the CR-TSI.

2.1.1.69 Passenger Information System (PIS):

Means a system providing the following functionality:

- crew audio communication;
- public address audio;
- automated passenger audio and visual broadcasts;
- Service Information audio and visual broadcasts;
- passenger alarm communication; and
- passenger Call For Aid communication.

TTS-76

2.1.1.70 Passenger Service Condition:

Means a condition of the Unit in which all Unit Subsystems are working without service impacting defects or faults such that;

- the driver can immediately apply tractive effort from an Occupied Cab;
- the pneumatic systems are pressurised to their nominal level with brakes, WSP and sanding fully operational;
- the driving cab and passenger saloon environment are being controlled about their set-point temperatures;
- the PIS audio and visual displays in all Vehicles are running the selected Service Information;
- the DOO CCTV is capable of presenting all DOO CCTV camera images for all Vehicles to the driver and is able to record these images;
- the saloon CCTV is operational and recording all cameras in all Vehicles;
- the GSM-R radio is ready for passenger service with all data entered;
- the cab and passenger saloon doors can be enabled, opened and closed;
- the signalling, OTMR and cab safety systems are fully operational; and
- all other cab and passenger environment Subsystems and controls are operational.

TTS-77

2.1.1.71 Performance Regime:

Means as defined in the MSA / TSA.

TTS-78

2.1.1.72 Persons with Reduced Mobility (PRM):

Means as defined within the PRM-TSI.

TTS-79

2.1.1.73 Powdered Snow:

Means un-compacted low density dry snow that occurs when both the tropospheric temperature and the surface temperature fall below the freezing point, causing the snow to have a minimal amount of liquid.

TTS-80

2.1.1.74 PRM-TSI:

TTS-81

Means the technical specification for interoperability relating to 'persons with reduced mobility' in the trans-European conventional and high-speed rail system.

2.1.1.75 RCD: TTS-84

Means Residual-Current Device.

2.1.1.76 Regenerative Brake/Braking:

Means a dynamic electric brake in which the brake force is produced by feeding the current generated during braking to the Traction Power Supply network or to any other means of energy storage. TTS-85

2.1.1.77 Rheostatic Brake/Braking:

Means a dynamic electric brake in which the brake force is produced by feeding the current generated during braking to a resistor. TTS-87

2.1.1.78 Reset:

Means the clearing of errors or events and returning the system and/or Unit to its normal condition or initial state in a controlled manner. TTS-88

2.1.1.79 RFID: TTS-2598

Means radio frequency identification.

2.1.1.80 Rolling Stock Library:

Means the national central database of rail vehicle design and operational data, which is maintained by the infrastructure controller's authorised agent. TTS-89

2.1.1.81 Route Control Centre (RCC):

Means the control centre responsible for the overall operation, control and monitoring of the Units. The RCC shall also provide route wide surveillance and strategic management of all operations together with the provision of information to all stations and other operational centres and authorities. TTS-90

2.1.1.82 Saloon CCTV:

Means a system of cameras, recording, transmission and display equipment to provide remote monitoring of the passenger saloon areas of the Unit. TTS-92

2.1.1.83 Second Person:

Means an Authorised Person that may be present in the driver's cab in addition to the driver to provide assistance for the purposes of training, or operating the Unit. TTS-94

2.1.1.84 Service Information:

Means the display of service specific information to passengers to ensure the passengers can be kept informed of events occurring on the LO Infrastructure. TTS-95

2.1.1.85 Shut Down State:

Means a state of the Unit where all Subsystems are in the fully switched off state and having executed any required 'power down' sequence and where the Unit auxiliary power supplies have been 'tripped'. In this state the Unit shall have; TTS-97

- The pantograph lowered and the DC shoegear retracted;
- The AC and DC main circuit breakers open;
- all cabs in a Non-occupied Cab state; and
- all passenger saloon doors closed and locked.

2.1.1.86 Simulator:

Means a modular system consisting of a full size independent driving cab, an instructor console, a trainee viewing facility, and associated ancillary equipment for the purpose of driver training and performance assessment. TTS-98

2.1.1.87 SRT-TSI:

Means the technical specification of interoperability relating to 'safety in railway tunnels' in the trans-European conventional and high-speed rail system. TTS-99

2.1.1.88 TETRA:

Means Terrestrial Trunked Radio, a European Telecommunications Standards Institute standard, first version published 1995 for professional mobile radio for use by government agencies, emergency services and rail transportation staff. TTS-101

2.1.1.89 TfL Live Service Update Board:

Means live transport Service Information to be made available to the Manufacturer on the Wayside to provide the current operating status of TfL transport services, such as but not limited to, other London Overground services, London Underground services and Docklands Light Railway services. TTS-103

2.1.1.90 T-Gamma (Tγ):

Means the energy dissipated in the contact patch per metre between the wheel and the rail, calculated as the product of the creep (friction) force and the creepage (distance slipped per unit of distance rolled). TTS-104

2.1.1.91 Not Used. TTS-105

2.1.1.92 TPWS:

Means Train Protection and Warning System, a system which shall be provided at certain signals, speed restrictions and buffer stops. The purpose of TPWS is to stop a Unit which has: TTS-106

- passed a signal at danger without authority; or
- approached a signal at danger too fast; or
- approached a reduction in permissible speed too fast; or
- approached buffer stops too fast.

2.1.1.93 Traction Power Supply:

Means the nominal 25kV AC overhead and nominal 750V DC third rail infrastructure power supplies to the Units that allow operation on the routes of the LO Infrastructure. TTS-107

2.1.1.94 Traction Power Supply Changeover:

Means a changeover of the Traction Power Supply provided to the Unit that will take place at certain locations of the LO Infrastructure and will constitute a changeover from: TTS-108

- the nominal 25kV AC overhead power supply to the nominal 750V DC third rail power supply'; or
- the nominal 750V DC third rail power supply to the nominal 25kV AC overhead power supply.

2.1.1.95 Traction System: TTS-109

Means the train Subsystem that provides motive power and electric dynamic brake for the Unit and shall be considered to comprise all the power and control components, hardware, software and firmware, from the pantograph (AC) or third rail shoegear (DC) to the traction motors, gearboxes and motor wheelsets.

2.1.1.96 Train Management System (TMS):

Means a computer system that controls, monitors, diagnoses and records Unit operation, including doors, HVAC, lights, passenger information and all other electronic Subsystems. TTS-110

2.1.1.97 Transversal TSI's:

Means the technical specifications for interoperability relating to the rolling stock subsystem as defined by the European Rail Agency. TTS-112

2.1.1.98 TSI: TTS-113

Has the meaning given to it in the Interoperability Regulations.

2.1.1.99 Unit:

Means a single fixed formation consisting of Vehicles coupled together and incorporating all Subsystems, such that it meets the requirements of the Train Technical Specification for all permissible fixed formation lengths and configurations and having two identical driving cabs, one positioned at each end. TTS-114

2.1.1.100 Unit Reporting Number:

Means a unique alpha/numeric identifier relating to the current service diagram, such as the assigned headcode. TTS-115

2.1.1.101 Universal Accessible Toilet (UAT): TTS-116

Means as defined in the PRM-TSI.

2.1.1.102 Usable Standing Area:

Means the floor area of the Unit which is available for the accommodation of standing passengers. TTS-117

2.1.1.103 User Population:

Means all users of the Unit (e.g. passengers, driver, train crew and maintenance staff) who shall range from 5th percentile female to 95th percentile male according to 'Adult Data, the hand book of Adult Anthropometric and Strength Measurements: Data for Design Safety, Department of Trade and Industry, 1998' or equivalent. TTS-118

2.1.1.104 Vehicle:

Means a single, one piece body together with all supporting running gear and interior, exterior and underframe fittings. TTS-119

2.1.1.105 Wayside:

Means any fixed infrastructure including, but not limited to:

- RCC;
- maintenance depot;
- shore data and passenger communications equipment; TTS-120
- the Purchaser or train operator service control points;
- locations required by the Manufacturer;
- Network Rail signalling centre; and

- Network Rail engineering data centre, including that for the GSM-R train radio.

2.1.1.106 Wheel Slip/Slide Prevention (WSP):

Means a Subsystem designed to make the best use of available adhesion by controlled reduction of the brake force or traction force to prevent wheelsets locking, sliding or spinning. TTS-121

2.1.1.107 Working Order:

Means as defined within BS EN 15663:2009 Railway applications - Definition of Vehicle reference masses Table 2. TTS-122

3 Rolling Stock Technical Requirements

TTS-123

3.1 Unit Lengths and Configurations

TTS-124

3.1.1.1 The Units shall consist of either of the following: TTS-125

- 4 Vehicle Units; and
- 5 Vehicle Units.

3.1.1.2 The 4 Vehicle Units shall not exceed 83m in length across coupling planes. TTS-126

3.1.1.3 The 5 Vehicle Units shall not exceed 104m in length across coupling planes. TTS-127

3.1.1.4 It shall be possible to convert a 4 Vehicle Unit to a 5 Vehicle Unit by the addition of an Intermediate Vehicle. TTS-128

3.1.1.5 It shall be possible to convert a 5 Vehicle Unit to a 4 Vehicle Unit by the removal of an Intermediate Vehicle. TTS-129

3.1.1.6 Any hardware equipment modifications required to the existing Unit to achieve the conversions defined in clauses 3.1.1.4 and 3.1.1.5 shall be kept to the absolute minimum. In so far as is possible, the modifications shall be constrained to items such as the appropriate labels and software. It shall be possible to complete the Unit conversions at a maintenance depot. TTS-130

3.1.1.7 The Units shall be capable of operating as either AC Only Units or Dual Voltage Units. TTS-131

3.1.1.8 It shall be possible to convert AC Only Units into Dual Voltage Units. It shall be possible to install the additional equipment at the maintenance depot. TTS-132

3.1.1.9 Except where explicitly defined in this specification, all 4 Vehicle Units shall be identical and all 5 Vehicle Units shall be identical. TTS-134

3.1.1.10 Where there are differences in Units, as permitted by clause 3.1.1.9, this shall be limited to the missing items of equipment and any appropriate software and labels. Conversions of Units, for example from an AC Only Unit to a Dual Voltage Unit shall in this way only require the fitting of the missing DC Traction System items and any associated software upgrades and label changes. Any equipment items that if fitted during the conversion process would require significant disruption to the Unit, for instance cable bus line installations or major pipe installations, shall be installed on all Units and where not used terminations shall be suitably protected. TTS-2599

3.1.1.11 Vehicles of the same type shall be interchangeable between any of the Units. TTS-135

3.1.1.12 The Units shall operate in passenger service with Open Wide Gangways between Vehicles. TTS-136

3.1.1.13 Units shall be able to operate in passenger service as 4 Vehicle Units or 5 Vehicle Units. TTS-137

3.1.1.14 Units shall be able to operate in passenger service as Multiple Unit formations of: TTS-138

- Two 4 Vehicle Units coupled together;
- Three 4 Vehicle Units coupled together;
- Two 5 Vehicle Units coupled together; and
- One 4 Vehicle Unit coupled with a 5 Vehicle Unit.

3.1.1.15 Units shall be able to operate in non-passenger service as Multiple Unit formations of:

- Four 4 Vehicle Units coupled together;
- Two 4 Vehicle Units and one 5 Vehicle Unit;
- One 4 Vehicle Unit and two 5 Vehicle Units; and
- Three 5 Vehicle Units coupled together.

TTS-139

3.1.1.16 When formed, the Multiple Unit shall automatically re-configure and function as if it was a single Unit and shall meet the requirements of a Unit other than where infrastructure constraints dictate otherwise and as agreed with the Purchaser. TTS-140

3.1.1.17 Where the requirement relates to functionality available in a cab of the Unit, including specific requirements relating to Occupied and Non-occupied Cabs, the requirement shall apply to all cabs of the Multiple Unit formation. TTS-141

3.1.1.18 The front overhang of the Driving Vehicle relative to the centre of the first axle shall be no greater than 3226mm in accordance with GM/RT2149 and GK/GN0628. TTS-142

3.2 Unit Performance and Journey Times

TTS-143

3.2.1.1 The Unit shall be capable of an initial acceleration of 0.8m/s^2 up to 25mph on level track under the conditions specified in clause 3.2.1.3. TTS-144

3.2.1.2 The Unit shall be capable of achieving and maintaining a maximum speed of 75mph on level track whilst operating into a headwind of 50kph under the conditions specified in clause 3.2.1.3. TTS-145

3.2.1.3 The performance specified in clauses 3.2.1.1 and 3.2.1.2 above shall be achieved under the following conditions:

- Operation from either an AC Traction Power Supply or a DC Traction Power Supply;
- A four or five Vehicle Unit formation;
- All line voltages down to 22.5kV when operating from an AC Traction Power Supply; TTS-146
- All line voltages down to 600V when operating from a DC Traction Power Supply;
- Up to and including Normal Payload; and
- Up to and including maximum auxiliary load.

3.2.1.4 The performance specified in clause 3.2.1.5 shall be achieved in conditions A and B which are defined as:

condition A:

Operation from the AC Traction Power Supply, using a line voltage down to 22.5kV;

A four or five Vehicle Unit formation; TTS-147

Unit braking at 7.5%g;

A Dwell Time of 30 seconds at each intermediate station;

Up to and including Normal Payload; and

Up to and including maximum auxiliary load.

condition B:

Operation from the AC Traction Power Supply, using a line voltage down to 22.5kV;

A four or five Vehicle Unit formation;

Unit braking at 7.5%g;

A Dwell Time of 30 seconds at each intermediate station;

From Normal Payload up to and including Exceptional Payload; and

Up to and including maximum auxiliary load.

3.2.1.5 The Unit shall complete the routes in the following table in no more than the simulated target times.

	Condition:	A	A	B	B
	Direction:	Up	Down	Up	Down
Route:	Stopping At:				
London Liverpool Street to Chingford	Bethnal Green Hackney Downs Clapton St. James St. (Walthamstow) Walthamstow Central Wood Street Highams Park	23.8	23.8	24.0	24.0
London Liverpool Street to Cheshunt	Bethnal Green Cambridge Heath London Fields Hackney Downs Rectory Road Stoke Newington Stamford Hill Seven Sisters Bruce Grove White Hart Lane Silver Street Edmonton Green Southbury Turkey Street Theobalds Grove	34.4	34.5	34.8	34.9

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London Liverpool Street to Enfield Town	Bethnal Green Cambridge Heath London Fields Hackney Downs Rectory Road Stoke Newington Stamford Hill Seven Sisters Bruce Grove White Hart Lane Silver Street Edmonton Green Bush Hill Park	29.2	29.1	29.5	29.4
	Direction:	West-bound	East-bound	West-bound	East-bound
Acton Central to Stratford (London)	Willesden Junction Kensal Rise Brondesbury Park Brondesbury West Hampstead Finchley Road and Frognal Hampstead Heath Gospel Oak Kentish Town West Camden Road Caledonian Road and Barnsbury Highbury and Islington Canonbury Dalston Kingsland Hackney Central Homerton Hackney Wick	38.9	39.4	39.2	39.7

All times are in decimal minutes (e.g. 13.75 = 13 minutes 45 seconds).

3.2.1.6 The performance specified in clause 3.2.1.7 shall be achieved in conditions C, D, E and F which are defined as:

condition C:

Operation from the third rail DC Traction Power Supply, using a line voltage of 600V;

A four or five Vehicle Unit formation;

Unit braking at 7.5%g;

A Dwell Time of 30 seconds at each intermediate station; TTS-149

Up to and including Normal Payload; and

Up to and including maximum auxiliary load.

condition D:

Operation from the third rail DC Traction Power Supply, using a line voltage of 600V;

A four or five Vehicle Unit formation;

Unit braking at 7.5%g;

A Dwell Time of 30 seconds at each intermediate station;
From Normal Payload up to and including Exceptional Payload; and
Up to and including maximum auxiliary load.

condition E:
Operation from the third rail DC Traction Power Supply, using a line voltage of 600V;
A four Vehicle Unit formation;
A maximum of 2250A shall be drawn from the third rail DC Traction Power Supply;
Unit braking at 7.5%g;
A Dwell Time of 30 seconds at each intermediate station;
Up to and including Normal Payload; and
Up to and including maximum auxiliary load.

condition F:
Operation from the third rail DC Traction Power Supply, using a line voltage of 600V;
A four Vehicle Unit formation;
A maximum of 2250A shall be drawn from the third rail DC Traction Power Supply;
Unit Braking at 7.5%g;
A Dwell Time of 30 seconds at each intermediate station;
From Normal Payload up to and including Exceptional Payload; and
Up to and including maximum auxiliary load.

