set on Units; and
• enable Wayside Staff and other interfacing systems to carry out other control functions stated elsewhere in this specification.

Cross reference: *See also Requirement TTS-421 (Selection of Train State from the Wayside) in Section 9.7.2 (Operational states)*
See also Requirement TTS-491 (Remote Recovery from Failure) in Section 9.5.4 (Reset and isolation)
See also Requirement TTS-1351 (Tractive Effort Limit) in Section 9.9 (Traction control)
See also Requirement TTS-1416 (Alarm Indication - Wayside) in Section 9.24.1 (Passenger Alarms)
See also Requirement TTS-1437 (Selective Door Inhibit) in Section 9.18.2 (Train-wide door control)
See also Requirement TTS-1462 (Switch Off lighting) in Section 9.33.1 (Lighting states and levels)
See also Requirement TTS-1490 (Dynamic Current Limit) in Section 9.13 (Power supply control)
See also Requirement TTS-1587 (LHRS Automatic Operation) in Section 9.21 (Heat management)
See also Requirement TTS-1810 (Reading Lights - Remote Control) in Section 9.33.2 (Reading lights)

12.1.7 TTS-3127 - Wayside Data System - Core Functions - CCTV Viewing

Viewing of CCTV images shall include the following functionality:
- retrieving image Train Data for off-board review and/or storage on secure digital media;
- searching and viewing image Train Data by the input of specific date, time, Unit, Vehicle or Event criteria (e.g. Train Captain markers);
- viewing live or recorded images from any camera on a Unit with a minimum of 4 images displayed simultaneously; and
- scrolling through image Train Data.

Cross reference: *See also Requirement TTS-552 (Live CCTV Transmission) in Section 9.26.1 (Requirements applicable to all CCTV Systems)*
See also Requirement TTS-553 (Recorded CCTV Transmission) in Section 9.26.1 (Requirements applicable to all CCTV Systems)
See also Requirement TTS-563 (Image Quality) in Section 9.26.1 (Requirements applicable to all CCTV Systems)
See also Requirement TTS-1197 (Train Captain Marker (FFRF)) in Section 9.26.2 (FFRF CCTV)
See also Requirement TTS-1300 (Fire Detection Internal CCTV) in Section 9.22.1 (Internal fire detection)
See also Requirement TTS-1420 (Train Captain Marker (Pantograph)) in Section 9.26.3 (Pantograph CCTV)

12.1.8 TTS-3109 - Wayside Data System - Key Data

The Train Data provided to, and accessed from, the Wayside Data System shall include: • condition based monitoring and trending data; • notifications of train fault event data; • attribute data associated with Events; • status of on-board isolations; • status of any functions that can be controlled from the Wayside; • test status and results; • software status of equipment; • hardware status of equipment; • Passenger load weigh information; • Saloon environment measurements; • train data recorder / juridical recorder data; • CCTV data; • infrastructure monitoring data; • equipment status information; • diagram allocation data; and • all other data identified by the Purchaser during the design and test process as being useful to assist in the operation of the Units.

12.1.9 TTS-3118 - Wayside Data System - Data Processing

The Wayside Data System shall allow Wayside Staff to search, extract, export, view and create graphs of the downloaded Train Data.

12.1.10 TTS-3103 - Wayside Data System - Accounts

Each Wayside Staff member shall have their own Wayside Data System account with a unique password. An administrator shall be able to define which facilities and functions are available to each user.

12.1.11 TTS-3101 - Wayside Data System - Account Administration

The Purchaser's administrative staff shall have control of access rights for the Purchaser's staff.

12.1.12 TTS-3102 - Wayside Data System - Number of Simultaneous Users

It shall be possible for at least 20 Wayside Staff to simultaneously access and use any of the functions of the Wayside Data System without affecting the tool's response.

12.1.13 TTS-3104 - Wayside Data System - Historic Data

The Wayside Data System shall provide immediate access to historic data to assist in analysing trends, patterns of events, reports and investigations from any time period within the life of the Units except for CCTV data which shall be available for six months.

12.1.14 TTS-3445 - Wayside Data Systems - Storage Integrity

Train Data shall be stored on the Wayside Data System with sufficient integrity such that:
- users cannot edit or change the Train Data; and
- the Train Data can be used by authorities during investigations.

12.1.15 TTS-3107 - Wayside Data System - Reports and Export

It shall be possible to export raw data, interpreted data and the results of any Wayside Data System query to a report in an open format that can be loaded into other applications

12.1.16 TTS-3108 - Wayside Data System - Identification of Issues

The Wayside Data System shall automatically identify and report any Units which are not reporting their status, Events or other system information.

12.1.17 TTS-3113 - Wayside Data System - Alerts

The Wayside Data System shall have the ability to generate customised reports and notifications and to send them to specified users, e.g. via email or SMS text message.

12.1.18 TTS-3114 - Wayside Data System - Search

It shall be possible to use the Wayside Data System to search for and extract data based on, but not limited to, combinations of the following:
- a specific Unit/Train or a group of Units/Trains;
- one or more individual Vehicle type(s) in a Train formation;
- one or more selectable periods of time (e.g. days, weeks or months);
- all or a combination of fault codes or Event triggers;
- all faults for one or more particular systems or priorities; and
- one or more geographical locations.

12.1.19 TTS-3142 - Wayside Data System - Data Prioritisation

It shall be possible to define a hierarchy of Train Data transmissions such that high priority data is always received at the Wayside in the appropriate timeframe.

12.1.20 TTS-3143 - Wayside Data System - Data Processing Time

The maximum time for presentation of high priority Train Data to the relevant user shall be 10 seconds, not including time for data to be transmitted from the Unit to the Wayside.

12.1.21 TTS-3119 - Wayside Data System - Fleet Overview

The Wayside Data System shall include a high level fleet overview screen where each Unit and its status with regard to important faults is displayed. It shall be possible to directly access greater detail for each individual Unit from this screen.

12.1.22 TTS-3120 - Wayside Data System - Command Log

The Wayside Data System shall log which User has initiated any control functions on which Units.

12.1.23 TTS-3121 - Wayside Data System - Command Feedback

Feedback shall be provided via the Wayside Data System on the success of each control trigger and the response of the Unit.

12.1.24 TTS-3123 - Wayside Data System - Start-Up Summary

The Wayside Data System shall provide a summary screen showing whether each Unit has received the command to prepare for service and whether each Train is now ready for service.

12.1.25 TTS-3125 - Wayside Data System - Geofencing

It shall be possible to apply logic which means that control functions are only applied when a Unit is situated in specific locations.

13 References

	Title	Reference	Revision
1	Interoperability Directive	Directive (EU) 2016/797	
2	Common Safety Method for risk evaluation and assessment	Commission Regulation (EU) 402/2013	
3	Railways (Interoperability) Regulations	S.I. 2011 No.3066 & Amendments	
4	Locomotives & Passenger Rolling Stock TSI	LOC & PAS TSI - Reg. (EU) No. 1302/2014	
5	Control-command and signaling TSI	CCS TSI - Reg. (EU) 2016/919	
6	Persons with Reduced Mobility TSI	PRM TSI - Reg. (EU) No. 1300/2014	
7	Noise TSI	NOI TSI - Reg. (EU) No. 1304/2014	
8	Energy TSI	ENE TSI - Reg. (EU) No. 1301/2014	
9	Infrastructure TSI	INF TSI - Reg. (EU) No. 1299/2014	
10	High Speed Rolling Stock TSI	HS RST TSI - 2008/232/CE	
11	Running Dynamics Application of EN 14363:2005 – Modifications and Clarifications	ERA/TD/2012-17/INT	v3.0
12	Interfaces between CCS track-side and other subsystems	ERA/ERTMS/033281	v3.0
13	Guide for the application of TSI LOC&PAS According to Framework Mandate C(2010)2576 final of 29/04/2010	ERA/GUI/07-2011/INT	v2.0
13A	EUAR opinion regarding CCS TSI Error Corrections	ERA/OPI/2017-2	
13B	EUAR opinion regarding a possible revision of CCS TSI - test specifications	ERA/OPI/2017-5	
14	GSM-R System Requirements Specification	EIRENE SRS	v16.0.0
15	ATO Over ETCS Glossary	EUG Reference: 13E154	v1.6
16	ERTMS/ETCS System Requirements Specification	UNISIG SUBSET 026	v3.6.0
16A	Performance Requirements for Interoperability	UNISIG SUBSET 041	v3.2.0
17	ATO over ETCS Operational Requirements	EUG Reference: 13E137	
18	ERA solution for CR1238 ETCS 040518	HS2-HS2-RR-SPE-000-000033 (no original doc ID - HS2 # issued)	P01
19	ATO over ETCS – System Requirement Specification	UNISIG SUBSET 125	v0.1.0
20	ATO-OB / ATO-TS Interface Specification	UNISIG SUBSET 126	v0.0.16
21	ATO-OB / ETCS-OB Interface Specification	UNISIG SUBSET 130	v0.1.0
21A	ATO over ETCS Release Note	AoE RN	v0.0.1
22	ATO – GB New Trains Onboard Subsystem Requirements Specification	STE/ATO/REQ/001	

	Title	Reference	Revision
23	13 A plugs, socket-outlets, adaptors and connection units. Specification for 13 A switched and unswitched socket-outlets	BS 1363-2:2016	
24	Lock assemblies operated by key from both the inside and outside of the door	BS 3621:2017	
25	Not Used	Not Used	
26	Code of practice for audio-frequency induction-loop systems (AFILS)	BS 7594:2011	
27	Lock assemblies operated by key from the outside of the door and by handle or thumb turn from the inside of the door	BS 8621:2017	
27A	Graphical symbols. Safety colours and safety signs. Colorimetric and photometric properties of safety sign materials	BS ISO 3864-4:2011	
28	Fire resistance tests for non-loadbearing elements. Walls	EN 1364-1:2015	
29	Particulate air filters for general ventilation Determination of the filtration performance.	BS EN 779:2012	
30	Playground Equipment and Surfacing Part 1: General Safety and Test Methods	BS EN 1176-1:2008	
31	Railway applications - Ride comfort for passengers - Measurement and evaluation	BS EN 12299:2009	
32	Railway applications Air conditioning for main line rolling stock Comfort parameters and type tests	BS EN 13129:2016	
33	Railway applications — Electrical lighting for rolling stock in public transport systems	BS EN 13272:2012	
33A	Railway applications Wheelsets and bogies Method of specifying the structural requirements of bogie frames	BS EN 13749:2011	
34	Railway applications Aerodynamics Requirements and test procedures for aerodynamics on open track	BS EN 14067-4:2013	
35	Railway applications Aerodynamics Requirements and test procedures for aerodynamics in tunnels	BS EN 14067-5:2006+A1:2010	
36	Railway applications Aerodynamics Requirements and test procedures for cross wind assessment	BS EN 14067-6:2010	

	Title	Reference	Revision
37	Railway applications. Aerodynamics Requirements and test procedures for cross wind assessment	prEN 14067-6:2016 (Draft for Public Comment 16 / 30326116 DC)	
38	Railway applications Testing for the acceptance of running characteristics of railway vehicles Testing of running behaviour and stationary tests	BS EN 14363:2005	
39	Railway applications Testing and Simulation for the acceptance of running characteristics of railway vehicles Running Behaviour and stationary tests	BS EN 14363:2016	
40	Railway applications — Body side entrance systems for rolling stock	BS EN 14752:2015	
41	Railway applications Air conditioning for driving cabs Part 1: Comfort parameters	BS EN 14813-1:2006+A1:2010	
42	Railway applications External visible and audible warning devices for trains Part 2: Warning horns	BS EN 15132-2:2013	
43	Railway applications Front windscreens for train cabs	BS EN 15152:2007	
43A	Railway applications Crashworthiness requirements for railway vehicle bodies	BS EN 15227:2008+A1:2010	
44	Railway applications - Gauges Part 2: Rolling stock gauge	BS EN 15273-2:2013	
45	Railway applications - Gauges Part 3: Structure gauges	BS EN 15273-3:2013	
46	Railway applications - Definition of vehicle reference masses	BS EN 15663:2009+AC:2010	
46A	Railway applications Requirements for bogies and running gears	BS EN 15827:2011	
47	Railway applications Noise emission Measurement of noise inside driver's cabs	BS EN 15892:2011	
48	Railway applications - Gangway systems between vehicles Part 1: Main applications	BS EN 16286-1:2013	
49	Railway applications — Design for PRM use — General requirements Part 1: Contrast	BS EN 16584-1:2017	
50	Railway applications — Design for PRM use — General requirements Part 2: Information	BS EN 16584-2:2017	

	Title	Reference	Revision
51	Railway applications — Design for PRM use — General requirements Part 3: Optical and friction characteristics	BS EN 16584-3:2017	
52	Railway applications Design for PRM use Equipment and components onboard rolling stock Part 1: Toilets	BS EN 16585-1:2017	
53	Railway applications Fire protection on railway vehicles Part 2: Requirements for fire behaviour of materials and components	BS EN 45545-2:2013+A1:2015	
54	Railway applications Fire protection on railway vehicles Part 3: Fire resistance requirements for fire barriers	BS EN 45545-3:2013	
55	Railway applications Fire protection on railway vehicles Part 4: Fire safety requirements for rolling stock design	BS EN 45545-4:2013	
56	Railway applications Fire protection on railway vehicles Part 6: Fire control and management systems	BS EN 45545-6:2013	
57	Railway applications Electromagnetic compatibility Rolling stock Train and complete vehicle	BS EN 50121-3-1:2006	
58	Railway applications Electromagnetic compatibility Rolling stock Apparatus	BS EN 50121-3-2:2006	
59	Railway applications Electromagnetic compatibility Rolling stock Train and complete vehicle	BS EN 50121-3-1:2017	
60	Railway applications Electromagnetic compatibility Rolling stock Apparatus	BS EN 50121-3-2:2016	
60A	Railway applications Fixed installations Electrical safety, earthing and the return circuit Part 1: Protective provisions against electric shock	BS EN 50122-1:2011 +A4:2017	
61	Railway applications - Environmental conditions for equipment Part 1: Rolling stock and on-board equipment	BS EN 50125-1:2014	

	Title	Reference	Revision
61A	Method of test for resistance to fire of unprotected small cables for use in emergency circuits	BS EN 50200:2015	
62	Railway applications Current collection systems Requirements for and validation of measurements of the dynamic interaction between pantograph and overhead contact line	BS EN 50317:2012	
63	Railway applications Current collection systems Technical criteria for the interaction between pantograph and overhead line (to achieve free access)	BS EN 50367:2012 (incorporating corrigenda June 2012 and August 2013)	
64	Railway Applications Power supply and rolling stock Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability	BS EN 50388:2012 (incorporating corrigenda August 2012, April 2013 and August 2013)	
64A	Railway Applications - Fixed installations and rolling stock - Technical criteria for the coordination between traction power supply and rolling stock to achieve interoperability - Part 1: general	prEN 50388-1:2017 (Draft for Public Comment 17 / 30356581 DC)	
65	Railway applications. Requirements for running capability in case of fire on board of rolling stock.	BS EN 50553:2012+A1:2016	
66	Electroacoustics. Hearing aids. Induction-loop systems for hearing aid purposes. System performance requirements	BS EN 60118-4:2015	
67	Sound system equipment Objective rating of speech intelligibility by speech transmission index	BS EN 60268-16:2011	
68	Plugs, socket-outlets and couplers for industrial purposes. Dimensional interchangeability requirements for pin and contact-tube accessories	BS EN 60309-2:1999+A2:2012	
69	Railway applications. Rolling stock equipment. Shock and vibration tests	BS EN 61373:2010	
70	Railway applications Urban guided transport management and command/control systems Part 2: Functional requirements specification.	BS EN 62290-2:2014	
70A	Acoustics -- Description, measurement and assessment of environmental noise -- Part 2: Determination of sound pressure levels	BS EN ISO 1996-2:2017	

	Title	Reference	Revision
71	Acoustics - Railway applications - Measurement of noise emitted by railbound vehicles	BS EN ISO 3095:2013	
72	Railway applications - Acoustics - Measurement of noise inside railbound vehicles	BS EN ISO 3381:2011	
73	Environmental labels and declarations. Type III environmental declarations. Principles and procedures	BS EN ISO 14025:2010	
74	Air filters for general ventilation Technical specifications, requirements and classification system based upon particulate matter efficiency (ePM)	BS EN ISO 16890-1:2016	
75	IEEE Standard for Communications-Based Train Control (CBTC) Performance and Functional Requirements	IEEE Std 1474.1-2004	
76	IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers	IEEE 1789-2015	
77	Railway Group Standards Code	RGSC01	Iss 4
78	Permissible Track Forces for Railway Vehicles	GM/TT0088	Iss 1
79	AWS and TPWS Application Requirements	RIS-0775-CCS	Iss 1
80	The Management of Packet 44 Applications	RIS-0784-CCS	Iss 1
81	GSM-R Train Voice Radio Systems	RIS-0794-CCS	Iss 2
82	Compatibility Requirements for Braking Systems of Rail Vehicles	GM/RT2045	Iss 4
83	Requirements for Rail Vehicle Structures	GM/RT2100	Iss 5
84	Rolling Stock Subsystem and Interface to AC Energy Subsystem	GM/RT2111	Iss 1
85	Vehicle Fire, Safety and Evacuation	GM/RT2130	Iss 4
86	Audibility and Visibility of Trains	GM/RT2131	Iss 1
87	On-board Energy Metering for Billing Purposes	GM/RT2132	Iss 1
88	Resistance of Railway Vehicles to Derailment and Roll-Over	GM/RT2141	Iss 3
89	Environment Inside Railway Vehicles (Audibility of detonators)	GM/RT2160	Iss 4
90	Requirements for Driving Cabs of Railway Vehicles	GM/RT2161	Iss 1
91	Requirements for the Size of Vehicles and Position of Equipment	GM/RT2173	Iss 2
92	Vehicle Registration, Marking and Numbering	RIS-2453-RST	Iss 1
93	Sanding Equipment	GM/RT2461	Iss 2
94	Design Requirements for a Driver's Reminder Appliance (DRA)	GM/RT2491	Iss 2

	Title	Reference	Revision
95	Power Operated External Doors on Passenger Carrying Rail Vehicles	GM/RT2473	Iss 2 (superseded)
96	Recommendations for Rail Vehicle Emergency and Safety Equipment	GM/RC2532	Iss 1
97	Guidance on Rail Vehicle Bodyshell, Bogie and Suspension Elements	GM/GN2686	Iss 1
98	Functioning and Control of Exterior Doors on Passenger Vehicles	RIS-2747-RST	Iss 1
99	GB Requirements for Platform Height, Platform Offset and Platform Width	GIRT7020	Iss 1
99A	Requirements for the Position of Infrastructure and for Defining and Maintaining Clearances	GIRT7073	Iss 2
100	Assessment of Compatibility of Rail Vehicle Weights and Underline Bridges	GE/RT8006	Iss 2
101	Not used.	Not used.	
102	Requirements for the Application of Standard Vehicle Gauges	GE/RT8073	Iss 3
103	Not used.	Not used.	
104	Rule Book - Train Driver Manual	GERM8000-traindriver	Iss 5
105	Graphics guidelines for safety signs	ITL/GN001	Rev. B
106	ETCS – Baseline 3 – GB Onboard New Trains Subsystem Requirements Specification	NEPT/ERTMS/REQ/0038	Iss 2.2
107	Interim System Requirements Specification for Connected Driver Advisory System (C-DAS)	NOS/CDAS/REQ/0017 153821-NWR-REQ-ESG-000001 – see https://www.rssb.co.uk/improving-industry-performance/ertms	Iss 1.1
108	General Maintenance Parameters for Overhead Line Electrification Equipment	NR/L2/ELP/21088	Iss 3
109	Standardisation of coupling arrangements	RSSB report T1003 (available at www.sparkrail.org)	
110	PeopleSize 2008	Available via openerg.com/psz	
111	Network Rail Sectional Appendix	https://www.networkrail.co.uk/industry-commercial-partners/information-operating-companies/national-electronic-sectional-appendix/	
112	Product category rules according to ISO 14025:2006 Product group: UN CPC 495 Rolling Stock	2009:05	Version 2.11
113	UNIFE Recyclability and Recoverability Calculation Method Railway Rolling Stock	Date: 01.03.2013	Version 00
114	Requirements and testing procedures for the LPCB approval and listing of intruder resistant building components, strongpoints, security enclosures and free-standing barriers	LPS 1175	Issue 7.2
115	Not Used.	Not Used.	

	Title	Reference	Revision
116	Rolling Stock Data Book	HS2-HS2-RR-DAT-000-000001	P03
117	Pre-Qualification Technical Specification	HS2-HS2-RR-SPE-000-000006	P06
118	HS2 Potential Vehicle Gauge	HS2-DGG-RR-DAT-000-000003	P01
119	Automatic Vehicle Identification System Specification	HS2-NRL-RR-SPE-000-000002	P01
120	HS2 OCS information for pantograph and current collection analysis	HS2-HS2-RR-REP-000-000056	P01
121	[● - Gauge supplied by Tenderer]	[● - Reference for vehicle gauge]	
122	Gauging Challenge	HS2-HS2-RR-SPE-000-000027	P02
123	Technical Standard - Water resources and flood risk consents and approvals	HS2-HS2-EV-STD-000-000015	P05
124	Not Used.	Not Used.	
125	Static Dwell Time Model	HS2-HS2-RR-CAL-000-000009	P03
126	Energy Assessment Tool	HS2-HS2-RR-CAL-000-000010	P03
127	HS2 Design Vision	HS2-HS2-DS-STR-000-000005	P02
128	Control Period 5 Vehicle Usage Charge Calculator and Notes	HS2-NRL-RR-MOD-000-000001	P01
129	HS2 Northolt Tunnel Gauge Cross Section with Zero Cant	PH1-HS2-CV-DSE-000-200009	P02
130	HS2 Northolt Tunnel Gauge Cross Section with Cant	PH1-HS2-CV-DSE-000-200010	P02

Appendix A - Train Operation Parameters

A.1 Introduction

A.1.1 This Appendix gives detailed data about the expected operation of the Units.

A.1.2 All data is based on the Phase 2a operation, when the HS2 Network is extended to Crewe.

A.1.3 This data shall be used for design purposes where it is necessary to consider operational data about the Units.

A.1.4 In-service operation may vary from these figure, particular during initial operations prior to Phase 2a opening and following the opening of Phase 2b.

A.2 Station and depot abbreviations

A.2.1 The following stations and depot are referred to by abbreviations in this Appendix:

- **EUS** – London Euston
- **BCS** – Birmingham Curzon Street
- **LIV** – Liverpool Lime Street
- **PRE** – Preston
- **MAN** – Manchester Piccadilly
- **GLC** – Glasgow Central
- **WWH** – Washwood Heath depot

A.3 Distance travelled and number of Units required in service

A.3.1 This section defines the average daily distance that Units will operate.

A.3.2 The annual and daily average Unit kilometre distance travelled is shown in Table A1. Note that the number of Units required does not include maintenance or operational spares.

Table A1 – Distance travelled by Units

Route	Units	Annual distance (,000 km)			Average km/day/Unit
		In-service	ECS	Total	
EUS-BCS	14	7,553	39	7,593	1,485
EUS-LIV	9	7,192	334	7,527	2,290
EUS-PRE	5	4,042	262	4,303	2,356
EUS-MAN	12	9,769	102	9,871	2,252

Route	Units	Annual distance (,000 km)			Average km/day/Unit
		In-service	ECS	Total	
EUS-GLC	9	7,901	186	8,087	2,460
Total	**49**	**36,457**	**923**	**37,380**	**2,090**

A.4 Number of journeys

A.4.1 This section defines the daily average number of journeys Units will undertake, to provide context for parameters which are based on a per journey basis.

A.4.2 The number of train journeys per Unit varies by route. The number of journeys each Unit is will make during a weekday is shown below in Table A2.

Table A2 – Daily weekday journeys

Route	Daily Single Journeys
EUS-BCS	12 - 15 (primary sets) 2 – 3 (strengthening sets)
EUS-LIV	7-8
EUS-PRE	6-8
EUS-MAN	6-10
EUS-GLC	4
Total	**49**

A.5 Number of coupling events

A.5.1 This section defines the average number of coupling events that a Unit will be required to undertake during an average day. An outline of a typical weekday is presented below:

- **EUS – BCS:** All 14 Units couple and uncouple twice per day, forming pairs of Units for the peak services. Four of the coupling events (8 Units) may take place overnight at WWH prior to start of service.

  An additional 2 Units begin the morning service uncoupled at EUS, and couple at BCS with an additional Unit from WWH. 1 Unit starts service as a single Unit at BCS, stabled at WWH. They then run as coupled Units in the morning peak, uncoupling for the inter-peak period (where second Units return to WWH).

  In the evening peak, these Units once again couple at BCS, and then uncouple for evening services after the peak (with the 2nd Unit returning to WWH). Overnight Units either berth at EUS or WWH.

- **EUS – LIV:** 1 Unit is expected to couple with a Unit on a EUS – PRE service at Euston at the end of the day for overnight stabling at Washwood Heath.

- **EUS – PRE:** 1 Unit is expected to uncouple with a Unit from a EUS – MA service in the morning at Euston having stabled overnight at WWH. At the end of the day, 1 Unit is expected to couple with a Unit from a EUS – LIV service for overnight stabling at WWH.

- **EUS – MAN:** 1 Unit is expected to uncouple with a Unit from a EUS – PRE service from WWH at Euston in the morning
- **EUS – GLC:** no coupling / uncoupling events expected on this pattern.

A.6 Time in 200m and 400m formation

A.6.1 This section defines what proportion of operational time the Units spend running alone and running coupled.

A.6.2 A 400m formation of two coupled Units is typically used in the morning and evening peaks on pattern 1,2,3 (EUS – BCS).

A.6.3 A summary of the 400m formation running time for pattern 1,2,3 and additional 400m formation running is provided in Table A3.

