Pre-Qualification Technical Summary

Document no.: HS2-HS2-RR-SPE-00000006

Contents

1 Introduction

This Pre-Qualification Technical Summary (PQTS) identifies the material technical requirements for the Rolling Stock. As stated in the Pre-Qualification Pack (PQP), HS2 Ltd intends to procure a single fleet of rolling stock that will be capable of operating on the HS2 Network and the Conventional Rail Network (CRN), referred to as the 'Conventional Compatible' or 'CC' fleet. All requirements in this document are applicable to this CC fleet.

This version of the PQTS supersedes the draft PQTS (revision P03) that was published by HS2 Ltd on 21/11/2016 as part of its pre-procurement market engagement. Applicants should refer to this version of the PQTS only.

This PQTS is a precursor to the full Train Technical Specification (TTS) which will be provided with the Invitation to Tender. The requirements of this PQTS will be incorporated into the TTS along with other more detailed performance and functional requirements. Note that the TTS will supersede and replace the PQTS. HS2 Ltd does not intend to change in any substantive way the requirements set out in this PQTS. However, HS2 Ltd reserves its right to do so and will identify any such changes in the TTS in due course.

The PQTS builds on the Outline Train Technical Requirements (OTTR)[1] that was previously published by HS2 Ltd on 12/03/2015 as part of its pre-procurement engagement. Whereas the OTTR contained all requirements that HS2 Ltd was considering at the time, the PQTS contains only the requirements considered material to bidders. Therefore, the absence of a requirement in the PQTS that was previously in the OTTR does not imply it has been withdrawn, only that it is not considered 'material'.

Requirements are indicated by the following format:

***ID* : PQTS-107 - Example Requirement (§1.6)**

Example requirement text.

Rationale : *This explains the source of the requirement and any other justification for the requirement.*

A number of requirements have been included where the final text is still under development. Final versions of the requirements will be provided in the TTS. These have the following format:

ID *: PQTS-382 - Example Draft Requirement (§1.8)*

Example draft requirement text

This document has the following sections:

- **Strategic goals and objectives** - sets out the high-level goals for the Rolling Stock
- **Operational duty** - provides high-level information about how and where the Rolling Stock will be operated. This section is supported by the Data Book[2], which details information ('domain knowledge') about the HS2 Network and the CRN.

- **Train formation** - defines key parameters about the length of the Unit and its Vehicles
- **Approvals -** sets out the legislation and regulations under which the Units will be introduced, which defines the standards and hence a significant proportion of the requirements for the Rolling Stock.
- **Performance -** sets out the requirements for the performance of the Unit, affecting the capacity and capability of the Rolling Stock systems
- **Functionality -** sets out requirements for how the systems onboard the Unit will function, and how these will integrate with wayside systems.
- **Interiors** - sets out requirements for the passenger and staff areas of the Unit and the process by which this will be developed.

The TTS will follow the same structure, and hence some sections of the PQTS contain no requirements.

2 Abbreviations and Definitions

Capitalised terms used but not defined in this PQTS have the meanings given in the "Glossary" section of the PQP

ATO - Automatic Train Operation

ATO Maximum Brake Rate - the maximum brake rate requested by ATO as defined in section 7.3.

ATO Normal Brake Rate - the brake rate that will normally be requested by ATO as defined in section 7.3.

Approvals Requirements - the set of detailed requirements that must be complied with to meet high-level requirements for authorisation, compatibility assessment and safety assessment as defined in section 6 of this document. This includes all applicable requirements from TSIs and NNTRs.

AWS - Automatic Warning System - *UK national train protection system - refer to GE/RT8075*[23]

CC - Conventional Compatible - *note that this was previously referred to as 'classic' compatible*

CCS - Control-command and Signalling

Contractual Energy Consumption Limit - a maximum energy consumption, measured in kWh/Unit.km for a defined journey, agreed between HS2 and the TMM - *see PQTS-49*

Contractual Pass-by Limit - a maximum pass-by noise level, measured in accordance with the NOI TSI[8], agreed between HS2 and the TMM - *see PQTS-186*

C-DAS - Connected Driver Advisory System - *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.*

Data Book - An appendix to this PQTS and TTS that contains route and environmental data for the HS2 Network and CRN - *reference [2]*

DeBo - Designated Body

Dwell Time - The time taken for a Unit to perform all normal aspects of station operations from wheels-stop to wheels-start, including:

- release of and opening of passenger doors, including deployment of any moving steps or gap fillers
- transfer of all passengers off or onto the train, including passengers with reduced mobility
- closing of doors and checking of platform train interface
- integration with any PEP system or train dispatch system

Splitting from or joining to another Unit is not included in this definition, and is separately specified.

ECML - East Coast Mainline - the current main line between London, Leeds, York, Newcastle and Edinburgh

EMC - Electro-magnetic Compatibility

ETCS - European Train Control System

ERTMS - European Rail Traffic Management System

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

Exceptional Payload - means as defined within EN 15663[11] Table 3 except that passenger mass shall be 90kg including luggage. 180kg/m² shall be applied in standing areas and catering areas.

FMECA - Failure Mode, Effects and Criticality Analysis

GoA2 - Grade of Automation level 2 - *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*

HS2 Design Panel - an independent, multidisciplinary design review panel established by HS2 to support the implementation of the HS2 Design Vision[33]

HS2 Contractual Vehicle Gauge - a vehicle gauge, recorded in RIS-2772-RST[28] format that will be agreed between HS2 Ltd and the TMM - *see PQTS-142*

HS2 Platform - a platform positioned at 1115mm above rail and an offset consistent with GC gauge (as defined in EN 15273-3[34]. 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 Network - the new infrastructure and railway systems being constructed by HS2 Ltd over which HS2 services will operate - *note that the CRN is not a subset of the HS2 Network*

HS2 Reference Gauge - a vehicle gauge, recorded in RIS-2772-RST[28] format that will be produced by HS2 Ltd and included in the TTS

ITT - Invitation to Tender

Moveable Step - a retractable device integrated into the vehicle forming a step with the threshold, fully automatic and activated/controlled in conjunction with the door release and opening/closing sequences to reduce the gap in width and height between vehicle and platform - *as defined by EN14752[29] with additional reference to door release*

NNTR - Notified National Technical Rule - *UK standard to address open points, specific cases and compatibility with the UK rail network*

NoBo - Notified Body

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 temperature curves

Normal Payload - means as defined in EN 15663[11] Table 3 except that passenger mass shall be 90kg including luggage.

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

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

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[5]*

RA - Route Availability - *As defined by GE/RT8006[22]*

RAMS - Reliability, Availability, Maintainability and Safety

RGS - Railway Group Standards - *the UK railway standards, many of which are notified to support the TSIs.*

TPWS - Train Protection and Warning System - *UK national train protection system - refer to GE/RT8075*[23]

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

Train - An operational formation of one or more Units.

Train Captain - The person with overall control of the Train, who will drive the Train on the CRN.

UAT - Universal Access Toilet

VHST - Very High Speed Train - *A high speed train with maximum speed above 250km/h*

VTISM - Vehicle Track Interaction Strategic Model - a whole life cost model for the vehicle-track system

VUC - Variable Usage Charge

WCML - West Coast Mainline - *the current main line between London, Birmingham, Liverpool, Manchester and Scotland. This route will form part of the CRN.*

Whole Life Value Evaluation Model - a cost/value model that is currently being developed that will form part of the tender evaluation.

3 Strategic goals and objectives

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;
- **Passenger experience -** a design that makes passengers feel safe, comfortable and welcome and is flexible in use and able to accommodate the needs of a diverse range of users including commuters, families and those with luggage. This also covers staff experience, welfare and provision, which is essential for providing an exceptional passenger experience;
- **Performance -** delivering a significant reduction in the journey times between UK cities
- **Railway capacity -** a design that supports the operation of an 18 train per hour per direction railway, with a platform-train interface 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 material;

- **Reliability -** a design and maintenance regime that delivers exceptional levels of reliability and operational robustness, comparable to high speed services delivered in other countries, 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;
- **Whole life, whole system cost -** a rolling stock solution that contributes to the HS2 railway business case and maximises value for money.

These goals will be achieved by compliance with the requirements of this document and the TTS, and also through implementation of appropriate processes by the TMM. To achieve these goals, the TMM will need to work collaboratively with HS2 Ltd, as contracting entity (see section 3 of the PQP in relation to expected counterparties to the Contracts), and other stakeholders in the HS2 railway. In particular, the TMM and HS2 Ltd will need to work with passenger user groups and the WCP Franchisee to develop the user facing elements of the Unit.

4 Operational duty

The Rolling Stock will operate services

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

Initial trial operations may be conducted on the CRN only.

Particular features of the HS2 Network include:

- Railway systems designed for a maximum speed of at least 360 km/h
- ETCS Level 2 fitted throughout
- Built to GC and GI2 gauges
- HS2 stations platforms built at a nominal height of 1115mm
- The railway 25kV overhead line power supply, installed at a constant nominal height of 5.08m
- Long tunnels under the Chilterns and London suburbs at the southern end of the route
- Tunnels that are single bore and smaller than tunnels on other high speed lines. Micro-pressure wave mitigation is incorporated into tunnel portals

Particular features of the CRN include:

- Current maximum linespeeds up to 125mph (ECML) and 110mph (WCML, assuming no tilt). Linespeeds may be raised in the future through infrastructure works and re-

signalling.