3.2.1.7 The Unit shall complete the routes in the following table in no more than the simulated target times.

	Condition:	C	C	D	D	E	E	F	F
	Direction:	Up	Down	Up	Down	Up	Down	Up	Down
Route:	Stopping At:								
London Euston to Watford Junction	South Hampstead Kilburn High Road Queen's Park Kensal Green Willesden Junction Low Level Harlesden Stonebridge Park Wembley Central North Wembley South Kenton Kenton Harrow and Wealdstone Headstone Lane Hatch End Carpenders Park Bushey Watford High Street	42.8	42.6	43.2	42.9	44.2	44.2	44.6	44.7
Dalston Junction to West Croydon	Haggerston Hoxton Shoreditch High Street Whitechapel Shadwell Wapping Rotherhithe Canada Water Surrey Quays New Cross Gate Brockley Honor Oak Park Forest Hill Sydenham Penge West Anerley Norwood Junction	35.3	34.7	35.7	35.1	37.0	36.7	37.5	37.2

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All times are in decimal minutes (e.g. 13.75 = 13 minutes 45 seconds).

3.2.1.8 The Unit shall meet all of the performance requirements in this section with wheels in any condition from new to fully worn. TTS-155

3.2.1.9 In the event that the line voltage is less than 22.5kV under AC Traction Power Supply operation or 600V under DC Traction Power Supply operation, the train performance shall be commensurate with the maximum current permitted to be drawn at that reduced line voltage as mandated by BS EN50388 or agreed with the Infrastructure Manager. TTS-156

3.2.1.10 The Unit shall have a jerk rate under all load conditions of not greater than 0.75m/s³. Maximum jerk rate shall be adjustable by authorised maintenance staff between 0.5m/s³ and 1m/s³. TTS-157

3.2.1.11 The Units shall be capable of continuously repeating any of the journeys specified, or combination of the journeys specified, in the time specified with a turnaround time of two minutes at each terminus. TTS-158

3.2.1.12 The Units shall be capable of operating up to their maximum speeds on journeys where the station stopping pattern is less frequent, or the distance between station stops is further than those detailed in 3.2.1.5 and 3.2.1.7, and as a consequence the average Unit speeds would be higher. Attention is drawn to the requirements of 3.2.1.2. TTS-159

3.3 Unit Configuration Times TTS-160

3.3.1.1 From initially being in the Shut Down State with pneumatic systems available for use, the Unit shall be capable of achieving the Operational State in a Passenger Service Condition in no more than 3 minutes. TTS-161

For this particular Operational State, the cab and saloon HVAC Subsystems shall be fully functional but shall not be required to have reached their set point temperatures.

3.3.1.2 From initially being in the Operational State in a Passenger Service Condition, with all passenger saloon doors enabled and open, the Unit shall be capable of achieving the Shut Down State in no more than 1 minute. TTS-162

To achieve this particular Shut Down state the passenger saloon doors shall not automatically close as a consequence of the shutdown sequence but shall be closed by the driver using the normal cab desk controls.

3.3.1.3 From the Unit initially being in an Operational State in a Passenger Service Condition with a driver in the Occupied Cab it shall be possible for:

- the driver to set this initial cab to the Non-occupied Cab state; and
- return the Unit to an Operational State in a Passenger Service Condition with either the same cab or any other cab now the Occupied Cab, in no more than 2 minutes. TTS-163

This time shall exclude the time it takes for the driver to walk from one cab to another cab.

3.3.1.4 From an initial Shut Down State, with all pneumatic air reservoirs empty but with all pneumatic air systems being fault free, the Unit shall be capable of achieving an Operational State in a Passenger Service Condition in no more than 20 minutes. TTS-164

3.3.1.5 The Unit's automatic coupling system shall enable coupling and uncoupling to be performed easily and reliably by a single operator from an adjacent driver's cab of one of the Units in no more than 1 minute. TTS-165

3.3.1.6 Traction Power Supply Changeovers shall be completed in no greater than TTS-166

the time in clause 3.12.2.5.

3.3.1.7 The timings required in this section shall be achieved on any part of the LO Infrastructure including depots and any stabling sidings. TTS-167

3.4 Energy Consumption TTS-168

3.4.1.1 The Units shall achieve no more than the following simulated net energy consumption values at the pantograph (all figures in kWh) in the conditions defined in 3.4.1.2.

	Condition:	A	A	B	B
	Direction:	Up	Down	Up	Down
Route:	Stopping At:				
London Liverpool St to Chingford	Bethnal Green Hackney Downs Clapton St. James St. (Walthamstow) Walthamstow Central Wood Street Highams Park Chingford	128.8	188.3	136.3	200.7
London Liverpool St to Cheshunt	Bethnal Green Cambridge Heath London Fields Hackney Downs Rectory Road Stoke Newington Stamford Hill Seven Sisters Bruce Grove White Hart Lane Silver Street Edmonton Green Southbury Turkey Street Theobalds Grove	291.9	310.1	314.9	334.9
London Liverpool St. to Enfield Town	Bethnal Green Cambridge Heath London Fields Hackney Downs Rectory Road Stoke Newington Stamford Hill Seven Sisters Bruce Grove White Hart Lane Silver Street Edmonton Green Bush Hill Park	216.2	239.2	233.7	259.1

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	Direction:	West-bound	East-bound	West-bound	East-bound
Acton Central to Stratford	Willesden Kensal Rise Brondesbury Park Brondesbury West Hampstead Finchley Road and Frognal Hampstead Heath Gospel Oak Kentish Town West Camden Road Caledonian Road and Barnsbury Highbury and Islington Canonbury Dalston Kingsland Hackney Central Homerton Hackney Wick	256.1	242.3	274.7	260.2

3.4.1.2 The following defines conditions A and B to support clause 3.4.1.1:

condition A:

Operation from the AC Traction Power Supply, using a line voltage down to 22.5kV;

A four or five Vehicle Unit formation;

Unit braking at 7.5%g;

A Dwell Time of 30 seconds at each intermediate station;

Up to and including Normal Payload; and

At maximum auxiliary load.

TTS-172

condition B:

Operation from the AC Traction Power Supply, using a line voltage down to 22.5kV;

A four or five Vehicle Unit formation;

Unit braking at 7.5%g;

A Dwell Time of 30 seconds at each intermediate station;

From Normal Payload up to and including Exceptional Payload; and

At maximum auxiliary load.

3.4.1.3 The Unit shall have a driver advisory system for use across the LO Infrastructure to give drivers a real-time view of their position in relation to the tactical needs of the service, thus supporting improved energy management and Unit regulation. The information provided shall include, as a minimum:

TTS-173

- actual Unit running against timetable; and
- target speed to maintain timetable slot while optimising energy consumption.

Attention is drawn to RSSB project report T724 which has evaluated such systems.

The driver advisory system shall be upgradeable to incorporate guidance sent by external traffic management systems.

3.4.1.4 The Unit shall incorporate energy metering equipment to permit the energy consumption to be measured and recorded. The energy metering system shall:

- meet the requirements of Annex D of the CR-TSI;
- measure and record data separately for operation on AC and DC Traction Power Supplies, including; TTS-174
- energy consumed from each Traction Power Supply;
- energy regenerated to each Traction Power Supply; and
- energy due to auxiliary loading.

3.4.1.5 Using the energy metering data measured and recorded in clause 3.4.1.4 it shall be possible to separately identify:

- the energy consumed while the Unit is stabled;
- the energy consumed on defined geographical sections of the route; and TTS-175
- the energy consumed over a time frame set by the Purchaser's operations staff.

3.4.1.6 The data from the energy metering system shall be readily accessible to the Purchaser at the Wayside and shall be presented in a format agreed with the Purchaser. TTS-176

3.4.1.7 The Unit shall have an intelligent stabling system which minimises energy consumption when the Unit is out of use. TTS-177

As a minimum this system shall reduce interior lighting levels and relax the HVAC system temperature regulation settings.

3.4.1.8 The intelligent stabling system together with the passenger saloon HVAC systems shall ensure that the Unit can enter passenger service at 30 minutes' notice for all external ambient conditions. TTS-178

3.4.1.9 The intelligent stabling system shall be capable of being activated and deactivated from within the cab, or remotely from the Wayside where the permissible bearer suggested by the Manufacturer is available. TTS-179

3.5 Unit Weight Targets TTS-180

3.5.1.1 The Design Mass in Working Order of a 4 Vehicle Unit shall not exceed 165 tonnes. This requirement applies to both AC Only Units and Dual Voltage Units. TTS-181

3.5.1.2 The Design Mass in Working Order of a 5 Vehicle Unit shall be proportional to that of the 4 Vehicle Unit. TTS-182

3.5.1.3 The maximum axle load of the Unit for the Design Mass under all load conditions up to Exceptional Payload shall not exceed 16.0 tonnes. This requirement applies to both AC Only Units and Dual Voltage Units. TTS-183

3.5.1.4 The Unit shall achieve a Route Availability of RA4 or better, as defined in GE/RT8006, under all load conditions up to Exceptional Payload. TTS-184

3.6 Environmental Operating Conditions

TTS-180

3.6.1.1 The Unit shall be capable of being powered up and continuing in Normal Operation in the full range of ambient and environmental conditions encountered in the United Kingdom. This includes being powered up after lengthy periods of being stabled without connection to a Traction Power Supply. TTS-186

3.6.1.2 The Unit shall operate without its performance being degraded by dust, pollen and similar airborne particles, including iron/iron oxides, brake pad dust and general organic matter, found in tunnel operating environments. TTS-187

3.6.1.3 Each Unit and all its constituent parts shall comply with the requirements of climatic zone T1 and altitude range A2 as specified in BS EN 50125-1:2014 Railway Applications - Environmental conditions for equipment, except that for the Unit's battery systems the minimum temperature requirement for performance in accordance with this specification shall be -17°C. TTS-188

3.6.1.4 The Unit shall be capable of Normal Operation under all forms of precipitation including Powdered Snow and alternate freeze/thaw conditions. TTS-189

3.6.1.5 The Unit shall, as far as reasonably practicable, be capable of operating under its own power through floodwater up to a depth of 100mm above the top of the running rail. TTS-190

3.6.1.6 The Unit shall, as far as reasonably practicable, be capable of Normal Operation under its own power through snow up to a depth of 200mm above the top of the running rail. TTS-191

3.6.1.7 The Unit shall, as far as reasonably practicable, be capable of operating under its own power through snow up to a depth of 300mm above the top of the running rail. TTS-192

3.6.1.8 The Unit shall be capable of Normal Operation during overhead line icing conditions. TTS-193

3.6.1.9 The Unit shall be capable of Normal Operation during third rail conductor icing conditions and the interaction between the third rail current collection shoegear, the third rail conductor and any on train protection systems shall not prevent Normal Operation. TTS-194

3.7 Gauging, Routes and Stepping Distance

TTS-195

3.7.1.1 The Unit dynamic lower gauge profile shall be in accordance with that defined in GE/GN8573, including consideration of credible suspension failure conditions. TTS-196

3.7.1.2 The Unit, including footsteps, shall be gauge cleared for passenger operation in Any Loading Condition on the routes defined in Schedule 4 of the MSA and which are labelled in that schedule as the passenger routes, including diversionary routes. TTS-197

3.7.1.3 The Unit, including footsteps, shall be gauge cleared for ECS operation on the routes defined in Schedule 4 of the MSA and which are labelled in this schedule as routes required for ECS moves only. TTS-198

3.7.1.4 Clearances between the Unit and the LO Infrastructure for all the routes defined in Schedule 4 of the TSA shall be in accordance with GC/RT5212. Any adoption of comparative gauging or other techniques or mitigations to permit operation at reduced clearances shall be undertaken in consultation with the Purchaser. TTS-200

3.7.1.5 The following stepping distance requirements between passenger doorways and station platforms shall be met:

- the stepping distance requirements of the PRM-TSI (GB special case) and Section B6.3 of Railway Group Standard GM/RT2149 shall be met; and
- stepping distances at legacy platforms (i.e. those platforms not dimensioned in accordance with the PRM-TSI (GB special case) and Section B6.3 of Railway Group Standard GM/RT2149) shall be minimised as far as practicable, having regard to the requirements of 3.7.1.2 and 3.7.1.3.

TTS-202

3.7.1.6 The Unit design shall deliver Level Boarding at existing LO Infrastructure locations where Level Boarding is currently achieved with the existing rolling stock design. The final design arrangement and capabilities for level boarding across the LO Infrastructure shall be agreed with the Purchaser. TTS-203

3.7.1.7 The Unit shall be capable of running on all LO Infrastructure, depots and sidings and over any track geometry compliant to GM/GN2690 Appendix 7, Issue 1, December 2004, for both mainline and non-passenger lines. TTS-204

3.7.1.8 The Unit shall be designed such that the pantograph sway remains within the limits specified in the Railway Group Standard GM/RT2149 or is compatible with the LO Infrastructure. TTS-205

3.7.1.9 Any loss of pressure in air suspension components on any Vehicle that may give rise to a reduction in passenger comfort, or have implications of gauge clearances, shall be reported to the driver and the Wayside as a TMS category A alarm so that appropriate action can be taken, such as reducing the Unit speed and adopting any additional operational procedures. TTS-206

3.8 Track Interaction, Wear and T-Gamma (Tγ)

TTS-207

3.8.1.1 The Unit shall minimise the amount of damage caused to the track. TTS-208

3.8.1.2 The risk of rolling contact fatigue and wear shall be quantified using the contact patch energy term T-Gamma which shall be determined from the results of vehicle dynamics simulations. Table 1 shows the boundary limits of T-Gamma (as a function of track curvature).

The values provided show the limits of T-Gamma when running at cant equilibrium and 80mm cant deficiency, calculated using the T-Gamma algorithm used in the VAMPIRE® vehicle dynamics software Version 5.50. TTS-209

It is permissible to calculate T-Gamma using alternative vehicle dynamics software, but in this case Bidders shall demonstrate that the vehicle dynamics simulation method used is equivalent to that used by the VAMPIRE® vehicle dynamics software (version 5.50).

3.8.1.3 At each value of curve radius the value of contact patch energy per wheel (T-Gamma), shall lie below that shown in Table 1 for each of the cant deficiency conditions given. TTS-210

3.8.1.4 The conditions for the calculations shall be as follows:

- Wheel-rail coefficient of friction of 0.45;
- new (design) wheel profiles;
- CEN60E1 (design) rail profiles; and
- Normal Payload.

TTS-211

Calculations shall be performed for each wheel of the most heavily laden of each bogie type fitted to the Unit and shall be presented as the average over at least 250m of continuous running over each curve radius for each of the cant deficiency conditions.

3.8.1.5

Curve (m)	T-Gamma limit values for Specified Cant Deficiency	
	0mm	80mm
200	525	525
400	280	280
500	155	140
600	90	75
700	70	55
800	63	45
1000	42	25
1200	30	17
1400	20	10
1800	12	5.5
2200	8	4
2500	6	2.5
3000	5	2

TTS-214

Table 1

3.9 Ride and Stability

TTS-215

3.9.1.1 The Unit ride comfort shall be optimised over the LO Infrastructure.

The ride comfort of the Unit shall be calculated in accordance with BS EN 12299:2009 'Railway Applications Ride Comfort for Passengers' using the Mean Comfort Standard Method;

TTS-216

3.9.1.2 The Unit shall ensure the Mean Comfort Index shall not exceed 2.2 when operating on any section of the LO Infrastructure.

The Mean Comfort Index shall be achieved at any loading between Design Mass in Working Order and Normal Payload; when measured at any point in the saloon; and at any speed between stationary and 75mph.

TTS-217

For each measurement location within the saloon the Mean Comfort Index shall be calculated by taking the arithmetic mean of all comfort indices calculated for that location.