Table A3 – 400m formation running time on EUS – BCS services (including ECS)

Diagram	AM coupled return journeys	AM coupled running time	PM coupled return journeys	PM coupled running time
101	1	02:03	1	02:03
102	1	02:03	2	04:23
103	1	02:03	2	04:23
104	2	04:44	1	02:03
105	2	04:44	1	02:03
106	1	02:24	1	02:03
107	1	02:24	1	02:03
407/602	407 is expected to couple with Unit 602 at 23:10 for berthing at Euston;			
601/804	601 is coupled with Unit 804 at Washwood Heath in the Depot			

A.7 Hours of operation

A.7.1 This section defines the average number of hours per day Units will need to be available and capable of passenger operation.

A.7.2 The average daily operating hours per pattern are shown in Table A4.

Table A4 – Average hours of weekday operation

Route	Average hours of operation
EUS-BCS	15.7
EUS-LIV	16.2
EUS-PRE	16.0
EUS-MAN	15.5
EUS-GLC	15.5

A.8 Number of door cycles

A.8.1 This section defines the average number of door cycles expected over the course of an average day.

A.8.2 The number of daily door cycles per Unit in each pattern is shown in Table A5. This is based on the assumption that 1 door cycle is expected at interim stations, and 2 are expected at terminus stations.

A.8.3 The door cycles for each Unit diagram is calculated by multiplying the number of journeys per day by the number of stops per journey, and then taking an average of the door cycles in that pattern.

Table A5 – Number of door cycles per day

Route	Average Intermediate stops	Average door cycles per Unit per day
EUS-BCS	1	69
EUS-LIV	3	53
EUS-PRE	4	55
EUS-MAN	2	47
EUS-GLC	2	23

A.9 Turnaround time

A.9.1 This section defines the average turnaround time Units will need to support at terminating stations between services.

A.9.2 The average turnaround time for each station, based on the weekday circulation plan (and therefore the planned timetable) is shown in Table A6.

Table A6 – Turnaround time

Route	Turnaround time (min)	Notes
EUS	00:25:00	00:33:00 for Glasgow trains
BCS	00:17:00	
LIV	00:43:00	min: 00:40:00; max: 00:46:00
PRE	01:16:00	
MAN	00:37:00	
GLC	00:47:00	

A.10 Number of Train Captain changes

A.10.1 This section defines the average number of Train Captain changes a Unit is expected to undertake on a daily basis.

A.10.2 The following assumptions are made with regard to the estimation of the number of Train Captain changes per day:

- average working day: 7 hours, 30 minutes;
- a physical needs break of 30 minutes;
- maximum continuous operational time of 4 hours and 30 minutes;
- ECS has not been taken into account;
- Train Captains remain on the same route, and return to their station of origin if possible; and
- the simplifying assumption that Train Captains remain on the same train has also been made (note that this could mean that these numbers could be reduced with more optimal crew scheduling).

A.10.3 It should also be noted that these numbers do not take into account the instances where more than one Train Captain may be needed on a train (where coupling / uncoupling events occur across different patterns).

Table A7 – Train Captain changes per operational pattern

Route	Train Captain changes per Unit per day, excluding ECS
EUS-BCS	3
EUS-LIV	3
EUS-PRE	4
EUS-MAN	4
EUS-GLC	2

Appendix B - Payload summary

B.1 Payload requirements

B.1.1 This Appendix provides a list of all of the TTS requirements that relate to the layout and payload of the Unit, and specifies which layout and payload should be used in each case. Notes below Table B1 provide clarifications.

B.1.2 This Appendix is informative only. The text of in the main body of the TTS represents the requirement to be achieved.

B.1.3 It is anticipated that either the 1SL or 2SL will be selected prior to contract award. Therefore, requirements that are split between 1SL and 2SL will be applied to whichever of the two layouts is selected.

Table B1 – Payload Conditions per requirement

ID	Requirement Name	Normal	Exceptional	Working Order	Normal	Normal Operational	Normal	Exceptional
		1SL	1SL	2SL	2SL	HDL	HDL	HDL
TTS-984	Standards (HS2)	✓ (4)	✓ (4)					
TTS-84	Standards (UK MLN)	✓ (4)	✓ (4)					
TTS-93	Journey Time (HS2)	✓						
TTS-94	Journey Time (CRN)	✓						
TTS-98	Minimum Acceleration 1	✓						
TTS-908	Minimum Acceleration 2	✓						
TTS-220	Rescue Performance							✓ (3)
TTS-101	Service Brake Performance (HS2)						✓	
TTS-102	Regenerative Braking Performance						✓	
TTS-2609	Emergency Brake Rate (HS2)						✓	

ID	Requirement Name	Normal	Exceptional	Working Order	Normal	Normal Operational	Normal	Exceptional
		1SL	1SL	2SL	2SL	HDL	HDL	HDL
TTS-2610	Emergency Braking Thermal Capacity						✓ (360km/h)	
TTS-103	Service Brake Performance (CRN)							✓
TTS-957	Hold Unit on Gradient							✓
TTS-115	HS2 1SL Energy Consumption	✓						
TTS-3327	HS2 2SL Energy Consumption				✓			
TTS-1921	CRN 1SL Energy Consumption	✓						
TTS-3328	CRN 2SL Energy Consumption				✓			
TTS-1923	Annual Average Auxiliary Consumption 1SL	✓						
TTS-3330	Annual Average Auxiliary Consumption 2SL				✓			
TTS-1174	Additional Auxiliary Capacity				✓ (1)			
TTS-2634	Obscured Windows	✓ (1)			✓ (1)			
TTS-1826	Lower Sector Vehicle Gauge							✓ (125mph)
TTS-911	Minimum and Maximum Mass and Axle Loads						✓	
TTS-132	Maximum Axle Load					✓		
TTS-133	Maximum Route Availability							✓ (5)
TTS-1723	Track Forces							✓
TTS-137	Variable Usage Charge (1SL)	✓						
TTS-3345	Variable Usage Charge (2SL)				✓			

ID	Requirement Name	Normal	Exceptional	Working Order	Normal	Normal Operational	Normal	Exceptional
		1SL	1SL	2SL	2SL	HDL	HDL	HDL
TTS-2611	Running Behaviour Capability						✓	✓
TTS-2621	Ride Quality – HS2			✓				
TTS-144	Ride Quality – CRN			✓				
TTS-2620	Ride Quality – Maximum	✓	✓	✓	✓	✓	✓	
TTS-161	Dwell Time Performance	✓ (2)						
TTS-1697	Emergency Exit Provision						✓	
TTS-1698	Evacuation Time						✓	
TTS-383	Heating Performance						✓ (2) (6)	
TTS-384	Cooling Performance						✓ (2)	
TTS-1074	Full [HVAC] Capacity Range							✓ (2)
TTS-1085	Fresh Air						✓ (2)	
TTS-2463	CO_2 Level – Across Route						✓ (2)	
TTS-388	CO_2 Level – Emergency							✓ (2)
TTS-3269	Fresh Air Flow - Emergency							✓ (2)
TTS-914	Heat Release – OOC Station	✓ (2)						
TTS-915	Heat Release – Euston Station	✓ (2)						
TTS-1582	Payload Information							✓
TTS-1979	Number of Seats	✓ (2)						

Notes on Table B1

1. Only the layout is considered, not the mass of the Passengers.
2. Only the number of Passengers is considered, not their mass.
3. The *rescued* Train shall be in Exceptional Payload (HDL), the *rescuing* Train shall be in any payload.
4. Where applicable compliance to standards will be assessed using the as-delivered layout. By default, this will be the 1SL, but could be varied through the contract according MSA Schedule 9, Appendix 1.
5. This requirement is based on a different calculation of exceptional payload, specific to this requirement only.
6. Heating performance is assessed with no passengers in the Saloon – effectively the working order payload condition.

Appendix C - Journey Time, Traction & Energy Consumption Calculations

C.1 Journey time and acceleration

C.1.1 The journey time requirements TTS-93 and TTS-94 shall be complied with using the following criteria:

- the route profile and maximum linespeeds shall be as specified in the Data Book[116], which specifies separate datasets for each direction;
- assessment shall be undertaken in both directions and both directions shall individually comply with the requirement;
- intermediate stops shall include a two-minute Dwell Time at each;
- on the HS2 Network, the brake rate shall be no higher than the 'ATO Maximum Brake Rate' (TTS-101) and shall be defined such that the stopping accuracy requirement (TTS-100) can be achieved;
- on the CRN, the service brake rate shall be no higher than that required by RGS (TTS-103);
- the maximum jerk rate shall be $0.5m/s^3$;
- the payload and layout of the Unit shall be Normal Payload (1SL) ;
- the line voltage shall be 22.5kV AC *;
- on HS2, the maximum voltage for regeneration shall be 29kV AC;
- on CRN, the maximum voltage for regeneration shall be 27kV AC;
- on HS2, the current limit shall be 1070A for a Train;
- on CRN, the current limit shall be 300A for a Train;
- the external temperature shall be 15°C *;
- the wind speed shall be 0m/s*;
- assessment shall be for a Unit without Infrastructure Monitoring equipment fitted;
- utilisation of adhesion shall not be higher than 0.19 below 300km/h and not higher than 0.10 at 300km/h and above *; and
- the full range of wheel sizes from new to fully worn *.

C.1.2 The acceleration requirements TTS-98 and TTS-908 shall be complied with using the following criteria:

- the maximum jerk rate shall be 0.5m/s³;
- the payload and layout of the Unit shall be Normal Payload (1SL) ;
- the line voltage shall be 22.5kV AC with a 1070A current limit for the Train *;
- the external temperature shall be 15°C *;
- the wind speed shall be 0m/s*;
- assessment shall be for a Unit without Infrastructure Monitoring equipment fitted;
- utilisation of adhesion shall not be higher than 0.19 below 300km/h and not higher than 0.10 at 300km/h and above *; and
- the full range of wheel sizes from new to fully worn *.

C.1.3 The above criteria shall be used for any simulations that are undertaken to demonstrate compliance with TTS-93, TTS-94, TTS-98 and TTS-908 during the tender or design phase of the project.

C.1.4 Any on-track testing to validate journey times and acceleration performance shall follow the above criteria where possible. For those criteria marked with an asterisk (*), the testing shall monitor the criteria during the test and the test report shall discuss the impact of any variation from the criteria above. Any changes to the route profile between the profile described in the Data Book and the route itself shall be established prior to the test.

C.2 Energy Consumption

C.2.1 Introduction

C.2.1.1 The energy consumption of the Unit will be assessed as part of Stage 5 of the Tender Evaluation. This requires the provision of three pieces of data:

1. average auxiliary consumption;
2. HS2 Energy Consumption; *and*
3. CRN Energy Consumption.

C.2.2 Auxiliary consumption assessment

C.2.2.1 Annual Average Auxiliary Consumption shall be calculated using the Energy Assessment Tool[126]. This calculation shall be used for evaluation of requirement TTS-1923 and TTS-3330.

C.2.2.2 Within the Energy Assessment Tool, the ‘Auxiliary Consumption’ sheet shall be completed by calculating the total average auxiliary power drawn at the pantograph of a Unit for each of the ambient conditions and payloads according to the following criteria:

- Assessment shall be for a Unit without Infrastructure Monitoring equipment fitted;
- Assessment shall include all auxiliaries that would be expected to run in normal service, with the average auxiliary power being based on the percentage of time

they would be expected to be operational when in passenger service; and

- Each set of ambient condition and train speed criteria as shown in Table C1 (these figures are reproduced in the Energy Assessment Tool)

Table C1: Ambient Conditions to be used in Average Auxiliary Consumption calculation

Annual Frequency	Ambient Temperature (°C)	Ambient RH (%)	Equivalent solar load (W/m²)	Train Speed (km/h)
0.03%	-6	100.0	0	360
0.06%	-5	100.0	0	360
0.32%	-4	100.0	0	360
0.45%	-3	100.0	0	360
0.58%	-2	100.0	0	360
1.16%	-1	99.0	0	360
1.79%	0	98.0	0	360
2.22%	1	96.7	0	360
2.36%	2	95.6	0	360
3.30%	3	94.7	0	360
4.13%	4	93.8	0	360
4.48%	5	93.0	0	360
5.34%	6	92.1	0	360
5.33%	7	91.3	0	360
5.66%	8	90.3	0	360
5.34%	9	89.2	0	360
5.74%	10	88.0	0	360
5.22%	11	86.7	0	360
5.09%	12	85.1	0	360
4.64%	13	83.4	0	360
4.38%	14	81.5	0	360
3.47%	15	79.4	400	0
2.59%	16	77.1	400	0
2.58%	17	74.6	400	0
2.04%	18	72.0	400	0
1.36%	19	69.2	400	0
1.06%	20	66.3	400	0
0.83%	21	63.4	400	0
0.60%	22	60.3	400	0

Annual Frequency	Ambient Temperature (°C)	Ambient RH (%)	Equivalent solar load (W/m²)	Train Speed (km/h)
0.35%	23	57.3	400	0
0.38%	24	54.2	400	0
1.98%	25	51.3	200	0
2.12%	26	48.0	200	0
3.19%	27	46.8	200	0
3.16%	28	45.8	200	0
2.99%	29	45.0	200	0
1.79%	30	44.3	200	0
1.12%	31	43.9	200	0
0.53%	32	43.8	200	0
0.19%	33	44.0	200	0
0.06%	34	44.4	200	0

C.2.2.3 The Energy Assessment Tool will provide the average auxiliary consumption based on the data provided.

C.2.3 HS2 Energy Consumption Assessment

C.2.3.1 HS2 Energy Consumption shall be calculated, for the purposes of TTS-115 and TTS-3327, using a return journey from Euston to Birmingham Curzon Street in 49 minutes each way, stopping at Old Oak Common and Birmingham Interchange (two-minute Dwell Time) in each direction. The total energy consumption for the return journey shall be divided by the distance (175.7km each way) to get an average energy consumption.

C.2.3.2 The energy consumption assessment shall be repeated assuming both the Normal Payload (1SL) and Normal Payload (2SL) and use the following criteria:

- a 200m Train formed from a Unit without Infrastructure Monitoring equipment fitted;
- the route profile and maximum linespeeds shall be as specified in the Data Book[116], which specifies separate datasets for each direction;
- the brake rate shall not exceed the 'ATO Normal Brake Rate' (defined in TTS-102);
- the maximum jerk rate shall be $0.5m/s^3$;
- energy consumption shall include the Annual Average Auxiliary Consumption for that payload (paragraphs C.2.2.1 and C.2.2.2 above) assuming that this load is applied throughout the simulation *;
- energy consumption shall include consumption during the intermediate dwells, but shall exclude terminal station dwells *;

- the wheels shall be in half-worn state *;
- the line voltage shall be 22.5kV AC with a 1070A current limit for the Train *;
- the maximum voltage for regeneration shall be 29kV AC;
- the external temperature shall be 15°C (not including the average auxiliary consumption calculation) *;
- the wind speed shall be 0m/s*;
- assessment shall be for a Unit without Infrastructure Monitoring equipment fitted; and
- utilisation of adhesion shall not be higher than 0.19 below 300km/h and not higher than 0.10 at 300km/h and above *.

C.2.3.3 The assessment shall exclude any power supply and network distribution losses, i.e. energy shall be measured at the pantograph.

C.2.3.4 The above criteria shall be used for any simulations that are undertaken to demonstrate compliance with TTS-115 and TTS-3327. A simulation shall be used to provide the HS2 Energy Consumption for the purposes of completing Stage 5 of the Tender Evaluation.

C.2.3.5 Any on-track testing to validate energy consumption shall follow the above criteria where possible. For those criteria marked with an asterisk (*), the testing shall monitor the criteria during the test and the test report shall discuss the impact of any variation from the criteria above. Any changes to the route profile between the profile described in the Data Book and the route itself shall be established prior to the test.

C.2.4 CRN Energy Consumption Assessment

C.2.4.1 CRN Energy Consumption shall be calculated, for the purposes of TTS-1921 and TTS-3328, using a return journey from Handsacre Junction to Glasgow in 03:28:00 (hours:minutes:seconds) each way, stopping at Preston (two-minute dwell) in each direction. The total energy consumption for the return journey shall be divided by the distance (452.1km each way) to get an average energy consumption.

C.2.4.2 The energy consumption assessment shall be repeated assuming both the Normal Payload (1SL) and Normal Payload (2SL) and use the following criteria:

- a 200m Train formed from a Unit without Infrastructure Monitoring equipment fitted;
- the Train starts at and returns to Handsacre Junction at Maximum Line Speed;
- the route profile and maximum linespeeds shall be as specified in the Data Book[116];
- the brake rate shall not exceed the CRN service brake rate (TTS-103);
- the maximum jerk rate shall be $0.5m/s^3$;

- energy consumption shall include the Annual Average Auxiliary Consumption for that payload (paragraphs C.2.2.1 and C.2.2.2 above) assuming that this load is applied throughout the simulation *;
- energy consumption shall include consumption during the intermediate dwells, but shall exclude terminal station dwells *;
- the wheels shall be in half-worn state *;
- the line voltage shall be 22.5kV AC with a 300A current limit for the Train *;
- the maximum voltage for regeneration shall be 27kV AC;
- the external temperature shall be 15°C (not including the average auxiliary consumption calculation) *;
- the wind speed shall be 0m/s*;
- assessment shall be for a Unit without Infrastructure Monitoring equipment fitted; and
- utilisation of adhesion shall not be higher than 0.19 *.

C.2.4.3 The assessment shall exclude any power supply and network distribution losses, i.e. energy shall be measured at the pantograph.

C.2.4.4 The above criteria shall be used for any simulations that are undertaken to demonstrate compliance with TTS-1921 and TTS-3328. A simulation shall be used to provide the CRN Energy Consumption for the purposes of Stage 5 of the Tender Evaluation.

C.2.4.5 Any on-track testing to validate energy consumption shall follow the above criteria where possible. For those criteria marked with an asterisk (*), the testing shall monitor the criteria during the test and the test report shall discuss the impact of any variation from the criteria above. Any changes to the route profile between the profile described in the Data Book and the route itself shall be established prior to the test.

Appendix D - Minimum Cross-sectional area

D.1 The following diagrams define minimum cross-sectional areas. To comply with a particular diagram, the cross-section must be maintained for the full length of the Contractually Protected Area. Where the Contractually Protected Area is the full width of the vehicle, the minimum cross-sectional area must be maintained on both sides of the aisle. Where the Contractually Protected Area is only on one side of the aisle due to the installation of electrical equipment cubicles or other items that could not be moved, half of the minimum cross-sectional area must be maintained from the vehicle longitudinal centre line.

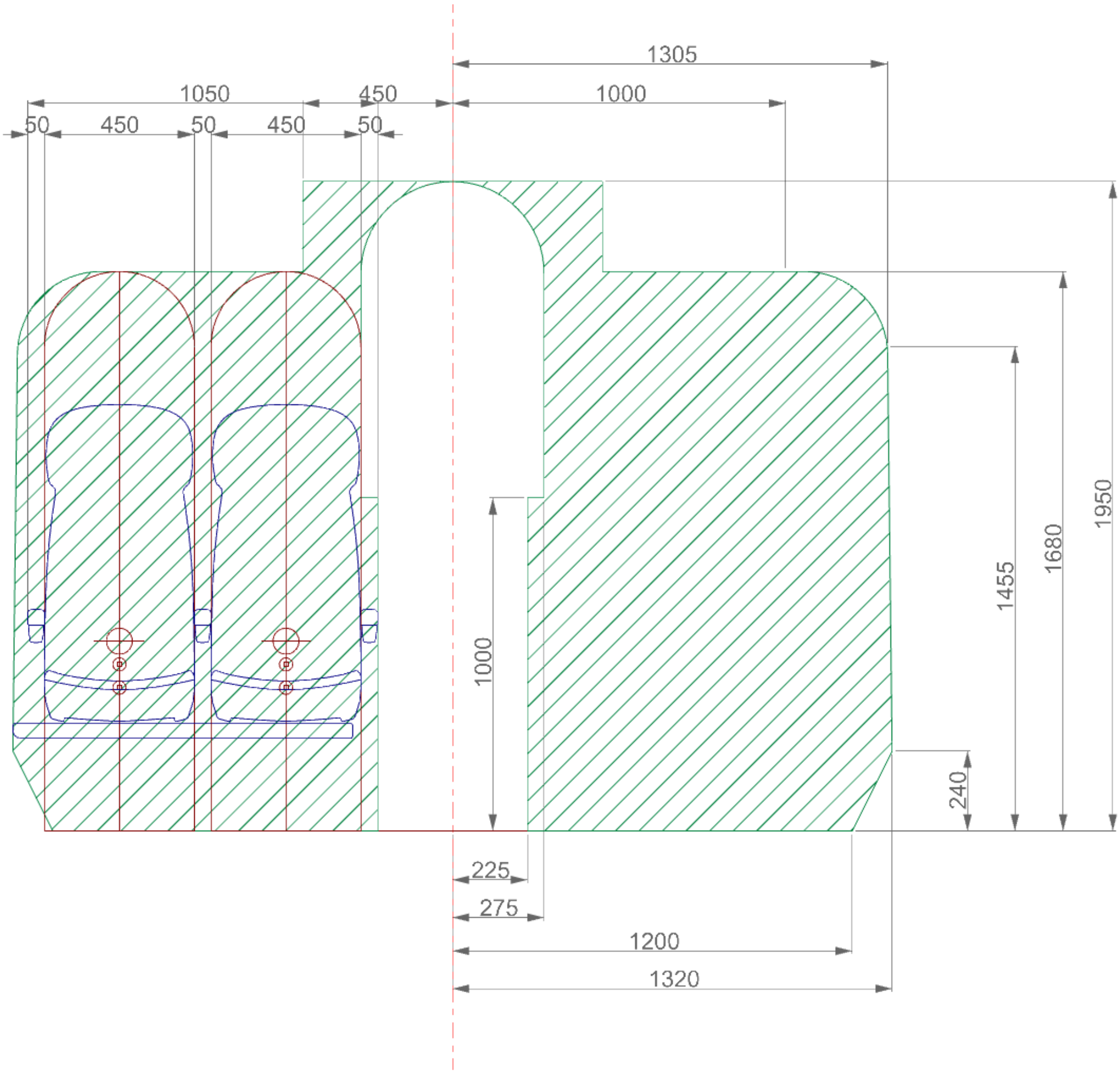
D.2 The space must be free of all equipment except:

- Passenger Seats;
- tables;
- facilities for Wheelchair Spaces;
- luggage stacks; and
- catering equipment.

D.3 Note that the diagrams include drawings of seats that meet the minimum dimensions of the HS2 Seat (Section 10.3.2). The position of the seats is informative only to enable the size of the cross-section to be perceived. If a wider interior can be achieved, seats may be positioned closer to the wall to give a larger aisle and hence improved dwell time according to the calculations in Appendix I of this TTS. The design and position of the seats will be subject to development via the Interiors Collaboration process in MSA Schedule 9, Appendix 1.

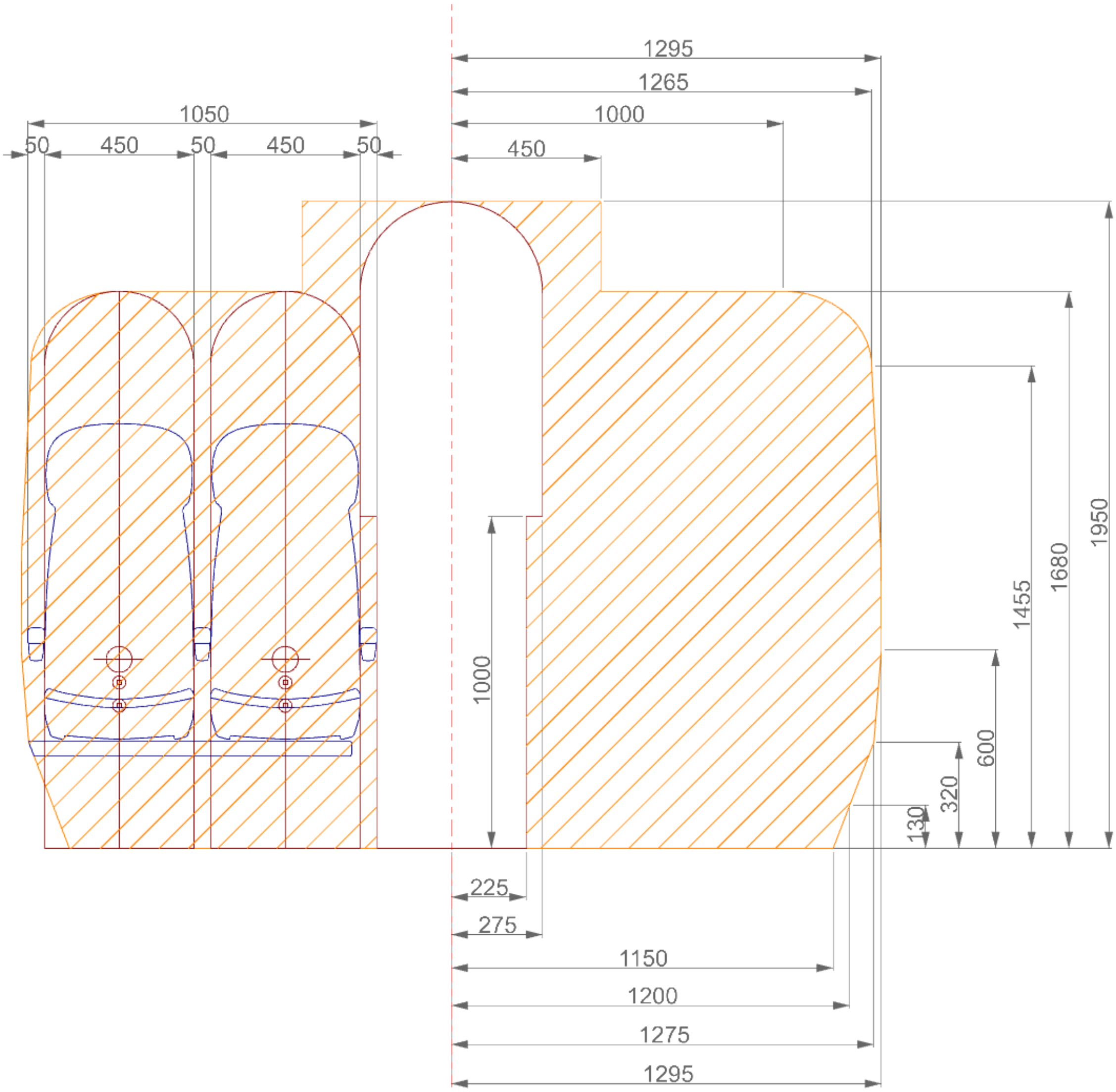
D.4 Figure D1 defines the 'Preferred 1' cross-section, which is the largest requirement. This is associated with reference TTS-1691 in the TTS Response Spreadsheet, Appendix A of the ITT.