- Structure gauge typical of UK rail network
- Fitted with colour light signals protected by AWS and TPWS systems. ETCS Level 2 may be fitted during the life of the rolling stock
- Platforms built to a nominal height of 915mm, but with significant variation.
- 25kV overhead line at variable height

Detailed data about the HS2 Network and CRN is provided in the Data Book.

A Train Service Specification will be provided with the TTS. The HS2 service will include:

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

It is estimated that each Unit will travel 610,000-670,000km per year, assuming a fleet of 60 Units.

5 Train formation

***ID* : PQTS-26 - Unit Length - Nominal (§5.1)**

The nominal length of the Unit shall be 200m.

Rationale : *The HS2 network is being designed for trains up to 400m as envisaged in the TSIs, enabling 400m (2 x 200m) Trains in the peak.*

***ID* : PQTS-315 - Unit Length - Maximum (§5.2)**

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

Rationale : *The HS2 network has been designed assuming a maximum Train length of 400m+1% from the now superseded HS RST TSI.*

6 Approvals

It is envisaged that some of the process requirements in this section will ultimately be captured in the main contractual documents published with the ITT.

6.1 Authorisation

***ID* : PQTS-156 - R(I)R Authorisation (§6.1.1)**

The TMM shall undertake the role of Project Entity defined in the Railways (Interoperability) Regulations[4] and shall procure authorisation for the rolling stock from the ORR (or other regulatory body as applicable).

Rationale : *This is consistent with the majority of UK rolling stock projects. It should be assumed that the current Interoperability Regulations, or a revised set of regulations to address the latest Interoperability Directive, will apply throughout the project.*

6.2 Standards

To meet the requirement for authorisation, the Unit will need to comply with the applicable TSIs and the NNTRs applicable to the CRN. Rolling Stock NNTRs for the HS2 Network will be developed by HS2 Ltd consistent with this PQTS and the TTS.

The requirements in the remainder of this document assume compliance with the TSIs and applicable NNTRs. Requirements to comply with specific TSIs and NNTRs will not be repeated unless it is necessary to make some clarification. Any non-compliance with a TSI or NNTR not defined in the requirements below will need to be agreed with HS2 Ltd.

The TMM will need to appoint a Notified Body and Designated Body to assess compliance with the TSIs and NNTRs. HS2 Ltd will seek assurance that the TMM is making adequate progress towards authorisation throughout the course of the project.

In their plan for approvals, the TMM will need to consider that the anticipated maximum speed of the Unit (360km/h) exceeds the technical scope of the LOC&PAS TSI[7] (350km/h).

The full list of NNTRs applicable to the CRN is available at:

https://www.gov.uk/government/publications/rail-interoperability-current-notified-national-technical-rules.

HS2 Ltd's requirements for compliance with standards other than TSIs and NNTRs (and standards referenced therein) are specified in the following sections. HS2 Ltd will not reject a Tender on the grounds that an aspect of the Rolling Stock proposal does not comply with these other standards, provided that the Tenderer otherwise proves in its Tender, by any appropriate means, that the solutions proposed satisfy in an equivalent manner the requirements defined in the TTS.

6.3 Compatibility

***ID* : PQTS-167 - Compatibility Assessment (HS2) (§6.3.1)**

The TMM shall demonstrate compatibility between the Unit and the HS2 Network.

Rationale : *The detailed process for demonstration of compatibility with the HS2 network is still to be defined. Requirements to define the interface with the HS2 network will be included in the TTS, and it is*

envisaged that compliance with these requirements, with appropriate verification, will demonstrate compatibility.
The designs of the HS2 network systems are still being developed. The TMM will need to support the HS2 systems integration process, including provision of data about the Unit's design and performance, and collaboration in the interface definition and integration activities.

***ID* : PQTS-165 - Compatibility Assessment (CRN) (§6.3.2)**

The TMM shall demonstrate compatibility between the Unit and the CRN in accordance with GE/RT8270[24] or any superseding standard.

Rationale : *GE/RT8270 requires the railway undertaking to demonstrate compatibility with infrastructure. In common with most UK rolling stock contracts, HS2 is allocating this responsibility to the TMM.*
HS2 Ltd is working with Network Rail to agree interface requirements for the CRN, which will be incorporated into the TTS. Compliance with these requirements will support compatibility with the CRN, but the TMM will remain responsible for gaining formal agreement with Network Rail.

***ID* : PQTS-306 - Compatibility 125mph (§6.3.3)**

The Unit shall be capable of Normal Operation at 125mph on the CRN where permitted. This shall be demonstrated by analysis and testing as necessary to support compliance with standards and compatibility assessment.

Rationale : *The CRN's current speed limits for non-tilting trains are 110mph on the WCML and 125mph on the ECML. HS2 Ltd is investigating increasing the speed limit on sections of the WCML to 125mph for non-tilting trains.*

***ID* : PQTS-307 - Compatibility 140mph (§6.3.4)**

The Unit shall be capable of Normal Operation at 140mph on the CRN where permitted. This shall be demonstrated by analysis.

Rationale : *It is further being considered whether some CRN routes could be upgraded to 140mph.*

6.4 Safety

***ID* : PQTS-168 - Risk Assessment (§6.4.1)**

The TMM shall undertake a risk assessment for the Unit in accordance with the Common Safety Method for Risk Evaluation and Assessment regulations[3] to demonstrate the safety of the Unit.

The TMM will need to work with HS2 Ltd to understand the systems definition and operational context in which the Unit is to be used. Hazards and controls exported on to HS2 systems, the CRN or the railway undertaking will need to be agreed with HS2 Ltd.

6.5 Assurance

HS2 Ltd will require that the TMM provides progressive assurance for the Rolling Stock. At stages through the project, the TMM will need to provide:

- information about the emerging design - e.g. descriptions, diagrams, drawings

- evidence to demonstrate that the design meets the requirements of the TTS, including design analyses and testing as appropriate
- assurance that the design and the supporting evidence have been reviewed by competent engineers or specialists with the appropriate degree of independence
- evidence that processes such as software development are progressing to quality and schedule

Close-out of the progressive assurance will support acceptance of each Unit.

7 Performance

7.1 Journey times

***ID* : PQTS-32 - Journey Time (HS2) (§7.1.1)**

The Unit, or a Train comprising two 200m Units, shall achieve a journey time between London Euston and Birmingham Curzon Street, in either direction, of less than 00:45:30 (hours:minutes:seconds). For the purposes of this requirement:
- the route profile and maximum linespeeds shall be as specified in the Data Book[2]
- the journey shall include stops at Old Oak Common and Birmingham Interchange with a 2-minute Dwell Time at each;
- the brake rate shall be the 'ATO Maximum Brake Rate' (PQTS-131);
- Normal Payload (see definitions, 90kg/passenger);
- the line voltage shall be 22.5kV AC with a 1070A current limit for the Train;
- the external temperature shall be 15°C;
- utilisation of adhesion shall not be higher than 0.15.

This requirement shall be achieved for the full range of wheel sizes from new to fully worn.

Cross Reference : *See also Requirement PQTS-131 in section 7.3 (Braking)*

Rationale : *HS2 Ltd is planning a timetabled journey time of 00:49:00 (hours:minutes:seconds) from London Euston to Birmingham Curzon Street stations; this is inclusive of 2 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. HS2 Ltd considers this requirement achieves the appropriate margin. The current limit and line voltage specified above is to be applied for journey time modelling and is reflective of typical voltage levels predicted on the HS2 Network. The final specification will include a current limit to be applied in service which is likely to be higher than the 1070A modelling limit and will be available to Trains under some operating conditions. This higher limit is under consideration in order to take account of factors such as higher auxiliary loads.*

***ID* : PQTS-34 - Journey Time (HS2+CRN, 200m) (§7.1.2)**

A Unit shall achieve a journey time between London Euston and Glasgow Central, in either direction, of less than 03:45:30 (hours:minutes:seconds). For the purposes of this requirement:
• the journey shall be via the HS2 Network to Handsacre Junction, and then via the CRN to Glasgow. The route profile and maximum linespeeds shall be as specified in the Data Book[2];
• the journey shall include stops at Old Oak Common and Preston with a 2-minute Dwell Time at each;
• the brake rate shall be the 'ATO Maximum Brake Rate' (PQTS-131) on the HS2 Network, and the service brake rate required by RGS (PQTS-127) on the CRN;
• Normal Payload (see definitions, 90kg/passenger);
• the line voltage shall be 22.5kV AC with a 1070A current limit on HS2 and a 300A current limit while operating on the CRN;
• the external temperature shall be 15°C;
• utilisation of adhesion shall not be higher than 0.15.
This requirement shall be achieved for the full range of wheel sizes from new to fully worn.