3.9.1.3 The specified Mean Comfort Index shall be sustainable without significant degeneration during the whole life of the Unit by appropriate maintenance, considering component degradation or wear.

TTS-218

3.9.1.4 The Unit suspension design shall permit operation and maintain stability with a maximum conicity of 0.4.

TTS-219

3.10 Noise and Vibration

TTS-220

3.10.1 External Noise

TTS-221

3.10.1.1 Unit external noise levels shall be compliant with the requirements detailed in the Noise-TSI. TTS-222

3.10.1.2 The Unit's auxiliary systems shall be designed and shall operate to minimise the emission of noise or discreet tones which may be of nuisance to neighbours at sites where the Units are stabled. TTS-223

3.10.1.3 The Unit shall be designed to mitigate flange squeal and wheel ringing on tight radius curves taking due consideration of the LO Infrastructure route alignment. TTS-224

3.10.2 Passenger Interior Noise

TTS-229

3.10.2.1 The following internal noise levels shall not be exceeded when operating up to the maximum operating speed, on straight open track compliant with the Noise TSI. The testing protocol and methodology detailed in BS EN ISO 3381 shall be adopted:

- 70 dB (A) in the Vehicle passenger saloon seated area measured at 1.2 and 1.6m above floor level. TTS-230
- 72 dB (A) in the doorway and stand back areas within the Vehicle measured at 1.2 and 1.6m above floor level.
- 72 dB (A) in the inter-car gangway areas measured at 1.6m above floor level.

3.10.2.2 The Unit shall not emit any prominent harmonics or discreet tones in any operating modes or conditions. Interior fittings and components shall not produce noise at any time through the life of the Unit. TTS-231

3.10.2.3 The maximum internal noise levels under stationary conditions in open air with all auxiliary systems operating normally shall not exceed 62dB(A) anywhere in the Vehicle passenger saloon measured at 1.2 and 1.6m above floor level. The testing protocol and methodology detailed in BS EN ISO 3381 shall be adopted. TTS-232

3.10.3 Cab Interior Noise and Vibration

TTS-233

3.10.3.1 Cab internal noise levels shall be compliant with the requirements detailed in the Noise TSI. Additionally the cab internal noise and vibration levels shall comply with the requirements of the Control of Noise at Work Regulations 2005, The Control of Vibration at Work Regulations 2005 and Railway Group Standard GM/RT2160. TTS-234

3.10.3.2 The cab internal noise levels when operating at up to maximum operating speed, on straight open track compliant with the Noise TSI, shall not exceed 73 dB(A), excluding the operation of any warning or alarm systems and the Units horn. The testing protocol and methodology detailed in BS EN 15892:2011 shall be adopted. TTS-235

3.10.3.3 The cab internal noise levels measured while the Unit is stationary shall not exceed 62 dB (A). The testing protocol and methodology detailed in BS EN 15892:2011 shall be adopted. TTS-236

3.10.3.4 The cab environment shall not be subject to any prominent harmonics or TTS-237

discreet tones (other than those specifically required for warning and alarm systems) in any operating modes or conditions. Interior fittings, components and ventilation equipment shall not produce such prominent harmonics or discreet tones at any time through the life of the Unit.

3.10.3.5 The partition and door between the driver's cab and the passenger saloon shall as far as practicable eliminate the transmission of obtrusive noises and conversation between the cab and the passenger accommodation, and vice versa. TTS-238

3.11 Fire Performance TTS-239

3.11.1.1 The Unit shall satisfy the fire safety requirements of the CR-TSI for Category A vehicles. TTS-240

3.11.1.2 The Unit shall additionally satisfy the Fire Safety requirements of GM/RT 2130 issue 4 for Operation Category OC2. TTS-241

3.11.1.3 The Unit shall additionally satisfy the requirements of EN45545 for vehicle Classification 2-N (OC2) as follows:

- EN45545-1 General issues;
- EN45545-2 Materials/ Components Fire Behaviour requirements;
- EN45545-3 Fire Protection on Railway Vehicles; TTS-242
- EN45545-4 Fire Safety Design Requirements;
- EN45545-5 Fire Safety requirements for Electrical Equipment; and
- EN45545-6 Fire Protection requirements on Railway Vehicles

3.11.1.4 Materials fire performance shall satisfy EN45545 Hazard Level 2 (HL2) classification requirements, as defined in EN45545-2. TTS-243

3.11.1.5 The passenger seats shall additionally satisfy the appropriate requirements defined in BS 6853 for Operation Category Ib. TTS-244

3.11.1.6 Fire barrier requirements (EN45545-3) as defined for position No 1 (Underfloor to top of floor covering) shall apply to the whole of the vehicle floor, including gangway locations, and shall additionally satisfy the requirements as for EN45545 OC3 vehicles. TTS-245

3.11.1.7 Fire barrier requirements (EN45545-3) as defined for position No 5 (Passenger area to Driver's cab) shall additionally satisfy the requirements as for EN45545 OC3 vehicles. TTS-246

3.11.1.8 Running capability shall be sufficient to ensure that, in the event of a fire being detected immediately on departure from a station, the Unit shall be capable of continued running for a minimum of four minutes.

The obligation to fulfil running capability in accordance with the SRT-TSI in respect of the braking system shall be extended to the traction system, and the running capability shall be maintained for four minutes after a fire has been detected. TTS-247

3.11.1.9 Fire detection requirements (EN45545-6) shall additionally satisfy the requirements as for EN45545 OC3, Design Category N vehicles. TTS-248

3.11.1.10 The fire detection system shall on notification of an incident additionally inform the driver of the detection and which vehicle zone is affected. TTS-249

3.11.1.11 When the zone where the fire is detected is within the passenger saloon area, the appropriate Saloon CCTV camera image shall automatically and TTS-250

instantaneously be displayed to the driver.

3.11.1.12 Following detection of a fire within a passenger area the recorded footage from the appropriate Saloon CCTV camera footage, for 5 minutes before and 30 minutes after detection, shall be over write protected. TTS-251

3.11.1.13 Following detection of a fire within a passenger area a smoke management process using the HVAC systems shall activate to manage fire effluents within the affected zone. Verification of this shall be demonstrated by simulation or tests agreed with the Purchaser. TTS-252

3.11.1.14 Following detection of a fire the automatic passenger saloon doors close function defined in clause 3.28.5.4 shall be disabled. The driver shall retain full manual control of the passenger saloon doors. TTS-253

3.11.1.15 In the event of a fire external to the Unit, the driver shall have the capability to manually suppress the inflow of external fresh air into the cabs and passenger saloon areas. The functionality shall be developed by the Manufacturer and be acceptable to the Purchaser. TTS-254

3.11.1.16 Fire extinguishers shall only be accessible to Authorised Persons. The location and capacity of fire extinguishers shall be agreed with the Purchaser. TTS-255

3.11.1.17 The requirements defined in clauses 3.11.1.2, 3.11.1.3, 3.11.1.4, 3.11.1.6, and 3.11.1.7, may alternatively be demonstrated by compliance to the requirements defined in BS6853 for Cat Ib requirements, in conjunction with requirements 3.11.1.18 and 3.11.1.19 subject to the Manufacturer being able to secure Relevant Approvals. TTS-256

3.11.1.18 Where the approach in clause 3.11.1.17 has been adopted a hazard analysis shall be performed as described in BS 6853. TTS-257

3.11.1.19 Where the approach in clause 3.11.1.17 has been adopted the Floor Fire Barrier requirements defined in BS6853 Section 7.1 shall additionally apply to the gangway floor as well as the vehicle structure. TTS-258

3.12 Traction Power Supply TTS-259

3.12.1 General TTS-260

3.12.1.1 The Unit shall be compatible with and capable of drawing power from the Traction Power Supply systems on the LO Infrastructure. TTS-261

3.12.2 Traction Power Supply Changeovers TTS-262

3.12.2.1 The Unit shall be capable of completing Traction Power Supply Changeovers at any speed from stationary up to 75mph. TTS-263

3.12.2.2 The Unit shall be designed such that the driver can manually complete a Traction Power Supply Changeover. TTS-264

3.12.2.3 The manual controls for initiating a Traction Power Supply Changeover shall be considered as primary driving controls in accordance with GM/RT 2161. TTS-265

3.12.2.4 The Unit shall be capable of completing automatic Traction Power Supply Changeovers, requiring no intervention by the driver, using a methodology agreed with the Purchaser and Infrastructure Managers. TTS-266

3.12.2.5 Traction Power Supply Changeovers shall be completed in no greater than 30 seconds. This changeover time shall be measured from the initiation of the changeover process to the point the Unit is ready to apply tractive effort TTS-267

post changeover.

3.12.2.6 Controls shall be provided allowing the driver to disable and re-enable the automatic Traction Power Supply Changeover function. TTS-268

3.12.2.7 The driver's manual controls for Traction Power Supply Changeover shall be available for use at all times, including during automatic Traction Power Supply Changeovers. TTS-269

3.12.2.8 Should the driver use the Traction Power Supply Changeover manual controls immediately prior to or during an automatic Traction Power Supply Changeover, the manual controls shall have priority. Any conflicts between commands from the automatic and manual controls for Traction Power Supply Changeovers shall be controlled in a safe manner. TTS-270

3.12.2.9 The Unit shall provide an indication to the driver that an automatic Traction Power Supply Changeover has been initiated and when it has completed. TTS-271

3.12.2.10 A failure of any Traction Power Supply Changeover sequence shall be reported to the driver. TTS-272

3.12.2.11 Traction Power Supply Changeover shall not:

- have any discernable effect on the passenger environment;
- affect the operation of the driver's controls (other than an inability to apply traction power or Regenerative Brake during the changeover); and TTS-273
- lead to an increase in driver workload other than that required to initiate the changeover (where manually initiated) and monitor the changeover process.

3.12.3 25kV AC Traction Power Supply TTS-274

3.12.3.1 The Unit shall be capable of operating on the 25kV AC Traction Power Supply within the range of voltages and frequencies defined in BS EN 50163:2004 + A1:2007 taking account of the UK special conditions defined in that standard. TTS-275

3.12.3.2 The Unit shall be designed so that, where reasonably practicable, it will be protected from damage when subject to AC voltages outside of the ranges defined in BS EN 50163:2004 + A1:2007. TTS-276

3.12.3.3 The Unit shall be fitted with a means to limit the maximum amount of power drawn from, and returned to, the AC Traction Power Supply. The Unit shall be designed such that the following limits may be separately set by authorised maintenance staff:

- the maximum amount of current a Unit may draw when operating from an AC Traction Power Supply;
- the maximum amount of current a Multiple Unit may draw when operating from an AC Traction Power Supply; TTS-277
- the maximum amount of current a Unit may return when operating from an AC Traction Power Supply; and
- the maximum amount of current a Multiple Unit may return when operating from an AC Traction Power Supply.

It shall be possible to set the limits listed above in increments of 1A and independently of any limits associated with the DC Traction Power Supply.

It shall also be possible to set different limits for different Unit lengths and also for Multiple Units.

3.12.3.4 The Unit shall have the capability to automatically vary the power limit for the four categories listed in clause 3.12.3.3, to one of a number of pre-defined power limit levels, according to the geographic location of the Unit whilst it is in service. The pre-defined power limit levels for each category shall be agreed with the Purchaser. TTS-278

3.12.3.5 The Unit shall be compatible with traction supply auto re-close as defined in BS EN 50388:2005. TTS-279

3.12.3.6 The Unit shall be compatible with a Traction Power Supply capable of delivering a maximum short circuit current as defined within BS EN 50388:2005. TTS-280

3.12.3.7 The inrush current of the Unit shall not exceed 500A. TTS-281

3.12.3.8 The closing of the main traction circuit breakers across all Units shall be staggered to prevent simultaneous inrush currents occurring on Units operating in the same electrical section. TTS-282

3.12.3.9 Whilst achieving the requirement of clause 3.12.3.8 the maximum stagger time delay on any Unit shall be restricted to that which is absolutely essential and shall be no greater than 1 second. TTS-283

3.12.3.10 Opening and closing of the main traction circuit breaker in the event of loss of 25kV AC Traction Power Supply to the Unit shall be in accordance with BS EN 50388:2005. TTS-284

3.12.3.11 When braking, the Unit shall regenerate energy into the AC Traction Power Supply within the parameters defined in Network Rail Standard NR/GN/ELP/27010. TTS-285

3.12.3.12 The Regenerative Braking system shall be configured to automatically resume Regenerative Braking immediately: TTS-286

- after passing through a neutral section; and
- after a Traction Power Supply Changeover completed at speed.

TTS-287

3.12.4 Third Rail DC Traction Power Supply

3.12.4.1 The Unit shall be capable of operating on the 750V DC Traction Power Supply within the range of voltages defined in BS EN 50163:2004 + A1: 2007 taking account of the UK special conditions defined in that standard. The nominal voltage shall be considered to be 750V DC. TTS-288

3.12.4.2 The Euston to Watford Junction sections of the LO Infrastructure are shared with London Underground's four rail DC Traction Power Supply system and have a nominal voltage less than 750V DC but within the range of voltages defined in clause 3.12.4.1. The Unit shall be capable of operating from this DC Traction Power Supply. TTS-289

3.12.4.3 In accordance with NR/GN/ELP/27010, the manner in which the maximum permissible current drawn from the third rail DC Traction Power Supply varies with line voltage shall be agreed with Network Rail. TTS-290

3.12.4.4 The Unit shall be fitted with a means to limit the maximum amount of power drawn from, and returned to, the DC Traction Power Supply. The Unit shall be designed such that the following limits may be separately set by authorised maintenance staff: TTS-291

- the maximum amount of current a Unit may draw when operating from a DC Traction Power Supply;
- the maximum amount of current a Multiple Unit may draw when operating from a DC Traction Power Supply;
- the maximum amount of current a Unit may return when operating from a DC Traction Power Supply; and
- the maximum amount of current a Multiple Unit may return when operating from a DC Traction Power Supply.

It shall be possible to set the limits listed above in increments of 10A independently of any limits associated with the AC Traction Power Supply.

It shall also be possible to set different limits for different Unit lengths and also for Multiple Units.

3.12.4.5 When operating on the East London Line Route, a 4 Vehicle Unit shall be restricted so that it shall draw no more than 2250A from the 750V DC Traction Power Supply. The current draw for a 5 Vehicle Unit and Multiple Unit configurations on this section of the LO Infrastructure shall be agreed with the Purchaser. TTS-292

3.12.4.6 On the Network Rail sections of LO Infrastructure, the same maximum current limit of clause 3.12.4.5 shall initially be applied, prior to final agreements being reached with the Purchaser and Network Rail. TTS-293

3.12.4.7 The Unit shall have the capability to automatically vary the power limit for the four categories listed in clause 3.12.4.4, to one of a number of pre-defined power limit levels, according to the geographic location of the Unit whilst it is in service. The pre-defined power limit levels for each category shall be agreed with the Purchaser. TTS-294

3.12.4.8 The Unit shall be designed so that, where reasonably practicable, it will be protected from damage when subject to DC voltages outside of the ranges defined in BS EN 50163:2004 + A1:2007. TTS-295

3.12.4.9 The Unit shall be compatible with a DC Traction Power Supply capable of delivering maximum short circuit currents as defined within BS EN 50388:2005 and NR/GN/ELP/27010. TTS-296

3.12.4.10 When braking, the Unit shall regenerate energy into the third rail DC Traction Power Supply within the parameters defined in Network Rail Standard NR/GN/ELP/27010 or as agreed with the Infrastructure Manager. TTS-297

It may be necessary to limit the maximum voltage generated by the Unit to a value less than U_{max2}. U_{max2} as defined in BS EN 50163:2004 + A1 : 2007. This limit shall be agreed with the Purchaser.

3.12.4.11 The Regenerative Braking system shall be configured to automatically resume regenerative braking into the third rail DC Traction Power Supply immediately: TTS-298

- after line gaps; and
- after a Traction Power Supply Changeover completed at speed.