Figure D1: 'Preferred 1' cross-sectional area



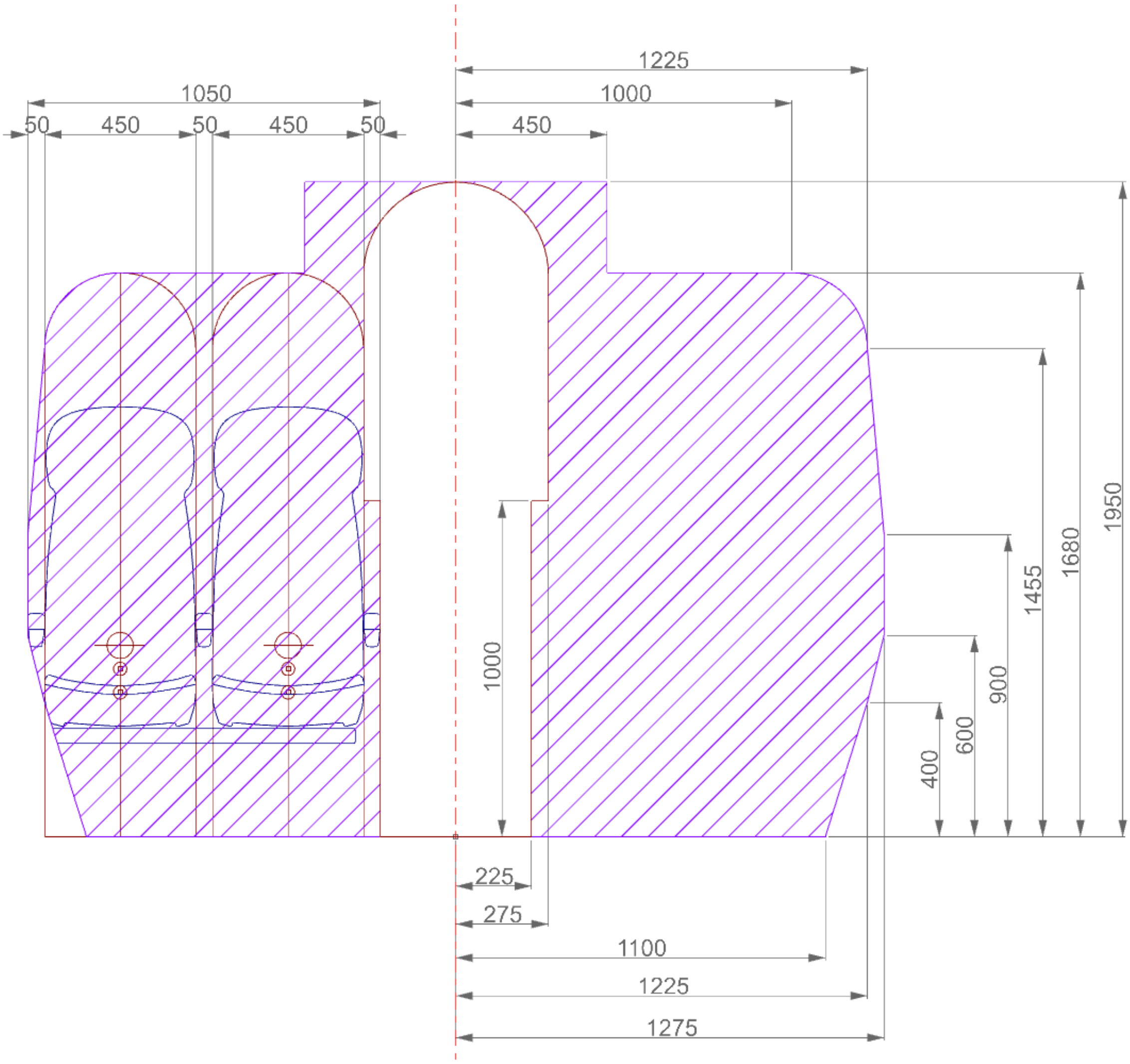
D.5 Figure D2 defines the 'Preferred 2' cross-section, which is the middle requirement. This is associated with reference TTS-1692 in TTS Response Spreadsheet, Appendix A of the ITT.

Figure D2: 'Preferred 2' cross-sectional area



D.6 Figure D3 defines the 'Mandatory' cross-section, which is the smallest requirement. This is associated with reference TTS-1693 in the TTS Response Spreadsheet, Appendix A of the ITT.

Figure D3: 'Mandatory' cross-sectional area



D.7 ***Update for contract** - only a single figure will be retained in the final contract.*

Appendix E - Vehicle masses and axle-loads

E.1 Table E1 lists the Normal Payload (HDL) vehicle masses and axle loads as required by TTS-911. All figures are in tonnes to one 1 decimal place (i.e. nearest 100kg).

Table E1 – List of Vehicle & payload masses and axle loads

Vehicle Designation	Vehicle & Payload Mass	Axle Load 1	Axle Load 2	Axle Load 3	Axle Load 4
[●]	[●]	[●]	[●]	[●]	[●]
[●]	[●]	[●]	[●]	[●]	[●]
[●]	[●]	[●]	[●]	[●]	[●]
[●]	[●]	[●]	[●]	[●]	[●]
[●]	[●]	[●]	[●]	[●]	[●]
[●]	[●]	[●]	[●]	[●]	[●]
[●]	[●]	[●]	[●]	[●]	[●]
[●]	[●]	[●]	[●]	[●]	[●]
[●]	[●]	[●]	[●]	[●]	[●]

E.2 ***Update for contract -*** *The above table will be populated as part of the tender submission (add and remove rows and columns as necessary)*

E.3 Figure E1 illustrates the positions of the above axles relative to the end of the Unit, assuming a deployed auto-coupler:

Figure E1 – Axle positions

[●]

E.4 ***Update for contract –*** *Tenderer to provide a simple diagram to illustrate axle positions.*

Appendix F - VUC Calculation

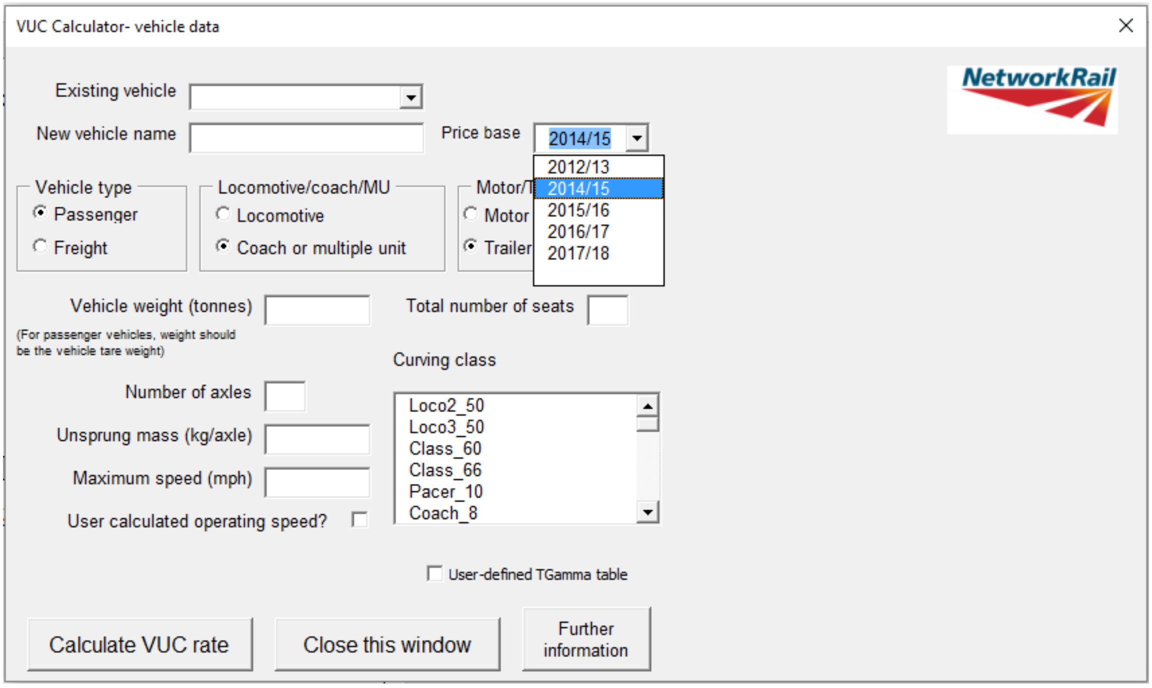
F.1 The following steps shall be undertaken to produce a VUC value in p/mile/Unit.

F.2 The Network Rail spreadsheet 'Vehicle-rate-calculator-v6k-Current-Prices-Ver-1.0.xls' shall be used. A version of this spreadsheet has been baselined by HS2 Ltd as HS2-NRL-RR-MOD-000-000001[128]. This spreadsheet calculates a VUC value per Vehicle.

F.3 For each Vehicle of the Unit, enter the vehicle information into the VUC spreadsheet as per the instructions contained in HS2-NRL-RR-MOD-000-000001 P01 CP5-VUC-Guidance-document.

F.4 In each vehicle calculation, ensure that '2014/15' is selected in the 'Price Base' drop-down menu as shown in Figure F1 below. It is necessary to re-select this for each vehicle

Figure F1 – VUC Calculator Screen Shot

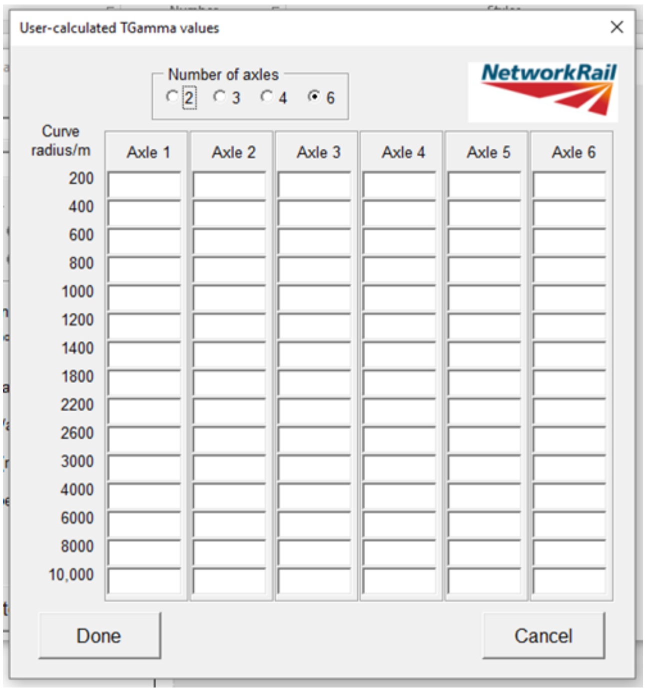


F.5 The Maximum speed shall be set to 125mph. No 'User calculated operating speed' shall be entered.

F.6 Add the number of seats according to the 1SL or 2SL as applicable. (Note that this calculation used 75kg per passenger, but no adjustment needs to be made to account for this.)

F.7 It will be necessary to use T-gamma values specific to the Unit since it is unlikely that the Unit will match existing rolling stock operating in the UK. Check the 'User-defined TGamma table' check-box. This will open a new dialogue box to be completed as shown in Figure F2. The T-gamma values calculated in accordance with Appendix G may be used to complete this table.

Figure F2 – T-gamma entry table



User-calculated TGamma values

Number of axles: 2 / 3 / 4 / 6 (6 selected)

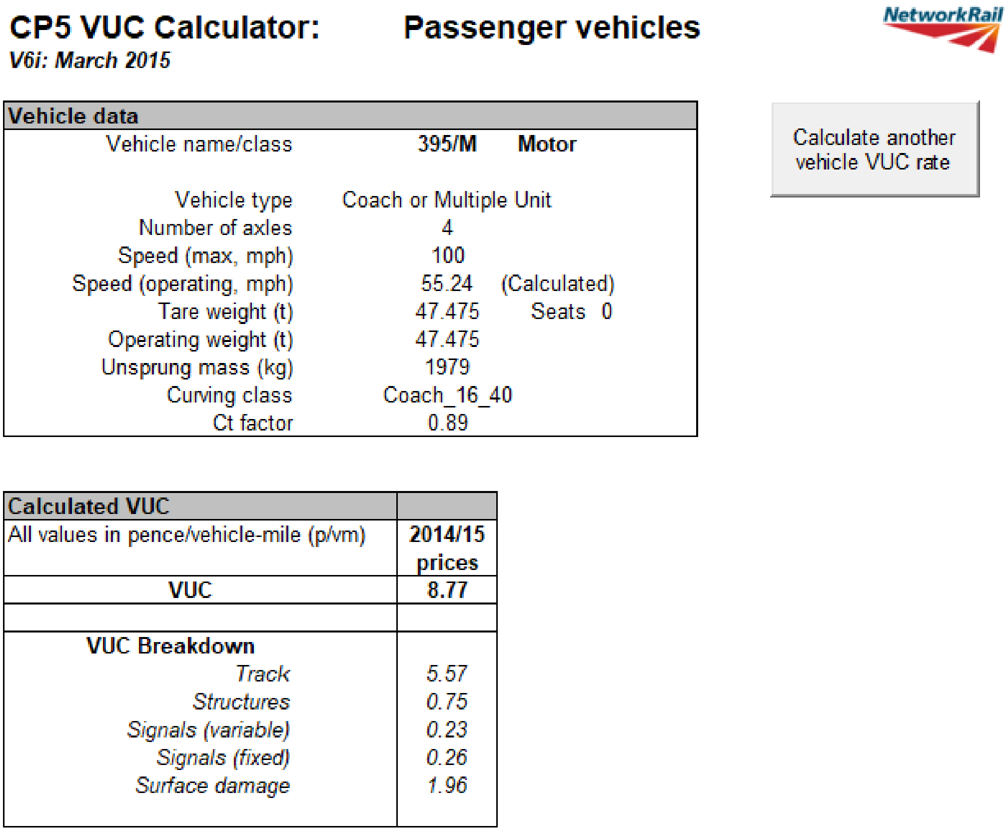
NetworkRail

Curve radius/m	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Axle 6
200						
400						
600						
800						
1000						
1200						
1400						
1800						
2200						
2600						
3000						
4000						
6000						
8000						
10,000						

Done   Cancel

F.8 The spreadsheet will produce a printable front-sheet summarising the VUC cost for the vehicle as shown in Figure F3. Screenshots or other copies of this sheet shall be included in the VUC report.

Figure F3 – VUC Calculator Results Sheet (showing example data for another vehicle class)



CP5 VUC Calculator: **Passenger vehicles**

V6i: March 2015

NetworkRail

Calculate another vehicle VUC rate

Vehicle data		
Vehicle name/class	**395/M**	**Motor**
Vehicle type	Coach or Multiple Unit	
Number of axles	4	
Speed (max, mph)	100	
Speed (operating, mph)	55.24	(Calculated)
Tare weight (t)	47.475	Seats 0
Operating weight (t)	47.475	
Unsprung mass (kg)	1979	
Curving class	Coach_16_40	
Ct factor	0.89	

Calculated VUC	
All values in pence/vehicle-mile (p/vm)	**2014/15 prices**
VUC	**8.77**
VUC Breakdown	
Track	*5.57*
Structures	*0.75*
Signals (variable)	*0.23*
Signals (fixed)	*0.26*
Surface damage	*1.96*

F.9 Produce a set of tables showing

- the parameters entered into the VUC spreadsheet;
- the cost per mile for each Vehicle in the Unit ; and
- the total cost per mile for the whole Unit.

F.10 Note that only the total cost per mile for the Unit forms part of the TTS (TTS-137 and TTS-3345). The individual vehicle costs are necessary as part of evidence to validate this requirement.

Appendix G - T-gamma and whole-Unit damage calculation methodology

This Appendix gives an explanation for how TTS-1236 and TTS-1715 shall be assessed.

G.1 Simulation Software

G.1.1 Recognised and validated railway vehicle dynamics software shall be used for the simulations. The software name and version number shall be stated in any assessment.

G.1.2 The analysis type should be a time-stepping integration (transient analysis) method. Outputs should be checked for evidence of any numerical instability or discontinuities and if necessary the integration timestep or other solver parameters should be adjusted to ensure that the results are valid.

G.2 Vehicle Models

G.2.1 The vehicle models shall be a realistic representation of the intended design. They shall be modelled in a Normal Payload (HDL) condition as this is the worst case for track damage.

G.2.2 Suspension parameters shall be nominal for this load condition.

G.2.3 It is permissible to model all Vehicles of the Unit, or to model a representative shorter formation of Vehicles, or model individual vehicles. The models shall include all types of Vehicle and running gear.

G.3 Track Geometry

G.3.1 A track geometry input file is provided in the 'Dyn Analysis Track Geometry' tab of the Data Book[116]. This includes a 'Spiral Curve' worksheet which defines the curvature, cant and Train speed profile for the rail damage assessment.

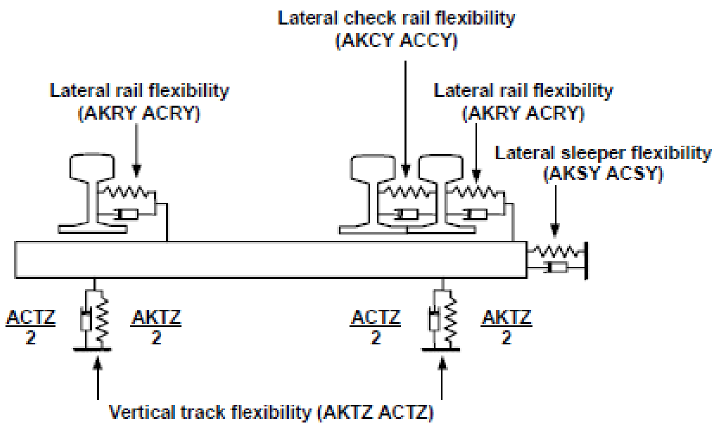
G.3.2 The track geometry channels are as follows:

- *Distance* is the run distance in metres.
- *Vertical Irregularity* is the mean top, equivalent to $(Top_L+Top_R)/2$ and represents the vertical displacement of the track centreline. Positive values represent downwards movement of the track. Units are in mm.
- *Crosslevel Irregularity* is the height of the left rail above the right. Positive values represent the left rail being higher than the right rail. Units are in mm.
- *Curvature* has units of 1/km and is positive for a right hand curve.
- *Vehicle speed* is defined in m/s

G.4 Track Stiffness and Damping

G.4.1 The track model used in the simulations can have a significant effect on the simulation results. The track model shown in Figure G1 and its associated parameters shall be used; this is equivalent to that used in VAMPIRE but may be implemented in other vehicle dynamics software packages.

Figure G1 - Track Stiffness Model



- "AKTZ" Track Vertical Stiffness 100MN/m
- "ACTZ" Track Vertical Damping 0.2 MNs/m
- "AKRY" Rail–sleeper Lateral Stiffness 43.0 MN/m
- "ACRY" Rail–sleeper Lateral Damping 0.24 MNs/m
- "AKSY" Sleeper – ground Lateral Stiffness 37.0 MN/m
- "ACSY" Sleeper–ground Lateral Damping 0.24 MNs/m
- "AKCY" Check Rail–rail Lateral Stiffness 500.0 MN/m
- "ACCY" Check Rail–rail Lateral Damping 0.75 MNs/m

G.4.2 If the software package has a multi-layer track model, other degrees of freedom should be made as stiff as possible in order to approximate towards the model shown in Figure G1.

G.5 Wheel/Rail Contact Data

G.5.1 The analysis shall be carried out with the following wheel/rail profile combination:

- Part-worn wheel profile – 'Analysis Worn Wheel' tab in the Data Book[116]
- New 60E2 rail inclined at 1:20 – 'Analysis Rail Profile' tab in the Data Book

G.5.2 The shapes of these wheel and rail profiles are defined as x-y coordinates in the Data Book. The wheel profile has been selected as representative of that likely to develop on Units following operation on the CRN and HS2 Network. Other conditions for the wheel/rail contact are as follows:

- Wheel flangeback spacing shall be 1360 mm
- Track gauge shall be 1435 mm
- Contact data should be calculated for appropriate wheel loads.
- The contact solver should use rigid body approximations (no plastic or non-Hertzian methods permitted)

G.5.3 The combination of these wheel and rail profiles gives a clear two-point contact condition as the contact moves from the tread to the flange. In two-point contact, the tread contact angle is ≈20° and the flange contact angle is ≈72°. The contact angle on the tread is always less than 30°; on the flange it is always greater than 30°.

G.5.4 The wheel-rail friction coefficient (μ) should be 0.32 on the tread contact, and 0.10 on the flange contact. For the purposes of this assessment, it may be assumed that flange lubrication is effective on the full range of curve radii where the wheel flange is in contact with the rail.

G.6 T-gamma (Tγ) simulations

G.6.1 The curving performance of the Unit shall be simulated by the supplier on the 'Spiral Curve' track. As noted above, it is permissible to model all Vehicles of the Unit, or to model a representative shorter formation of Vehicles, or model individual vehicles. The models shall include all types of Vehicle and running gear. Where shorter formations or individual vehicles are modelled, the processing of the results shall account for the actual number of wheelsets/bogies to represent the performance of the complete unit formation.

G.6.2 The outputs of the simulation shall be:

- The total contact patch energy dissipation value (Tγ, including spin creep) at the high rail tread contact of each wheelset of the Unit; and
- The direction of the wheel/rail creep force vector in plan view, at the high rail tread contact of each wheelset of the Unit.

G.6.3 Tread contacts may be identified as those having a contact angle less than 30°.

G.7 Post-processing

G.7.1 The assessment is based on two parameters, each of which shall be expressed as a function of curve radius:

- Maximum Tγ on the high rail tread contact of any wheelset; and
- Rolling contact fatigue (RCF) damage on the high rail tread contacts (summed for the whole Unit)

G.7.2 Tγ and RCF on flange contacts, and on the low rail, should be excluded from the damage assessment. Flange contacts may be identified as those having a contact angle greater than 30°.

G.7.3 The simulation output data shall be split into 19 segments, representing the 19 curve radius bands listed in Table G1. Note that the curve radius band represents the local radius at the relevant wheelset, rather than (for example) the curve radius at the leading wheelset of a train formation which could be on a sharper curve further along the spiral.

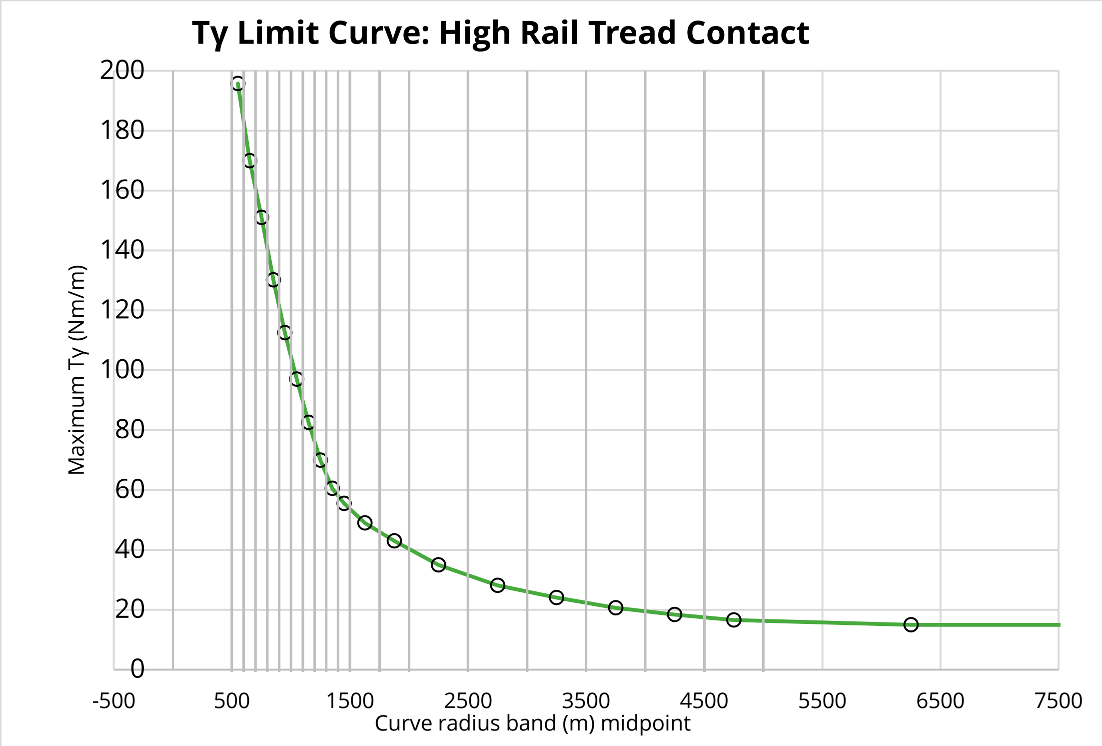
G.8 Ty Limit Line

G.8.1 The Ty for each high rail tread contact shall be averaged along the length of each segment. The maximum of these average values for any wheelset shall be used to populate a copy of Table G1. The values shall be compared to the corresponding limit values listed in Table G1 and illustrated in Figure G2. These represent the maximum permitted values for any wheelset on the Unit and shall not be exceeded.