Cross Reference : *See also Requirement PQTS-127 in section 7.3 (Braking)*
See also Requirement PQTS-131 in section 7.3 (Braking)

ID *: PQTS-222 - Journey Time (HS2+CRN, 400m) (§7.1.3)*

The journey times for a Train comprising two Units operating on the CRN are still under consideration. HS2 Ltd recognises that a Train current limit of 300A will constrain achievable journey times for longer formations and is therefore investigating whether the maximum line current can be increased for the CRN.

7.2 Traction

***ID* : PQTS-327 - Minimum Acceleration 1 (§7.2.1)**

From a stationary position, a Train shall achieve a speed of 360km/h and cover a distance of 40km in no more than 535 seconds on straight, level track.
For the purposes of this requirement:
• Normal Payload shall be assumed (see definitions, 90kg/passenger);
• the line voltage shall be 22.5kV AC with a 1070A current limit for the Train;
• the external temperature shall be 15°C;
• utilisation of adhesion shall not be higher than 0.15.
This requirement shall be achieved for the full range of wheel sizes from new to fully worn.

Rationale : *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.*

***ID* : PQTS-462 - Minimum Acceleration 2 (§7.2.2)**

From a starting speed of 200km/h, a Train shall achieve a speed of 360km/h and cover a distance of 40km in no more than 450 seconds on straight, level track.
For the purposes of this requirement:
- Normal Payload shall be assumed (see definitions, 90kg/passenger);
- the line voltage shall be 22.5kV AC with a 1070A current limit for the Train;
- the external temperature shall be 15°C;
- utilisation of adhesion shall not be higher than 0.15.

This requirement shall be achieved for the full range of wheel sizes from new to fully worn.

Rationale : *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.*

***ID* : PQTS-463 - Minimum Acceleration 3 (§7.2.3)**

From a starting speed of 230km/h, a Train shall achieve a speed of 360km/h and cover a distance of 40km in no more than 440 seconds on straight, level track.
For the purposes of this requirement:
- Normal Payload shall be assumed (see definitions, 90kg/passenger);
- the line voltage shall be 22.5kV AC with a 1070A current limit for the Train;
- the external temperature shall be 15°C;
- utilisation of adhesion shall not be higher than 0.15.

This requirement shall be achieved for the full range of wheel sizes from new to fully worn.

Rationale : *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.*

7.3 Braking

ID *: PQTS-122 - ATO Stopping Accuracy (§7.3.1)*

The braking system, together with the ATO will need to achieve a level of stopping accuracy that will be defined in the TTS.

Rationale : *The level of accuracy to be achieved will depend on whether a PEP system is fitted to the railway, and the type of system.*

***ID* : PQTS-131 - Service Brake Performance (HS2) (§7.3.2)**

The Unit shall be able to achieve the following 'ATO Maximum Brake Rate' for any payload up to Normal Payload.

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

Rationale : *This brake curve represents the full service brake application on the HS2 network under ATO control.*

***ID* : PQTS-130 - Regenerative Braking Performance (§7.3.3)**

The Unit shall be able to regenerate 100%, after losses, of the energy from braking at the following 'ATO Normal Brake Rate' for any payload up to Normal Payload:

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

Rationale : *100% regeneration during normal service is important for energy efficiency, maintenance cost and environmental impact. Regenerative braking functionality will form part of the energy consumption element of the Whole Life Value Evaluation Model.*

***ID* : PQTS-127 - Service Brake Performance (CRN) (§7.3.4)**

The Unit shall be able to achieve service braking performance in accordance with GM/RT2045 [16] curves C1 and D1 up to 140mph for any payload up to Exceptional Payload.

Rationale : *These brake curves are for compatibility with CRN signalling and would be the brake performance when the Train Captain applied a full service brake in manual control.*

Emergency braking performance is specified in the LOC&PAS TSI. Enhanced emergency braking performance as specified in clause 2.3.2.2 of GM/RT2045[16] is not required.

***ID* : PQTS-439 - Design for No Receptivity (§7.3.6)**

The Unit shall be capable of achieving brake performance in PQTS-131 and PQTS-127 without relying on the regenerative electro-dynamic brake.

Rationale : *The HS2 Network and CRN power supply systems will not be receptive 100% of the time.*

7.4 EMC

ID *: PQTS-330 - EMC (CRN) (§7.4.1)*

Electromagnetic emissions from the Unit shall be limited to levels that will not create a hazard to the safe operation of infrastructure systems and equipment on the CRN.

Rationale : *This has been included to highlight the importance of electromagnetic compatibility. 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 on-board the Unit may be required to prevent interference.*

ID *: PQTS-411 - EMC (Neighbouring Railways) (§7.4.2)*

Electromagnetic emissions from the Unit shall be limited to levels that will not create a hazard to the safe operation of infrastructure systems and equipment on the neighbouring railways.

Rationale : *HS2 services will run in proximity to a number of other rail systems, including London Underground 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.*

7.5 Energy collection

7.5.1 *Power supply*

There are no 'material' requirements for power supply over-and-above the Approvals Requirements.

Cross Reference : *See also section 8.5 (Power supply)*

7.5.2 *Pantograph*

***ID* : PQTS-9 - OLE Compatibility (HS2) (§7.5.2.1)**

The Unit shall be fitted with pantograph(s) that are compatible with the overhead line equipment on the HS2 Network when operating up to 360 km/h as a single Unit or a formation of two Units. The overhead line equipment on the HS2 Network will:
- be compliant with the ENE TSI[6]; *and*
- will all be at a nominal height of 5.08m throughout the HS2 Network

Rationale : *This forms part of the overall compatibility assessment. The constant wire height on the HS2 Network should permit a design of pantograph with very limited operating height range and enhanced aerodynamics and noise emissions.*

***ID* : PQTS-10 - OLE Compatibility (CRN) (§7.5.2.2)**

The Unit shall be fitted with pantograph(s) that are compatible with the overhead line equipment on the CRN when operating up to the maximum line speed (see Data Book[21]) as a single Unit or a formation of two Units.

Rationale : *This forms part of the overall compatibility assessment. HS2 is seeking more detailed design data and requirements for the CRN.*

7.6 Energy consumption

***ID* : PQTS-49 - Energy Consumption (§7.6.1)**

The Unit shall not exceed the Contractual Energy Consumption Limit when undertaking a return journey under the following conditions.
- Euston to Birmingham Curzon Street in 49 minutes each way (route as Data Book), stopping at Old Oak Common and Birmingham Interchange (2 minute Dwell Time) in each direction; no dwell time at Birmingham Curzon Street or Euston included.
- Energy to include traction, auxiliary and HVAC loads for temperature range T1 as specified in EN 50125[14].
- Energy to include consumption during the intermediate dwells, but to exclude terminal station dwells
- Energy is net consumption, i.e. energy consumed minus energy regenerated
- Normal Payload (see definitions, 90kg/passenger)
- Constant line voltage of 25 kV, fully receptive to regenerated energy
- Excludes any power supply and network distribution losses (i.e. energy is measured at the pantograph)

Rationale : *In order to minimise whole life, whole system cost and environmental impact, the HS2 rolling stock is required to operate as efficiently as possible within the operational requirements. HS2 Ltd will develop driving profiles and a traffic management system that contributes to the achievement of this aim. It is expected that the rolling stock design will incorporate features and technologies that enable energy conservation, efficiency and recovery and thereby reduce total energy consumption and the subsequent output of waste heat.*

The Contractual Energy Consumption Limit will be agreed between the TMM and HS2 Ltd. The level of the Contractual Energy Consumption Limit will be incentivised through the Whole Life Value Evaluation Model. The HS2 business case is based on an assumed energy consumption of 22.6 kWh/Unit-km in the above conditions.

7.7 Auxiliary power supply

No 'material' requirements have been identified for auxiliary power supply.

7.8 Structural integrity

***ID* : PQTS-261 - Design Life (§7.8.1)**

The primary structure of the Unit, including at least the carbody, bolster and bogie (if applicable), shall have a design life of at least 35 years.

ID *: PQTS-414 - Fatigue Loads from Tunnels (§7.8.2)*

The fatigue loadcases for the Unit will need to consider the effects of operation through the tunnels on the HS2 Network.

Rationale : *The maximum operating speed and the tunnel dimensions mean that the fatigue loads will be considerably higher than other VHSTs.*

7.9 Gauging

***ID* : PQTS-226 - Vehicle Gauge (HS2) (§7.9.1)**

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[10].

Rationale : *The HS2 Network is being constructed to this reference profile.*

***ID* : PQTS-142 - Vehicle Gauge (CRN) (§7.9.2)**

The Unit's swept envelope shall remain within the HS2 Contractual Vehicle Gauge.

The HS2 Contractual Vehicle Gauge will be agreed between the TMM and HS2 Ltd as follows:

- HS2 will provide HS2 Reference Vehicle Gauges with the TTS for 23m and 25m vehicles, with 16m and 17m bogie spacings, respectively. Draft versions of these gauges are provided with Appendix A of this document.
- HS2 will specify a minimum internal cross-section for the passenger saloon in the TTS.
- Provided that the minimum internal dimensions are still achieved, each Tenderer will

be able to propose an alternative vehicle gauge to the HS2 Reference Vehicle Gauges in their tender response to account for their preferred vehicle design. Changes may be made to the running gear arrangement, the static profile, the vehicle length or the vehicle movements as deemed necessary by the Tenderer.