3.12.4.12 The Unit shall be equipped with sufficient current collection shoegear appropriately spaced to reduce the interruption of the DC Traction Power Supply when passing over section gaps. TTS-299

3.12.4.13 The current collection shoegear shall be isolated but not earthed when the Dual Voltage Unit is operating on a 25kV AC Traction Power Supply. TTS-2600

3.12.4.14 The Unit shall be designed such that the loss of a single current collection shoe in each electrically distinct part of the DC Traction System power circuit busline shall not result in a failure to meet the specified journey times. TTS-2601

3.12.4.15 When operating on the third rail DC Traction Power Supply, the Unit shall not form an electrical connection or a transient connection by arcing, over a section gap, where the third rail section gap is 40m or more in length. TTS-300

3.13 Traction System

TTS-301

3.13.1.1 The Traction System fitted to the Unit shall ensure that the Unit meets the requirements defined within this specification, including when configured in single Unit and Multiple Unit configurations, for passenger service, rescue operations and non-passenger moves. The following specification sections define requirements of particular importance to the Traction System:

- Unit Lengths and Configurations (Section 3.1);
- Unit Performance and Journey Times (Section 3.2);
- Energy Consumption (Section 3.4);
- Traction Power Supply (Section 3.12);
- Pantographs (Section 3.14);
- DC Current Collection, Sleet Brushes and De-icing Equipment (Section 3.15);
- Rescue Functionality (Section 3.24);
- Reliability (Section 3.41); and
- EMC (Section 3.43).

TTS-302

3.13.1.2 The Traction System shall be capable of operating from either the AC Traction Power Supply or the DC Traction Power Supply, using common components in the power and control circuit where appropriate. TTS-303

3.13.1.3 The Traction System shall be configured to eliminate, where practicable, the possibility of the Unit becoming totally immobilised due solely to a fault with the Traction System. TTS-304

3.13.1.4 The operation of the Traction System (including regenerative braking functionality as required by Section 3.19) shall be compatible with the OHL neutral section layouts and third rail gaps encountered on the LO Infrastructure. TTS-305

3.13.1.5 All Units shall include traction shore supply receptacles and associated safety interlocking to interface with a 750V DC nominal depot supply used to shunt a Unit out of a maintenance shed. TTS-2602

3.14 Pantographs

TTS-306

3.14.1.1 The Units pantograph position and performance shall be suitable for operation on all the LO Infrastructure which will include a mixture of legacy Network Rail OHL and new TSI compliant OHL. TTS-307

3.14.1.2 The dynamic response of the Unit pantograph shall be compatible with the rates of change in vertical alignment of track and overhead equipment on the LO Infrastructure. The alignment of OHL shall be assumed to be in accordance with NR/GN/ELP/27088 and new GOB Infrastructure shall be assumed to be in accordance with BS EN 50119:2009 +A1 2013. TTS-308

3.14.1.3	The Unit design shall ensure that when operating in multiple that the pantograph spacing shall comply with the requirements of the Energy-TSI, clause 4.2.17 type B. Should the design not fully comply with clause 4.2.17 type B, the proposed pantograph spacing and design shall be demonstrated as being acceptable with the OHL design in accordance with the process outlined in the Energy-TSI. In addition to the requirements of the Energy-TSI the requirements of draft standard GM/RT2111 shall be achieved.	TTS-309
3.14.1.4	The pantograph fitted to the Unit shall comply with the characteristics and requirements for pantograph configuration stated in BS EN 50206-1:2010.	TTS-310
3.14.1.5	The pantograph head for the Unit shall comply with BS EN 50367:2012, Annex B figure B.6.	TTS-311
3.14.1.6	The maximum pantograph head width i.e. the carbon spacing perpendicular to the direction of travel for the Unit shall be 260mm.	TTS-312
3.14.1.7	The pantograph for the Unit shall be designed to have contact forces compliant with BS EN 50367:2012 and draft standard GM/RT2111.	TTS-313
3.14.1.8	The pantograph for the Unit shall be designed to operate with the range of design contact wire height as specified in the Network Rail Standard NR/GN/ELP/27088, with maximum permitted tolerances, between a minimum design height of 4165mm and a maximum permissible design height of 6200mm dynamic.	TTS-314
3.14.1.9	The pantograph for the Unit shall be designed to operate with a maximum lateral deviation of the contact wire of +/-565mm at 4.7m, with respect to the nominal position of the track and operate with a contact wire deviation of +/-400mm at contact wire heights up to 5.75m.	TTS-315
3.14.1.10	The pantograph for the Unit shall be equipped with an automatic over height dropping device to fully lower the pantograph when the height limit of 6365mm is reached as specified in draft standard GM/RT2111.	TTS-316
3.14.1.11	The pantograph for the Unit shall be equipped with an auto drop device (ADD) to fully lower the pantograph if damage occurs to contact strips that is liable to cause subsequent damage to the overhead line, in accordance with BS EN 50206-1:2010 and draft standard GM/RT2111.	TTS-317
3.14.1.12	The pantograph ADD device shall have a manually operated isolation device accessible from within the Unit. Operation of the ADD isolation device shall be indicated to the driver.	TTS-318
3.14.1.13	Operation of the pantograph ADD device shall be immediately reported to the driver.	TTS-319
3.14.1.14	Clause not used.	TTS-320
3.14.1.15	The Unit shall be equipped with AVI tags to fulfil the requirements of Network Rail Standard NR/PS/ELP/21072 Trackside Pantograph Monitoring Equipment.	TTS-321
3.14.1.16	A minimum of two AVI tags per Unit, one per Unit side shall be fitted. The AVI tag dimensions will have the following maximum dimensions 300mm long, 100mm wide and 50mm deep, with an approximate mass of 100g.	TTS-322
3.14.1.17	The AVI tags shall be fitted to ensure they are not shielded or obstructed by any bodyside fittings, vinyl livery film or bodyside sacrificial coatings.	TTS-323
3.14.1.18	The AVI tags shall be positioned on the Unit in the solebar region at a height of between 1.0m and 1.4m above rail level (ARL) and located no greater	TTS-324

than 1m behind the bogie pivot point.

3.14.1.19	The Unit shall be fitted with automatic power control (APC) equipment in accordance with NR/GN/ELP/27010 and draft standard GM/RT2111.	TTS-325
3.14.1.20	The Unit APC system shall have the future capability to include an interface with an ETCS Eurobalise to allow it to control operation of the APC system. It shall be possible for the Eurobalise to control the operation of APC for each pantograph circuit breaker individually.	TTS-326
3.15	**DC Current Collection, Sleet Brushes and De-icing Equipment**	TTS-327
3.15.1	**DC Current Collection**	TTS-328
3.15.1.1	Dual Voltage Units shall be fitted with retractable current collection shoegear, suitable for operation over all LO Infrastructure. The retractable shoegear design shall not impose gauge restrictions on where the Units may operate.	TTS-329
3.15.1.2	The retractable current collection shoegear shall be compliant with the requirements of Network Rail standard NR/GN/ELP/27010 and draft standard GM/RT2113.	TTS-330
3.15.2	**Third Rail Conductor Sleet Brushes**	TTS-334
3.15.2.1	The Dual Voltage Units shall be fitted with appropriate retractable sleet brushes that remove snow, ice and slush from the head of the third conductor rail.	TTS-335
3.15.2.2	The Units sleet brushes shall be capable of being lowered and raised by the driver via a single pushbutton situated on the cab desk.	TTS-336
3.15.2.3	The AC Only Units shall have passive provision for future fitment of sleet brushes.	TTS-337
3.15.3	**Third Rail De-icing System**	TTS-338
3.15.3.1	Three Dual Voltage Units shall be fitted with a de-icing system that shall apply a pre-controlled amount of de-icing fluid to the third conductor rail.	TTS-339
3.15.3.2	The de-icing system shall only apply de-icing fluid on the side of the Vehicle where and when a third conductor rail is present and only while the Unit is moving.	TTS-340
3.15.3.3	The de-icing equipment shall be capable of being switched on and off by the driver via a single pushbutton situated on the cab desk.	TTS-341
3.15.3.4	The type of de-icing fluid used shall be agreed with the Purchaser.	TTS-342
3.15.3.5	The application rate of the de-icing fluid shall be agreed with the Purchaser.	TTS-343
3.15.3.6	AC Only Units shall have passive provision for future fitment of de-icing equipment.	TTS-344
3.16	**Auxiliary Power Systems**	TTS-345
3.16.1.1	The Unit shall have an auxiliary power system that provides the power to support the electrical equipment (other than Traction System) of the Unit.	TTS-346
3.16.1.2	The capacity of the Unit's auxiliary power supply shall be continuously rated at 10% over the calculated design loading, to allow for the demand from any additional equipment fitted during the life of the Unit.	TTS-347

3.16.1.3 In the event of loss of power supply the Unit shall have a battery system that maintains power for at least the following systems for a minimum of 90 minutes:

- Standby Lighting (as defined within BS EN 13272:2012);
- external lights;
- door control systems, minimum 1 actuation of 1 door per side per Vehicle; TTS-348
- public address systems;
- crew communications systems;
- train protection systems and on-board signalling equipment; and
- the GSM-R train radio.

Ventilation fans shall be maintained by the battery system for at least 60 minutes following the loss of power supply.

3.16.1.4 In addition to the requirements of clause 3.16.1.3 the following systems shall be provided with a power supply from the battery system for a further 90 minutes (in accordance with the requirements of the CR-TSI and SRT-TSI):

- public address systems; TTS-349
- crew communications systems; and
- the GSM-R train radio.

3.16.1.5 The Unit shall include redundancy within the auxiliary power system such that in the event of partial failure, the available power is distributed to maintain passenger comfort and Unit functionality as far as practicable. TTS-350

3.16.1.6 In the event of a short term Traction Power Supply interruption of 120 seconds or less, all Subsystems designed to be powered from the Unit battery charger supply shall remain powered. TTS-351

3.16.1.7 In addition to the requirements of 3.16.1.6, in accordance with BS EN 13272: 2012, general lighting shall be maintained from the Unit battery supply for no less than 10 minutes after the loss of Traction Power Supply. TTS-352

3.16.1.8 In the event of any loss of Traction Power Supply the Unit and its Subsystems shall always be capable of being fully restarted immediately following restoration of the Traction Power Supply. TTS-353

3.16.1.9 All Units shall include battery charging receptacles / sockets that enable an external battery charging supply to be connected directly to the battery whilst being disconnected from the main Unit wiring. The interface shall be acceptable to the Purchaser. TTS-354

3.16.1.10 Faults with the auxiliary power systems that may lead to the non-operation of any of the Unit Subsystems shall be recorded within the Train Management System and alarms generated with the appropriate category. TTS-355

3.17 Unit Construction TTS-356

3.17.1.1 The Unit structures and equipment shall be designed to achieve the required design life against foreseeable fatigue cases having regard to:

- the annual fleet diagram mileage specified in the MSA and TSA; TTS-357
- the duty cycles associated with achieving the Journey Times; and

- Normal Payload passenger loadings.

3.17.1.2 Ripples or distortions in the Vehicle body side shall be less than 2mm over a length of one metre (excluding Vehicle roof and under frame). TTS-358

3.17.1.3 The Unit shall, as far as practicable, have smooth exterior body contours to allow efficient automatic or manual washing. TTS-359

3.17.1.4 The Unit shall be fully watertight and prevent the ingress of water to the cab and passenger saloon including the gangway area under all operating conditions and when passing through automatic washing plant or when being manually washed using pressure washers. TTS-360

3.17.1.5 The Unit shall be fitted with gutters above exterior doorways to reduce water ingress into Vehicles through open doorways. TTS-361

3.17.1.6 The Unit shall be designed to ensure that condensate or water cannot accumulate within Vehicles and that all areas are adequately sealed or drained. TTS-362

3.17.1.7 Vehicle roofs, roof wells, roof mounted equipment, fitments and antennae shall not allow rain water or melting snow to accumulate. TTS-363

3.17.1.8 Bogies and underframe mounted equipment and components shall be capable of being externally cleaned without detriment, using high pressure hot water and steam jet cleaning equipment, with or without detergents. TTS-364

3.17.1.9 The Unit shall be designed to allow for timely repair, which shall include, but is not limited to the occurrence of the following scenarios:

- low speed buffer stop impacts - up to 10mph;
- low speed derailments - up to 10mph;
- depot side swipes - where the corner of one Vehicle contacts the side of another Vehicle due to two Units being left too close to points and crossings causing linear damage down the side of the Unit at up to 10mph; TTS-365
- running over small obstacles on the track e.g. shopping trolleys - up to the maximum speed of the Unit; and
- re-painting or refinishing following localised damage to the Vehicle painted finish.

3.18 Exterior Appearance and Livery TTS-367

3.18.1.1 The Unit shall have an exterior appearance and styling representing good practice in modern suburban rolling stock and metro design and reflecting the requirements in Appendix E. TTS-368

3.18.1.2 The Unit shall be delivered in a livery, including branding acceptable to the Purchaser. TTS-369

3.18.1.3 Exterior data (e.g. Unit Vehicle identifying numbers, data panels etc.) visible above platform level shall be integrated with the livery to the maximum degree permitted by Applicable Laws and Standards, and shall be acceptable to the Purchaser. TTS-370

3.18.1.4 The Unit livery shall clearly differentiate passenger doorways designated for use by PRM in a manner that is discreet and consistent with the Unit livery, for example by the use of colour bands adjacent to the passenger doorway. TTS-371

The means by which this shall be achieved shall be acceptable to the

Purchaser.

3.18.1.5	The Unit shall be painted and permit the application and removal of vinyl film to the painted finish without degradation.	TTS-372
3.18.1.6	The painted finish shall have a high quality of detailing and finish, which shall remain durable and colour-fast for a life of not less than 12 years in service.	TTS-373
3.18.1.7	Any vinyl films used as part of the finish shall have a life of no less than 6 years.	TTS-374
3.18.1.8	The exterior finishes shall be resistant to the effects of any fluids (such as graffiti removal or cleaning chemicals) likely to be encountered in the railway environment.	TTS-375
3.18.1.9	The exterior finishes shall conform to the Schedule of Finishes agreed with the Purchaser.	TTS-376

3.19 Braking System

TTS-377

3.19.1 Braking System General

TTS-378

3.19.1.1	The braking system shall provide sufficient levels of braking to permit control of the Unit's speed to meet service operation and Journey Time requirements.	TTS-379
3.19.1.2	The braking system on the Unit shall combine a friction brake with dynamic electric braking.	TTS-380
3.19.1.3	The friction brake shall be rated with sufficient braking performance and thermal capability to meet the mandated stopping distances for the agreed operational load conditions and speeds. Any operational constraints on the repeated use of the friction brake shall be agreed by the Purchaser.	TTS-381
3.19.1.4	The braking system shall be sufficient to support the rescue scenarios detailed within this specification.	TTS-382
3.19.1.5	The braking system shall achieve Full Service braking in compliance with GM/RT2044 Appendix 3, curve A3.	TTS-383
3.19.1.6	For AC Only Units, the dynamic electric brake shall function as a Regenerative Brake to maximise the recovery of energy.	TTS-384
3.19.1.7	For Dual Voltage Units, the dynamic electric brake shall function as a Regenerative Brake to maximise the recovery of energy while operating on AC receptive infrastructure.	TTS-385
3.19.1.8	For Dual Voltage Units, the dynamic electric brake shall function as a Regenerative Brake to maximise the recovery of energy while operating on DC receptive infrastructure.	TTS-386
3.19.1.9	For Dual Voltage Units, the dynamic electric brake shall function as a Rheostatic Brake only on routes not permitting regeneration.	TTS-387
3.19.1.10	The Regenerative Brake shall be sized and configured to maximise energy recovery during a full service brake application.	TTS-388
3.19.1.11	The braking system shall control the blending of the brakes to maximise the use of Regenerative Brake wherever possible and ensure that the most energy efficient and cost effective overall braking system combination is employed.	TTS-389

3.19.1.12 The brake system shall control the blending of the brakes under all foreseeable conditions of wheel to rail adhesion. TTS-390

3.19.1.13 The electric dynamic Brake shall be capable of being isolated if necessary for operational or safety reasons. The method of isolation shall be acceptable to the Purchaser. Isolation and re-instatement shall be recorded by the TMS and displayed to the driver. TTS-391

3.19.1.14 The Unit must be capable of automatically holding and safe starting on gradients without rolling back or forwards on the maximum gradient on LO Infrastructure. The design settings for the automatic holding brake shall prevent the risk of the Unit being gapped at neutral sections or gaps in the third conductor rail. TTS-392

3.19.1.15 The braking system shall incorporate a mechanism to allow the release and isolation of individual Vehicle brakes, for operation under degraded modes or to allow recovery. TTS-393

The mechanism shall be secured against misuse, and shall be accessible when the Vehicle is operating in any location on LO Infrastructure.