Table G1 - Ty for worst wheelset as a function of curve radius

Curve radius band	Ty at high rail tread contact: average over radius band	
(m)	Worst wheelset	Limit value
501 to 600		195.8
601 to 700		170.0
701 to 800		151.0
801 to 900		130.2
901 to 1000		112.5
1001 to 1100		97.0
1101 to 1200		82.6
1201 to 1300		70.0
1301 to 1400		60.5
1401 to 1500		55.5
1501 to 1750		49.0
1751 to 2000		43.0
2001 to 2500		35.0
2501 to 3000		28.2
3001 to 3500		24.1
3501 to 4000		20.6
4001 to 4500		18.3
4501 to 5000		16.5
Greater than 5000		15.0

Figure G2 - Graphical representation of Ty limit line

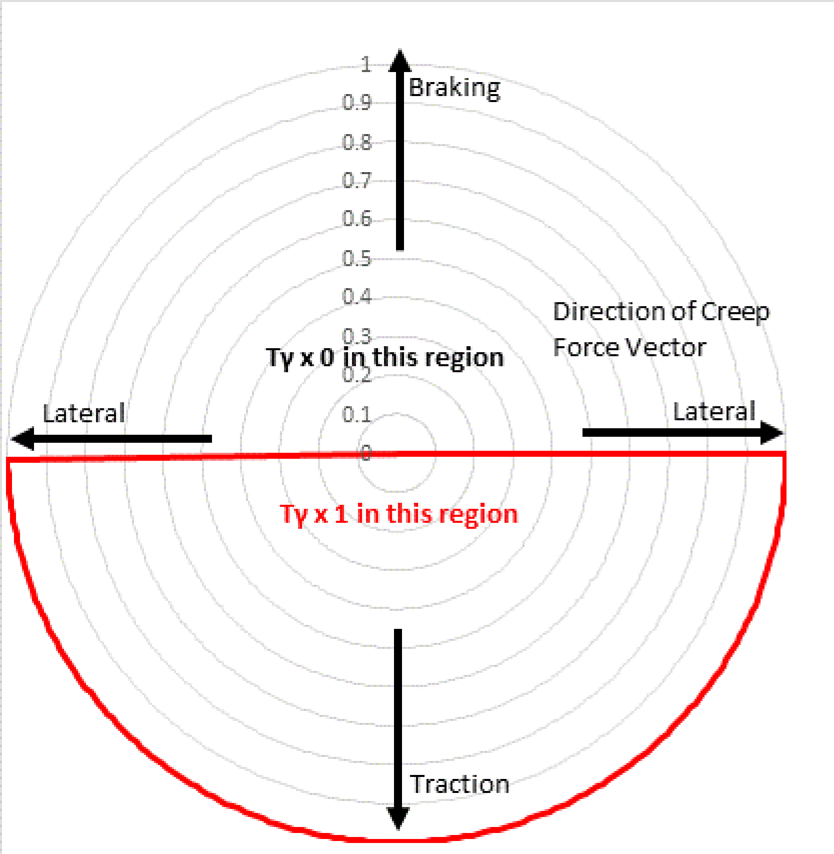


G.9 RCF Limit Line

G.9.1 All wheelsets of the Unit shall be assessed. The Ty for each high rail tread contact shall be averaged along the length of each segment (as for the Ty assessment). The direction of the creep force vector for each high rail tread contact shall also be averaged along the length of each segment.

G.9.2 For segments where the longitudinal component of the average creep force vector is in the traction direction (i.e. acting backwards on the rail), the Ty is capable of causing RCF damage and should be scaled by a factor of 1. For segments where the longitudinal component of the average creep force vector is in the braking direction (i.e. acting forwards on the rail), the Ty shall be set to zero (neglected). This scaling is illustrated in Figure G3.

Figure G3 - Ty Scaling Function



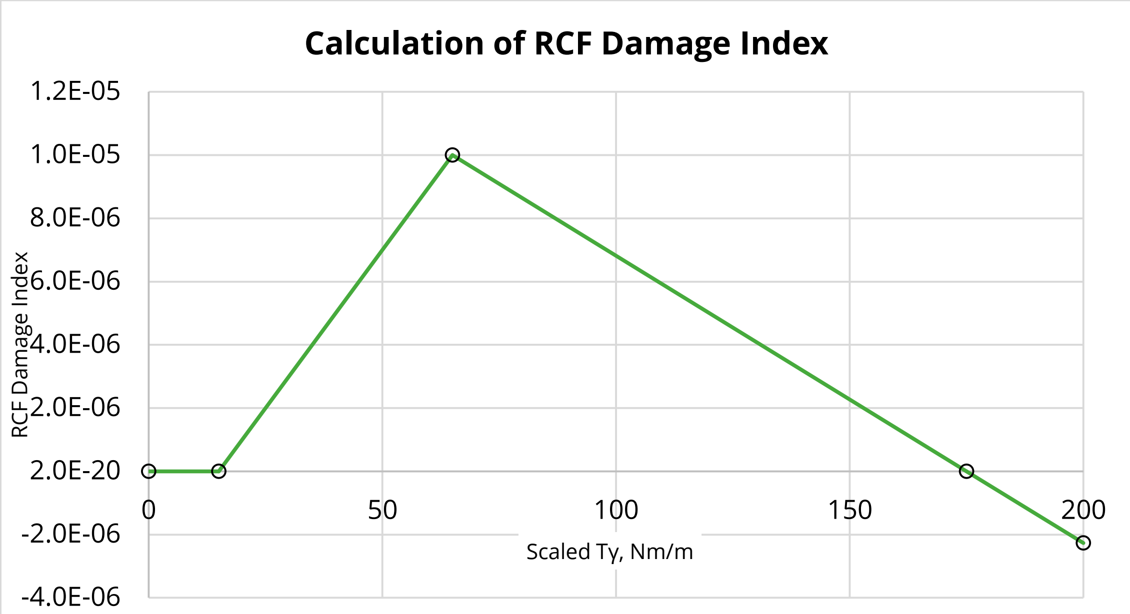
Note: it is acknowledged that alternative scaling functions exist. Analysis for the prescribed wheel/rail profile combination under a wide range of conditions indicates that the results for all three common scaling functions are similar.

G.9.3 The scaled Ty value shall then be converted into an RCF damage index, using the relationship shown in Table G2 and Figure G4.

Table G2 - RCF damage index curve

Ty	RCF damage index
0	0
15	0
65	1.00E-05
175	0
200	-2.27E-06

Figure G4 - Conversion of Scaled Ty to RCF Damage Index



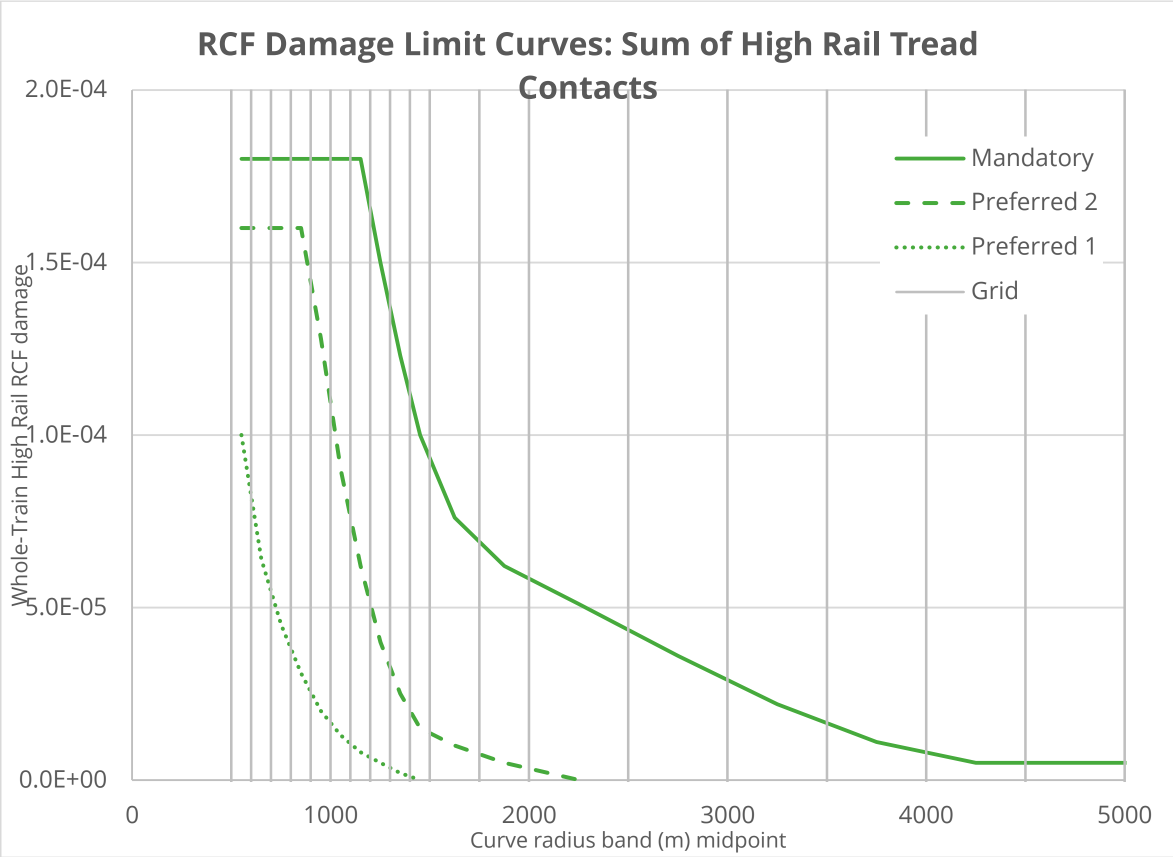
G.9.4 Within each curve radius segment, the RCF damage index on the high rail tread contacts shall be summed for all wheelsets in an entire Unit, to provide a 'whole-Unit RCF damage' value. These values shall be used to populate a copy of Table G3. The values shall be compared to the corresponding limit values listed in Table G3 and illustrated in Figure G5; these represent the maximum permitted values and must not be exceeded.

Table G3 - RCF damage for whole unit as a function of curve radius

Curve radius band (m)	High Rail RCF Damage			
	Whole unit	Limit value	Preferred 1	Preferred 2
601 to 700		0.000180	0.000160	0.000100
701 to 800		0.000180	0.000160	0.000064
801 to 900		0.000180	0.000160	0.000045
901 to 1000		0.000180	0.000128	0.000031
1001 to 1100		0.000180	0.000090	0.000020
1101 to 1200		0.000180	0.000062	0.000013
1201 to 1300		0.000150	0.000040	0.000008
1301 to 1400		0.000123	0.000025	0.000005
1401 to 1500		0.000100	0.000015	0.000002
1501 to 1750		0.000076	0.000010	0.000000
1751 to 2000		0.000062	0.000005	0.000000
2001 to 2500		0.000051	0.000000	0.000000
2501 to 3000		0.000036	0.000000	0.000000
3001 to 3500		0.000022	0.000000	0.000000
3501 to 4000		0.000011	0.000000	0.000000

Curve radius band (m)	High Rail RCF Damage			
	Whole unit	Limit value	Preferred 1	Preferred 2
4001 to 4500		0.000005	0.000000	0.000000
4501 to 5000		0.000005	0.000000	0.000000
Greater than 5000		0.000005	0.000000	0.000000

Figure G5 - Graphical representation of RCF damage limit curves



G.10 Data Book

G.10.1 The Data Book[116] includes the following data:

- x-y co-ordinates of rail profile
- x-y co-ordinates of wheel profile
- track geometry for spiral curve, including distance, curvature, cant and speed channels

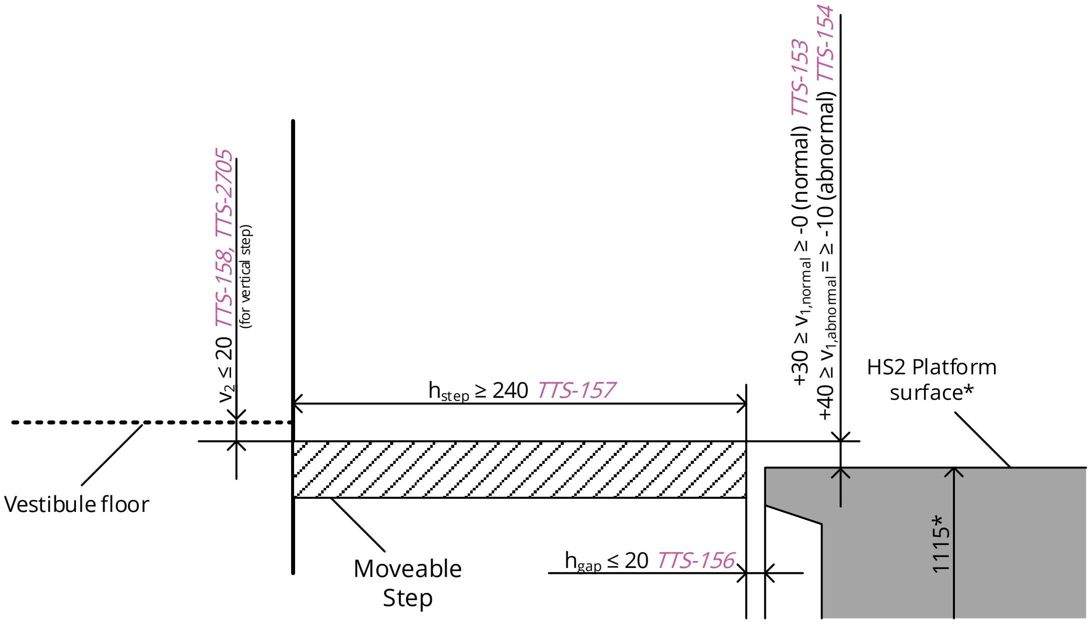
Appendix H - Platform-train interface diagrams

H.1 The following diagrams illustrate possible platform-train interface arrangements on the HS2 Network and how the requirements of section 7.15 apply.

H.2 Figure H1 illustrates a solution where the plane of the Moveable Step is horizontal and there is a vertical step between the Moveable Step and the Vestibule floor.

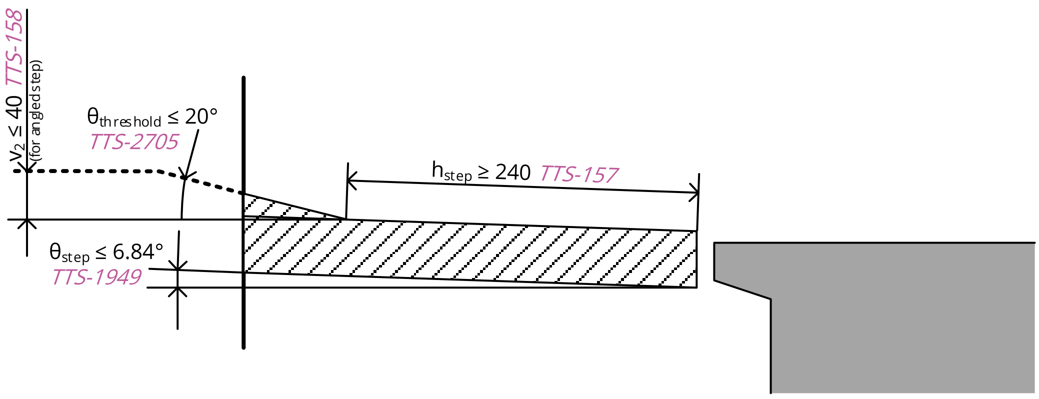
* For the purpose of compliance with these requirements, the platform surface should be assumed to be at exactly 1115mm

Figure H1 – Horizontal Moveable Step with step at door threshold



H.3 Figure H2 illustrates a solution where the plane of the Moveable Step slopes down towards the platform and there is a larger vertical distance between the Moveable Step and the Vestibule floor, necessitating a ramp at the door threshold.

Figure H2 – Sloping Moveable Step with ramp at door threshold.

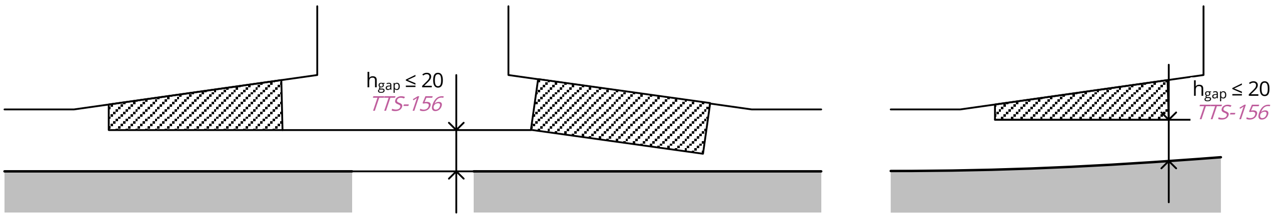


H.4 Figure H3 illustrates how the maximum horizontal step from the step to the platform, h_{gap}, must be less than 20mm considering examples where:

- the bodyshell is not parallel to the platform
- the step does not deploy at right-angles to a straight platform
- the step deploys on a curved platform

H.5 Figure H3 is not to scale.

Figure H3 – Horizontal gap examples



Appendix I - Static Dwell Time Model

I.1 Introduction

I.1.1 In order to deliver compliance with TTS-161 the design shall deliver a 95% confidence of achieving a 2-minute dwell according to the Static Dwell Time Model provided as part of this appendix.

I.1.2 This model has been developed to allow common assessment of the key architectural elements that make up the Unit design whilst allowing for the likely development of the interior layouts following contract award.

I.1.3 The assessment is based on a dimensioned set of Vehicle Layout Drawings of each Vehicle in the Unit.

I.2 Definitions

Term	Definition
Vehicle Layout Drawing	A plan-view drawing of the vehicle showing the position of Exterior Doors, Interior Doors, Passenger Seats, interior walls and any equipment such as Toilets and Bulk Luggage Storage Areas. The drawing shall be dimensioned to show the widths of clearways through the Vehicle. These drawings will need to be considered aligned with each other in the formation of a Unit.
Door 1	For each Vehicle Layout Drawing, the Exterior Doors in the Vestibule shown on the left of the drawing shall be Door 1 for the purposes of this assessment.
Door 2	For each Vehicle Layout Drawing, for each Vehicle with more than one Exterior Door, the Exterior Doors in the second Vestibule shown from left to right on the drawing shall be Door 2 for the purposes of this assessment.
Busiest Door	The door of a Vehicle through which the most Passengers will pass – calculated as per paragraph I.3.2.2
First Decision Point	The location at which a Passenger must first evaluate and act in the normal course of their journey to their seat. This marks the end of the Free Flow Area and could be any one of the following: • A Bulk Luggage Storage Area • A luggage stack • The first Passenger Seat within the Saloon The First Decision Point would not be a Toilet, Catering Area or similar.
Free Flow Area	The space between the edge of the Vestibule and the First Decision Point.

Term	Definition
Mid-Point Between Doors	The point half-way between the centres of any two adjacent Exterior Doors (which may be in separate Vehicles), measured along the centre line of the Vehicles. This point is used to define which door any Passenger Seat is closest to. It is assumed Passengers go to the closest Exterior Door.
Free Flow Area Mid-Point	The point half way between the left-hand and right-hand edges of the Free Flow Area, measured along the centre line of the Free Flow Area. If the Free Flow Area is a complex shape the centre line should be derived based on the transverse width of the Free Flow Area at any point.

I.1 All measurements required for the Static Dwell Time Model shall be in the horizontal plane and shall be rounded to the nearest mm.

I.3 Use of the Static Dwell Time Model

I.3.1 Model configuration

I.3.1.1 To complete the Static Dwell Time Model[125] spreadsheet, specific data about the proposed Unit design shall be completed on the “Static Dwell Time Assessment” sheet. The information shall be completed in the order described here in order to activate the correct cells of the calculator.

- **Supplier Name :** The name of the Tenderer shall be entered here for reference.
- **Rolling Stock Design Name** : A name for the specific Unit design can be entered, again for reference.
- **Vehicles / Unit** : The number of Vehicles available for Passengers shall be entered here. This will activate the cells required for subsequent criteria.
- **Vehicle Description** : Each Vehicle shall be given a name / ID that corresponds to the referenced Vehicle Layout Drawings. Each Vehicle shall have a unique name / ID.
- **Doors / Vehicle / Side :** The number of Exterior Doors provided on each side of each Vehicle shall be entered here.
- **Seats to Left of Door 1** : For each Vehicle, the number of seats which are to the left of Door 1 on the Vehicle Layout Drawing and closer to Door 1 than any other Exterior Door shall be entered.
  Note 1: This may include seats in the adjacent Vehicle to the left in the Unit formation. The Mid-Point Between Doors and the back of each seat shall be used to determine which door a seat is closest to.
  Note 2: The number of seats shall include all seating positions within Multi-Purpose Areas and Wheelchair Spaces.
  Note 3: This will be zero if all the Vehicles have Exterior Doors at the end of each vehicle.

- **Seats to Right of Door 1** : For each Vehicle, the number of seats which are to the right of Door 1 on the Vehicle Layout Drawings and closer to Door 1 than any other Exterior Door shall be entered.

- **Seats to Left of Door 2** : For each Vehicle, the number of seats which are to the left of Door 2 on the Vehicle Layout Drawings and closer to Door 2 than any other Exterior Door shall be entered.

- **Seats to Right of Door 2** : For each Vehicle, the number of seats which are to the right of Door 2 on the Vehicle Layout Drawings and closer to Door 2 than any other Exterior Door shall be entered.
  Note 1: This may include seats in the adjacent Vehicle to the right in the Unit formation. The Mid-Point Between Doors and the back of each seat shall be used to determine which door a seat is closest to.
  Note 2: The number of seats shall include all seating positions within Multi-Purpose Areas and Wheelchair Spaces.
  Note 3: This will be zero if all the Vehicles have Exterior Doors at the end of each vehicle.

I.3.2 Dimensions associated with Busiest Door

I.3.2.1 In this section of the Static Dwell Time Model, cells will be activated based on the information provided in the Model Configuration section. If changes are made to the Model Configuration the information required for this section may also change.

I.3.2.2 The Busiest Door will be determined for each Vehicle and shown in the 'Busiest Door' column. The inputs required for this section shall be provided for the door defined as the Busiest Door for that Vehicle.

I.3.2.3 Cells shown in grey can be left blank

- **Distance from Vestibule to First Decision Point Left** : The central distance between the left edge of the Vestibule with the Busiest Door and the First Decision Point to the left of that Busiest Door. This is dimension **e)** on Figures I1 and I2.

- **Distance from Vestibule to First Decision Point Right** : The central distance between the right edge of the vestibule associated with the Busiest Door and the first decision point to the right of that Busiest Door. This is dimension **f)** on Figures I1 and I2.

- **Vestibule Egress Width Left** : The transverse width available to Passengers at floor level 30cm to the left of the vestibule with the Busiest Door. This is dimension **g)** on Figures I3 and I4.

- **Vestibule Egress Width Right :** The transverse width available to Passengers at floor level 30cm to the right of the vestibule with the Busiest Door. This is dimension **h)** on Figures I3 and I4.

- **Mid Free Flow Area Left** : The transverse width available to Passengers at floor level at the mid-point of the Free Flow Area to the left of the Vestibule with the

Busiest Door. This is dimension i) in Figures I5 and I6.

- **Mid Free Flow Area Right** : The transverse width available to Passengers at floor level at the mid-point of the Free Flow Area to the right of the vestibule associated with the Busiest Door. This is dimension **j)** on Figure I5 and I6
- **First Decision Point Width Left** : The transverse width available to Passengers at floor level at the First Decision Point to the left of the Vestibule with the Busiest Door. This is dimension **k)** on Figures I7 and I8.
- **First Decision Point Width Right** : The transverse width available to Passengers at floor level at the First Decision Point to the right of the vestibule with the Busiest Door. This is dimension **l)** on Figures I7 and I8
- **Aisle Width Left** : The narrowest transverse width of the aisle within the Saloon to the left of the Busiest Door. This shall only include the area of Saloon closer to the Busiest Door than any other door.
  Note: depending on the configuration of the Saloon this narrowest width may be between seats, tables, luggage stacks, etc.
- **Aisle Width Right** : The narrowest transverse width of the aisle within the Saloon to the right of the Busiest Door. This shall only include the area of Saloon closer to the Busiest Door than any other Exterior Door.

Figure I1 – Definition of distance from Vestibule to First Decision Point.