- It is envisaged that any reduction or increase in the required infrastructure works for the alternative gauge, compared to the HS2 Reference Vehicle Gauges, will be considered in the tender evaluation
- If the tender is accepted any alternative gauge will form the HS2 Contractual Vehicle Gauge. The HS2 Reference Vehicle Gauge will be adopted as the HS2 Contractual Vehicle Gauge if no alternative is proposed.
- Gauges will be recorded in RIS-2773-RST[28] format

***ID* : PQTS-64 - Gauging Methodology (CRN) (§7.9.4)**

The Unit shall be gauged with the CRN in accordance with GM/RT2173[18] and GE/RT8273[25], using absolute gauging methodology.

Cross Reference : *See also Requirement PQTS-165 in section 6.3 (Compatibility)*

Rationale : *Gauge clearance will form part of compatibility assessment, which will be in the TMM's scope – see PQTS-165. It is necessary to apply absolute gauging for new passenger vehicle designs.*

HS2 Ltd will procure any infrastructure works to achieve gauge clearance for the HS2 Contractual Vehicle Gauge. Any infrastructure works necessary to achieve gauge clearance for the as-built vehicles that were not identified as being necessary for the HS2 Contractual Vehicle Gauge will be procured by the TMM.

***ID* : PQTS-216 - Front End Overhang (§7.9.6)**

The maximum distance between the end of the Unit and the first axle shall be 4.200m.

Cross Reference : *See also Requirement PQTS-416 in section 8.6 (Brake control)*

Rationale : *This requirement is the same as LOC&PAS TSI [7] clause 4.2.3.3.1.2, referencing ERA/ERTMS/033281[37] clause 3.1.2.6.*
A deviation to GM/RT2173 issue 1 clause 3.3.1.e (maximum overhang of 3.226m) will be required and will be supported by HS2. This deviation will be supported by
- roll back protection / hill-start functionality (PQTS-416) and
- the taper of the nose that is necessary to meet gauging and aerodynamic requirements.

7.10 Mass and static loads

HS2 Ltd has no requirement for maximum Unit mass. The mass of the Unit will be indirectly managed through incentivisation of energy consumption and track wear as part of the Whole Life Value Evaluation Model.

***ID* : PQTS-118 - Maximum Axle Load (§7.10.2)**

The Unit shall have a maximum axle load of 17 tonnes in the condition 'operational mass under normal payload' as defined in point 2.1 of EN 15663[11].

Rationale : *This is the normal interface requirement between rolling stock and infrastructure for high speed lines. The HS2 Network is being designed for maximum 17 tonne axle load.*

***ID* : PQTS-119 - Maximum Route Availability (§7.10.3)**

The Unit shall not exceed Route Availability of RA7 calculated in accordance with GE/RT8006[22]. For this calculation, exceptional payload shall include a standing passenger loading of 320kg/m².

Rationale : *A payload of 320kg/m² is specified by GE/RT8006, and is separate from the Exceptional Payload used for other performance characteristics.*
RA7 is the limit for all CRN core routes and all proposed diversionary routes for operation up to 90mph.

***ID* : PQTS-464 - Maximum Route Availability (Normal Payload) (§7.10.4)**

The Unit shall not exceed Route Availability of RA5 calculated in accordance with GE/RT8006[22], except that it shall be calculated with Normal Payload.

Rationale : *A limit of RA5 is understood to be necessary to operate at differential speed limits on the CRN. It may be possible to exceed this limit with agreement from Network Rail.*

ID *: PQTS-453 - Bridge Resonance Assessment (§7.10.5)*

A 'second stage compatibility assessment', as described in GE/RT8006 section 4.3, will be required to assess compatibility of the Unit with CRN underline bridges. HS2 Ltd is investigating how to manage any required infrastructure modifications identified by this assessment, e.g. include the costs in the Whole Life Value Evaluation Model.

Rationale : *The Route Availability system only applies to passenger rolling stock for speeds up to 90mph. Above this speed a more complex analysis is required.*
It is expected that rolling stock designs that are closer to existing rolling stock operating on the CRN will require less modifications to the infrastructure.

ID *: PQTS-380 - Payload Definition (§7.10.6)*

For all Approvals Requirements related to vehicle mass and payload, the definitions of:
- *Normal Payload - as EN 15663[11] but with 90kg/person*
- *Exceptional Payload - as EN 15663[11] but with 90kg/person and 180kg/m²*

shall be used.

Rationale : *EN15663 specifies 80kg per person including luggage. The 2014 Health Survey for England has an average 76kg across the whole adult population. Considering luggage and the range of possible passengers a 90kg limit has been specified. HS2 is considering what level of standing passengers should be assessed for exceptional payload. An automatic reduction in maximum speed at higher payload is being considered.*

7.11 Track interaction

7.11.1 Track damage

ID *: PQTS-236 - Track Damage Optimisation (§7.11.1.1)*

The Unit will need to be designed for optimised performance on both the HS2 Network and the CRN. This will be evaluated in the Tender through the use of one or more track damage models based on the proposed train parameters, each contributing to the Whole Life Value Evaluation Model:

- *On the CRN the most up to date Variable Usage Charge (VUC) calculator[32] will be used to understand the cost of operating the Rolling Stock on CRN infrastructure;*
- *On the HS2 Network HS2 Ltd is determining the most appropriate model to be used. A bespoke track damage model may be developed that is optimised around the specific infrastructure design and maintenance arrangements for HS2.*

ID *: PQTS-243 - Track Damage Limitations (§7.11.1.2)*

Whilst VUC and other damage models are indicative of the cost of track maintenance to the infrastructure manager, it may be necessary to introduce further requirements in to the TTS to ensure Vehicle-Track Interaction is properly managed.

7.11.2 Track curvature

***ID* : PQTS-207 - Minimum Horizontal Track Curvature (§7.11.2.1)**

The Unit, and a Train formed of two coupled Units, shall be able to operate over the following minimum track curve radii:

- horizontal single curve - 120m
- horizontal reverse curve - 150m - 3m straight - 150m

Rationale *: These curves represent the minimum curves experienced on the CRN and the proposed depots. They also consider standards for new track installations that may be constructed during the life of the Units.*

ID *: PQTS-454 - Minimum Horizontal Track Curvature (Passenger Service) (§7.11.2.2)*

HS2 Ltd is still investigating the minimum curves on passenger lines on the CRN. The minimum curve radii is likely to be larger than those specified in in PQTS-207.

7.12 Running behaviour

HS2 Ltd is not specifying any material requirements for running behaviour over-and-above the Approvals Requirements.

7.13 Ride quality

ID *: PQTS-155 - Ride Quality (§7.13.1)*

The ride quality of the Unit will need to meet or exceed the quality of existing vehicles, considering operation on both the HS2 Network and CRN. HS2 Ltd benchmarking the ride quality of existing VHSTs and UK high speed trains. It is envisaged that ride quality will be specified in accordance with EN 12299[9].

7.14 Aerodynamics

***ID* : PQTS-188 - Pressure Sealing (§7.14.1)**

While traversing tunnels on the HS2 Network (as defined in the Data Book[2]) the maximum change of pressure inside the rolling stock shall be:

- No greater than 0.5kPa during any 1 second period
- No greater than 2.5kPa during any 10 second period

HS2 Ltd has included 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 rolling stock design.

7.15 Access and egress

The Unit will need to interface with both HS2 Platforms (section 7.15.1) and CRN platforms (7.15.2). The Unit does not need to have compatibility with any other platform heights.

To meet the requirements for platform-train interface, it is assumed that the Unit will be fitted with a Moveable Step at each doorway that will be deployed at each station and retracted when the Unit is in motion.

7.15.1 Platform-train interface (HS2)

HS2 Ltd require the Unit to achieve 'Step-free Access' with a HS2 Platform (1115mm-high, 1655mm offset on straight track, adjusted for curves). Bidders 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. The requirements for Step-free Access are listed below. Refer to Figure 1 in Appendix B for visual representation of these requirements.

***ID* : PQTS-400 - Platform-Step Vertical Limit (Normal) (§7.15.1.2)**

The maximum vertical step between the deployed Moveable Step and an HS2 Platform shall be +20/-0mm except under Exceptional PTI Conditions.

Rationale *: The maximum single step negotiable, unaided, by 98% of wheelchair users is +20mm; higher steps are negotiable but with decreasing success rates.*

***ID* : PQTS-402 - Platform-Step Vertical Limit (Exceptional) (§7.15.1.3)**

The maximum vertical step between the deployed Moveable Step and an HS2 Platform shall be +30/-10mm under all conditions including Exceptional PTI Conditions.

The TMM and HS2 will agree the **Exceptional PTI Conditions,** which are expected to include rarely-experienced vehicle conditions such as deflated suspension or Exceptional Payload.