TTS-394

3.19.2 Automatic Parking Brake System

3.19.2.1 An automatic spring applied parking brake shall be incorporated into the brake system design. TTS-395

3.19.2.2 The control of the parking brake shall be such that on a Unit initially held by the parking brake, the parking brake shall not release until the service friction brake has been fully established. TTS-396

3.19.2.3 The interaction of the parking brake and the service brakes shall be such that during any transitional phase between parking brakes off, parking brakes on and service brakes on and service brakes off, that holding force is maintained to achieve the requirements of this specification. TTS-397

3.19.2.4 The performance for the parking brake shall secure the Unit under Any Loading Condition on the steepest gradient on LO Infrastructure. TTS-398

3.19.2.5 The Unit shall allow the manual application of the parking brakes from inside the driving cabs under degraded modes of operation. TTS-399

Access to this facility shall be by Authorised Person and controlled as part of the key strategy.

3.19.2.6 Under failure conditions it shall be possible to manually release the parking brakes without train crew going underneath or between Vehicles. The release mechanism shall be accessible from track level and platforms. TTS-400

TTS-401

3.19.3 Braking System Controls

3.19.3.1 Brake system to driver interfaces and controls, including master controllers, isolation devices, and indicator devices, shall meet all Applicable Laws and Standards and shall be subject to human factors assessment. TTS-402

TTS-403

3.20 Wheel Slip / Slide Protection System

3.20.1.1 A wheel slip / slide protection (WSP) system, complying with BS EN 15595 and taking account of the guidance in the national foreword regarding UK adhesion levels, shall be provided on all axles to control the level of traction and braking during conditions of reduced wheel to rail adhesion. TTS-404

3.20.1.2 The design of the Unit's wheel slip / slide system shall incorporate all TTS-405

relevant recommendations of the RAIB Autumn Adhesion Investigations reports available at http://www.raib.gov.uk/, reference 070108_R252006.

3.20.1.3 The WSP system shall maximise the use of the available wheel-rail adhesion and minimise the thermal damage to the wheel and to the rail in all reasonably foreseeable UK wheel-rail conditions. TTS-406

3.20.1.4 The WSP system shall integrate both the control of the friction brake and the dynamic electric brake, and under all foreseeable conditions of wheel-rail adhesion shall be capable of controlling the level of slide. TTS-407

3.20.1.5 The dynamic electric brake shall not become permanently disabled by operation of the WSP system, either on an individual Vehicle or on the whole Unit. Dynamic electric brake functionality shall automatically resume after the Unit has been braked to a standstill. TTS-408

3.20.1.6 The WSP system operation shall be logged by the TMS, capturing WSP activity, time and location. The information shall be sufficient to allow real time reporting and subsequent analysis by the operator of the location and severity of low adhesion conditions on LO Infrastructure. TTS-409

3.20.1.7 The WSP activity data shall be available for downloading to the Wayside within one minute of the activity occurring and shall be readily accessible to the Purchaser. The degree of WSP activity required to trigger the report to the Wayside shall be configurable and shall be agreed with the Purchaser. The data shall be presented in a format agreed with and acceptable to the Purchaser. Refer also to 3.39.4. TTS-410

3.21 Sanding System TTS-411

3.21.1.1 The Unit shall be fitted with a sanding system that conditions the rail head under low levels of adhesion. The system shall be integrated into both the traction and braking systems. TTS-412

3.21.1.2 The sanding system shall automatically apply sand to the wheel rail interface when wheel slide is detected during braking, irrespective of the level of braking being demanded. TTS-413

3.21.1.3 The sanding system shall allow the driver to demand sand application if required during traction. The demanded application of sand shall only be allowed when wheel spin is detected during traction. The application of sand during traction shall be automatically inhibited if the sand level is low. TTS-414

3.21.1.4 The sanding system shall be configured to maximise the efficiency of sanding and the improvement of adhesion between wheel and rail. To support this, the sanding system shall be capable of delivering variable rates of sand while operating in the braking mode. TTS-415

3.21.1.5 The variable sand rate shall be linked to Unit speed to maximise the improvement in adhesion. TTS-416

3.21.1.6 The Unit design shall have the capability for sand to be delivered to the railhead by more than one Unit within any multiple formations of Units, to provide efficient sanding for the train. The Purchaser will support the Manufacturer in the development of any necessary derogation from the requirements of GM/RT2461 Issue 1:2001. TTS-417

3.21.1.7 The sanding system shall allow the manual isolation of the sand delivery equipment at each position where it is fitted. TTS-418

3.21.1.8 The sanding system shall comply with the requirements of GM/RT2461, TTS-419

where it does not conflict with the requirements of this specification.

3.21.1.9 The sanding system operation shall be logged by the TMS, capturing sanding activity, time, location and remaining sand levels. The information shall be sufficient to allow real time reporting and subsequent analysis by the operator. The details shall be sufficient to reliably inform maintenance staff when to replenish the storage of sand on a Unit. TTS-420

3.21.1.10 The sanding activity data shall be available for downloading to the Wayside within one minute of the activity occurring and shall be readily accessible to the Purchaser. The degree of sanding activity required to trigger the report to the Wayside shall be configurable and shall be agreed with the Purchaser. The data shall be presented in a format agreed with and acceptable to the Purchaser. Refer also to 3.39.4. TTS-421

3.21.1.11 The sanding system shall permit the sand to be replenished by Authorised Persons while the Unit is at station platforms, by a method to be agreed with the Purchaser. TTS-422

3.21.1.12 The sanding system shall permit the sand to be replenished from the Vehicle exterior, by Authorised Persons, while the Unit is stationary in sidings and staff are working from ground level. TTS-423

3.22 Lubrication System TTS-424

3.22.1.1 The Unit shall have passive provision for the future installation of a wheel flange lubrication system to control wheel / rail wear and prevent sustained generation of flange squeal or wheel ringing. TTS-425

3.22.1.2 The provision for a flange lubrication system may be of either the solid stick type system or an automatic sprayed grease type system. TTS-426

3.22.1.3 Irrespective of the type of wheel flange lubrication system offered, it shall ensure that all wheels of the Unit are adequately lubricated to manage wheel / rail wear and noise. TTS-427

3.22.1.4 The passive provision shall allow the flange lubrication applicators to be installed on at least one wheel position per side of every Vehicle. TTS-428

3.22.1.5 If the proposed wheel flange lubrication system is of the sprayed grease type, the system shall be configurable so that the application of lubricant is automatically controlled relative to: TTS-429

- Route section;
- Unit geographical location;
- Unit speed; and
- Actual track curvature.

3.23 Couplers TTS-430

3.23.1 Driving End Couplers TTS-431

3.23.1.1 The Units shall be equipped with an automatic mechanical, electrical and pneumatic coupling system compatible with Dellner type 12, such that Units can be readily coupled together for multiple operation, rescue and shunting purposes. TTS-432

3.23.1.2 The feature adopted to allow automatic coupling of electrical systems between Units, shall be provided with a means by which a driver or Authorised Person can prevent the automatic coupling of the electrical TTS-433

systems, preventing the transfer of electrical faults from one Unit to the other coupled Unit.

3.23.1.3 The automatic coupler shall be mechanically and pneumatically compatible with 'Electrostar' (Class 375, 376, 377, 378, 379) and 'Desiro' (Class 360, 450, 444, 350) units fitted with Dellner type 12 Driving End couplers and nominally 7 bar pneumatic systems to the extent necessary for rescue purposes only. TTS-434

3.23.1.4 The automatic coupler shall be fitted with the centreline of the coupling face 925mm above rail level. TTS-435

3.23.1.5 The automatic coupler mechanism shall be provided with a visible indication that coupling has been successfully completed. TTS-436

3.23.1.6 The automatic couplers shall enable splitting and joining of Units on all LO Infrastructure, depots and sidings and over any track geometry compliant to GM/GN2690 Appendix 7, Issue 1, December 2004, for both mainline and non-passenger lines. TTS-437

Supplementary measures may be proposed to ensure compliance with this requirement on extreme curvature.

3.23.1.7 The automatic couplers shall enable splitting and joining of Units, with either or both Units having deflated air suspension. TTS-438

3.23.1.8 The automatic coupler shall allow Units to run coupled on all LO Infrastructure, depots and sidings and over any track geometry compliant to GM/GN2690 Appendix 7, Issue 1, December 2004, for both mainline and non-passenger lines. TTS-439

3.23.1.9 In addition to the requirements of 3.23.1.8 the automatic coupler shall allow Units to run coupled together without damage to either Unit on the following infrastructure at Ilford Depot:

- A reverse curve consisting of a 134m curve, a straight section of 4.7m and a subsequent curve of 109m (i.e. 134m-4.7m-109m reverse curve), and TTS-440
- A reverse curve consisting of a 133m curve, a straight section of 1.6m and a subsequent curve of 102m (i.e.133m-1.6m-102m reverse curve).

3.23.2 Inter-Vehicle Couplers within Units

TTS-441

3.23.2.1 Within the Unit, inter-Vehicle couplings shall be of the fixed bar type (not automatic). These shall be separable in the depot to facilitate maintenance and repair. TTS-442

3.23.2.2 The inter-Vehicle couplers shall allow Unit operation on all LO Infrastructure, depots and sidings and over any track geometry compliant to GM/GN2690 Appendix 7, Issue 1, December 2004, for both mainline and non-passenger lines. TTS-443

3.23.2.3 In addition to the requirements of clause 3.23.2.2 the inter-Vehicle coupler shall allow Units to traverse the following infrastructure without becoming damaged at Ilford Depot: TTS-444

- A reverse curve consisting of a 134m curve, a straight section of 4.7m and a subsequent curve of 109m (i.e. 134m-4.7m-109m reverse curve), and

- A reverse curve consisting of a 133m curve, a straight section of 1.6m and a subsequent curve of 102m (i.e.133m-1.6m-102m reverse curve).

3.23.3 Cab End Coupler Adaptors

TTS-445

3.23.3.1 Coupling adaptors shall enable Units to be recovered by a locomotive fitted with any of the following:

TTS-446

- a standard (UIC or RGS) draw hook and shackle; and
- a standard (UIC or RGS) draw hook and drop head buckeye coupler.

3.23.3.2 Coupling adaptors shall enable the Units to couple for rescue purposes to other unit types (including the Class 315 and Class 317) fitted with a tightlock coupler. TTS-2603

3.23.3.3 Coupling adaptors, including any hoses, shall be compatible with and suitable for use with a locomotive and other unit types fitted with a standard UK (nominal 7 bar) air brake system to allow connection of the main reservoir supply and the design shall ensure fail safe protection in the event of a train division. TTS-447

3.23.3.4 The design of the adaptor couplings shall be acceptable to the Purchaser. TTS-448

3.24 Rescue Performance and Functionality

TTS-449

3.24.1.1 It shall be possible for a Unit in Any Loading Condition to rescue another failed or otherwise un-powered Unit in Any Loading Condition, whether being propelled or hauled. In the event of such a rescue, the formation shall be:

TTS-450

- capable of starting from standstill on the steepest gradient;
- capable of traversing any of the LO Infrastructure, without any limitation on distance travelled;
- capable of operating at speeds of up to 75mph; and
- the available traction power of the rescuing Unit shall be no less than that available when operating normally.

3.24.1.2 It shall be possible for two coupled fully working Units in Any Loading Condition to rescue two failed or otherwise un-powered Units in Any Loading Condition, whether being propelled or hauled. In the event of such a rescue, the formation shall be:

TTS-451

- capable of starting from standstill on the steepest gradient;
- capable of traversing any of the LO Infrastructure, without any limitation on distance travelled;
- capable of operating at speeds up to 75mph; and
- the available traction power of the rescuing Units shall be no less than that available when operating normally.

3.24.1.3 In addition to the requirements of clauses 3.24.1.1 and 3.24.1.2, it shall be possible for a Unit to rescue two failed or otherwise un-powered Units (whether being propelled or hauled), starting from standstill. Where the traction system design and capability required to fulfil the train performance requirements in section 3.2 and also clauses 3.24.1.1 and 3.24.1.2 would result in limitations on loading conditions, gradients, operating speeds and / TTS-452

or distance travelled for this particular rescue scenario, the limitations shall be identified and agreed with the Purchaser.

3.24.1.4 For the rescue operations defined in clauses 3.24.1.1 and 3.24.1.2 it shall be possible to stop and re-start at any point on the route without limitation. TTS-453

3.24.1.5 For the rescue operations defined in clause 3.24.1.3 it shall be possible to stop and re-start at any point on the route without any additional limitation other than those agreed in clause 3.24.1.3. TTS-454

3.24.1.6 The rescue operations defined in clauses 3.24.1.1, 3.24.1.2 and 3.24.1.3 shall be achieved with line voltages down to and including 17.5kV for the AC Traction Power Supply and down to an including 550V for the DC Traction Power Supply. TTS-455

3.24.1.7 It shall be possible to undertake the rescue operation with any cab as the Occupied Cab. Where the Occupied Cab is not at the front of the formation any controls required in the lead cab to assure safety along with any supporting operational rules shall be agreed with the Purchaser. TTS-456

3.25 Inter-Vehicle Gangways

TTS-457

3.25.1.1 Inter-Vehicle gangways shall be fitted between all Vehicles making up the Unit. TTS-458

3.25.1.2 Gangways shall be as wide as practicable, having sufficient width to allow at least two 95th percentile adult UK male passengers to pass each other line abreast unimpeded. TTS-459

3.25.1.3 Gangways shall allow the self-propelling of passengers in wheelchairs through the Unit while the Unit is on any section of the LO Infrastructure. TTS-460

3.25.1.4 The minimum height within the gangway shall be sufficient for the 95th percentile adult UK male to pass through unimpeded. TTS-461

3.25.1.5 Gangway floors shall be level with the main saloon floors and free from gaps and trip hazards. TTS-462

3.25.1.6 To allow passengers to safely stand in the gangway areas suitable grab rails or other handholds shall be provided.

Any restrictions on the placing of grab rails in gangways necessary to prevent passengers being exposed to different electrical touch potential between vehicles shall be acceptable to the Purchaser. TTS-463

3.25.1.7 Gangways shall be sealed against the ingress of noise, draughts, precipitation, fire and smoke. TTS-464

3.25.1.8 The Unit shall not be equipped with inter-vehicle gangway doors. TTS-465

3.25.1.9 The Gangways shall allow Unit operation and not suffer damage due to Vehicle movements on all LO Infrastructure and over any track geometry compliant to GM/GN2690 Appendix 7, Issue 1, December 2004, for both mainline and non-passenger lines. TTS-466

3.25.1.10 In addition to the requirements of 3.25.1.9 the gangways shall allow Units to traverse the following infrastructure without becoming damaged at Ilford Depot:

- A reverse curve consisting of a 134m curve, a straight section of 4.7m and a subsequent curve of 109m (i.e. 134m-4.7m-109m reverse curve), and TTS-467
- A reverse curve consisting of a 133m curve, a straight section of

1.6m and a subsequent curve of 102m (i.e.133m-1.6m-102m reverse curve).

3.26 External Features (Lighting / Horns / Grab rails / Footsteps) TTS-468

3.26.1 External Lighting TTS-469

3.26.1.1 The Unit external lights shall comply with the requirements of GM/RT2483 Visibility Requirements for Trains. TTS-470

3.26.1.2 The Unit shall have driver's controls for the external lighting system that are compliant with GM/RT2483. TTS-471

3.26.1.3 In addition to 'on' and 'off' there shall be an 'automatic' tail light setting which defaults the local tail light to be 'on' at the end of the Unit that has a Non-occupied Cab and is not coupled to another Unit. The tail light functionality shall be acceptable to the Purchaser. TTS-472

3.26.1.4 The status and control setting of the tail lights at the rear of the Unit shall be reported to the driver by the TMS or other means acceptable to the Purchaser. TTS-473

3.26.1.5 The Unit shall be fitted with Bodyside Indicator Lights (BIL) that complies with the requirements of GM/RT2473 clauses B.7.5.2 and B.7.5.5. In addition the BIL shall provide the following functions:

- the BIL on a Vehicle shall flash when a Passenger Emergency Alarm is operated on that Vehicle; and TTS-474
- the BIL on a Vehicle shall flash when the fire detection system is triggered on that Vehicle.