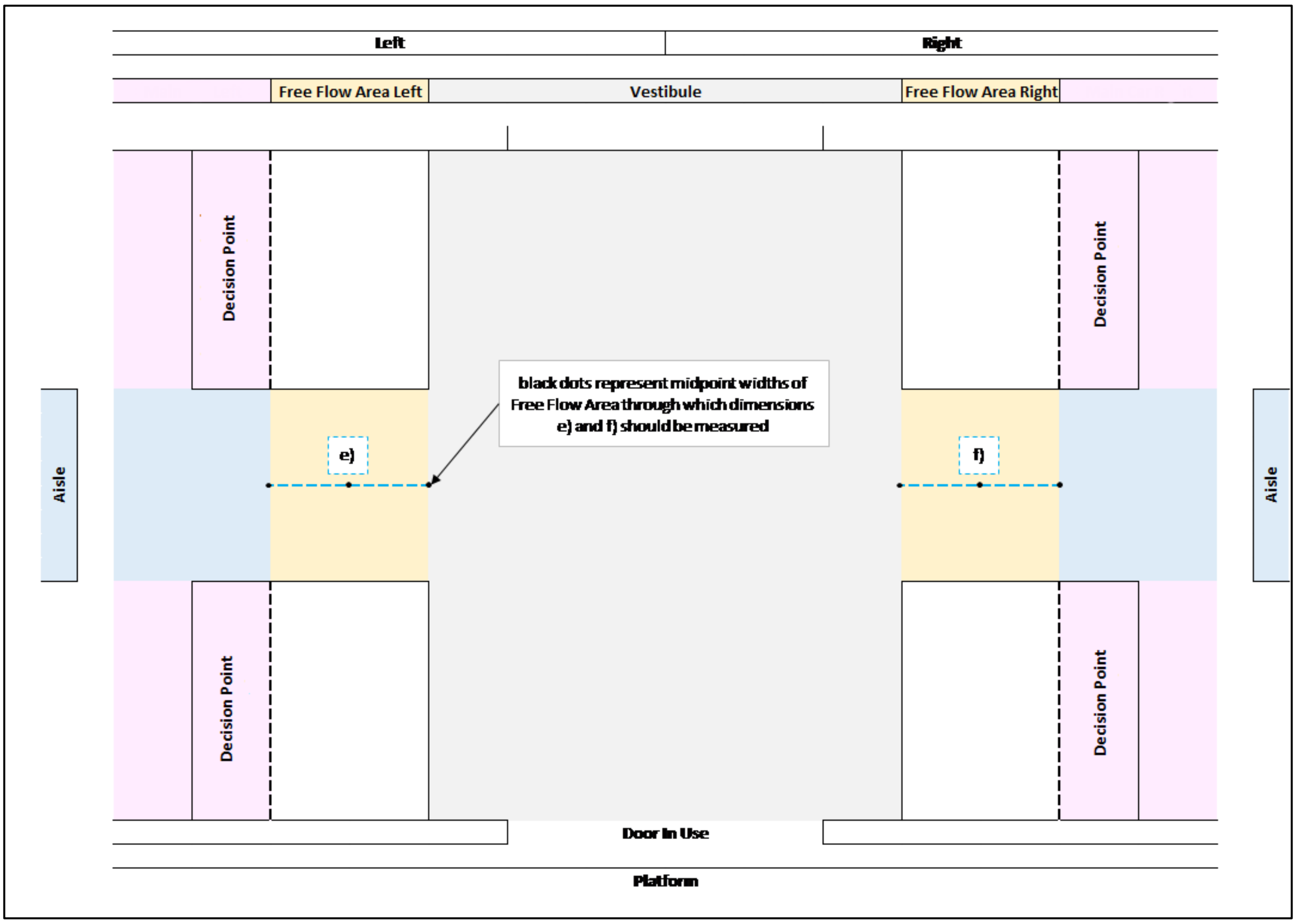


Figure I2 - Definition of distance from Vestibule to First Decision Point

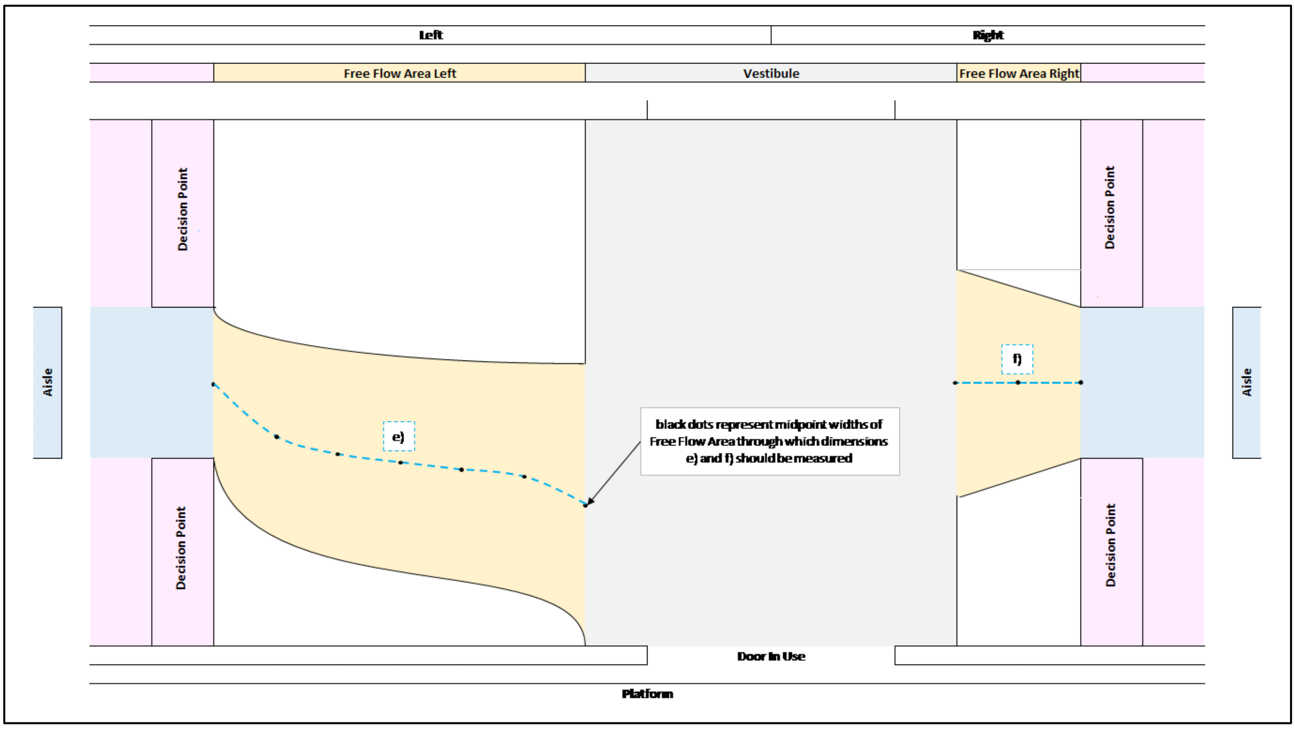


Figure I3 – Vestibule Egress Width

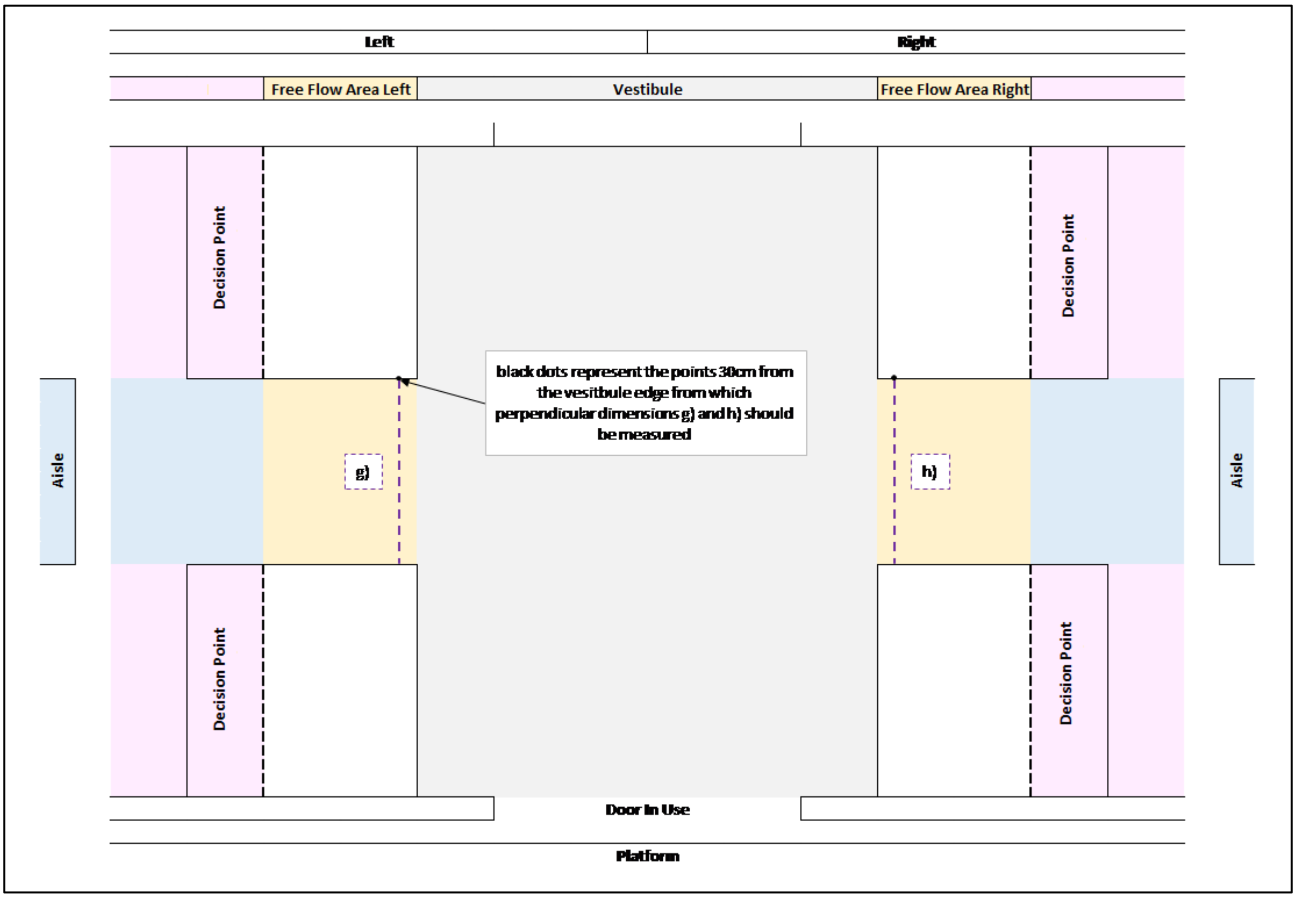


Figure I4 – Vestibule Egress Width

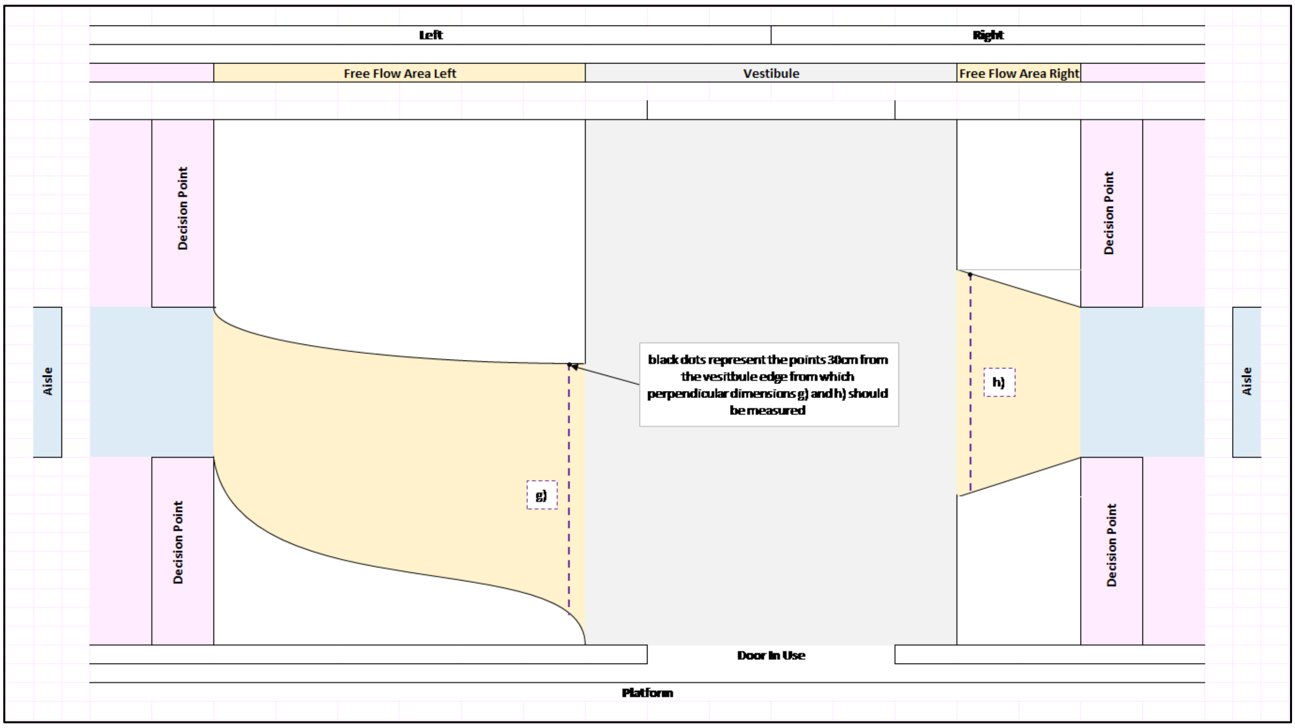


Figure I5 – Mid Free Flow Area Width

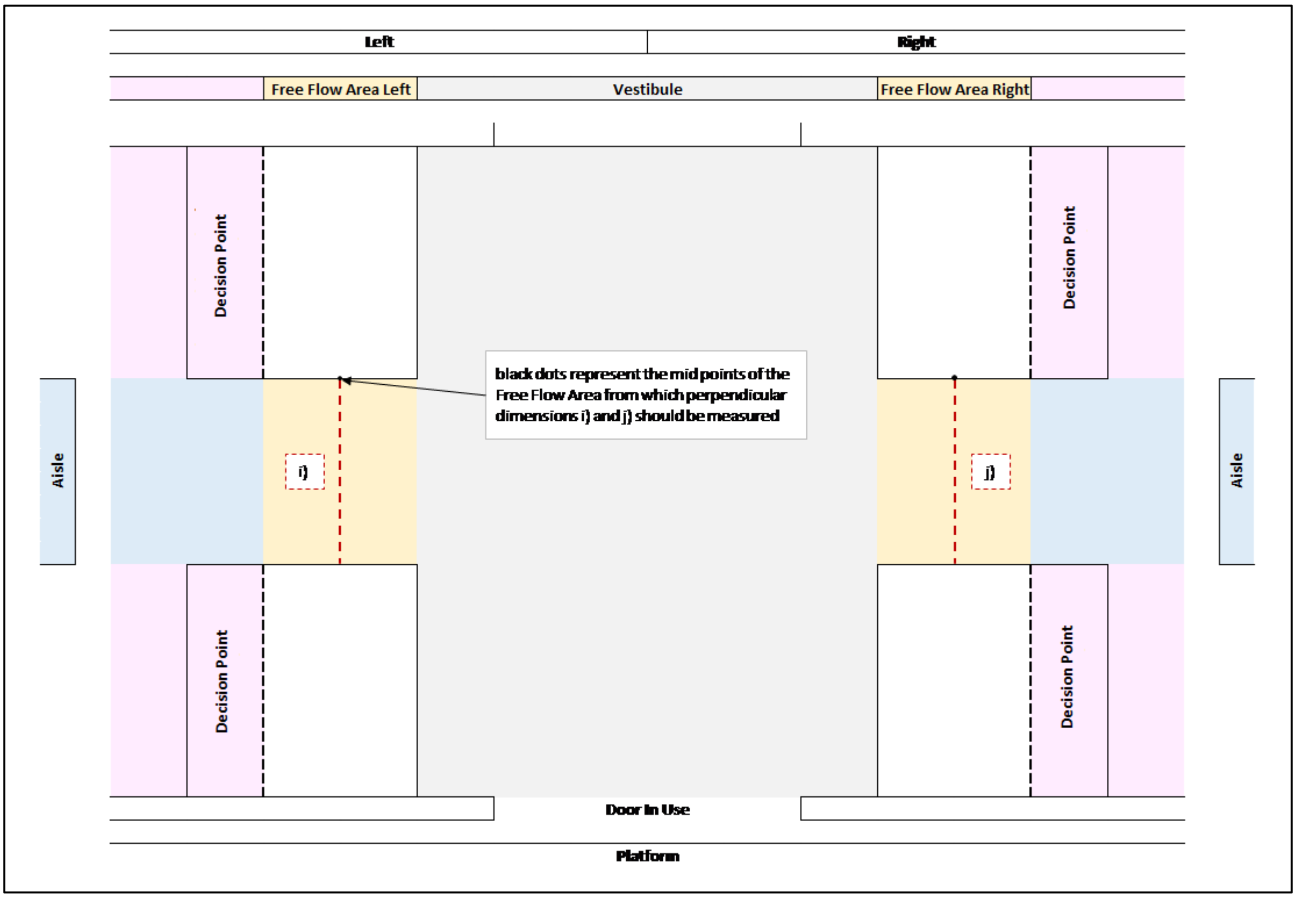


Figure I6 – Mid Free Flow Area Width

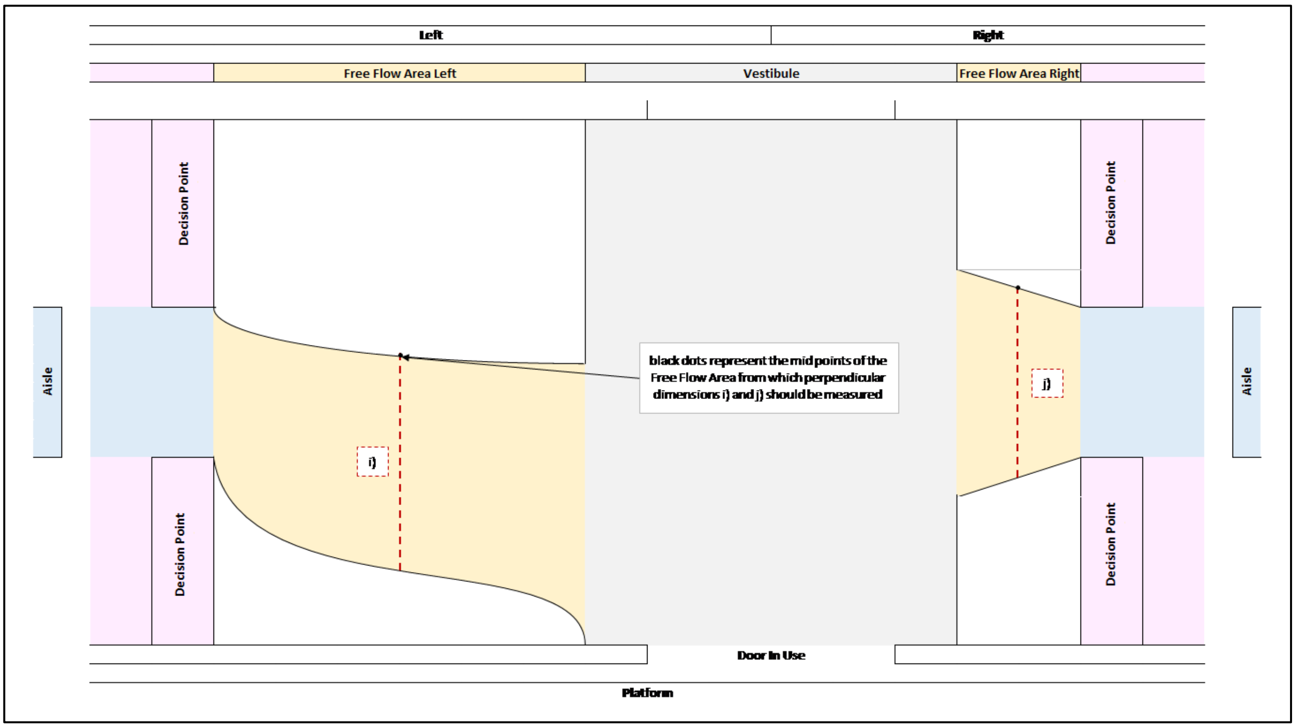


Figure I7 – First Decision Point Width

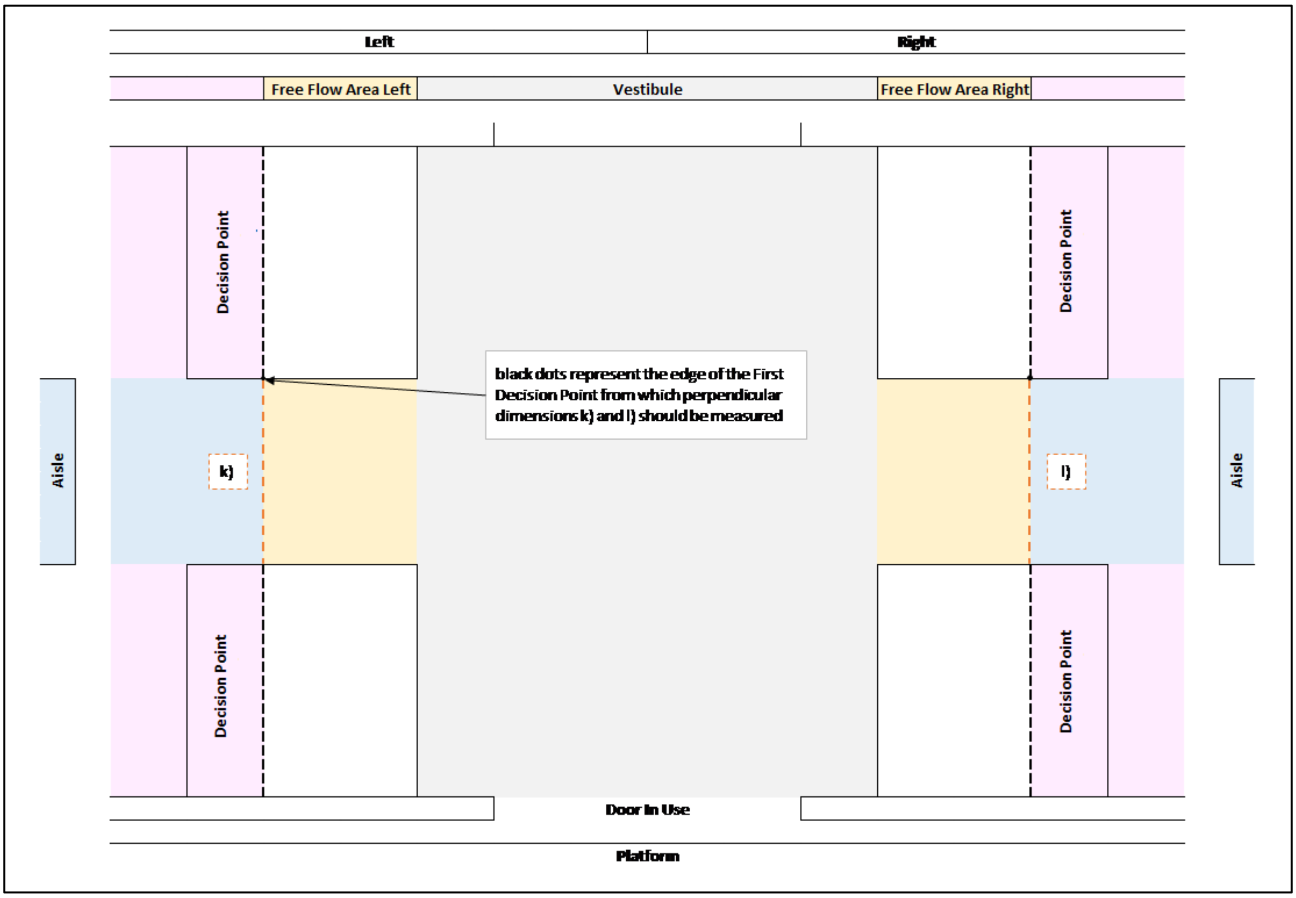
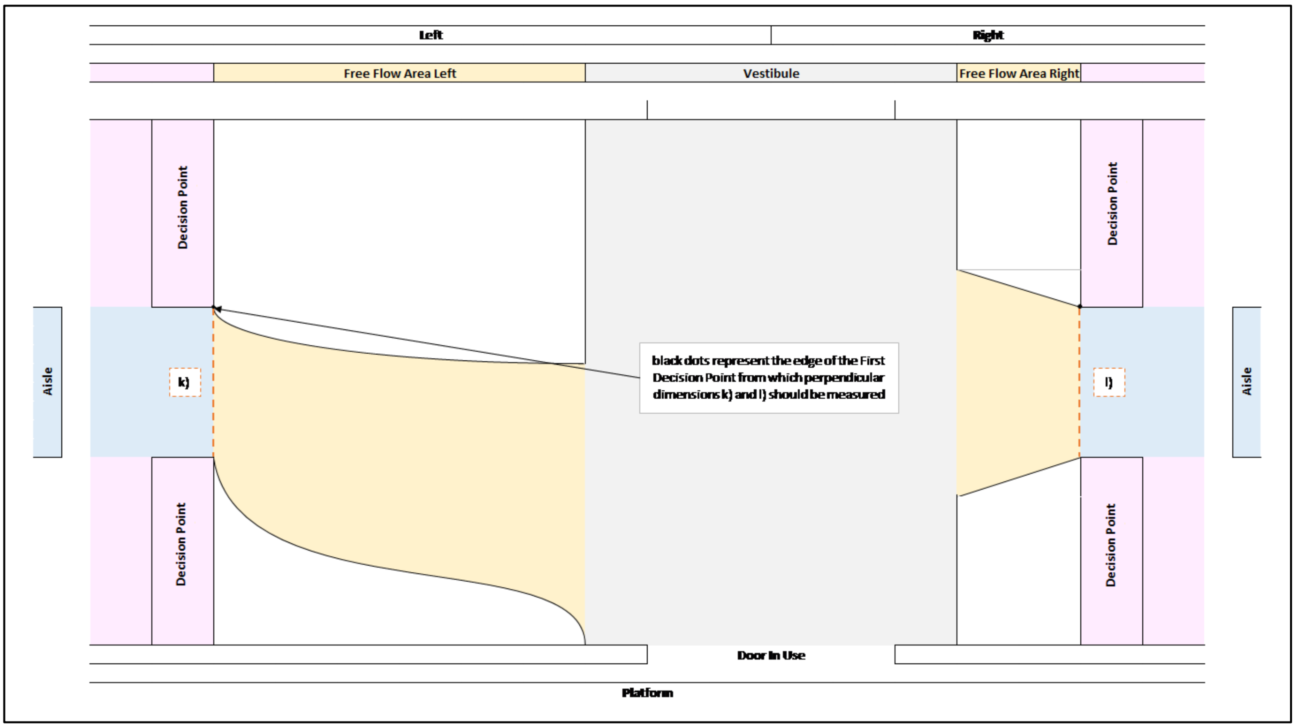


Figure I8 – First Decision Point Width



I.4 Operational Component of Dwell Time

I.4.1.1 This cell shall be completed with the total time to complete the elements of the dwell when Exterior Doors are not fully open and Moveable Steps are not fully deployed. It shall include:

- time from wheel stop to Exterior Doors fully open and Moveable Steps fully deployed, including any processing time and warning alarms;
- five seconds for platform staff to check that Passengers have stopped boarding the Train and that doors can now be closed;
- time from a Train-wide door close command being given (from a location on the Train) to Exterior Doors being closed and locked and Moveable Steps retracted and locked, including any processing time and warning alarms;
- four seconds for platform staff to check the PTI and transmit a 'right away' signal;
- one second for the Train Captain to respond to the 'right away' signal and press 'ATO Start'; and
- time from the 'ATO Start' button being pressed to the wheels starting to move.