***ID* : PQTS-403 - Platform-Step Horizontal Limit (§7.15.1.5)**

The maximum horizontal gap between the deployed Moveable Step and an HS2 Platform shall be 30mm.

***ID* : PQTS-405 - Deployed Step Depth (§7.15.1.6)**

When deployed, the Moveable Step shall have a minimum horizontal surface depth (perpendicular to the bodyside) of 240mm.

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

***ID* : PQTS-406 - Step-Vestibule Vertical Limit (§7.15.1.7)**

The maximum vertical distance between the Moveable Step and the floor of the vestibule shall be 30mm.

7.15.2 Platform-train interface (CRN)

Platforms on the CRN have a nominal height of 915mm as defined by GI/RT7073[21]. However, many of the platforms on the CRN fall outside the tolerance specified in this standard. The Data Book[2] contains current data on platform heights and offsets. The following requirements are specified for compatibility with these platforms.

***ID* : PQTS-289 - Step Position - PRM TSI (§7.15.2.2)**

With respect to the PRM TSI[5] requirements for 'step position for vehicle access and egress' (clause 4.2.2.11 and clause 7.3.2.6), the Unit shall comply with the requirements for a 915mm high platform at a platform offset as defined in GI/RT7073[21].

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

***ID* : PQTS-408 - Moveable Step on CRN (§7.15.2.3)**

While operating on the CRN, the distance of deployment of the Moveable Step shall be individually configurable at each doorway, for each station platform.

Rationale : *CRN platforms have a range of heights and offsets and some are positioned on very small radius curves. HS2's proposal is that in most cases the step will fully deploy and oversail CRN platforms to remove the gap between train and platform and ensure a full-size stepping surface.*

7.15.3 Dwell time

***ID* : PQTS-72 - Dwell Time (§7.15.3.1)**

The Unit shall enable a maximum Dwell Time of 2 minutes at intermediate stations.

The parameters under which this dwell time is to be achieved and the method of demonstration will be confirmed in the ITT. It is envisaged that HS2 Ltd will provide a dwell time model to Tenderers. Tenderers will be required to populate this model with their proposed Unit design in order to demonstrate the achieved dwell times. The following provides an indication of the most onerous expected boarding and alighting scenarios against which the Unit design will be evaluated:

- Scenario 1: 55% of train capacity boarding, no alighting passengers, 85% business / 15% leisure travellers
- Scenario 2: 40% of train capacity boarding, no alighting passengers, 50% business / 50% leisure travellers

7.15.4 Door positions

***ID* : PQTS-239 - Evacuation Door Position (§7.15.4.1)**

The Unit shall include doorways suitable for passenger evacuation that are positioned such that when two Units are coupled, in any possible orientation, the centre-line of the evacuation doorways shall be 350±10m apart.

Rationale : *This is to support the tunnel evacuation strategy. The HS2 tunnels have cross passages positioned at approximately 350m intervals. In an evacuation scenario, the Train will stop with evacuation doors aligned as close as possible to the cross-passages. The tunnel ventilation will be able to create a bubble of fresh air 10m in each direction from the cross-passage door. See Figure 2 in Appendix B.*

***ID* : PQTS-241 - Train Captain's Door Location (§7.15.4.2)**

Access shall be provided to allow the Train Captain to enter the cab from the side of the Unit without needing to pass through the passenger saloon.

Rationale : *The Train Captain will need to enter and exit the Unit without passing through the passenger saloon. The Train Captain could use a passenger door if there is a vestibule between the cab and saloon. The LOC&PAS TSI[7] requires a cab emergency exit in this scenario.*

7.15.5 Evacuation

ID *: PQTS-184 - Evacuation (§7.15.5.1)*

The Unit design will need to facilitate evacuation at locations other than stations. Scenarios include evacuation to: • *ballast-level;* • *a 760mm above-rail-level walkway in the tunnels;* or • *a maintenance walkway on a viaduct.* *On-board equipment will need to be provided for these scenarios including equipment to support evacuation of PRMs.*

7.15.6 Door throughway width

***ID* : PQTS-413 - Minimum Door Horizontal Throughway (§7.15.6.1)**

All passenger doors shall have a minimum clear throughway width of 900mm

Rationale : *The PRM TSI[5] mandates a minimum of 800mm which is considered insufficient for manual wheelchair users as it only allows 50mm per side for the users hands.*
DfT Inclusive Mobility Best Practice document states that 100mm clearance for hands is desirable, leading to a dimension of 900mm. 900mm is also required for a person using crutches or a walking frame.

7.16 Internal climate

No 'material' requirements have been specified for internal climate.

7.17 Heat output

ID *: PQTS-449 - Heat Release - OOC Station (§7.17.1)*

During the Dwell Time at Old Oak Common station, the heat released from the Unit shall not exceed approximately 700 kW.

Rationale : *See PQTS-458*

ID *: PQTS-458 - Heat Release - Euston Station (§7.17.2)*

During the period between services at Euston station, the heat released from the Unit shall not exceed approximately 350kW

Rationale : *Old Oak Common and Euston stations have restrictions on their ventilation. It is necessary to limit heat output from the Unit. During extended dwells at Euston, it is envisaged that the Unit will enter an 'Extended Dwell' mode with reduced HVAC performance, traction cooling and other auxiliary loads.*
Current analysis has assumed a constant heat transfer along the length of the Unit. Further requirements may be necessary to manage concentrated heat outputs from particular vehicles.

7.18 Noise

7.18.1 External noise

***ID* : PQTS-186 - Pass-by Noise (§7.18.1.1)**

The limit value for pass-by noise, measured in accordance with the NOI TSI[8], and EN ISO 3095[12] referenced therein, shall not exceed the Contractual Pass-by Limit.

The Contractual Pass-by Limit, will be agreed by the TMM and HS2 as follows:

- The maximum value of Contractual Pass-by Limit will be that specified in the NOI TSI[8].
- However, the HS2 Phase One Environmental Statement[40] for the HS2 Programme has assumed a pass-by value 3 dB(A) below that specified in the superseded HS RST TSI[31] (the **ES Pass-by Value**). The High Speed Rail (London - West Midlands) Act 2017 and the HS2 Environmental Minimum Requirements place commitments on HS2

Ltd that must be fulfilled in order to maintain the deemed planning consent for the scheme. These commitments include the need to take all reasonable steps not to exceed the airborne noise levels predicted in the HS2 Phase One Environmental Statement.

- HS2 Ltd expects to invite Tenderers to propose Contractual Pass-by Limits that are lower than that specified in the NOI TSI, with the objective of meeting or exceeding the ES Pass-by Value.
- Each Tenderer will need to demonstrate their confidence in achieving the Contractual Pass-by Limit by reference to modelling and testing. The proposed Contractual Pass-by Limit may be adjusted to reflect HS2 Ltd's level of confidence in its deliverability.
- The adjusted Contractual Pass-by Limit value will be included in the Whole Life Value Evaluation Model - a value will be included in the evaluation for each dB decrease in noise below the NOI TSI. This will ensure that rolling stock costs for noise mitigation are balanced against other noise mitigations (e.g. noise barriers) that would be required to mitigate the impact on the railway's neighbours.
- Each Tenderer will need to demonstrate in their Tender why their proposed value for the Contractual Pass-by Limit cannot be further reduced, considering value assigned to a reduction in the Whole Life Value Evaluation Model.
- The TMM is expected to be required through the TSA to maintain and, where possible, improve the noise performance beyond the Contractual Pass-By Limit throughout the life of the Unit.

ID *: PQTS-250 - High-level Noise (§7.18.1.3)*

As well as overall pass-by limits, HS2 Ltd is considering how and whether to specify requirements for high-level noise emanating from roof area of the train, including the pantograph.

Rationale *: Noise barriers 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.*

7.18.2 Internal noise

***ID* : PQTS-192 - Saloon Noise (§7.18.2.1)**

The A-weighted equivalent continuous sound pressure level ($L_{pAeq,20s}$), measured in accordance with EN ISO 3381[13], at any point within the seated area of the passenger saloon shall not exceed 73 dB(A), while the Unit is operating in the open on reference track as defined in EN ISO 3095[12].

ID *: PQTS-420 - Saloon Noise (Tunnel) (§7.18.2.2)*

HS2 is considering how to specify noise levels when operating through tunnels, in cuttings or behind noise barriers.

Rationale *: A high proportion of the HS2 network is in tunnel or cutting or behind a noise barrier or parapet.*

7.19 Operational environment

***ID* : PQTS-94 - Climate Zone Definitions (§7.19.1)**

Each Unit and all its constituent parts shall comply with the requirements of EN 50125-1[14] Railway Applications – Environmental conditions for equipment according to the following definitions:

- Climatic Zone - T1
- Altitude Range - A2

***ID* : PQTS-386 - Maximum Snow & Flood Water Levels (§7.19.2)**

The Unit shall be capable of Normal Operation when:

- Snow is up to 200mm above the rail level
- Flood water is up to 50mm below top of rail level

Rationale : *The UK Rule Book[30] 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 top of rail level.*

***ID* : PQTS-111 - Initial Operating Conditions (§7.19.3)**

The Unit shall be capable of Normal Operation during the initial operation phase in the HS2 tunnels (following each phase of construction), where higher levels of dust (including concrete) associated with construction are likely to be present. An increased maintenance regime could be considered as an acceptable mitigation during this period.