3.26.2 Horns

3.26.2.1 The Unit warning horns shall comply with the requirements of GM/RT2484 Audibility Requirements for Trains. TTS-476

3.26.2.2 The Unit warning horns shall, so far as is practicable, limit the spread of noise beyond the railway boundary and in any case not exceed permitted cab interior noise requirements defined in Applicable Laws and Standards. TTS-477

3.26.2.3 The Unit shall have a low volume audible warning device for use in depots and maintenance areas. The volume, tone and operation of this device shall be acceptable to the Purchaser. TTS-478

3.26.2.4 The operation of the warning horns and low volume audible device shall be unaffected by accumulation of snow and ice. TTS-479

3.26.3 Grab Rails and Footsteps TTS-480

3.26.3.1 The Unit shall incorporate steps and handholds to facilitate safe and easy train crew access to the cab through the external cab access door. TTS-481

3.26.3.2 The Unit shall incorporate fixed footsteps and handholds at passenger bodyside doorways to facilitate safe and efficient passenger entry and exit, in accordance with the requirements of the PRM-TSI. TTS-482

3.26.3.3 The Unit shall incorporate appropriate means of temporarily securing standard UK 'not to be moved' boards towards the front of the Driving Vehicle, accessible from platform level and rail level and visible from the side of the Unit. TTS-483

3.26.3.4 The Unit shall incorporate appropriate means of temporarily securing standard UK portable lights as defined in BR/TS 0629 and BR/TS 0630 on the front of the Driving Vehicle. TTS-484

3.27 DOO and Crew Operation TTS-485

3.27.1 General Requirements TTS-486

3.27.1.1 The Unit shall be operable by a single driver for Driver Only Operation. TTS-487

3.27.1.2 The Unit shall be capable of operation by a driver and a second crew member to assist with Unit dispatch. The second crew member shall be able to facilitate this operation from a Non-occupied Cab. TTS-488

3.27.1.3 The Unit functionality and controls that support the operation of the passenger bodyside doors for Driver Only Operation and driver / second crew member operation are defined in section 3.28. TTS-489

3.27.2 DOO CCTV TTS-490

3.27.2.1 The Unit shall operate with a self-contained Unit based digital CCTV system enabling DOO. This shall allow the monitoring of:

- passenger interchange when the passenger doors are open; TTS-491
- the closing sequence of the Unit doors;
- the safe dispatch of the Units from station platforms.

3.27.2.2 The DOO CCTV system shall utilise cameras mounted on each Vehicle bodyside which shall provide coverage of:

- each passenger saloon door;
- a significant length of the Vehicle bodyside; and TTS-492
- as much of the Vehicle inter-ends as it is reasonably practicable to cover.

3.27.2.3 The DOO CCTV system shall have two colour CCTV display screens located in the driver's cab. TTS-493

3.27.2.4 The DOO CCTV system shall present images to the driver at no less than12 frames per second. TTS-494

3.27.2.5 The DOO CCTV system is essential to the operation of the Unit's and as such shall be highly reliable ensuring all the camera images that shall be presented to the driver for a given location are always displayed. TTS-495

3.27.2.6 The two colour displays for presentation of the DOO CCTV camera images to the driver shall be suitably sized and satisfy human factors requirements for the visibility of targets within each image. TTS-496

3.27.2.7 The DOO CCTV camera images as they appear on the CCTV displays shall be of sufficient size, quality and resolution to support safe despatch of the Units. As a minimum compliance with RIS-2703-RST Issue 01 shall be achieved, excluding the Optional interfaces 4.1 and 4.2.

Additionally, and with reference to RIS-2703-RST, this shall include achieving the minimum resolution requirements of G3.2.2.5 for the camera through to the cab displays. TTS-497

Additionally, the target object, used to achieve the minimum angular size vision detection requirement in 5.3.1 of RIS-2703-RST, shall be a child

target height of 825mm as defined in GN48a of GE/GN8560 Issue 01.

3.27.2.8 The driver's CCTV cab displays shall be viewable from the driver's normal seated position facing forwards. TTS-498

3.27.2.9 The arrangement of the DOO CCTV camera images on the CCTV cab display shall be logical, intuitive and consistent and shall take account of 3.4.7 and 3.4.8 and the supporting guidance in RIS-2703-RST Issue 01. The logical format for four Vehicle Units, five Vehicle Units and then Multiple Unit configurations of these Units shall be considered. TTS-499

3.27.2.10 The arrangement of the camera images across the two CCTV cab displays, for Unit and Multiple Unit configurations, shall support up to 12 DOO CCTV camera images to align with the maximum number of Vehicles that may operate in passenger service. TTS-500

3.27.2.11 The Manufacturer shall propose the arrangement of camera images where Units are coupled for Empty Coaching Stock movements or rescue operations and the number of Vehicles exceeds 12. TTS-501

3.27.2.12 The final arrangement of the DOO CCTV camera images across the two CCTV cab displays for the varying operating modes and numbers of Vehicles shall be proposed by the Manufacturer for agreement with the Purchaser. TTS-502

3.27.2.13 When a CCTV cab display is presenting DOO CCTV camera images to the driver, depending on the arrangements adopted, any blank sectors of the display shall include text to confirm to the driver that those areas have been intentionally left bank. TTS-503

3.27.2.14 For normal driving operation, the DOO CCTV camera images shall be displayed in the Occupied Cab when the Unit is stationary and no more than 2 seconds after the passenger bodyside doors have been enabled. Only the DOO CCTV camera images for each Vehicle on the side where the passenger bodyside doors have been enabled shall be displayed to the driver. TTS-504

3.27.2.15 The DOO CCTV camera images shall continue to be displayed when the passenger bodyside doors are closed and while the Unit accelerates away from the platform. TTS-505

3.27.2.16 The DOO CCTV camera images shall be removed from the CCTV displays when the Unit has reached a speed threshold. The speed threshold shall be proposed by the Manufacturer based on a human factors assessment balancing the needs to ensure safe despatch whilst ensuring the driver is not distracted from other driving duties. The speed threshold shall be agreed with the Purchaser. TTS-506

3.27.2.17 It shall be possible following a request from the Purchaser for authorised maintenance staff to adjust the speed threshold at which the DOO CCTV images are removed from the display screens. It shall not be possible for drivers to make this adjustment. TTS-507

3.27.2.18 If the passenger bodyside doors are enabled on both sides of the Unit no DOO CCTV camera images shall be displayed to the driver. TTS-508

3.27.2.19 In the event that the passenger bodyside doors are enabled on one side of the Unit, are closed by the cab door close command and then the doors on the other side of the Unit are subsequently enabled, the DOO CCTV images presented to the driver shall be consistent with the enabled side. TTS-509

3.27.2.20 Using either soft pushbuttons on the TMS HMI or the CCTV cab displays it shall be possible to request the display of DOO CCTV camera images, when the Unit or Multiple Unit is stationary in both the Occupied and Non-occupied Cabs. TTS-510

3.27.2.21 Using the soft pushbutton functionality it shall be possible to select either:

- the normal multi-camera DOO CCTV dispatch images from either side of the Unit, only one side of the Unit at a time; or
- an individual full screen DOO CCTV camera image from any camera on any Vehicle. TTS-511

It shall be possible to navigate to the soft pushbuttons and display the DOO CCTV images in no more than 5 seconds.

3.27.2.22 When DOO CCTV images are displayed using the soft pushbutton functionality they shall be removed from the CCTV cab displays when, either:

- the function is cancelled using an additional soft pushbutton; or TTS-512
- the Unit has reached the agreed speed threshold defined in clause 3.27.2.16.

3.27.2.23 The DOO CCTV system shall always display the camera images from the correct side of each Vehicle corresponding to:

- for the Occupied Cab, the side for which either the passenger bodyside doors have been enabled or the side that has been selected using the soft pushbuttons; and TTS-513
- for the Non-occupied Cab, the side which has been selected using the soft pushbuttons.

3.27.2.24 The DOO CCTV system shall present real time camera images to the driver with end to end system latency no greater than 200 milliseconds. TTS-514

3.27.2.25 The display of the DOO CCTV images shall include overlay text including a 'heartbeat' / 'life sign' visual indication. The 'heartbeat' / 'life sign' indication shall be generated at the camera and displayed on each image and shall be able to demonstrate that the image has not frozen. The content and positioning of the overlay text shall be agreed with the Purchaser. TTS-515

3.27.2.26 Where the DOO CCTV system fails to display a DOO CCTV camera image the failure shall be clearly identified to the driver by appropriate message text in place of where the image should be. TTS-516

3.27.2.27 The DOO CCTV system shall have a comprehensive fault reporting interface with the TMS. TTS-517

3.27.2.28 The DOO CCTV images as they are presented on the CCTV display screens shall be of high quality and shall not suffer from image degrading artefacts, ghosting or distortion. TTS-518

3.27.2.29 The quality of the DOO CCTV images presented to the driver shall not be adversely affected by reflections from cab lighting. TTS-519

3.27.2.30 The quality of the DOO CCTV images presented to the driver shall be sufficient to support safe despatch of the Units for the full range of external conditions, including but not limited to rain, snow, direct sunlight, sunlight reflections, humidity and temperature fluctuations. This shall include the effects of direct and reflected sunlight on both the bodyside mounted TTS-520

cameras and the DOO CCTV displays in the cab.

3.27.2.31 The quality of the DOO CCTV images presented to the driver shall be sufficient to support safe despatch of the Units for the full range of platform lighting conditions, day and night, for all platforms of the LO Infrastructure. TTS-521

3.27.2.32 Should the CCTV cab displays used to display DOO CCTV camera images be shared with other CCTV functions, for example the display of any Saloon CCTV images following an Event Trigger, the priority of the DOO CCTV system with respect to these other CCTV functions shall be agreed with the Purchaser. TTS-522

3.27.2.33 Where another higher priority CCTV function replaces the DOO CCTV camera images on the CCTV cab displays, when the higher priority function has finished the DOO CCTV camera images shall automatically be re-displayed in order to support the safe dispatch of the Unit. TTS-523

3.27.2.34 Where the DOO CCTV system shares components with other Subsystems the safety and reliability importance of the DOO CCTV shall be taken into account and given appropriate priority. TTS-524

3.27.2.35 All DOO CCTV camera images that are presented on the cab displays shall be recorded at no less than 12 frames per second. The recording media shall retain a minimum of 31 days DOO CCTV footage before overwriting the oldest footage. TTS-525

3.27.2.36 The DOO CCTV image recording function shall use solid state or hard drive recording technology. TTS-2604

3.27.2.37 The DOO CCTV image recording function shall not be able to cause a failure of the DOO CCTV system to display the live DOO CCTV camera images on the cab CCTV displays. TTS-526

3.27.2.38 The DOO CCTV cab displays in an Occupied or Non-occupied Cab shall permit authorised maintenance staff, operations staff or emergency services staff to view recorded DOO CCTV camera footage by using a selection menu screen either on the TMS HMI or the CCTV cab displays. The functionality shall permit the selection of recorded footage based on Vehicle, camera, date and time. Access to this functionality shall be password protected. TTS-527

3.27.2.39 The DOO CCTV system recording equipment shall be located in secure locations and shall provide for the removal of data storage media by maintenance or operation staff for investigative purposes if required. TTS-528

3.27.2.40 The removal of data storage media from the Unit shall not prevent the presentation of live DOO CCTV images to the driver. TTS-529

3.27.2.41 The DOO CCTV system shall be configured so that all live and recorded images on a Unit may be accessed via a single diagnostic port (location of port to be acceptable to the Purchaser) using a laptop computer or other device. TTS-530

3.27.2.42 Special tools, equipment and software required for the processing and analysis of the DOO CCTV system data shall allow the following:

- retrieving image data via the diagnostic port referenced in clause 3.27.2.41, for off-board review and/or transfer and storage on separate secure digital media; TTS-531
- retrieving image data from a data storage media removed from the Unit, as referenced in clause 3.27.2.39, for off-board review and/or

storage on another separate secure digital media;

- searching and viewing recorded data by the input of specific date, time or Event Trigger criteria, either via the Unit diagnostic port or by plugging into the data storage media removed from the Unit;
- viewing images from any DOO CCTV camera with a minimum of 4 images displayed simultaneously, either via the Unit diagnostic port for live or recorded footage or by plugging into the data storage media removed from the Unit for recorded footage; and
- scrolling through image data, with play, pause, fast forward and fast rewind functions, either via the diagnostic port or by plugging into the data storage media removed from the Unit.

3.27.2.43 The process of DOO CCTV image recording, on the Unit and through to off-board review and storage shall be permanently watermarked to provide a secure and auditable trail of evidence that satisfies the requirements of evidential continuity, proving that the data has not been tampered with in any way. As a minimum the watermarking of images shall include:

- Unit identification; TTS-532
- Unit Reporting Number;
- Vehicle number;
- camera position; and
- date and time.

3.28 Passenger Bodyside Door Systems TTS-533

3.28.1 General Requirements TTS-534

3.28.1.1 The Unit shall be provided with reliable and mechanically secure power operated passenger bodyside door systems. The doors shall be of either a sliding pocket or sliding plug type, such that each door leaf does not project beyond the main bodyshell profile when the Unit is in motion. All passenger bodyside doors shall be an identical design. TTS-535

3.28.1.2 Each Vehicle shall be provided with two passenger bodyside doors per side nominally located at the one third and two thirds longitudinal position. TTS-536

3.28.1.3 In the open position each passenger bodyside door shall have a throughway width of between 1450mm and 1550mm. TTS-537

3.28.1.4 The mechanical and electrical design of the passenger bodyside door system shall optimise passenger interchange within the Dwell Time of each station. This shall be achieved by optimising the time taken, from the respective initiating commands for:

- the doors to enable and subsequently fully open from a closed state; and TTS-538
- the doors to close from a fully open state and achieve Unit wide traction door interlock.

3.28.1.5 Maximum door closing forces of the passenger bodyside doors shall be in accordance with BS EN 14752:2005. TTS-539

3.28.1.6 The passenger bodyside doors shall incorporate obstacle detection in TTS-540

accordance with BS EN 14752:2005.

3.28.1.7 The passenger bodyside doors obstacle detection shall ensure that following the detection of an obstacle the door system shall perform a series of automatic partial door re-open and re-close cycles. Should the door remain blocked after the completion of the re-open and re-close cycles the door shall:

- automatically return to the fully open position;
- allow the driver to quickly initiate a new door close cycle at the affected door(s) without the need to leave the driving cab or completely re-enable the Unit doors; and TTS-541
- if after returning to the fully open position and if not commanded to close by the driver the door shall automatically close 5 seconds after it has returned to the open state.

3.28.1.8 When a door has re-opened to the fully open position at the end of the obstacle detection cycles, the appropriate Saloon CCTV camera image covering the affected door shall be displayed to the driver along with supporting event description text. The Saloon CCTV camera image shall be removed from the display when the door has been closed. Should more than one door be blocked, the Saloon CCTV camera image for all doors shall be displayed in a configuration to be agreed with the Purchaser. TTS-542

3.28.1.9 The passenger bodyside door system shall have the capability to adjust the following aspects of the obstacle detection process:

- door re-opening distance; and TTS-543
- closing forces.

3.28.1.10 The passenger bodyside door system shall additionally have the capability to adjust the number of partial re-open and re-close obstacle detection cycles prior to the door re-opening to the fully open position. This number shall be configurable between 0 and 7 cycles, where:

- 0 cycles corresponds to the door returning to the fully open position when the first obstacle is detected; TTS-544
- 1 cycle corresponds to one partial re-open and re-close cycle before the door, if still blocked, returns to the fully open position; and
- so on up to 7 cycles.

The initial setting shall be agreed with the Purchaser.