I.4.1.2 The time shall not include any actions associated with communicating with the PEP system or waiting for response from this system.

I.4.1.3 The time should be provided as an integer in seconds.

I.5 Results Summary

I.5.1.1 Following completion of the Static Dwell Time Model a result will be provided in the Proportion of Non-Compliant Dwell Times column, this will show the result for each Vehicle and the overall worst case Vehicle. To demonstrate compliance with TTS-191 the result of the worst case door shall be 95% or greater, i.e. the Unit Summary cell shall be conditionally formatted green.

Appendix J - Equivalent Global Warming Impact

J.1 Overall structure of calculation

J.1.1 The global warming potential of the Unit shall be calculated in accordance with EN ISO 14025[73], and the product category rules for rolling stock[112]

J.1.2 The calculation shall include evaluation of:

- the upstream module, i.e. the contribution of components of the Unit
- the core module, i.e. the contribution of assembly of the components
- the downstream operation module, i.e. the contribution of energy consumption in service
- the downstream maintenance module, i.e. the contribution of the materials energy used in maintaining the Unit

J.1.3 It is not necessary to consider a mid-life refurbishment that changes the design of the Unit since the scope of such a refurbishment cannot be determined. The calculation should assume the Unit is maintained in the original design.

J.1.4 It is not necessary to consider end-of-life given the relative small contribution. End-of-life has not been considered in setting the requirement.

J.1.5 Any calculation shall set out values for each of the elements shown in paragraph J.1.2.

J.2 Inputs into calculation

J.2.1 Inputs into the calculation shall be according EN ISO 14025, and the product category rules for rolling stock. The upstream and core module shall be calculated according to these rules and the materials and facilities used by the TMM.

J.2.2 For the downstream operation module, the following rules shall be used for the purposes of the equivalent global warming impact only[1]:

- the average in-service consumption for the HS2 Network and the CRN, calculated in accordance with TTS-115 and TTS-192 respectively and Appendix B, shall be used to assess average energy consumption of the Unit;
- the Unit shall be assumed to operate 43% on the HS2 Network and 57% on the CRN;
- the Unit shall travel 739,694 km / year;

[1] These rules have been used to develop requirement TTS-847 and should therefore be assumed for consistency. Other parts of the MSA may specify different train operation parameters, and these should be used for all other analyses.

- the life of the Unit shall be 35 years, starting in 2026;
- the passenger load factor of each service shall be 80%; *and*
- the carbon content of the UK electricity supply shall be assumed to be as defined in Table J1.

Table J1 – HS2 Grid decarbonisation factors

Year	Emissions intensity gCO_2e/kWh
2026	147
2027	145
2028	122
2029	106
2030	103
2031	97
2032	91
2033	79
2034	78
2035	65
2036	58
2037	52
2038	46
2039	40
2040	34
2041	32
2042	30
2043	29
2044	27
2045	25
2046	23
2047	22
2048	20
2049 onwards	18

J.2.3 For the downstream maintenance module, the assessment shall consider the equivalent global warming impact of the materials used during the TMM's maintenance exams. The energy usage of maintenance facilities shall not be included since this is predominantly outside the TMM's control. The energy usage during cleaning and servicing shall not be included because the HS2 Train Operator will be responsible for these tasks.

J.3 Data for TTS-847

J.3.1 Table J2 shows the calculated values for upstream, core and downstream that have been used to calculate requirement TTS-847. This is provided for information only and compliance with the sub-components is not required.

Table J2 – Calculated values for equivalent global warming impact (kg CO2 eq / passenger km)

	Upstream	Core	Downstream		Total
			Use	Maintenance	
Preferred 1 Value	1.49E-04	4.80E-05	2.03E-03	1.07E-04	2.33E-03
Preferred 2 Value	2.98E-04	9.61E-05	2.14E-03	2.14E-04	2.75E-03

Appendix K - Typical cleaning chemicals

K.1 The Unit will be cleaned at Washwood Heath depot and other depots where the Unit is stabled. It will not be possible to control the cleaning chemicals used at other depots.

K.2 Table K1 lists chemicals that may be used to clean the exterior of the Unit in either a washing plant or through hand cleaning.

Table K1 – List of possible exterior cleaning chemicals

Supplier	Product Name	PH Levels	Purpose
Arrow Wash	Ecowash Autoshine	PH Neutral	Wash plant
CIS	Train wash 01	Unknown	Hand wash
Tammermatic	Swanline Acid	Acid	Wash plant
Tammermatic	Swanline Alkaline	Alkaline	Wash plant
Tammermatic	Swanline Wash	PH Neutral	Wash plant
Wilcomatic	Ultimate FleetWash TFR	Unknown	Wash plant
Bonderite	BONDERITE C-MC N DB	PH Neutral	Wash plant

K.3 Table K2 lists chemicals that may be used to clean the interior of the Unit including hard surfaces and fabrics / carpets.

Table K2 – List of possible interior cleaning chemicals

Supplier	Product Name	Purpose
Arrow	Carpet Shampoo 631	Carpet Cleaner
Arrow	HR6 Enz-Odours	Spot Stain Remover
Arrow	HR10 Chewing Gum Remover	Chewing Gum Remover
Arrow	GL Remover	Glue / label remover
Arrow	Erase	Graffiti Remover Spray
Arrow	HR8 Superclean Lemon	Hard Surface Cleaner
Chela	BioChela Fresh	Toilet Cleaning (Cubicle)
RJN Chemicals	FreshClean	Multi Cleaner
Autoglym	No.56 Express Wash	General Purpose Cleaning
Pakex (UK) plc	DP20 Disinfectant	Toilet Surfaces and Bio hazard surface Wipes
Cutan	Multi-Purpose Wipes	General Purpose Cleaning Wipes
Autoglym	Window Clean	Glass Cleaner

Supplier	Product Name	Purpose
i) –Pakex (UK) plc ii) Graffex	i) Super Graffiti Remover** ii) Ecosafe	Internal Graffiti Remover (Hard Surfaces)
i) PHD ii) DPD Solutions	Chewing Gum Remover Desolv	Chewing Gum Remover
Autoglym	Autofresh	Air Freshener
Autoglym	No.82 Washroom Cleaner	Toilet cleaner
i) PHD ii) Pro Chem iii) Amberclens	i) Plush carpet & upholstery cleaner ii) Fibre & Fabric Rinse iii) Foam cleaner	Carpet / upholstery cleaner
Bio spot	Hydro-chloride Tablets	Depot/CET use

Appendix L - Application of GB Onboard New Trains Subsystem Requirements Specification

L.1 Table L1 list clauses of the GB Onboard New Trains Subsystem Requirements Specification[106] ('ENTOSS') that are either 'preferred' (**Pref.** in Table L1) or 'application-specific' (**Appl.** in Table L1). For the reasons defined in Table L1, HS2 Ltd requires compliance with those requirements identified as **Y** in the final column of Table L1.

Table L1 - Application of GB Onboard New Trains Subsystem Requirements Specification

ENTOSS-ID	ENTOSS requirement text	Status	Rationale	Guidance	Comply?
	2 Responsibility				
	2.2 Configuration Management				
ENTOSS-12	The part number, serial number and modification version of all software-driven line-replaceable units shall be available to be viewed electronically.	Pref.	The ability to view electronically the configuration of the line-replaceable units of the system allows for rapid verification of the modification state; this is particularly of use during a modification programme.	Such functionality could be provided by the system in question; however, an integrated solution using the on-board Train Management System is preferable. 'Software-driven' line-replaceable units include all equipment that can feasibly report its status to the train, but excludes 'hardware-only' line-replaceable units without such intelligence.	Y
	3 System Requirements				
	3.1 Braking				
ENTOSS-401	The service and emergency braking rates used within the ETCS brake model shall be modified automatically from detection of the operational status of any special brake systems used.	Pref.	To enable the most accurate braking rate input to the ETCS brake model.	Special brakes include any regenerative, eddy current or magnetic shoe brakes used on the vehicle.	Y

ENTOSS-ID	ENTOSS requirement text	Status	Rationale	Guidance	Comply?
ENTOSS-402	The train brake system shall have an ETCS Kdry (99%) value in excess of 0.95 at all speeds.	Pref.	A higher value of Kdry results in better performance under the ETCS.	The tolerance and reliability of the brake system is captured within the ETCS parameter Kdry, which has a direct impact on the assumed deceleration of the train	Y
ENTOSS-403	The train brake system shall have an ETCS Kwet value in excess of 0.85 at all speeds.	Pref.	A higher value of Kwet results in better performance under the ETCS.	The braking performance of the train under representative wet rail conditions (as prescribed by EN15595) has a direct impact on the assumed deceleration of the train.	Y
	3.1 Traction Power				
ENTOSS-404	When the ETCS trackside commands it, the traction current demanded from the infrastructure by the vehicle traction systems shall be limited by the train.	Appl.	This function prevents traction systems drawing excessive current from the infrastructure traction power supply system; it simplifies the implementation of new stock on routes where the traction supply requires upgrade without then inhibiting rolling stock performance on other route sections.	Packet 40 (change of allowed current consumption) and Packet 44 (external data) will be used to provide data to vehicle systems to limit the traction current that can be consumed.	Y
ENTOSS-405	When the ETCS trackside commands it, traction power regeneration into lineside electrification systems shall be inhibited by the train.	Appl.	This function allows the vehicle to be operated on routes where the traction supply is not designed for regeneration without then inhibiting the regeneration function on other route sections. This provides greater opportunity to derive business benefits from the regenerative function of the train.	Packet 68 (track conditions) and Packet 44 (external data) can provide data to vehicle systems to prevent the traction system from regenerating electricity under braking and feeding that back into the Overhead Line Equipment (OLE) / 3rd rail.	Y

ENTOSS-ID	ENTOSS requirement text	Status	Rationale	Guidance	Comply?
ENTOSS-406	For manual traction change-over systems, the 'change of traction system' announcement shall be displayed on the ETCS Driver Machine Interface in sufficient time for the driver to be able to switch over to the correct traction system by the time that they reach the required location.	Appl.	It is important to ensure that the driver is alerted clearly and with reasonable notice to prevent any disruption that may result from failure to select the correct traction system in time.	It is expected that the 'change of traction system' announcement will be displayed at least 5 seconds before the switchover location is reached.	N
	3.2 Isolation				
ENTOSS-24	The ETCS isolation facility shall be available in each driving cab.	Appl.	The driver needs to be able to isolate the ETCS without leaving the cab.	Though provision should be made to allow the isolation of the ETCS from any cab, it should only be functional in the active cab. The isolation facility will be located beyond the reach of the driver when in the normal driving position.	Y
ENTOSS-31	It shall be technically possible to operate the rail vehicle or train indefinitely in revenue-earning service in overlay and ETCS-unfitted areas with the ETCS Onboard solution in Isolation (IS).	Appl.	To minimise unnecessary service disruption were trains can continue to operate normally under the control of an alternative signalling system.	To facilitate or support continued service operation in IS on infrastructure equipped with lineside signals and alternative train protection systems, Class B protection systems need to remain available when the ETCS Onboard solution is isolated. Consideration will be given to if, or how, this requirement could be met when the Class B protection system is integrated into the ETCS Driver Machine Interface in some form. The positioning and size of the speedometer will also need to be considered, such that it is appropriate for a driver to utilise for continuous operation. This technical requirement does not infer that operation in IS is either commercially acceptable or the intended approach for operation on non-ETCS-fitted infrastructure.	Y

ENTOSS-ID	ENTOSS requirement text	Status	Rationale	Guidance	Comply?
	3.5 Tandem Working				
ENTOSS-40	The ETCS 'allow Non Leading mode' vehicle interface shall be implemented.	Appl.	The current intention is to use Non Leading (NL) for tandem working and some banking or rescue operations.	Inclusion of this function on locomotives working in variable consist trains is highly recommended. There may also be merit in enabling this functionality on other types of rolling stock.	Y
ENTOSS-41	The ETCS 'Passive Shunting Permitted' interface shall be implemented.	Appl.	The current intention is to use Passive Shunting (PS) for 'top and tail' working where the trailing locomotive is unmanned yet left running.	Inclusion of this function on locomotives working in variable consist trains is highly recommended. There may also be merit in enabling this functionality on other types of rolling stock.	Y
	3.8 On Track Machine Operation				
ENTOSS-408	When an engineering train is changed into working mode, it shall cause the ETCS Onboard solution to enter Sleeping (SL).	Appl.	The ETCS Onboard solution is not required to control movements when an engineering train is in working mode.	This specification is not for On-Track Machines	N
ENTOSS-46	It shall not be necessary to isolate the ETCS Onboard solution when the rail vehicle or train is performing its intended track maintenance functions.	Appl.	Isolating the ETCS Onboard solution has operational implications and should be avoided. Safety requirement for Hazard OB-H003.	This specification is not for On-Track Machines	N
	3.10 Cab detection				

ENTOSS-ID	ENTOSS requirement text	Status	Rationale	Guidance	Comply?
ENTOSS-411	It shall be possible to close the desk remotely from the opposite end of the vehicle, unit or train, subject to certain conditions being met.	Appl.	This will avoid the need for the driver to walk the length of the train.	In the event that the desk is not closed by the driver upon leaving the cab, it will be possible to close the desk from the opposite end of the train, subject to certain conditions being met. For example: o Enabling the cab active signal within another cab of the train. o Operating the driving controls within another cab of the train. Likewise, certain circumstances may prevent the cab active being remotely cancelled. For example: o The vehicle is moving. o A direction is still selected in the original cab. Such a method of remotely closing the desk means that the 'cab open' function may be better served by a push button or Train Management System option, rather than a physical switch or key that cannot be remotely reset.	Y
ENTOSS-412	Subject to certain conditions being met, a desk shall automatically close after a configurable time delay.	Appl.	Whilst desk closure is beneficial for security, there are operational benefits to leaving it open in certain circumstances.	The active ETCS desk will automatically close after a vehicle-specific delay if it can be inferred that the driver has left the cab. Such signals may be that: o the vehicle is stationary. o no direction is selected. o there has been no driver interaction with the Driver Machine Interface (DMI) or controls during that period. A typical delay may be 30 minutes to account for the driver leaving the train to attend to an incident elsewhere on the vehicle, although this will depend upon operator preference.	Y

ENTOSS-ID	ENTOSS requirement text	Status	Rationale	Guidance	Comply?
ENTOSS-414	Where there is only one ETCS Onboard solution, the driver shall be able to see an indication in their cab that the ETCS Onboard solution has been isolated from the other cab.	Appl.	The driver needs to be aware of the status of the ETCS. Safety requirement for Hazard OB-H003.	This could be displayed on the ETCS Driver Machine Interface.	Y
ENTOSS-301	Where two European Vital Computers (EVCs) exist, an indication as to the status of both EVCs shall be displayed (or indicated) in both cabs.	Appl.	Safety requirement for Hazard OB-H003.	Indication should make clear which EVC is isolated.	Y
	3.11 Self-Test				
ENTOSS-415	Where two ETCS Onboard solutions exist on board, an indication as to the status of both ETCS Onboard solutions shall be displayed (or indicated) in both cabs.	Appl.	This applies to a single vehicle where two ETCS Onboard solutions are present. Safety requirement for Hazard OB-H003.	This can be displayed using the ETCS Driver Machine Interface in each cab.	Y
	3.12 Driver Machine Interface (DMI)				
ENTOSS-417	[Provisional] The ETCS Onboard solution shall not allow the driver to select Shunting (SH) in Levels NID_NTC=20 and 21.	Normative	This protects against erroneous selection of the SH (shunting) during a mission and suppression of the AWS / TPWS. Safety requirement addressing Hazard OB-H021.	See Open Point 4 in the ETCS System Requirements Specification [106].	N

ENTOSS-ID	ENTOSS requirement text	Status	Rationale	Guidance	Comply?
ENTOSS-63	The ETCS Driver Machine Interface (DMI) shall comply with the principles of EN 894-1:1997 Chapter 4 [RD17].	Pref.	EN 894-1:1997 sets out good practice principles for effective human-machine interaction, and should be considered as complementary to ERA_ERTMS_015560 with regard to the ETCS DMI.	Where conflict exists, the Agency specifications must take precedence. The ETCS DMI should be considered as the primary driver control and speedometer as set out in GM/RT2161. End user consultation is seen as being a critical part of achieving acceptance of the system; therefore, it is highly recommended that this form part of the project development alongside the implementation of standards and good practice guidance.	Y
ENTOSS-64	The ETCS Driver Machine Interface (DMI) shall comply with section 4.2 of EN 9241-400:2007 [RD19].	Pref.	Section 4.2 refers to design requirements for physical input devices, and should be considered as complementary to ERA_ERTMS_015560 [RD15] with regard to the ETCS DMI.	Where conflict exists, the Agency specifications must take precedence.	Y
ENTOSS-65	The ETCS Driver Machine Interface (DMI) shall conform to the requirements set out in Table B.2 of EN 9241 11:1998 [RD20] for the usability objectives.	Pref.	EN 9241 11:1998 is seen as complementary to ERA_ERTMS_015560 with regard to the ETCS DMI.	The usability objectives are: 'Meets needs of trained users', 'Minimization of support requirements', 'Learnability', 'Error tolerance' and 'Legibility'. Where conflict exists, the Agency specifications must take precedence.	Y
ENTOSS-66	The ETCS Driver Machine Interface (DMI) shall meet the requirements for legibility in the cab environment set out in EN 894-2:1997 [RD21].	Pref.	EN 894-2:1997 refers to the real life clarity of the artefacts on the display compared with the display background once factors such as lighting, backlighting, reflections and vibration are taken into account.	EN 894-2:1997 recommends a contrast ratio between symbols, letters, numbers etc. and their immediate backgrounds of 6:1. The ratio should be at least 3:1. This document is seen as complementary to ERA_ERTMS_015560 with regards to the ETCS DMI. Where conflict exists, the Agency specifications must take precedence.	Y

ENTOSS-ID	ENTOSS requirement text	Status	Rationale	Guidance	Comply?
ENTOSS-67	The ETCS Driver Machine Interface (DMI) positioning in the cab for 'detection' and 'monitoring' tasks by the driver shall be at least 'acceptable', as set out in EN 9241 11:1998 [RD20] section 4.1.	Pref.	EN 9241 11:1998 is seen as complementary to ERA_ERTMS_015560 [RD15] with regard to the ETCS DMI.	Where conflict exists, the Agency specifications must take precedence.	Y
ENTOSS-70	The driver shall be able to interact with the ETCS Driver Machine Interface (DMI) display area without being impeded by other cab equipment, controls or structure.	Pref.	The cab design should minimise the obscuration of the DMI screen when the driver interacts with cab equipment; it should also limit the likelihood of the driver accidentally operating the DMI while using adjacent vehicle controls.		Y
	3.13 Entry and Interaction				
ENTOSS-81A	The ETCS data entry process shall be configured to enable data entry to be completed within 60s of the ETCS Onboard solution being ready to accept data entry in Standby (SB) (Status S0).	Pref.	The time needed to initialise the ETCS Onboard solution should be kept to a minimum as it has operational implications.	The Agency specification ERA_ERTMS_015560 clearly specifies the ETCS Driver Machine Interface (DMI) data entry process; however, there are certain elements which can be configured to minimise driver workload, including: o Rationalisation of the DMI presets to an easily interpreted set. o Auto population of train data from the vehicle's Train Management System (subject to the limitations on the safety and security integrity of the Train Management System and the train data). o Non-display of data options that are not appropriate to that installation of the ETCS Onboard solution.	N

ENTOSS-ID	ENTOSS requirement text	Status	Rationale	Guidance	Comply?
ENTOSS-307	Where the ETCS data is known, it shall be populated automatically for the driver to accept or modify.	Appl.	Manual entry of train data introduces the risk of incorrect braking data being used to populate the ETCS, thereby rendering the ETCS braking curves unsafe. This risk can be reduced by automatic provisioning of train data from systems that hold accurate data on the train consist.		Y
ENTOSS-157	Provision shall be made for an external data connection to be used for the remote population of train data.	Appl.	For rail vehicles or trains where it is not practical to provide the ETCS with train data from other systems on board the vehicle automatically, it is still prudent to provide the ability to populate the data from other remote systems through the addition of further equipment at a later date. The ETCS Onboard solution should therefore accommodate this additional connection.		Y
ENTOSS-87	The ETCS train-type data entry process shall use no more than five menu levels.	Pref.	This will prevent the driver being presented with too much information.	If the train-type menus are presented as a series of nested lists (i.e. where selection of one train type on the first list presents a second list of subtypes, etc.), then human factors research suggests that the driver would not be able to manage the data entry process if more than five layers of nested lists were present.	Y
ENTOSS-88	A menu shall not be shown where there are one or zero data sets on that menu level.	Pref.	This will prevent the driver being presented with unnecessary information.	This requirement applies to train data sets; it is not applicable to menu levels intended only ever to have one option for confirmation, e.g. override window.	Y
ENTOSS-89	The vigilance timer in the cab shall be reset whenever the driver presses any valid button on the ETCS Driver Machine Interface (DMI) associated with a genuine DMI interaction.	Pref.	This will facilitate simple cancellation of the timer, whilst ensuring that the safety purpose of the timer is maintained.		Y

ENTOSS-ID	ENTOSS requirement text	Status	Rationale	Guidance	Comply?
ENTOSS-93	When a 'Set Speed' automatic speed control function is active, the speed set point shall be displayed on the ETCS Driver Machine Interface (DMI) speed dial.	Appl.	This functionality is appropriate for vehicles where a 'Set Speed' system exists.		Y
ENTOSS-95	Any automatic 'Set Speed' control shall be disengaged immediately the ETCS Onboard solution commands a brake intervention.	Appl.	It is possible that, on entering target speed monitoring, a set speed control could cause an intervention. This requirement is designed to eliminate the possibility that, when the ETCS revokes the brake demand (because the train speed is below the permitted speed), the set speed control then increases the speed to the previous level. Safety requirement addressing Hazard OB-H018.	This requirement is only applicable to vehicles fitted with a 'Set Speed' system; for vehicles where such a system exists, this functionality is deemed to be the most appropriate	Y
ENTOSS-419	The units used on the set speed system shall be the same as those of the current speed displayed to the driver.	Appl.	This requirement mitigates the risk of an incorrect speed being selected as a result of different units of speed measurement being used on different systems.	If the set speed control is configured in discrete steps, consideration should be given to the appropriateness of the step interval for the units of measurement in use. For example, a set speed control configured only in 5mph steps will not generally align to commonly used speed limit values on lines operated in km/h. This requirement is only applicable to vehicles fitted with a 'Set Speed' system; for vehicles where such a system exists, this functionality is deemed to be the most appropriate.	Y
	3.15 Speed Display				

ENTOSS-ID	ENTOSS requirement text	Status	Rationale	Guidance	Comply?
ENTOSS-98	The driver shall be presented with vehicle speed information whilst the ETCS Onboard solution is isolated.	Appl.	A speed display being available to the driver when the ETCS Onboard solution is isolated mitigates risks associated with having no ETCS speedometer due to ETCS failure; it also assists the driver training programme in being able to run trains irrespective of ETCS driver training on unfitted lines. Safety requirement addressing Hazard OB-H026.	This may be achieved by providing an independent speedometer (via the TMS or other systems), or configuring the ETCS Onboard solution to display speed whilst the broader system functionality is isolated. Requirements governing the accuracy of speed indicating systems are set out in RIS-2004-RST.	Y
	3.16 Odometry and Tachometry System				
ENTOSS-424	The ETCS Onboard solution shall determine its position with an error of no more 1% of distance travelled from the last balise when operating at constant speed.	Pref.	Excessive positional error within the odometry system results in a reduction in train performance.	Whilst the positional error might increase to 5%+/-5m over the range of train conditions (acceleration, braking, slip, slide), it is reasonable to expect better performance in steady state conditions.	N
ENTOSS-425	The train shall automatically recalibrate the ETCS odometry in response to wheel wear.	Pref.	Whilst manual measurement of the wheel diameters is the default option, it is not preferred.	It is preferable for the ETCS Onboard solution to re-calibrate itself automatically to account for a reduction in wheel diameters as wheels wear.	Y
	3.19 Data Radio				
ENTOSS-114	In the event of failure or degradation of one of the ETCS Data Only Radios, the ETCS Onboard solution shall use the remaining available data radio to maintain ETCS functionality.	Pref.	To allow the train to continue its operations.	In the event of the failure of a radio when in service, it is preferable that the system should optimise operation based on remaining radio capability. The ETCS application may make use of the two radio mobiles within the ETCS data radio for optimum performance during cell handover or RBC transition.	Y
	3.21 Control of Ancillary Systems				