***ID* : PQTS-112 - Tunnel Environment - Summer (§7.19.4)**

The Unit shall be capable of Normal Operation in the summer tunnel environmental conditions which are assumed to transition from approximately 25°C at the tunnel entry portal to 35°C within the tunnel. Tunnel relative humidity is assumed to vary between 30% and 50% during summer.

***ID* : PQTS-135 - Tunnel Environment - Winter (§7.19.5)**

The Unit shall be capable of Normal Operation in the winter tunnel environmental conditions which are assumed to transition from approximately 0°C at the tunnel entry portal to 30°C within the tunnel. Tunnel relative humidity is assumed to vary between 90% at the cool end of the tunnel and 20% to 30% at the warm end of the tunnel.

***ID* : PQTS-136 - Tunnel Congestion Conditions - Average (§7.19.6)**

The Unit shall be capable of Normal Operation when trains stop in the tunnels during operational congestion. During this time, the tunnel environmental conditions shall be assumed to be an average of 43°C.

***ID* : PQTS-137 - Tunnel Congestion Conditions - Maximum (§7.19.7)**

The Unit shall be capable of Normal Operation 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 shall be assumed to be 50°C for up to 5 minutes during this time.

ID *: PQTS-138 - Tunnel Environment - Variation (§7.19.8)*

Tunnel environmental conditions refer to the well-mixed average conditions within the tunnel. The design of the Unit shall account for the spatial variation in temperatures when in operation and when stopped within tunnels and at stations.

7.20 Materials

No 'material' requirements have been identified regarding the use of materials.

7.21 Fire

***ID* : PQTS-146 - Fire Categorisation (§7.21.1)**

With respect to section 4.2.10 of the LOC&PAS TSI[7], the Unit shall be assessed as Category B.

Rationale *: The HS2 route contains long tunnels that considerably exceed the 5km limit for Category A rolling stock.*

7.22 Reliability

HS2 Ltd has set an overall railway reliability target for a moving annual average delay per HS2 service on the HS2 Network of no greater than 30 seconds at destination. To support this, the following reliability target values have been derived for the Unit, which apply to operation on both the HS2 Network and CRN. These targets are based on a fleet of 60 units travelling 610-670,000km per year.

These reliability targets will be used for the evaluation of the tender. The values will be aligned with reliability targets forming part of the acceptance criteria.

***ID* : PQTS-195 - MDBF - 3 min (§7.22.1.1)**

The mean distance between failures causing a delay of over 3 minutes shall be at least 300,000 km.

***ID* : PQTS-199 - MDBF - 60 min (§7.22.1.2)**

The mean distance between failures causing a delay of over 60 minutes and/or requiring detrainment and evacuation of passengers between stations shall be at least 7,000,000 km.

In order to achieve these reliability levels, it is expected that the design of the Unit will include the following features and functions:

- Appropriate redundancy of key mission-critical systems

- Systems designed to permit operation in degraded mode that minimise the impact on mission-critical functions
- On-board and train-wayside diagnostic systems and condition monitoring
- Systems designed to permit rapid boot-up and resetting
- The ability to remotely isolate affected systems

ID *: PQTS-256 - Operational Reliability Targets (§7.22.3)*

To incentivise implementation of these strategies, HS2 Ltd is considering specification of reliability targets for key components of the overall HS2 operation, e.g.
- *Proportion of station stops that exceed the allocated dwell time due to a Unit fault*
- *Proportion of transitions between HS2 and CRN that are delayed due to a Unit fault*

8 Functionality

HS2 Ltd considers that the detailed functionality of the rolling stock should be developed with the TMM during the course of the project. To achieve this, the TTS will contain high-level functions and the split between rolling stock and wayside systems. The TMM would then develop the detailed functionality to deliver these functions with input and review by HS2 and wider stakeholders where appropriate.

8.1 Train protection

***ID* : PQTS-238 - ETCS (§8.1.1)**

The Unit shall be able to operate at the following ETCS application levels:
- Level NTC
- Level 0
- Level 1
- Level 2

Rationale *: Level NTC is required for 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 Network Rail infrastructure.

***ID* : PQTS-387 - Train Integrity Function (§8.1.2)**

The on-board equipment shall be prepared for migration to ETCS application Level 3 and as such shall include train integrity supervision.

***ID* : PQTS-242 - Conventional Signalling Systems (§8.1.3)**

On the CRN, the Unit shall be able to operate under lineside signalling with protection from AWS and TPWS.

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.*

***ID* : PQTS-41 - Signalling Transition - Speed (§8.1.4)**

The Unit shall be able to transition from the train protection system on the HS2 Network and to the system on the CRN at all speeds up to line speed.

***ID* : PQTS-294 - Signalling Transition - Continuous Protection (§8.1.5)**

Throughout each train protection system transition the Unit shall remain protected by at least one of the train protection systems.

8.2 Train driving

ID *: PQTS-36 - ATO (§8.2.1)*

The current assumption is that in Normal Operation, Trains will operate under ATO (GoA2) while on the HS2 Network and that ATO data will be provided over ERTMS. ATO will only be possible in ETCS full supervision mode. The TMM will be responsible for delivering the on-board CCS equipment. This will require the TMM to work closely with HS2 Ltd and our trackside CCS supplier and to integrate systems which will together provide the required railway functionality.

Rationale : *HS2 Ltd has 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.*

On the CRN, the Unit will be operated in manual driving mode.

***ID* : PQTS-181 - Driving Transition - Manual > ATO (§8.2.3)**

The Unit shall be capable of transitioning from manual driving to ATO at any line speed without intervention by the Train Captain.

Rationale : *Although detailed functional design may determine that positive action is required for ATO to take over, HS2 does not want the systems to be constrained to this.*

***ID* : PQTS-182 - Driving Transition - ATO > Manual (§8.2.4)**

The Unit shall be capable of transitioning from ATO to manual driving at any line speed following positive action by the Train Captain.

***ID* : PQTS-44 - C-DAS (§8.2.5)**

The Unit shall include a Connected Driver Advisory System (C-DAS) that will provide advice to the Train Captain when driving manually on the CRN or HS2 Network.

Rationale : *Correct presentation of trains at junctions with HS2 is necessary to achieve the high reliability of operations on HS2.*

The following table shows all of the possible operational states:

Network	Train Protection	Driving Control	Driving Advice
HS2	ETCS	ATO (GoA2)	Not required
HS2	ETCS	Manual (1)	C-DAS (2)
HS2	ETCS	Manual	None
CRN	AWS / TPWS	Manual	C-DAS
CRN	AWS / TPWS	Manual	None (3)
CRN	ETCS (4)	Manual	C-DAS
CRN	ETCS (4)	Manual	None

(1) ATO should be operational on HS2 for the majority of time
(2) C-DAS would operate on HS2 when ATO is not operational
(3) C-DAS should be operational on CRN for the majority of time
(4) ETCS not yet fitted to CRN, but may be fitted during the life of the Unit

8.3 Train dispatch

ID *: PQTS-183 - Train Dispatch (§8.3.1)*

HS2 Ltd is still determining how Train dispatch will be achieved and the method of dispatch selected is likely to be significantly affected by decision on whether to fit a PEP system. Options under consideration include:

- *Dispatch by platform staff in communication with a Train Captain*
- *Dispatch by platform staff in communication with a train guard*
- *Dispatch by one or two members (one in each Unit) of on-train staff using images from train-borne cameras*
- *Dispatch by one or two members (one in each Unit) of on-train staff using images from platform mounted cameras*
- *Automatic dispatch using train-borne detection of obstacles on the route ahead and obstacles in the platform-train interface*
- *Automatic dispatch using infrastructure mounted detection of obstacles on the route ahead and obstacles in the platform-train interface*

The performance requirements for Train dispatch, along with the scope for the TMM, will be detailed in the TTS. It is possible that the Unit will be required to support more than one of the options listed above.

8.4 Interworking & coupling

***ID* : PQTS-89 - Interworking Function (§8.4.1)**

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.

Rationale *: To achieve the capacity requirements of HS2, 2 x 200m Trains will operate at peak times. These trains must achieve all normal passenger service functions. Units may reverse direction during operation, so it cannot be assumed that the two Units will have the same orientation.*

***ID* : PQTS-152 - No Impacts from (Un)Coupling (§8.4.2)**

Coupling and uncoupling operations shall not impose restrictions on other operational aspects, such as train doors needing to be closed on a stationary Unit during coupling / uncoupling operations

Rationale : *Some 2 x 200m 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.*

***ID* : PQTS-151 - Maximum Couple Time (§8.4.3)**

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. It includes the time to make an electrical connection and re-configure systems into a single operational Train. It includes the time for the combined Train to receive a movement authority.