3.28.1.11 Adjustments to the passenger bodyside door obstacle detection function shall be capable of being performed as part of an overnight maintenance activity. TTS-545

3.28.1.12 The passenger bodyside doors shall provide passive anti-entrapment functionality by satisfying a fabric pull out test, as defined in Appendix A. The method used to provide this function shall be a well proven reliable solution from existing passenger services similar to those of the Unit. TTS-546

3.28.1.13 Each passenger bodyside door shall include a window. The size and positioning of the window shall as a minimum be sufficient to permit passengers standing adjacent to the doorway to view platform station name signage, and the size shall be maximised within the constraints of, inter alia, weight and safety. TTS-547

3.28.1.14 The passenger bodyside door glazing shall, as far as practicable, be flush with the outer surface of the door. TTS-548

3.28.1.15 The passenger bodyside door tracks and runners shall be designed to limit the ingress and build-up of detritus, snow and ice. TTS-549

3.28.1.16 The passenger bodyside door tracks and runners shall be designed so that they can be readily cleaned. TTS-550

3.28.1.17 Where the design incorporates passenger bodyside door pockets they shall be provided with internal maintenance access to enable the removal and cleaning of door tracks and runners by maintenance staff. Access shall be secure against vandalism, but shall allow ease of access with the minimum of tools and component removal. TTS-551

3.28.1.18 The passenger bodyside door design shall be sufficiently robust to prevent inadvertent loss of door-traction interlock due to pressure pulses, Vehicle movements and loadings, including passengers leaning against the doors. TTS-552

3.28.1.19 Any recess of the passenger bodyside door surface from the bodyside of the main vehicle skin shall not impact on the ability for the driver to complete safe despatch of the Unit using the DOO CCTV system. TTS-553

3.28.2 Passenger Bodyside Door Control TTS-554

3.28.2.1 The passenger bodyside door controls shall be in accordance with the requirements of the CR-TSI. The door controls shall allow the following modes of operation: TTS-555

- Driver Only Operation;
- driver and train crew operation; and
- emergency detrainment and evacuation.

3.28.2.2 The passenger bodyside door controls shall include ASDO and CSDE functionality. TTS-556

3.28.2.3 In accordance with the requirements of the CR-TSI clause 4.2.5.6 each Unit shall be provided with an automatic door-traction interlock system to prevent traction power being applied when not all Unit doors are closed. TTS-557

The status of the Unit door-traction interlock shall be displayed to the driver in all door modes. The indication shall be provided by a blue light positioned in a prominent location on the driver's desk.

3.28.2.4 In accordance with the requirements of the CR-TSI clause 4.2.5.6 each driving cab shall be provided with an isolation switch to permit the movement of the Unit under failed door-traction interlock conditions. Use of this isolation switch shall be subject to operational controls. TTS-558

3.28.2.5 Operation of the door-traction interlock isolation switch shall be logged in the TMS and OTMR and reported to the Wayside. TTS-559

3.28.2.6 In accordance with the requirements of the CR-TSI each passenger bodyside door shall be provided with a mechanism to allow the locking out of service of an individual door from the inside and outside of each Vehicle. The mechanism from outside of the Vehicle shall be accessible from platform and ballast level. The mechanism shall be operated by a suitable key of a type agreed with the Purchaser. TTS-560

3.28.2.7 The passenger bodyside doors adjacent to each cab shall include key operated, non-latching, internal and external access controls to allow TTS-561

Authorised Persons to access the Unit regardless of whether the Unit is powered.

3.28.2.8 The Unit shall have a terminal station door control mode which when enabled shall permit the driver or Authorised Persons to progressively move through the inside of the Unit checking for passengers, escort them off the Unit and close the passenger bodyside doors of each vehicle in turn such that they then cannot be re-opened from the outside of the Unit. TTS-562

3.28.2.9 The terminal station door control mode shall be enabled using 'soft pushbutton' controls available on the TMS HMI. TTS-563

3.28.2.10 The Unit shall exit from the terminal station door control mode when either:

- the mode is switched off using a 'soft pushbutton' control available on the TMS HMI; or
- all passenger bodyside doors have been closed and locked; or
- the Unit is configured to re-enter passenger revenue service where normal door controls will be required.

TTS-564

3.28.2.11 The Unit shall have a door control mode which shall permit the driver to inhibit the opening of passenger bodyside doors on the leading vehicle. TTS-2605

TTS-565

3.28.3 Driver and Train Crew Operation Control

3.28.3.1 The passenger bodyside door controls shall allow the driver to prevent individual bodyside doors from opening by the use of soft pushbutton controls on the TMS HMI. TTS-566

3.28.3.2 The passenger bodyside door control system shall have the necessary functionality to permit operation by train crew or any combination of driver and train crew. TTS-567

3.28.3.3 The following passenger bodyside door system operations shall be permitted:

- driver commanded release and open of all passenger bodyside doors;
- driver or train crew commanded close of all passenger bodyside doors; and
- driver release of all passenger bodyside doors, to allow passengers to open (or close) individual doors using the external or internal local door controls.

TTS-568

3.28.3.4 The train crew commanded close of all passenger bodyside doors shall be possible from any Non-occupied Cab. The train crew shall be able to provide a train dispatch signal to the driver. TTS-569

TTS-570

3.28.4 Driver Only Operation Control

3.28.4.1 The passenger bodyside door system controls shall be designed to permit DOO. TTS-571

3.28.4.2 The following passenger bodyside door system operations shall be permitted under DOO control:

- driver commanded release and open of all passenger bodyside doors;

TTS-572

- driver commanded close of all passenger bodyside doors; and
- driver release of all passenger bodyside doors, to allow passengers to open (or close) individual doors using the external or internal local door controls.

3.28.5 Passenger Door Controls

TTS-573

3.28.5.1 Each passenger bodyside doorway shall incorporate two sets of internal door open and door close pushbuttons. The pushbuttons shall be positioned adjacent to the doorway on either side, shall comply with the requirements of the PRM-TSI, and be installed to minimise the likelihood of inadvertent operation. TTS-574

3.28.5.2 The passenger bodyside door system shall have the capability for authorised maintenance staff only to disable the internal passenger door close pushbuttons at each doorway. This functionality shall be provided through an interface on the TMS HMI and shall have password protection to ensure only maintenance staff have access to the function. TTS-575

3.28.5.3 Each passenger bodyside doorway shall incorporate an external door open pushbutton, which shall comply with the requirements of the PRM-TSI. TTS-576

3.28.5.4 The passenger bodyside door system shall incorporate automatic door close after a predetermined period of no boarding or alighting in order to preserve interior temperatures and minimise air conditioning load. The period shall be maintainer adjustable and settable within a range of 15 to 75 seconds. The initial setting shall be 45 seconds. TTS-577

3.28.5.5 The automatic door close functionality shall be inhibited at passenger doorways designated for use by PRM. TTS-578

3.28.5.6 Each passenger bodyside door shall not close while passengers are boarding or alighting through that doorway, unless commanded by the driver or train crew. TTS-579

3.28.6 Passenger Bodyside Door Emergency Open Control

TTS-580

3.28.6.1 The Unit shall have passenger bodyside internal and external emergency open controls and functionality in accordance with the requirements of the CR-TSI. TTS-581

3.28.6.2 The internal emergency opening device shall only allow the door to be opened at speeds below 3kph. TTS-582

3.28.6.3 The operation of an internal emergency open control device and its location on the Unit shall be immediately reported to the driver and Wayside. TTS-583

3.28.6.4 The operation of an internal emergency open control device shall cause the Saloon CCTV system to automatically display the camera image from the local vestibule to the driver. TTS-584

3.28.6.5 The external emergency open control devices shall be operable from rail and platform level and shall be protected to prevent inadvertent and limit unauthorised operation. TTS-585

3.28.7 Passenger Bodyside Door Status Reporting

TTS-586

3.28.7.1 The TMS shall report the operational status of each passenger bodyside door to the driver via the cab HMI screen in a manner that makes the current operational status of each door clear and unambiguous. The status TTS-587

display format and appearance shall be agreed with the Purchaser.

3.28.7.2 The status of each passenger bodyside door shall be reported to the driver such that, as a minimum, the following operational modes are clearly distinguishable:

- door released;
- door open;
- door obstacle detection; TTS-588
- door closed and locked;
- door locked out of service;
- door internal emergency open device operated;
- door external emergency open device operated; and
- local door control system fault, including loss of communication.

3.28.7.3 In the event of a passenger bodyside door system failure the TMS shall immediately report the fault to the driver and advise a course of action to resolve the fault and keep the Unit in service. TTS-589

3.28.8 Correct Side Door Enable Functionality TTS-590

3.28.8.1 The passenger bodyside door system shall be provided with a Correct Side Door Enable (CSDE) function. TTS-591

3.28.8.2 The CSDE function shall be compatible with a Hima-Sella Tracklink III RFID tag system, with infrastructure mounted passive RFID tags and Unit mounted RFID tag readers and controls to obtain passenger bodyside door information relevant to each platform. TTS-592

3.28.8.3 The CSDE function shall be an advisory system used to validate driver door enable commands. TTS-593

3.28.8.4 Should the CSDE function agree with the driver's enable commands then the passenger bodyside doors shall enable as normal. TTS-594

3.28.8.5 Should the CSDE function not agree with the driver's enable commands then the passenger bodyside doors shall not be enabled and the driver shall be warned. The driver shall be able to re-enable the doors and the following controls shall apply:

- if the subsequent re-enable agrees with the CSDE function the passenger bodyside doors shall enable as normal; or
- if the subsequent re-enable does not agree with the CSDE function but has been provided within a time 'X' seconds of the original warning to the driver, the passenger bodyside doors shall enable on the side selected by the driver; or TTS-595
- if the subsequent re-enable does not agree with the CSDE function and has been provided after a time 'X' seconds of the original warning to the driver, the passenger bodyside doors shall not be enabled and the driver warning cycle shall repeat.

The timing duration of 'X' seconds shall be subject to agreement with the Purchaser.

3.28.8.6 To support operation of the Unit on LO Infrastructure not installed with RFID tags the Unit shall have the ability to isolate the RFID tag CSDE system TTS-596

functions on the Unit and prevent any unnecessary RFID tag CSDE fault messages being reported to the driver on the TMS HMI. The method used to isolate the Unit RFID tag CSDE functions shall only be available to Authorised Persons using a secure method and procedure agreed with the Purchaser.

3.28.8.7 Should a valid LO Infrastructure RFID tag be read by a Unit when the RFID tag CSDE system is isolated this shall be reported as a TMS category A alarm. TTS-597

3.28.9 Automatic Selective Door Operation (ASDO) TTS-598

3.28.9.1 The passenger bodyside door system shall be provided with an ASDO function. Where passenger bodyside doors are not aligned with platforms, these doors shall be prevented from opening. TTS-599

3.28.9.2 The design and operation of the ASDO system shall take into consideration the guidance contained in Railway Group Guidance Note GE/GN8577 'Guidance on the Application of Selective Door Operation Systems'. TTS-600

3.28.9.3 The ASDO function shall be operable in all Unit and Multiple Unit configurations. TTS-601

3.28.9.4 The source data for the ASDO function shall be provided by two mechanisms to determine the geographical / platform location and door release pattern. These are;

- a mechanism using a global navigation satellite solution augmented as a minimum by odometry and Unit tracking functions; and TTS-602
- a mechanism compatible with a Hima-Sella Tracklink III RFID tag system, with infrastructure mounted passive RFID tags and Unit mounted RFID tag readers and controls. This shall be the same RFID tag that provides the CSDE functionality in section 3.28.8.

3.28.9.5 The mechanism using a global navigation satellite shall take account of the guidance contained in Railway Group Guidance Note GE/GN8578. TTS-603

3.28.9.6 For Unit operations on LO Infrastructure not installed with RFID tags, the ASDO function shall be entirely provided by the mechanism that does not require the use of infrastructure mounted devices. Additional augmentation shall be used to assure safe passenger bodyside door control and operation. TTS-604

3.28.9.7 To support operation of the Unit on LO Infrastructure not installed with RFID tags the Unit shall have the ability to isolate the RFID tag ASDO functions on the Unit and prevent any unnecessary RFID tag ASDO fault messages being reported to the driver on the TMS HMI. The method used to isolate the Unit RFID tag ASDO functions shall only be available to authorised maintenance persons by use of a secure procedure agreed with the Purchaser TTS-605

3.28.9.8 For Unit operations on LO Infrastructure with RFID tags installed the Unit shall use the RFID tag system as the primary ASDO function. The ASDO function not requiring infrastructure mounted devices shall remain available and be used where an RFID tag has not been read or the RFID tag system has failed. TTS-606

3.28.9.9 To support permanent operation of the Unit on LO Infrastructure routes where an ASDO function is not required the ability to isolate both ASDO TTS-607

mechanisms shall be provided. The method used shall only be available to authorised maintenance staff by use of a secure procedure agreed with the Purchaser.

3.28.9.10 The integration of the two ASDO mechanisms shall be subject to detailed safety studies conducted by the Manufacturer, including operational scenarios, covering normal and degraded cases, such as but not limited to coupling / uncoupling events and Unit rescue. TTS-608

3.28.9.11 The ASDO function shall be designed to make maximum use of the available platform by selecting or inhibiting individual doors according to a predetermined pattern associated with each platform. TTS-609

3.28.9.12 The individual ASDO settings for each location shall be configurable by authorised maintenance persons using a secure procedure agreed with the Purchaser. TTS-610

3.28.9.13 The ASDO function shall remain effective in inhibiting the appropriate doors even when the Unit is to change direction (e.g. at a terminus) and the Occupied Cab changes from one end to the other. TTS-611

3.28.9.14 The Unit shall provide a clear status indication to the driver of which ASDO mechanism are operational on the Unit. This indication may be provided by the TMS HMI. As a minimum, this indication shall be provided each time a cab becomes an Occupied Cab prior to entering service and each time there is a failure of an ASDO mechanism that prevents it operating safely. The ASDO status indication just prior to entering service shall include verifying the location status of the Unit. The driver shall be required to acknowledge all indications and this shall be recorded in the OTMR. TTS-612

3.28.9.15 The OTMR shall provide a contemporaneous record of which ASDO mechanisms are active and in operational use. TTS-613

3.28.9.16 In the event that there is a complete failure of the ASDO mechanisms the Unit shall provide the driver with the ability to enable doors on particular Vehicles using the TMS HMI. This function shall be provided in a manner that prevents inadvertent operation. TTS-614

3.29 Train Control and Protection TTS-615

3.29.1 General TTS-616

3.29.1.1 The Unit shall be compatible with the train protection systems installed on the LO Infrastructure. The Unit shall be fitted with the following train protection systems:

- AWS and TPWS; and
- London Underground tripcock trainstop protection. (Dual Voltage Units only) TTS-617
- London Underground tripcock trainstop protection passive provision. (AC Only Units only)

3.29.1.2 The Unit shall be designed to allow the easy removal of the London Underground tripcock trainstop protection system. The design shall provide for a safe and reliable means of re-terminating any pneumatic and electrical connections once the tripcock is removed. TTS-2606

3.29.1.3 The Unit shall have the passive provision for the installation of an ETCS train protection system. This passive provision shall be compliant to ETCS TTS-618

Baseline 3 or later updates agreed with the Purchaser should the equipment be installed.

3.29.1.4 The passive provision for ETCS shall require:

- the space envelope for all ETCS equipment, including the ETCS DMI;
- the inclusion of the actual mechanical mounting points for all ETCS equipment, including the ETCS DMI, such that the ETCS equipment can be immediately installed at a later date;
- the installation of the ETCS Vehicle cables appropriately terminated in all instances. This shall apply where the point to point routing of these cables would not be easily installed if the ETCS equipment is fitted after construction of the Vehicles; TTS-619
- the power supply provision to power-up all the ETCS equipment from the train auxiliary supplies; and
- the supply of a technical description stating the upgrades required to other Unit systems, such as but not limited to, the Train Management System. Such additional upgrades shall be minimised in so far as is possible.

With regard to the passive provision for the ETCS DMI it is permissible for the space envelope and mounting positions to be facilitated by the replacement of an appropriate desk panel.