ENTOSS-ID	ENTOSS requirement text	Status	Rationale	Guidance	Comply?
ENTOSS-433	The ETCS Onboard solution shall be configured such that the Neutral Section symbols displayed on the ETCS Driver Machine Interface (DMI) are those indicating automatic control of the vehicle in-feed circuit breakers.	Appl.	Vehicle in-feed circuit breakers will open automatically on the GB mainline railway.	The DMI symbol for automatic control of the in-feed circuit breakers must be displayed so that the driver is able to ramp down traction prior to reaching the Neutral Section area.	Y
ENTOSS-131	The ETCS Onboard solution shall not extend the time during which traction power is lost when crossing neutral sections beyond that already experienced through the operation of the existing vehicle systems.	Appl.	Extending the time over which traction power is lost may impact train performance on the route.		Y
	4 NATIONAL SYSTEMS				
	4.1 AWS / TPWS				
ENTOSS-131A	The ETCS Onboard solution shall be configured to include Level NTC, NID_C=20 and 21.	Appl.	The system needs to be able to support all Levels.		Y
	The ETCS Onboard solution shall work in conjunction with any applicable Class B protection systems so as to allow the vehicle to operate correctly on non-ETCS fitted infrastructure.	Appl.	The system needs to be able to operate on non-ETCS-fitted infrastructure.		Y
	4.1.2 Standalone System				

ENTOSS-ID	ENTOSS requirement text	Status	Rationale	Guidance	Comply?
ENTOSS-437	Where trains are fitted with an existing ATP system, the ATP / ETCS control device shall enable the appropriate train protection system (ATP or ETCS) and disconnect the other system.	Appl.	Only one train protection system can be responsible for safety.		N
	4.2 Tilt Authorisation and Speed Supervision				
ENTOSS-440	Where tilting functionality is integrated into the ETCS, the ETCS shall output a tilt authorisation command to the tilt system.	Appl.	An option is for tilt commands received from either the RBC or balises to be processed / interpreted by the ETCS Onboard sub-system which will control the Tilt Mechanism.	The Onboard will need to be able to undertake the full functionality of the current TASS system (speed supervision and tilt authorisation) when in Level NTC using the balise reader provided for ETCS. When operating in ETCS Levels 2/3, the Onboard will only need to utilise the Packet 44 data sent by the RBC.	N
ENTOSS-441	On trains where tilt is selectively authorised, the Onboard shall monitor and correctly interpret a 'tilt healthy' signal from the tilt system.	Appl.	The availability of the tilt system enables the Onboard to supervise the train to the correct speed in ETCS Levels 2/3 by selecting the appropriate speed profile. If the system is unavailable due to a fault or isolation, then the speed of the train will be restricted by the ETCS.	Changes in the 'tilt healthy' signal will be managed as a change in train category from a source other than the driver, in accordance with 5.17 of Subset 026. A change in state requires the train to be at a stand or be brought to a stand.	N
ENTOSS-442	Where tilting functionality is not integrated into the ETCS, the Onboard shall pass all Packet 44 data relating to Tilt Authorisation and Speed Supervision (TASS) received via RBC or balise to the external TASS system.	Appl.	An option is to retain a modified version of the current on-board TASS system and this requires the ETCS to pass the relevant data to that system.	The current system is based on an ETCS architecture with a balise reader and restricted functionality European Vital computer.	N

ENTOSS-ID	ENTOSS requirement text	Status	Rationale	Guidance	Comply?
ENTOSS-444	The driver shall be advised of the health status of the tilt system in all levels.	Appl.	The driver needs to be aware of whether the tilt system is available for use.	The indication could be provided via a separate indicator or combined within the ETCS Driver Machine Interface.	N
ENTOSS-445	The driver shall be advised of the authorisation of tilt in all levels.	Appl.	The driver needs to be aware of when the tilt system is authorised, primarily, in Level NTC.	The indication could be a separate indicator or combined within the ETCS Driver Machine Interface.	N
ENTOSS-446	The driver shall be able to isolate the tilt system.	Appl.	Where the driver becomes aware of a fault or potential fault with the tilt system, or due to other restrictions they need to have a control to isolate it.	The control should be separate to the ETCS Driver Machine Interface and apply to the whole train. Operation of the control in one cab should result in a loss of tilt system health indications in both cabs.	N
	5.2 Future Provisions				
ENTOSS-155	A minimum of five spare digital inputs and outputs shall be provided by the ETCS Onboard solution to accommodate anticipated future functionality.	Appl.	Provision is needed for external data connections to interface with future on-board systems.	Five was seen as a reasonable number for additional future provision. This does not invalidate any supplier providing more than five spares. Any innovative solutions are welcomed.	Y
	5.3 Additional (Driver Training) Display				
ENTOSS-439	Driving indications shall be made visible to anyone seated in a non-driving seat in the cab.	Appl.	Driver instructors may need to monitor driving performance during training and service conditions, which requires observation of movement authorities and other DMI data.	Direct observation of the ETCS Driver Machine Interface (DMI) may be achieved as a result of the cab layout; however, it is possible that the DMI might not be visible from a non-driving seat. In such a scenario, the driver instructor will require the provision of additional or portable DMI equipment (e.g. repeater DMI, laptop, providing indications only). As such, appropriate power and signal connections, as well as a mounting bracket, would be required.	Y
	6 INSTALLATION DESIGN				
	6.1 General				

ENTOSS-ID	ENTOSS requirement text	Status	Rationale	Guidance	Comply?
ENTOSS-162	The ETCS Onboard solution shall incorporate modularity and the facility to upgrade or replace parts of the system separately	Appl.	As with most on-board electronic components, the ETCS solution should be easily replaceable and modular in design.		Y
	7 MAINTENANCE				
	7.1 General				
ENTOSS-196	It shall take no more than fifteen minutes for an ETCS Driver Machine Interface (DMI) to be replaced, configured and tested by a single trained person.	Appl.	DMIs are expected to need replacing more regularly than other components. This should be a quick operation performed by a single trained person.	Whilst most components will be changed at maintenance depots, it is feasible that DMIs will be swapped out by station-based maintenance staff while the rail vehicle or train is in service. As such, the requirements for changing a DMI are much more stringent than for other components.	Y
	7.2 Diagnostic tools				
ENTOSS-203	Software-based diagnostic tools shall be designed for use on standard modern operating systems.	Pref.	This is to allow the software to be installed and used seamlessly.	The software should not rely on legacy operating systems for its operation; it should function correctly within modern, commercially available operating systems. This may include, but is not limited to, Windows, iOS, Linux and Android systems.	Y
ENTOSS-206	Software-based diagnostic tools shall use modern, universally available interfaces for communicating with the ETCS Onboard solution.	Pref.	Ethernet, USB, Wi-Fi and other common interfaces will be utilised to avoid potential obsolescence issues with the device hardware.	RS232, RS485 and other legacy interfaces should be avoided.	Y
ENTOSS-207	Functionality shall be provided to download remotely ETCS diagnostic information stored on board while the rail vehicle or train is in service.	Appl.	The ability to identify faults within the ETCS Onboard solution from locations remote to the vehicle is deemed to be beneficial.	This may be facilitated through exporting system fault logs at defined intervals, or upon demand via a remote communication medium.	Y

ENTOSS-ID	ENTOSS requirement text	Status	Rationale	Guidance	Comply?
ENTOSS-211	Functionality shall be provided to download data from the Data Recording Unit remotely whilst the vehicle is in service.	Appl.	The ability to download Juridical Recording Unit data from the ETCS Onboard solution from locations remote to the vehicle is deemed to be beneficial.	This may be facilitated through exporting JRU logs at defined intervals, or upon demand, via a remote communication medium. It may be deemed acceptable for only a subset of the data to be available for download whilst the vehicle is in motion if it can be shown to be sufficient for the needs of the operator.	Y
ENTOSS-214	ETCS Onboard solution diagnostic information shall be displayed to authorised persons without the need for equipment other than access keys.	Pref.	As with most electronic equipment, a maintainer must be able to interrogate the ETCS diagnostic information from displays / interfaces integrated within the ETCS Onboard solution.	There should be no need to use maintenance tools or laptop-based interrogation software, other than access keys, if located in a secure area.	Y
ENTOSS-217	The ETCS Onboard solution shall be able to identify malfunctioning ETCS line replaceable units to an authorised person before they cause a service failure.	Pref.	Failures in unmonitored hardware (wiring degradation, sticking relays, etc.) cannot reasonably be expected to be identified before failure.	Partial failure of redundant systems or tolerable but unusual activity (e.g. abnormal data errors, dropped connections, inconsistent ETCS input and software watchdog resets) are examples of faults which a system may reasonably identify before it results in a failure.	Y
ENTOSS-224	Detailed maintenance information about the cause of ETCS faults and appropriate remedial action shall be provided by the on-board systems.	Pref.	An ETCS fault should be reported in relevant train management systems which can be accessed by the driver and/or maintainers.	When the vehicle is fitted with train control systems which report faults directly to drivers, and / or to maintainers remotely, the ETCS fault logging system should be integrated with the vehicle system if it is economical for it to do so. The failure of one system in an integrated solution should not affect the fault logging of other systems.	Y

Appendix M - Default colour palette and exterior livery

M.1 Introduction

M.1.1 This appendix provides an initial set of colours for an external livery and interior colour scheme of the Unit.

M.1.2 The current content of this Appendix is based on HS2 Ltd's internal industrial design guidelines. This is specified for the purposes of the Tender only so that all Tenders are based on a consistent colour scheme.

M.1.3 Agreement of the colour scheme does not take place until the Preliminary Design Stage. It is anticipated that colours will be altered from those shown below. This will form part of the collaboration process described in MSA Schedule 9, Appendix 1. This process will include the external livery. Since the colour scheme is not due to be agreed until the Preliminary Design Stage, any change from the colours listed below will not be considered a Change in accordance with MSA Schedule 17, Change Procedure.

M.2 Colour palette

M.2.1 Figure M1 and Table M1 show the primary and secondary colour palette, and accent colours. In addition to these colours, black, white and shades of grey may also be used.

Figure M1 – Colour Palette

Table M1 – RGB values for colour palette

Colour	R	G	B
HS2 Blue	30	55	115
Purple	190	90	155
Green	70	170	60
Orange	255	128	0
Light Blue	95	184	244
Pink	229	50	65

M.2.2 For the purposes of the tender, it is not necessary to exactly match these colours, provided similar colours are used.

M.3 Livery diagram

M.3.1 Figures M2 and M3 illustrate an external livery. Note that blue sections should be HS2 Blue as specified in Table M1, or a close approximation of this.

Figure M2 – ¾ view of Unit livery

Figure M3 – Side view of Unit Livery

M.3.2 Figures M2 and M3 are not intended to illustrate anything except the Unit livery and are not intended to show a preferred vehicle configuration, door position or any other design solution.

M.4 Internal colours

M.4.1 The interior colour scheme for the purposes of the tender should be

- Seat moquette - predominantly 'HS2 Blue'
- Flooring - dark grey
- Interior panelling - a suitable light colour such as RAL 9001 and does not have to use the HS2 colour palette.

M.4.2 Other colours in the HS2 colour palette should be used sparingly through the vehicle - e.g. grab-handles.

Appendix N - Contractually Protected Area

N.1 Principle

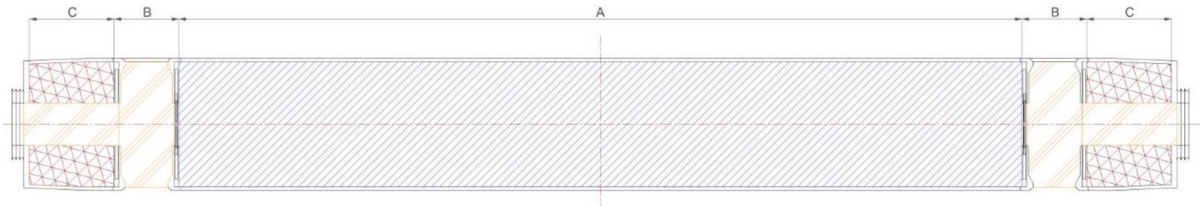
N.1.1 The Contractually Protected Area is the area of the interior that can flexibly be used for the fitment of interior equipment. All of the Contractually Protected Area shall comply with the minimum cross-sectional area (TTS-633) either for the full width of the Vehicle or for the half-width of the Vehicle.

N.1.2 Figures N1 and N2 illustrate possible arrangements of the Contractually Protected Area.

N.1.3 In all Figures, the Vestibules (B) are excluded from the Contractually Protected Area, since the Exterior Doors could not easily be moved during refurbishment.

N.1.4 Figure N1 shows a solution where the Exterior Doors are 1-2m from the Vehicle end. Area C may be usable for Toilets, electrical equipment cubicles, Bulk Luggage Storage Areas and other purposes, but it cannot be used for Passenger Seats. Therefore, the Contractually Protected Area would exclude area C. A Toilet, Bulk Luggage Storage Area or Catering Trolley Stowage Point positioned in area C would not comply with TTS-3354, TTS-3352 or TTS-3353 respectively.

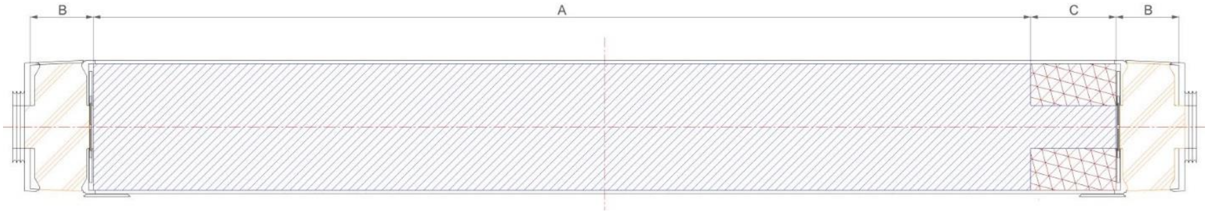
Figure N1 – Example Contractually Protected Area



N.1.5 In Figure N2, the area C may be part of the Contractually Protected Area depending on its use.

- If both area Cs contain electrical equipment cubicles or other items that cannot be moved during a refurbishment, they are not part of the Contractually Protected Area, and the Contractually Protected Area would finish to the left of area C, i.e. area A only as shown in Figure N2.
- If both area Cs contained Toilets, Bulk Luggage Storage Areas, Catering Trolley Stowage Points, the whole area up to the Vestibule would be included in the Contractually Protected Area, i.e. Areas A and C as shown in Figure N2. Note that these positions would comply with TTS-3354, TTS-3352 or TTS-3353 respectively.
- If one of the area Cs contained flexible equipment and one contained fixed equipment, the contractually protected area would contain just the flexible area, provided at least half the Vehicle width was available. The flexible half would need to comply with the relevant figure of Appendix D.

Figure N3 – Example Contractually Protected Area



N.2 Contractually Protected Areas

N.2.1 The following diagrams contain the agreed Contractually Protected Areas.

Figure N3 –Contractually Protected Area – Vehicle [●]

[●]

Figure N4 –Contractually Protected Area – Vehicle [●]

[●]

Figure N5 –Contractually Protected Area – Vehicle [●]

[●]

Figure N6 –Contractually Protected Area – Vehicle [●]

[●]

Figure N7 –Contractually Protected Area – Vehicle [●]

[●]

Figure N8 –Contractually Protected Area – Vehicle [●]

[●]

N.2.2 ***Update for contract –*** *Tenderer to provide the above figures for each Vehicle. A single diagram may be provided for multiple vehicles if applicable. More figures may be added.*

Appendix O - Non-compliances to Industry Standards

O.1 Tables O1 and O2 lists all of the agreed non-compliances with mandatory standards including:

- Clauses of a TSIs where the TMM intends to adopt an innovative approach
- Clauses of Railway Group Standards where the TMM intends to raise a deviation in accordance with the RGS Code[77].
- Clauses of Railway Industry Standards that are referenced by the TTS where compliance will not be achieved.

O.2 Refer to MSA Schedule 10, Section 4 for details of the formal procedure for managing non-compliances.

O.3 Table O1 lists the non-compliances where HS2 Ltd is responsible for gaining agreement for the non-compliances

O.4 ***Draft for ITT –*** *Tenderer to complete length of required overhang.*

Table O1 – List of non-compliances for which HS2 Ltd is responsible

Standard	Clause	Clause Text	Reason for non-compliance	Alternative requirement
GMRT2173 Iss 1	3.3.1.e	Maximum vehicle overhang of 3.226 m from the wheel centre of the first / last axle to the end of the vehicle	Aerodynamic and noise requirements necessitate a longer nose than conventional UK rolling stock.	[●]
LOC&PAS TSI	4.2.9.3.1 (2) ¶3	The system shall allow for the adjustment (at workshop, as a maintenance activity) of the time X within the range of 5 seconds to 60 seconds.	Greater flexibility is required for when the Unit is being controlled by ATO On-board	*To be determined following human factors assessment*

O.5 Table O2 lists all of the agreed non-compliances where the TMM is responsible for gaining agreement for the non-compliance.

O.6 ***Draft for ITT –*** *The current version of Table O2 shows non-compliances that HS2 Ltd will agree to, but that are still at the TMM's risk. The TMM may adopt these and complete the missing information or remove this if not necessary for the Unit. If the TMM requires additional non-compliances these must be raised as a clarification question through the tender process prior to tender submission - refer to section 5.7 of the ITT.*

Table O2 – List of non-compliances for which TMM is responsible

Standard	Clause	Clause Text	Reason for non-compliance	Alternative requirement
GM/RT2111 Iss 1	4.11.1	Each 25 kV electric rail vehicle fitted with a pantograph shall be fitted with an independently operating APC receiver to control the circuit breaker(s) associated with that pantograph, as set out in 3.8.	[If applicable] The routes where HS2 Units will operate will be fitted with Eurobalises to achieve the APC function	Each 25kV unit shall be compatible with Eurobalises that are set up to provide automatic power control function.
GM/RT2141 Iss 3	2.4.1.1	Vehicles shall be designed with mass distribution and suspension characteristics which ensure the capability to run round smooth curves at constant speed, without rolling over, at: b) Not less than 21° cant deficiency for all other vehicles	[●]	[●] *TMM to propose alternate requirements which must be at least 18°.*
GM/RT2160 Iss 4	2.1.1	Driving cabs shall have acoustic characteristics that ensure that exploding detonators, as specified in BR 0640A, can be heard inside the cab at any vehicle speed and readily distinguished from background noise	[●]	[●] *TMM to propose alternate means of identifying detonators*
LOC&PAS TSI	4.2.8.2.9.1.1	The installation of a pantograph on an Electric unit shall allow mechanical contact from at least one of the contact wires at heights between: (1) 4 800 mm and 6 500 mm above rail level for tracks designed in accordance with the gauge GC.	[●]	[●]
[●]	[●]	[●]	[●]	[●]

O.7 Table O3 lists non-compliances with the current draft of the ATO over ETCS SRS[19]. The TMM and HS2 Ltd shall work to agree any necessary approval for these non-compliances.

Table O1 – List of non-compliances for which HS2 Ltd is responsible

Standard	Clause	Clause Text	Reason for non-compliance	Alternative requirement
AoE SRS - SUBSET 125	7.1.1.4	**Note:** The ATO-OB disengages when it stops the train at a Stopping Point independent of whether the ATO-OB has stopped the train within the stopping window or not. It is therefore a manual operation, by driver, to align the train or to take other actions, if necessary, depending on local procedures.	It is required that the Train should automatically re-align to minimise delays	**TTS-2349** - When the Train comes to a stop at a Stopping Point, if the Train has either: • overrun the Stopping Point by a distance less than a maximum overrun distance; or • stopped short of the Stopping Point, the On-board ATO shall not disengage and shall automatically re-align the Train with the Stopping Point.

Appendix P - Interior Noise Measurements

P.1 General requirements for interior noise testing

P.1.1 All interior noise testing shall be carried out in accordance with EN ISO 3381[72], including both open track and tunnel measurements. This Appendix contains clarifications to the application of this standard.

P.1.2 The TMM shall record the exact details of the testing to be undertaken in a test specification, which shall address all of the items in this Appendix. This test specification shall be submitted for Document Approval by HS2 Ltd prior to the test.

P.1.3 The vehicles where noise measurements are being made shall contain all interior components. Any deviation of the tested vehicles from the agreed design shall be recorded in the test specification (or as an addendum to the specification) prior to the test, with an explanation of why the deviations will not affect the result.

P.2 Open Track Measurements

P.2.1 General requirements

P.2.1.1 All open track testing should be carried out at 360km/h on track conforming to EN ISO 3095[71]. If track with a line speed of 360 km/h that conforms to EN ISO 3095 is unavailable, an alternative location or combination of locations shall be identified and recorded in the test specification. If necessary, the test specification shall identify how measured results shall be adjusted to account for deviations from the EN ISO 3095 and 360km/h.

P.2.1.2 Any adjustments to the pass/fail criteria to account for the test location shall be agreed via the test specification prior to the start of testing.

P.2.2 Maximum Noise Measurements

P.2.2.1 The test measurements shall be made at the single loudest point considering all of the Saloons of the Unit. The height of the measurement shall be 1.2m (i.e. seated height). The loudest point may be determined from existing evidence of comparable rolling stock or modelling specific to the Unit. If the loudest point is not at a typical location for high noise levels (e.g. under the pantograph, above running gear) testing shall be carried out to determine the location of the highest noise level.

P.2.2.2 If several locations are identified that could be the loudest location, the testing shall be carried out at all such locations simultaneously, and the loudest of these locations shall be considered in comparison to the requirement.

P.2.2.3 Unless the Unit is completely symmetrical, both directions of operation of the Unit shall be considered, with all systems (e.g. pantograph) in their normal configuration for the direction of running.

P.2.2.4 Three separate recordings shall be made at the test location(s) and the results averaged in accordance with EN ISO 3381 section 7.1.

P.2.2.5 Provided that the average of the three measurements at the loudest location is less than or equal to the requirement, the requirement will be considered to be achieved. No adjustment shall be made to the measured noise levels except as set out in the test specification and agreed with HS2 Ltd prior to the test.

P.2.3 Average Noise Measurements

P.2.3.1 The test measurements shall be made at the centre-point of each Saloon. This shall be as close as possible to:

- the longitudinal centre-point between the Partition at each end of the Saloon
- the longitudinal centre-line of the vehicle
- 1.2m above floor level.

but such that the microphone is at least 200mm from any seat in any direction.

P.2.3.2 The exact position of the microphone for each vehicle shall be detailed in the test specification.

P.2.3.3 The test should ideally make measurements in all vehicles simultaneously. If sufficient measurement apparatus is unavailable, the test specification shall explain how variability between different runs will be accounted for.

P.2.3.4 If it can be demonstrated that two or more vehicles will have the same internal noise level (e.g. from previous testing), it is not necessary to measure each vehicle; the results of the equivalent vehicle may be duplicated.

P.2.3.5 Three measurements shall be made for each vehicle. If the spread of the measurements at any one location is larger than 3 dB, a new series of measurements shall be made. An arithmetic mean of all the measurements (e.g. 24 measurements for an 8-Vehicle Unit) shall be calculated and rounded to the nearest decibel.

P.2.3.6 Provided the average of the measured noise levels is less than or equal to the requirement, the requirement will be considered to be achieved. No adjustment shall be made to the average of the measured noise levels except as set out in the test specification and agreed with HS2 Ltd prior to the test.

P.3 Noise testing in tunnels

P.3.1 Noise measurement test site

P.3.1.1 All tunnel noise measurements should be carried out at 320 km/h in the Northolt Tunnel. Assumed characteristics for the Northolt Tunnel are provided in section P.3.3, below.

P.3.1.2 Prior to testing starting, a comparison of the characteristics of the as-built Northolt Tunnel and the characteristics in section P.3.3 shall be completed. If necessary the pass/fail criteria for the test shall be adjusted to account for any change of characteristics. This shall be agreed via the test specification prior to the start of testing.

P.3.1.3 If an alternative test location is used, adjustments shall be made to account for the differences between the test location and the characteristics in section P.3.3.

P.3.2 Noise measurements within the vehicle

P.3.2.1 The test measurements shall be made at the single loudest point considering all of the Saloons of the Unit. The height of the measurement shall be 1.2m (i.e. seated height). The loudest point may be determined from existing evidence of comparable rolling stock or modelling specific to the Unit. If the loudest point is not at a typical location for high noise levels (e.g. under the pantograph, above running gear) testing shall be carried out to determine the location of the highest noise level. The loudest point for tunnel noise measurements may be different from the loudest point for open track measurements.

P.3.2.2 If several locations are identified that could be the loudest location, the testing shall be carried out at all such locations simultaneously, and the loudest of these locations shall be considered in comparison to the requirement.

P.3.2.3 Unless the Unit is completely symmetrical, both directions of operation of the Unit shall be considered, with all systems (e.g. pantograph) in their normal configuration for the direction of running.

P.3.2.4 Three separate recordings shall be made at the test location(s) and the results averaged in accordance with EN ISO 3381 section 7.1.

P.3.2.5 Provided the average of the measured noise levels at the loudest location is less than or equal to the requirement, the requirement will be considered to be achieved. No adjustment shall be made to the average of the measured noise levels except as set out in the test specification and agreed with HS2 Ltd prior to the test.

P.3.3 Characteristics of Northolt Tunnel

P.3.3.1 For the purposes of TTS-184, this section details the assumed characteristics of Northolt Tunnel:

P.3.3.2 The tunnel is 13.4 km in length.

P.3.3.3 The tunnel will comprise 2 separate single track bores.

P.3.3.4 Tunnel cross sections are detailed in:

- PH1-HS2-CV-DSE-000-200009[129] for straight track
- PH1-HS2-CV-DSE-000-200010[130] for canted track

P.3.3.5 All wall surfaces will consist of rough concrete with spectral acoustic absorption characteristics according to Table P1. No secondary absorption will be provided.

Table P1 – Spectral acoustic absorption characteristics

Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
Absorption	0.02	0.02	0.03	0.03	0.03	0.04	0.07	0.07

P.3.3.6 The trackform will comprise slab track with characteristics according to Table P2.