Rationale : *Achievement of this time is necessary to support the planned Train Service Specification.*

***ID* : PQTS-235 - Maximum Uncouple Time (§8.4.4)**

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 departs. The Train shall come to a stop only once in the process: it will come to a stop in the correct place for the uncoupling to occur and the next wheel movement will be when one of the newly-uncoupled Units departs on the next stage of its journey.

Rationale : *The 120 second duration supports completion of uncoupling in a standard station dwell time.*

ID *: PQTS-234 - Automation of Coupling (§8.4.5)*

HS2 Ltd is currently investigating options for providing increased automation of the coupling procedure when compared to current UK mainline practice with the aim of minimising the time taken to complete the coupling of Units and eliminating the need for the second Unit to stop prior to coupling to the first Unit. It is considered that this automation would use an on-board distance measurement system to control the speed of the moving Unit on the final part of the approach to the stationary unit. This would be available under all levels of train protection.

Cross Reference : *See also Requirement PQTS-238 in section 8.1 (Train protection)*

The current assumption is that the Unit will only have compatibility with rolling stock procured as part of Phase 2b for rescue and recovery.

Rationale : *Achieving interworking between the Unit and rolling stock procured as part of Phase 2b (which may be supplied by different manufacturers) is considered too complex.*

8.5 Power supply

***ID* : PQTS-194 - Power Supply Transition (§8.5.1)**

The Unit shall provide automatic transition between the power supplies available on the HS2 Network and the CRN at any applicable line speed.

***ID* : PQTS-229 - Dynamic Current Limit (§8.5.2)**

The maximum line current drawn by the Unit shall be capable of being adjusted for temporary or geographic limitations, or to permit operation on other routes. The adjustment shall be capable of being made while the Unit is in service without interaction from on-train staff.

Rationale : *HS2 Ltd is undertaking studies to further optimise allowable train current limits on both the HS2 network and CRN. This could include:*
- *varying current limit by location*
- *specifying a more complex current limit varying with time or speed, rather than a simple maximum*
- *altering current limits in particular scenarios, for either the whole fleet or certain units.*

8.6 Brake control

***ID* : PQTS-416 - Holding Brake (§8.6.1)**

The Unit shall have a holding brake function that prevents any roll-back when the Unit comes to a halt or starts moving when the Unit is on a gradient.

Cross Reference : *See also Requirement PQTS-216 in section 7.9 (Gauging)*

Rationale : *This supports the adoption of a 4.2m overhang on the CRN.*

8.7 Infrastructure monitoring

ID *: PQTS-265 - Infrastructure Monitoring (§8.7.1)*

A proportion of the Units will have infrastructure monitoring equipment fitted, such as track geometry and overhead line monitoring systems. HS2 Ltd is considering whether to
- *include this equipment in the TMM's scope; or*
- *specify space envelopes and power supply interfaces to permit the equipment to be free-issued to the TMM*

A number of infrastructure-monitoring cameras will be required on all Units.

9 Interiors

9.1 Passenger capacity

The interior layout of the Unit will be agreed between the TMM and HS2 Ltd, following review with stakeholders included the WCP Franchisee. For the purposes of the Tender, each Tenderer will need to provide a **Reference Interior Layout** that meets the following requirements. These requirements may vary for the final agreed layout, and the TTS (and wider Contract terms) will include provisions to manage this variation.

***ID* : PQTS-394 - RIL Representative (§9.1.2)**

The Reference Interior Layout shall be representative of the available interior space on the Unit and shall take account of bodyside door positions, equipment cubicles, structural partitions, bulkheads or any other restrictions that will limit the use of interior space. Such limitations shall be identified.

The number of seats in the Reference Interior Layout will form an input into the Whole Life Value Evaluation Model. This will be informed by the HS2 business case which is currently based on a total capacity of 528 seats.

***ID* : PQTS-357 - RIL First Class / Standard Class Split (§9.1.4)**

The Reference Interior Layout shall include First Class seating arranged in 2+1 formation and Standard Class seating arranged in 2+2 formation. The split between the two classes shall be 80-85% Standard / 20-15% First.

***ID* : PQTS-359 - RIL Standard Class Seat Pitch (§9.1.5)**

The layout of standard class seating in the Reference Interior Layout shall ensure: • airline seating - 80mm clearance between a 95th percentile male and the back of the seat in front. • bay seating - 160mm clearance between two 95th percentile males sitting opposite each other

Cross Reference : *See also Requirement PQTS-352 in section 9.5 (Human factors)*

***ID* : PQTS-362 - RIL First Class Seat Pitch (§9.1.6)**

The layout of first class seating in the Reference Interior Layout shall ensure: • airline seating - 250mm clearance between a 95th percentile male and the back of the seat in front. • bay seating - 500mm clearance between two 95th percentile males sitting opposite each other

Cross Reference : *See also Requirement PQTS-352 in section 9.5 (Human factors)*

***ID* : PQTS-365 - RIL Wheelchair Spaces (§9.1.7)**

The Reference Interior Layout shall have at least two wheelchair spaces per class, i.e. at least four in total. Wheelchair spaces shall be integrated into the saloon and passengers using the spaces shall not feel isolated from other passengers. Wheelchair spaces shall have at least one facing companion seat.

***ID* : PQTS-366 - RIL Toilets (§9.1.8)**

The Reference Interior Layout shall include at least eight toilets of which at least two shall be UATs.

***ID* : PQTS-367 - RIL First Class Catering (§9.1.9)**

The Reference Interior Layout shall include facilities to prepare at seat first class meals, cooked on-board

***ID* : PQTS-368 - RIL Standard Class Catering (§9.1.10)**

The Reference Interior Layout shall include a café area at least 4m long and the full width of the vehicle. There shall be no passenger seats in the café area.

***ID* : PQTS-369 - RIL Train Manager's Office (§9.1.11)**

The Reference Interior Layout shall include a train manager's office at least 1m wide and 1.5m long.

***ID* : PQTS-370 - RIL Bike Racks (§9.1.12)**

The Reference Interior Layout shall include bike racks with space for four bikes (Tenderer to determine design and size of bike rack). The bike racks shall be positioned adjacent to an external doorway. Passengers with bikes shall not have to return to the platform between placing their bike in the rack and finding their seat.

9.2 Intervehicle gangway

ID *: PQTS-444 - Wide Gangway (§9.2.1)*

All inter-vehicle 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[35], clause 7.3 3.

Cross Reference *: See also Draft Requirement PQTS-454 in section 7.11.2 (Track curvature)*

Rationale *: Enabling wheelchairs to move between vehicles will provide greater flexibility in the interior e.g. a universal toilet could be accessed from adjacent vehicles.*

9.3 Cab design

ID *: PQTS-397 - HF Assurance - Cab (§9.3.1)*

The TMM will need to provide human factors assurance for the cab design and the operation of the Unit. This will be more comprehensive than the consideration of anthropometric measurements specified in the LOC&PAS TSI[7].

ID *: PQTS-437 - Cab Side Visibility (§9.3.2)*

The cab will need to include side windows to provide visibility of platforms and signage.

Rationale *: The side window will support the Train Captain to stop the Train accurately. Full requirements on operation and cab visibility are still being developed.*

9.4 Industrial design

ID *: PQTS-228 - Industrial Design Input (§9.4.1)*

The TMM will need to develop the interior design with input into the design of key passenger-facing elements of the Unit such as seating, tables, interior trim, lighting and toilets from:

- *stakeholder groups*
- *the HS2 Design Panel*
- *a third-party industrial designer procured by HS2 Ltd*
- *the WCP Franchisee*

9.5 Human factors

***ID* : PQTS-352 - Population (§9.5.1)**

The PeopleSize dataset[27] shall be used for used for any anthropometric measurements, adjusted for predicted secular growth of the user population over the life of the Train.

Rationale : *This is HS2's preferred dataset. This requirement is in addition to the Approvals Requirements concerning anthropometric measurements in the LOC&PAS TSI[7].*

10 Referenced standards, legislation & documents

This section contains full details of all standards, legislation and documents referenced throughout the document. This list is provided for reference only; requirements to comply with these standards are contained through this document. General requirements with regards to Standards are given in section 6.2, above.