Table P2 – Trackform characteristics

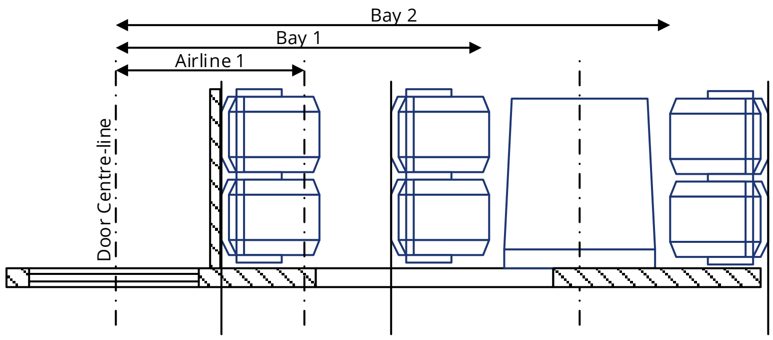
Rail support	Distance (m)	0.6
Rail Pad/ Baseplate pad	Static Stiffness (MN/m)	-
	Dynamic Stiffness (MN/m)	200
	Damping loss factor	0.2
Sleeper/block	Mass (Kg)	119.5
Sleeper/ Block pad	Static Stiffness (MN/m)	-
	Dynamic Stiffness (MN/m)	45
	Damping loss factor	0.2

Appendix Q - Layout examples

Q.1 Distance from door to seats

Q.1.1 Figure Q1 shows how the dimension from doors to seats must be measured for requirement TTS-2075.

Figure Q1 – Example door to seating position dimensions



Q.1.2 The distance is always measured from the centre-line of the doorway, along the centre-line of the vehicle. The distance from the door or seat to the centre-line does not need to be considered

Q.1.3 For airline seating, the dimension should be measured to the mid-point of the pitch of the Seating Position, half-way between the rearmost position on the back of the seats - see dimension 'Airline 1'.

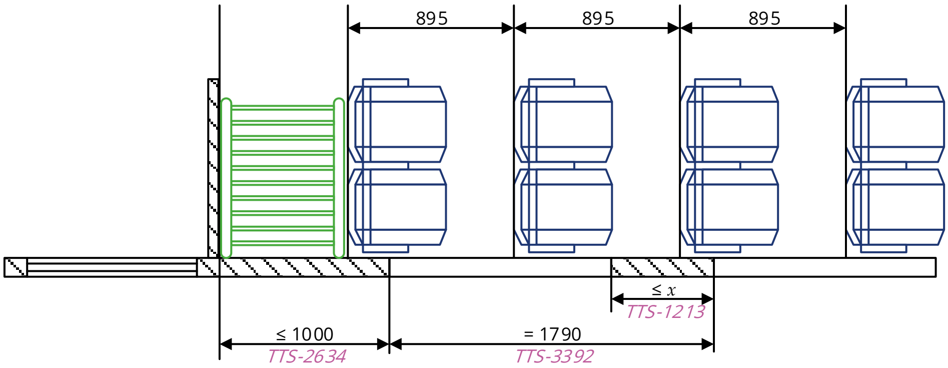
Q.1.4 For bay seating, the bay must be first divided in two along the centre of the bay. Each side of the bay contains two Seating Positions. Each Seating Position is then measured from the mid-point between the back of the seat and the centre of the bay - see dimensions 'Bay 1' and 'Bay 2'. It may be that one side of the bay is closer to an Exterior Doorway at the opposite end of the vehicle to the other side of the bay. This is compliant if both sides are within 12m of their respective Exterior Doorways.

Q.1.5 For Wheelchair Spaces, the dimension should be measured to the mid-point of the Wheelchair Space. However other requirements on accessibility should mean that the whole Wheelchair Space is within 12m of the nearest Exterior Doorway.

Q.2 Window size and spacing

Q.2.1 Figure Q2 provides an explanation of the Window size and spacing requirements in Section 11.1.3 of the TTS.

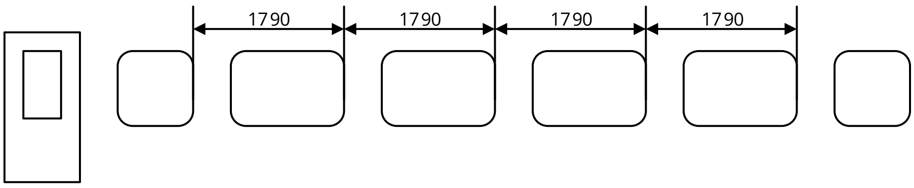
Figure Q2 – Window spacing requirements



Q.2.2 TTS-3392 requires that Windows are provided along the Saloon and that these must start no more than 1000mm from the start of the Saloon. The start of the Saloon should be measured from the face of the partition at the end of the Saloon.

Q.2.3 TTS-3392 requires that the 'pitch' of the Windows is 1790mm (with an appropriate tolerance for Carbody manufacture). This distance is specified to align with the seat pitch and so should not be higher or lower. 1790mm may be measured between any feature that is common to each Window. The last Window at either end of the Vehicle may be a different size (smaller or larger). A different size Window may be provided at both ends of the vehicle (as shown in Figure Q3), at one end only or not at all (i.e. all Windows are the same size.

Figure Q3 – Window spacing along the Vehicle

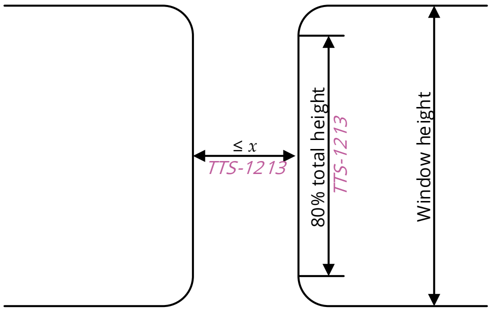


Q.2.4 Within the Tender, the size of the deadlights (x in Figures Q2 and Q4) is incentivised (via additional TTS compliance score, which will contribute to the tie-break) to be as small as possible. The dimension of the deadlight is the distance between the edge of the un-obscured glass on one Window and the edge of un-obscured glass on the adjacent Window. The following components are considered part of the deadlight:

- the Carbody between the Windows;
- the frame of the Window, depending on how the Window is mounted to the Carbody;
- any internal panelling that will block view through the Window; and
- any obscuration applied to the Window.

Q.2.5 The dimension of the deadlight must be maintained over at least 80% of the height of the Window. The width of the deadlight can increase at the top and bottom of the Window as shown in Figure Q4 to enable rounded corners.

Figure Q4 – Window spacing along the Vehicle



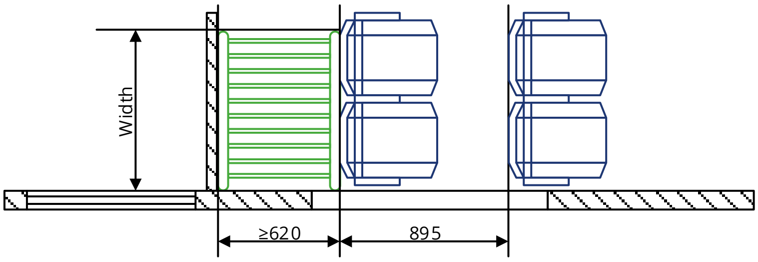
Q.3 Luggage Stack Dimensions

Q.3.1 For the purposes of TTS-3351, each luggage stack shall be at least 620mm, measured parallel to the length of the Vehicle, as shown in Figure Q3.

Q.3.2 For the purposes TTS-3361, each luggage stack shall be exactly 620mm respectively, measured parallel to the length of the Vehicle, as shown in Figure Q3.

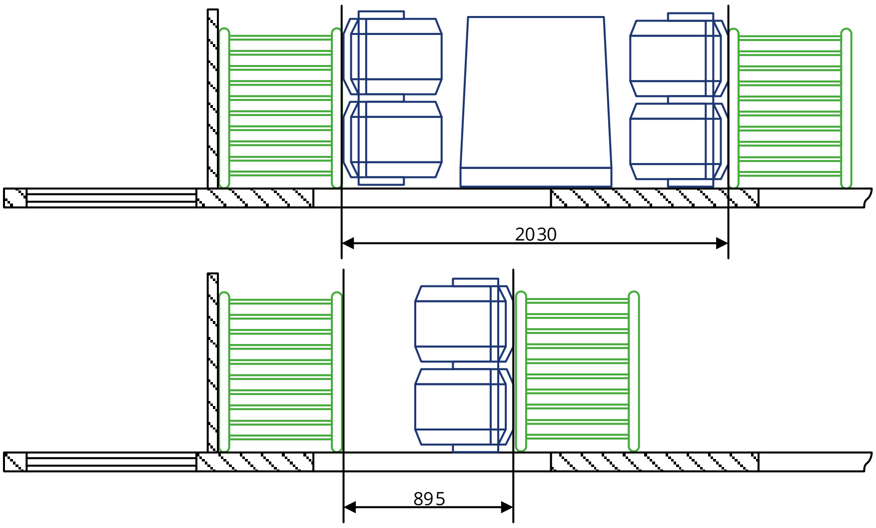
Q.3.3 The dimension of 620mm is based on a stack fitting Large Bags with some allowance for the structure of the luggage stack.

Figure Q5 – Luggage stack dimensions



Q.3.4 For the 1SL, the luggage stack may be longer than 620mm to provide additional storage to meet the total luggage storage capacity of TTS-676 and TTS-677. However, separate luggage stacks are required to comply with TTS-3351. Luggage stack must be separated by seats (as shown in Figure Q4) or shall be on other sides of the aisle.

Figure Q6 – Examples of minimum separation of luggage stacks



Q.3.5 The width of the luggage stack (as shown in Figure Q3) is not assessed for TTS-3351 - it is assumed to be approximately the width of two seats. For TTS-676 and TTS-677, more detailed drawings of the shape of the luggage stack will be required to demonstrate the amount of Large Bags and Small Bags that could be stored in each luggage stack, and in the luggage rack.

Appendix R - Two-Space Layout (2SL) Requirements

R.1 This Appendix lists the changes to the requirements in Section 11.1 that would be implemented if the Two-Space Layout (2SL) was implemented instead of the One-Space Layout (1SL). The 2SL shall be based on the 1SL and shall only include those changes necessary to achieve compliance with the changed requirements. No further changes may be made. The compliance to scored requirements should be the same

R.2 The 2SL shall have two classes of accommodation, one based on the HS2 Seat as per the 1SL, and one based on the Premium Seat.

ID	Req't Name	One Space Layout	Two Space Layout	Eval
		11.1.1 Passenger Seats		
TTS-1979	Number of Seats	There shall be [●] Passenger Seats in the One-Space Layout.	*n/a - not required for 2SL*	WLV
TTS-2239	Seat Pitch	The One-Space Layout shall provide the following seat pitches, i.e. the distance from the rearmost point of one seat to the rearmost point of the next seat: • airline seating - 895mm; *and* • bay seating - 2030mm. Nominal seat pitches shall not be greater or less than these values.	The **Two**-Space Layout shall provide the following seat pitches, i.e. the distance from the rearmost point of one seat to the rearmost point of the next seat: • airline seating - 895mm; *and* • bay seating - 2030mm. Nominal seat pitches shall not be greater or less than these values.	Mandatory
TTS-1980	Seat Arrangement	The One-Space Layout shall include HS2 Seats that shall be arranged transversely so that there are no more than two seats adjacent to each other (commonly referred to as 2+2 seating).	The **Two**-Space Layout shall include two levels of seating provision: • Premium Seats arranged transversely so that there are no more than two seats adjacent to each other on one side of the aisle and no more than one seat on the other (commonly referred to as 2+1 seating); and • HS2 Seats arranged transversely so that there are no more than two seats adjacent to each other (commonly referred to as 2+2 seating).	Mandatory
TTS-2703	Two-Space Layout - Seating Provision Split		**The split between the two seating provisions shall be 80-85% HS2 Seats / 20-15% Premium Seats, based on the total number of Passenger Seats.**	Mandatory
TTS-1815	Maximum Seating Area Size		**If a Vehicle contains both HS2 Seats and Premium Seats, at least 30% of the area of the Saloon shall be allocated to each seating type.**	Mandatory
TTS-734	Aisle Clearway	*With reference to PRM TSI[6] Clauses 4.2.2.6 and 7.3.2.4*, the aisle between Passenger Seats shall provide a minimum horizontal clearway of 450mm at all points of the Saloon.	*With reference to PRM TSI[6] Clauses 4.2.2.6 and 7.3.2.4*, the aisle between Passenger Seats shall provide a minimum horizontal clearway of 450mm at all points of the Saloon.	Mandatory

ID	Req't Name	One Space Layout	Two Space Layout	Eval
TTS-2710	Longitudinal Seating	The One-Space Layout shall have no longitudinal Passenger Seats.	The **Two**-Space Layout shall have no longitudinal Passenger Seats.	Mandatory
TTS-2015	Bay/Airline Seating Arrangement	The One-Space Layout shall include seat bays (including Multi-Purpose Areas) as follows: • a minimum of 32 Full Seat Bays per Unit • a minimum of 2 Full Seat Bays per Vehicle.	The **Two**-Space Layout shall include seat bays (including Multi-Purpose Areas) as follows: • a minimum of **28** Full Seat Bays per Unit • **a minimum of 4 Half Seat Bays per Unit** • a minimum of 2 **seat bays, either Full Seat Bays or Half Seat Bays**, per Vehicle	Mandatory
TTS-2004	Multi-Purpose Areas	All Vehicles within the One-Space Layout that do not contain Wheelchair Spaces shall have one Multi-Purpose Area.	All Vehicles **with HS2 Seats** that do not contain Wheelchair Spaces shall have one Multi-Purpose Area.	Mandatory
TTS-2005	Multi-Purpose Areas - Location	Multi-Purpose Areas shall be located at the end of a Saloon such that there are no other seats between the Multi-Purpose Area and the nearest Exterior Door.	Multi-Purpose Areas shall be located at the end of a Saloon such that there are no other seats between the Multi-Purpose Area and the nearest Exterior Door.	Mandatory
TTS-2075	Distance from Seats to Doors	All Seat Positions shall be no more than 12m from an Exterior Door, measured along the centre-line of the Vehicle from the mid-point of the Seating Position to the centre-line of the Exterior Doorway, as shown in Figure Q1 in Appendix Q.	All Seat Positions shall be no more than 12m from an Exterior Door, measured along the centre-line of the Vehicle from the mid-point of the Seating Position to the centre-line of the Exterior Doorway, as shown in Figure Q1 in Appendix Q.	Mandatory
		11.1.2 Wheelchair Spaces		
TTS-1982	Number of Wheelchair Spaces per Unit	The One-Space Layout shall have four Wheelchair Spaces.	The **Two**-Space Layout shall have four Wheelchair Spaces**, with at least one Wheelchair Space in a Premium Seating area and at least one Wheelchair Space in an HS2 Seating area**.	Mandatory
TTS-2009	Number of Wheelchair Spaces per Vehicle	The One-Space Layout shall have no more than two Wheelchair Spaces in any Vehicle.	The **Two**-Space Layout shall have no more than two Wheelchair Spaces in any Vehicle.	Mandatory
TTS-1502	Positioning of Wheelchair Spaces	*With reference to PRM TSI[6] Clause 4.2.2.3.2 (4),* the closest doorway to the Wheelchair Spaces shall be an Evacuation Door, which shall be positioned to comply with TTS-165.	*With reference to PRM TSI[6] Clause 4.2.2.3.2 (4),* the closest doorway to the Wheelchair Spaces shall be an Evacuation Door, which shall be positioned to comply with TTS-165.	Mandatory
TTS-1051	Companion Seats	*With reference to PRM TSI[6] Clause 4.2.2.2 (9),* companion seats shall be provided for all Wheelchair Spaces. These seats shall not be positioned on the opposing side of the aisle.	*With reference to PRM TSI[6] Clause 4.2.2.2 (9),* companion seats shall be provided for all Wheelchair Spaces. These seats shall not be positioned on the opposing side of the aisle.	Mandatory
TTS-1054	Wheelchair Spaces - Access	Where two Wheelchair Spaces are positioned in the same Vehicle they shall be configured to ensure that if one space is occupied this shall not prevent access or egress by a wheelchair from the other Wheelchair Space.	Where two Wheelchair Spaces are positioned in the same Vehicle they shall be configured to ensure that if one space is occupied this shall not prevent access or egress by a wheelchair from the other Wheelchair Space.	Mandatory
		11.1.3 Window-alignment		

ID	Req't Name	One Space Layout	Two Space Layout	Eval
TTS-2634	Area with Windows	All parts of the Saloon and areas that could be converted to Saloon shall have apertures for Windows. The maximum longitudinal distance from the start of the Saloon to the first Window aperture shall be 1000mm. If these apertures are not adjacent to Seating Positions in the 1SL or 2SL the Window shall be obscured.	*Not evaluated for the Two-Space Layout*	Scored
TTS-3392	Window Pitch	For all Windows on a Vehicle, except those at the end of each Vehicle, the longitudinal distance between the start of one Window and the start of the next shall be 1790mm.	*Not evaluated for the Two-Space Layout*	Scored
TTS-3202	Number of Window Types	There shall be no more than two sizes of Window used on the Unit.	*Not evaluated for the Two-Space Layout*	Scored
TTS-1213	Minimise Deadlight Area	The size of the deadlight, measured between adjacent sections of un-obscured glass over 80% of the height of the Window (see Figure Q5), shall not exceed **Preferred 1:** The deadlight shall not exceed 300mm. **Preferred 2:** The deadlight shall not exceed 350mm. **Preferred 3:** The deadlight shall not exceed 400mm. **Preferred 4:** The deadlight shall not exceed 450mm. **Preferred 5:** The deadlight shall not exceed 500mm.	*Not evaluated for the Two-Space Layout*	Scored
TTS-2633	Window Height	The height of the Windows shall enable the User Population to see a point at track level, 10m laterally from the Unit, while: • seated in any Passenger Seat; • seated in a Wheelchair; and • standing in the centre of the aisle in the Saloon.	*Not evaluated for the Two-Space Layout*	Scored
TTS-1219	Door Windows	The lower edge of the transparent section of Exterior Door windows shall be not more than 1200mm above floor level and the upper edge shall be at least 1700mm above floor level. The minimum horizontal width of the Exterior Door windows shall be 300mm.	*Not evaluated for the Two-Space Layout*	Scored
		11.1.4 Toilets		
TTS-1983	Number of Toilets	The One-Space Layout shall include at least eight Toilets. At least two of these Toilets shall be Universal Toilets.	The **Two**-Space Layout shall include at least eight Toilets. At least two of these Toilets shall be Universal Toilets.	Mandatory

<table>
<tr><th>ID</th><th>Req't Name</th><th>One Space Layout</th><th>Two Space Layout</th><th>Eval</th></tr>
<tr><td>TTS-691</td><td>Distance from Seats to Toilets</td><td>The mid-point of all Seating Positions shall be no more than 25m from the nearest Toilet, measured along the centre-line of the Unit to the nearest point of the Toilet door.</td><td>The mid-point of all Seating Positions shall be no more than 25m from the nearest Toilet, measured along the centre-line of the Unit to the nearest point of the Toilet door.</td><td>Mandatory</td></tr>
<tr><td>TTS-2227</td><td>Doors between Saloons and Toilets</td><td>Including the toilet door, there shall be at least two doors between any Seating Position and any Toilet.</td><td>Including the toilet door, there shall be at least two doors between any Seating Position and any Toilet.</td><td>Mandatory</td></tr>
<tr><td>TTS-2236</td><td>Doors between Toilets and Catering Facilities</td><td>Including the toilet door, there shall be at least two doors between any Catering Area and any Toilet.</td><td>Including the toilet door, there shall be at least two doors between any Catering Area and any Toilet.</td><td>Mandatory</td></tr>
<tr><td>TTS-3354</td><td>Toilet Position</td><td>All Toilets shall be positioned adjacent to a Saloon such that they could be converted to part of that Saloon (as shown in Appendix N, Figure N2).</td><td>Not evaluated for the Two-Space Layout</td><td>Scored</td></tr>
<tr><td></td><td></td><td>11.1.5 Luggage</td><td></td><td></td></tr>
<tr><td>TTS-678</td><td>Visibility of Luggage</td><td>All luggage storage, except that stored in the Bulk Luggage Storage Area, shall be contained within and be accessible from the Saloon</td><td>All luggage storage, except that stored in the Bulk Luggage Storage Area, shall be contained within and be accessible from the Saloon</td><td>Mandatory</td></tr>
<tr><td>TTS-3351</td><td>Minimum Luggage Stack Provision</td><td>Each Vehicle shall have at least the following number of luggage stacks, based on the number of Seating Positions:
<table>
<tr><th>Seating Positions</th><th>Minimum Luggage Stacks</th></tr>
<tr><td>0 – 24</td><td>1</td></tr>
<tr><td>25 – 48</td><td>2</td></tr>
<tr><td>49 – 72</td><td>3</td></tr>
<tr><td>73 +</td><td>4</td></tr>
</table>
Each such luggage stack shall have a minimum longitudinal length of 620mm as shown in Appendix Q, Figure Q5.
Each luggage stack shall be separate from other luggage stacks as shown in Appendix Q, Figure Q6.</td><td>Each Vehicle shall have at least the following number of luggage stacks, based on the number of Seating Positions:
<table>
<tr><th>Seating Positions</th><th>Minimum Luggage Stacks</th></tr>
<tr><td>0 – 24</td><td>1</td></tr>
<tr><td>25 – 48</td><td>2</td></tr>
<tr><td>49 – 72</td><td>3</td></tr>
<tr><td>73 +</td><td>4</td></tr>
</table>
Each such luggage stack shall have a minimum longitudinal length of 620mm as shown in Appendix Q, Figure Q5.
Each luggage stack shall be separate from other luggage stacks as shown in Appendix Q, Figure Q6.</td><td>Mandatory</td></tr>
<tr><td>TTS-676</td><td>Luggage per Passenger - Small Bag</td><td>Each Vehicle shall have sufficient luggage capacity for 50% of Passengers, spread evenly through the Saloon, to bring a Small Bag.
Each Passenger's Small Bag shall be within 3m of their Seating Position.
Luggage stacks, luggage racks and space between back-to-back Passenger Seat may be used for this purpose. Other under-seat storage and Bulk Luggage Storage Areas shall not be used for this storage of Small Bags.</td><td>Not evaluated for the Two-Space Layout</td><td>Scored</td></tr>
</table>

ID	Req't Name	One Space Layout	Two Space Layout	Eval
TTS-677	Luggage per Passenger - Large Bag	Each Vehicle shall have sufficient luggage capacity for 25% of Passengers, spread evenly through the Saloon, to bring one Large Bag. Each Passenger's Large Bag shall be stored between a Passenger's Seating Position and the nearest Exterior Doorway. Luggage stacks and space between back-to-back Passenger Seat may be used for this purpose. Other under-seat storage and Bulk Luggage Storage Areas shall not be used for this storage of Large Bags.	*Not evaluated for the Two-Space Layout*	Scored
TTS-284	Bulk Luggage Storage	The One-Space Layout shall include two Bulk Luggage Storage Areas per Unit.	The **Two**-Space Layout shall include two Bulk Luggage Storage Areas per Unit.	Mandatory
TTS-2014	Bulk Luggage Storage Location 1	The Bulk Luggage Storage Area shall be positioned adjacent to a Vestibule. Passengers shall not have to return to the platform between placing items in the storage and finding their seat.	The Bulk Luggage Storage Area shall be positioned adjacent to a Vestibule. Passengers shall not have to return to the platform between placing items in the storage and finding their seat.	Mandatory
TTS-3352	Bulk Luggage Storage Location 2	The Bulk Luggage Storage Area shall be positioned adjacent to a Saloon such that it can be converted to part of that Saloon (as shown in Appendix N, Figure N2).	*Not evaluated for the Two-Space Layout*	Scored
		11.1.6 Catering		
TTS-1911	Catering	The 1SL shall include two Catering Trolley Storage Points. Each Catering Trolley Storage Point shall be located in different halves of the Unit.	**n/a - replaced by TTS-2677 and TTS-2745, below**	Mandatory
TTS-2677	Café-Shop		**The Two-Space Layout shall include one Catering Café-Shop, located within one of the Vehicles with HS2 Seats.**	Mandatory
TTS-2745	Kiosk		**The Two-Space Layout shall include one Catering Kiosk within one of the Vehicles with Premium Seats.**	Mandatory
TTS-3353	Catering Position	The Catering Trolley Storage Points shall be positioned adjacent to a Saloon such that it can be converted to part of that Saloon (as shown in Appendix N, Figure N2).	*Not evaluated for the Two-Space Layout*	Scored
		11.1.7 PIS display position		
TTS-1388	Screen Position	The main colour PIS displays in the Saloon shall be positioned such that all Seating Positions in the 1SL are facing a screen not more than 12m away.	*Not evaluated for the Two-Space Layout*	Scored
		11.1.8 Other equipment		
TTS-3076	Litter Bins	The One-Space Layout shall include two Litter Bins in each Vestibule.	The **Two**-Space Layout shall include two Litter Bins in each Vestibule.	Mandatory

ID	Req't Name	One Space Layout	Two Space Layout	Eval
TTS-3077	Ramp and Evacuation Equipment	The One-Space Layout shall include for each Vehicle that contains Wheelchair Spaces: • one Wheelchair Ramp; • one Evacuation Device; and • two Evacuation Wheelchairs; and storage cupboards to store this equipment	The **Two**-Space Layout shall include for each Vehicle that contains Wheelchair Spaces: • one Wheelchair Ramp; • one Evacuation Device; and • two Evacuation Wheelchairs; and storage cupboards to store this equipment	Mandatory
		11.1.9 Partitions		
TTS-2713	Partitions Between Seating Areas		**If a Vehicle contains both HS2 Seats and Premium Seats, a Full-width Partition shall be provided between the areas.**	Mandatory
TTS-2029	Partial Partitions		**The Two-Space Layout shall include a Partial Partition in each Vehicle.**	Mandatory