	Title	Reference	Revision
1	Outline Train Technical Requirements	HS2-HS2-RR-SPE-00000002	P01
2	Rolling Stock Data Book	HS2-HS2-RR-DAT-00000001	P01
3	Common Safety Method for risk evaluation and assessment	Commission Regulation (EU) 402/2013	
4	Railways (Interoperability) Regulations	S.I. 2011 No.3066 & Amendments	
5	Persons with Reduced Mobility TSI	PRM TSI - Reg. (EU) No. 1300/2014	
6	Energy TSI	ENE TSI - Reg. (EU) No. 1301/2014	
7	Locomotives & Passenger Rolling Stock TSI	LOC & PAS TSI - Reg. (EU) No. 1302/2014	
8	Noise TSI	NOI TSI - Reg. (EU) No. 1304/2014	
9	Railway applications - Ride comfort for passengers - Measurement and evaluation	BS EN 12299:2009	
10	Railway applications - Gauges Part 2: Rolling stock gauge	BS EN 15273-2:2013	
11	Railway applications - Definition of vehicle reference masses	BS EN 15663:2009+AC:2010	
12	Acoustics - Railway applications - Measurement of noise emitted by railbound vehicles	BS EN ISO 3095:2013	
13	Railway applications - Acoustics - Measurement of noise inside railbound vehicles	BS EN ISO 3381:2011	
14	Railway applications - Environmental conditions for equipment Part 1: Rolling stock and on-board equipment	BS EN 50125-1:2014	
15	Not used	Not used	
16	Compatibility Requirements for Braking Systems of Rail Vehicles	GM/RT2045	Iss 4

	Title	Reference	Revision
17	Rolling Stock Subsystem and Interface to AC Energy Subsystem	GM/RT2111	Iss 1
18	Requirements for the Size of Vehicles and Position of Equipment	GM/RT2173	Iss 1
19	Guidance on Traction and Rolling Stock - Mechanical Coupling Systems	GM/GN2690	Iss 1
20	Interface between Station Platforms, Track and Trains	GI/RT7016	Iss 5
21	Requirements for the Position of Infrastructure and for Defining and Maintaining Clearances	GI/RT7073	Iss 1
22	Assessment of Compatibility of Rail Vehicle Weights and Underline Bridges	GE/RT8006	Iss 2
23	AWS and TPWS Interface Requirements	GE/RT8075	Iss 2
24	Assessment of Route Compatibility of Vehicles and Infrastructure	GE/RT8270	Iss 3
25	Assessment of Compatibility of Rolling Stock and Infrastructure – Gauging and Stepping Distances	GE/RT8273	Iss 1
26	Not used	Not used	n/a
27	PeopleSize 2008	Available via openerg.com/psz	
28	Format for Vehicle Gauging Data	RIS-2773-RST	Iss 1
29	Railway applications — Body side entrance systems for rolling stock	BS EN 14752:2015	
30	Rule Book - Train Driver Manual	GERM8000/traindriver	Iss 3
31	High Speed Rolling Stock TSI	HS RST TSI – 2008/232/EC	
32	https://www.networkrail.co.uk/industry-commercial-partners/information-operating-companies/cp5-access-charges/		
33	HS2 Design Vision	HS2-HS2-DS-STR-000-000005	P01
34	Railway applications - Gauges Part 3: Structure gauges	BS EN 15273-2:2013	
35	Railway applications - Gangway systems between vehicles Part 1: Main applications	BS EN 16286-1:2013	
36	Permissible Track Forces for Railway Vehicles	GM/TT0088	Iss 1
37	Interfaces between CCS track-side and other subsystems	ERA/ERTMS/033281	v3.0
38	HS2-25 Vehicle Gauge	HS2-DGG-RR-DAT-000-000001	P01
39	HS2-23 Vehicle Gauge	HS2-DGG-RR-DAT-000-000002	P01
40	HS2 Phase One Environmental Statement, volume 5: sound, noise and vibration, Appendix SV-001-000, Annex D2		

Appendix A - Gauging drawings

Reference documents [38] and [39] are preliminary versions of the HS2 Reference Vehicle Gauges for 25m vehicles / 17m bogie-spacing (HS2-25) and 23m vehicles / 16m bogie spacing (HS2-23), respectively. The vehicle gauges have been developed for conventional bogies, which are used for the majority of UK passenger vehicles. However, HS2 Ltd does not have a preference for running gear solution. Vehicle gauges for articulated vehicles can be developed from these gauges, but it is assumed that significantly different vehicle movements would be required. 25m vehicles were considered based on the maximum unit length (200m) and typical existing designs of very high speed trains. 23m vehicles were considered based on existing UK intercity vehicles and a possible 9 x 22.3m Unit formation.

The vehicle gauges have been developed with consideration of structures on the CRN and a simplified assessment of passing clearances. These gauges remain to be developed in the following areas:

- The gauges currently require a number of sub-standard clearances to be resolved. Resolution of these clearances may lead to the reductions in the size of the vehicle gauges. In particular, the lower corners of the lower sector may need to be re-profiled to remove fouls of underline bridge girders
- The gauges only consider a preliminary assessment of passing clearances. HS2 Ltd is investigating the potential to increase the vehicle width at waist level (approximately 1500mm above rail level).
- Initial analysis of the HS2-25 gauge showed the need for a centre-taper, reducing the semi-width to a maximum of 1336mm. It is assumed that further analysis will demonstrate that this taper is not required, but this analysis is not yet complete. The HS2-25 gauge assumes that this taper will not be required.
- HS2 Ltd is investigating the potential to make changes to structures on the CRN to enable an increase in the size of the vehicle gauges. In particular, the scope for adjusting platforms to provide more space in the footstep area will be investigated.
- The vehicle movements (included in the files) are based on soft suspension. Stiffer suspension may permit an increase in static gauge without reducing the clearance to infrastructure
- HS2 Ltd is investigating the current minimum wire height on the CRN, which may lead to some increase or reduction in maximum vehicle height to ensure sufficient electrical clearance.

Appendix B – Supporting figures

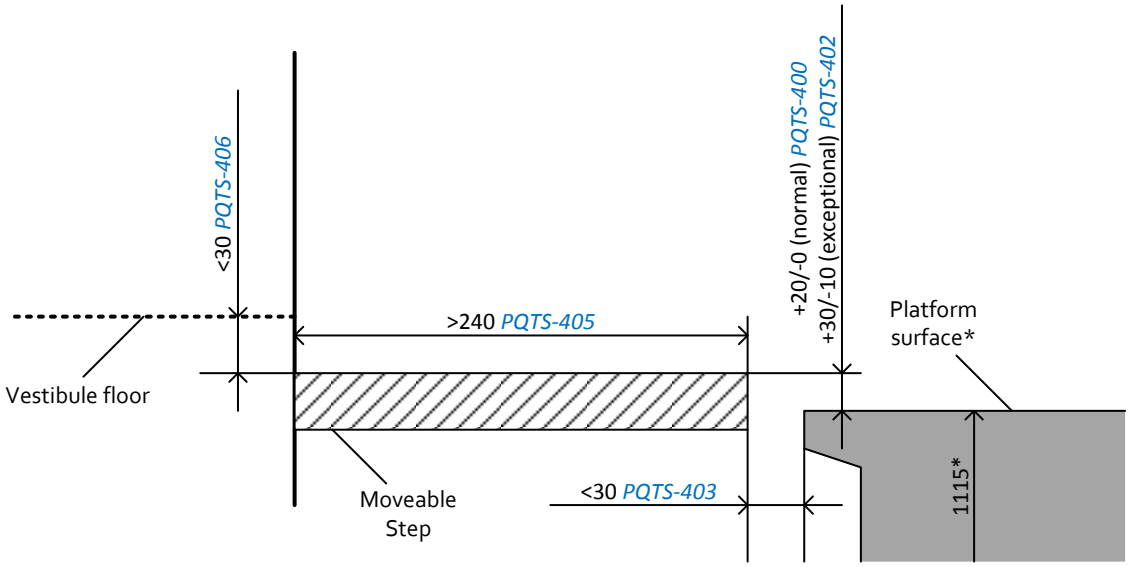

Figure 1 - Platform-train interface requirements for HS2 Platform

* For the purpose of compliance with these requirements, the platform surface should be assumed to be at exactly 1115mm

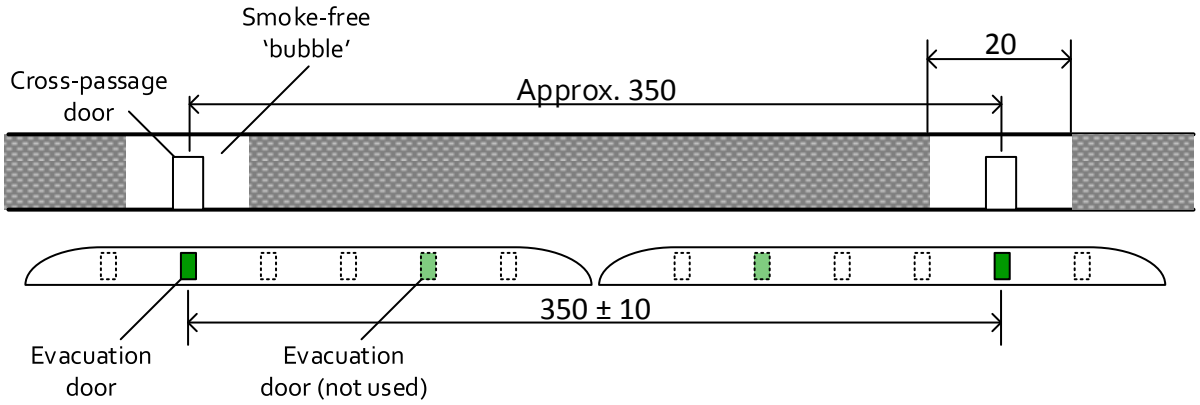

Figure 2 - Positioning of doorways for evacuation ('evacuation doors') for compatibility with tunnel cross-passages.

Figure 2 relates to PQTS-239. Doorways suitable for evacuation must be positioned within the two smoke-free 'bubbles'. Units could be couple in any orientation.