3.29.1.5 The passive provision for the ETCS train protection system shall consider Rail Industry Standard for On-board ETCS, RIS-0340-CCS or updated documents reflecting the ETCS Baseline 3 installation or any agreed later baseline. TTS-620

3.29.1.6 The passive provision for the ETCS train protection system defined in clause 3.29.1.3 shall include the capability to operate in Level STM with the AWS / TPWS protection systems as a National Train Control (NCS) system. This passive provision requirement shall also include the capability to transition between the AWS / TPWS and ETCS train protection systems at any speed. Through such transitions the Unit shall remain protected by at least one of the train protection systems. TTS-621

3.29.1.7 The Unit speed indication shall be displayed at all times in mph when operating with the train protection systems defined in clause 3.29.1.1. TTS-622

3.29.2 Driver's Activity Control (Vigilance) Function TTS-623

3.29.2.1 The Unit shall be equipped with a driver's activity control function in accordance with the CR-TSI. The system shall permit adjustment of time 'X' defined within the CR-TSI. The value of 'X' and adjustment method shall be acceptable to the Purchaser. TTS-624

3.29.3 Driver's Reminder Appliance TTS-625

3.29.3.1 The Unit shall be equipped with a DRA in each driving cab which complies with the requirements of GM/RT2491. TTS-626

3.29.4 Station Dwell Timer TTS-627

3.29.4.1 A timer clock shall be provided in a prominent position in the driving cab to TTS-628

indicate to the driver the time, in seconds, that have elapsed since wheel stop. This clock shall automatically commence counting up from zero seconds at any wheel stop while the cab is activated. The timer clock display shall be blank while the Unit is in motion and shall be capable of being disabled.

3.29.5 Slow Speed Control

TTS-629

3.29.5.1 The Unit shall be equipped with a slow speed mode with speed settings of 3 and 10mph. At each setting the Unit speed shall be controlled to be within +/- 1 mph of the set speed, irrespective of the effect of gradient. TTS-630

3.29.5.2 The slow speed mode controls shall be independent from the service traction and brake controller and shall be capable of being used in the event of particular failures of the service traction controller. TTS-631

3.29.5.3 When operating in slow speed mode the driver's normal train controls shall remain available to ensure safe operation of the Unit, including the capability to apply the Unit's emergency brake. TTS-632

3.30 Radio Systems

TTS-633

3.30.1 General

TTS-634

3.30.1.1 The Unit shall be equipped with GSM-R radios to permit the driver to communicate with the signaller and for the passing of urgent safety-related data between the Unit and the Wayside. TTS-635

3.30.1.2 The Unit's radio and telecommunications systems shall comply with the requirements of Railway Group Standards GK/RT0094. TTS-636

3.30.1.3 To maximise the effectiveness of the aerials for all radio systems fitted to the Unit, the design shall take into account Railway Group Guidance Note GK/GN0602 and RSSB research Report T739. TTS-637

3.31 OTMR

TTS-641

3.31.1.1 Each Unit shall be equipped with OTMR's that comply with the CR-TSI, NNTRs and the requirements defined below. TTS-642

3.31.1.2 The Unit must incorporate suitable connections in each cab so as to allow the download of OTMR data from that cab to a laptop, when the OTMR is powered. TTS-643

3.31.1.3 The Unit shall permit data being recorded via the OTMR system (or a subset agreed with the Purchaser) to be transmitted remotely to the Wayside, where it may be recorded and kept for review after an event. TTS-644

3.31.1.4 The OTMR shall record the driver's identity. TTS-645

3.31.1.5 In addition to the mandatory requirements, the OTMR, shall monitor and record:

- dynamic brake achieved; TTS-646
- brake cylinder pressure; and
- operation of sanders.

3.31.1.6 Special tools, equipment and software required for the processing and analysis of the OTMR system data shall allow the following: TTS-647

- retrieve data for off-board review and/or storage on secure digital

media;

- search and view data by the input of specific date, time or Event Trigger criteria; and
- scroll through of data.

3.32 Saloon, Forward Facing and Pantograph Monitoring CCTV Systems

TTS-648

3.32.1 Saloon CCTV

TTS-649

3.32.1.1 The Unit shall be provided with a Saloon CCTV system to monitor passengers' movements and actions in order to provide evidence which could be used for criminal prosecution and deter antisocial behaviour and crime. TTS-650

3.32.1.2 The Saloon CCTV system images for all cameras on the Unit shall be digitally encoded and recorded. TTS-651

3.32.1.3 The Saloon CCTV system shall comply with the requirements of the National Rail CCTV Steering Group guidance document 'National Rail & Underground Closed Circuit Television (CCTV) Guidance Document', unless otherwise defined within this specification. TTS-652

3.32.1.4 The Saloon CCTV system shall incorporate sufficient cameras, integrated into the Vehicle interior design, to provide the maximum practicable coverage of all interior areas of the Unit. The coverage shall ensure that:

- all areas of the saloon, including gangway area, are covered by at least one camera;
- blind spots are minimised; TTS-653
- each camera position is covered by at least one other camera; and
- all passenger doorways are covered.

The exact number and positioning of cameras shall be acceptable to the Purchaser.

3.32.1.5 The Saloon CCTV system images shall be captured in colour. The images shall be of high quality and as a minimum shall be in accordance with that defined within Table 2 of the National Rail CCTV Steering Group guidance document 'National Rail & Underground Closed Circuit Television (CCTV) Guidance Document'. TTS-654

The image quality terms defined within the National Rail CCTV Steering Group guidance document shall be in accordance with the corresponding definitions of clause 7.6 of BS EN 50132-7:1996 'Alarm Systems - CCTV surveillance systems for use in security applications - Application guidelines'.

3.32.1.6 The image quality of the saloon CCTV system shall be sufficient to permit the driver to observe smoke build up within the passenger saloon. TTS-655

3.32.1.7 The Saloon CCTV system camera images shall be captured and recorded at no less than 12 frames per second. TTS-656

3.32.1.8 The Saloon CCTV camera images shall be recorded on solid state or hard drive recording technology. TTS-2607

3.32.1.9 The Saloon CCTV system cameras and installation shall as far as practicable ensure that they are protected from all foreseeable forms of TTS-657

tampering, attack or vandalism.

3.32.1.10 The Saloon CCTV system shall allow the viewing of live or recorded images, using a menu style interface, from any Saloon CCTV camera on the Unit by Authorised Persons or emergency services staff. Viewing shall be permitted as follows: TTS-658

- in a Non-occupied Cab at any time; and
- in an Occupied Cab when the Unit is stationary.

The Saloon CCTV system functionality shall be unaffected when images are being viewed from any cab.

3.32.1.11 The menu style interface permitting the viewing of images as required by clause 3.32.1.10 shall provide the capability to select the camera position, Vehicle and either a live image or the date and time of a recorded image. The functional interface for this control shall be agreed with the Purchaser. TTS-659

3.32.1.12 Where an Authorised Person switches between different Saloon CCTV images, the display image shall fully refresh in no more than 0.5 seconds. TTS-660

3.32.1.13 The Saloon CCTV system shall allow the Authorised Person to select a mode that allows scrolling through the display images on a Vehicle by Vehicle basis for the complete Unit, to assist assessing whether passengers have detrained. TTS-661

3.32.1.14 Following an Event Trigger anywhere on the Unit, the Saloon CCTV system shall have the capability to automatically display images from cameras providing coverage of the Event Trigger location, on the driver's display. CCTV images from multiple Event Triggers shall be queued for the driver to scroll through on demand. The protocol and timing for presenting the images to the driver shall be agreed with the Purchaser. TTS-662

3.32.1.15 The Saloon CCTV system image recordings shall mark when an Event Trigger occurs. TTS-663

3.32.1.16 The Saloon CCTV system shall retain all recorded CCTV images for 31 calendar days. TTS-664

3.32.1.17 The Saloon CCTV system recording equipment shall be located in secure locations and shall provide for the removal of data storage media by maintenance or operation staff for investigative purposes if required. TTS-665

3.32.1.18 The removal of data storage media from the Unit shall not prevent the viewing of live Saloon CCTV images in the drivers cab. TTS-666

3.32.1.19 The Saloon CCTV system shall be configured so that all live and recorded images on a Unit may be accessed via a single diagnostic port (location of port to be acceptable to the Purchaser) using a laptop computer or other device. TTS-667

3.32.1.20 The Saloon CCTV system shall permit, subject to the availability of a suitable transmission method, recorded or live CCTV images from an operating Unit to be viewed at a Wayside location including the RCC. The resolution required by 3.32.1.5 is not essential for the remote viewing functionality. Similarly it is permissible for the frame rate for the remote viewing function to be lower than that specified in 3.32.1.7. The frame rate shall be agreed with the Purchaser. TTS-668

3.32.1.21 Special tools, equipment and software required for the processing and analysis of the Saloon CCTV system data shall allow the following: TTS-669

- retrieving image data via the diagnostic port referenced in clause 3.32.1.19 for off-board review and/or transfer and storage on secure digital media;
- retrieving image data from any data storage media removed from the Unit as referenced in clause 3.32.1.17 for off-board review and/or transfer and storage on secure digital media;
- searching and viewing data by the input of specific date, time or Event Trigger criteria, either via the Unit diagnostic port or by plugging into the data storage media removed from the Unit;
- viewing images from any Saloon CCTV camera on the Unit with a minimum of 4 images displayed simultaneously, either via the Unit diagnostic port or by plugging into the data storage media removed from the Unit; and
- scrolling through image data, with play, pause, fast forward and fast rewind functions, either via the diagnostic port or by plugging into the data storage media removed from the Unit.

3.32.1.22 The Saloon CCTV recorded images, on the Unit and through to off-board removal and storage shall be permanently watermarked to provide a secure and auditable trail of evidence that satisfies the requirements of evidential continuity, proving that the data has not been tampered with in any way. As a minimum the watermarking of images shall include:

- Unit identification;
- Unit Reporting Number; TTS-670
- Vehicle number;
- camera position; and
- date and time.

The recorded Saloon CCTV image format shall be to a standard acceptable to the Purchaser.

3.32.2 Forward Facing and Pantograph Monitoring CCTV TTS-671

3.32.2.1 Each driving cab shall be provided with a forward facing CCTV (FFCCTV) system compliant with Railway Group Guidance Note GM/GN2606. TTS-672
(Note that conditional requirements defined within GM/GN2606 shall be considered to be mandated.)

3.32.2.2 The Unit FFCCTV system shall be provided with an additional camera(s) on the pantograph vehicle which shall be fitted to the Unit roof to observe pantograph performance and the interface with OHL contact wire. The camera coverage shall be sufficient to provide an initial assessment of the condition of the contact surface of a pantograph head, when the head is in the lowered position. TTS-673

3.32.2.3 The FFCCTV (including the pantograph) system images shall be digitally encoded and recorded. TTS-674

3.32.2.4 The FFCCTV (including the pantograph) camera images shall be recorded on solid state or hard drive recording technology. TTS-2608

3.32.2.5 The FFCCTV system shall be available to assist reverse operation by displaying images from the FFCCTV system in the Non-Occupied Cab to TTS-675

the driver in the Occupied Cab in real time.

3.32.2.6 The FFCCTV and pantograph camera recording function shall be an extension of that used for the Saloon CCTV cameras such that:

- the images are retained for 31 calendar days;
- the recordings are held in the same secure locations, but still accessible for the removal of the data storage media; and TTS-676
- the live and recorded data is accessible from a single Unit diagnostic port.

3.32.2.7 The removal of data storage media from the Unit shall not prevent the viewing of live FFCCTV and pantograph camera images in the drivers cab. TTS-677

3.32.2.8 The FFCCTV system recorded images shall include references to allow the Unit position, date and time to be determined for each image. The referencing of the recorded images shall be sufficient to provide evidential continuity. TTS-678

3.32.2.9 The FFCCTV camera image(s), including pantograph camera image, shall be available for display in any cab of the Unit. It shall be possible to select the required FFCCTV or pantograph camera image using a menu screen and selection criteria similar to that of the Saloon CCTV system. The menu shall allow for the selection of either real time or recorded images. TTS-679

3.32.2.10 The recording and retrieval of the FFCCTV and pantograph camera images 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. TTS-680

The recorded FFCCTV image format shall be from one of the options given in GM/GN2606 and shall be acceptable to the Purchaser.

3.32.2.11 The FFCCTV system shall permit, should subject to the availability of a suitable transmission method, recorded or live FFCCTV images from the Unit to be viewed at a Wayside location including the RCC. The resolution required by 3.32.2.1 is not essential for the remote viewing functionality. Similarly a reduced frame rate is permissible by agreement with the Purchaser. TTS-681

3.32.2.12 Special tools, equipment and software required for the retrieval, processing and analysis of the FFCCTV system data shall be in accordance with GM/GN2606 and allow the following:

- retrieving image data via the diagnostic port referenced in clause 3.32.1.19 for off-board review and/or transfer and storage on secure digital media;
- retrieving image data from any data storage media removed from the Unit as referenced in clause 3.32.1.17 for off-board review and/or transfer and storage on secure digital media; TTS-682
- searching and viewing data by the input of specific date, time or Event Trigger criteria, either via the Unit diagnostic port or by plugging into the data storage media removed from the Unit; and
- scrolling through image data, with play, pause, fast forward and fast rewind functions, either via the diagnostic port or by plugging into the data storage media removed from the Unit.

3.33 Passenger Environment

TTS-683

3.33.1 Interior Style and Ambience

TTS-684

3.33.1.1 The Vehicle interior design shall present a cohesive, modern interior style, ambience and appearance. TTS-685

3.33.1.2 The interior styling and layout shall take account of the guidance within Appendix E. TTS-686

3.33.1.3 The interior finishes shall conform to the Schedule of Finishes agreed with the Purchaser. TTS-687

3.33.2 Persons with Reduced Mobility Accommodation

TTS-688

3.33.2.1 The passenger interior shall comply with the regulatory requirements for PRM. TTS-689

3.33.2.2 Priority seats as required by PRM-TSI shall be clearly distinguished from other passenger seats by the adoption of a different seat fabric colour and/or pattern. TTS-690

3.33.2.3 Where interior layouts include both longitudinal and transverse seating, priority seats shall be equally distributed between the two types of seating. TTS-691

3.33.2.4 The Units shall be equipped with 2 wheelchair spaces in a Vehicle accessed via the same set of passenger bodyside doors. TTS-692

3.33.2.5 The location of wheelchair spaces shall be acceptable to the Purchaser and to ensure compatibility with the LO Infrastructure this location shall be on the same Vehicle and shall use the same set of passenger bodyside doors as existing Class 378 four and five Vehicle Units. TTS-693

3.33.2.6 Three tip-up seats shall be located within each wheelchair space for the use of other passengers when the wheelchair space is unoccupied. However they shall not encroach on the wheelchair space dimensional requirements when in the stowed position. TTS-694

3.33.2.7 Where wheelchair spaces are positioned adjacent to each other, if one space is occupied this shall not prevent access or egress by a wheelchair from the other wheelchair space. TTS-695

3.33.2.8 The Unit shall be provided with secure enclosed storage of one wheelchair ramp per Vehicle with wheelchair spaces. The storage facility shall be located in the vicinity of the designated wheelchair accessible doorways. TTS-696

3.33.2.9 To minimise the risk of incidents during boarding or alighting of wheelchair users the Unit doorway design shall incorporate features which positively and firmly locate the wheelchair ramps to the doorway. When the portable wheelchair ramp is positioned in the doorway it shall not be possible for the Unit door to close. TTS-697

Attention is drawn to RSSB project report T759 which has considered wheelchair boarding and alighting risks.

3.33.3 Interior Layout and Capacity

TTS-698

3.33.3.1 The Unit internal design and seat configuration shall be such that the Vehicles will deliver a desirable environment for passengers both on longer distance journeys as well as the shorter services. This must be achieved without compromising overall capacity and station Dwell Times. TTS-699

3.33.3.2	The 4 Vehicle Unit interiors shall provide accommodation for a minimum of 660 passengers, total capacity (seated and standing) measured in accordance with clauses 3.33.3.13, 3.33.3.14, 3.33.3.15 and 3.33.6.3.	TTS-700
3.33.3.3	The 4 Vehicle Unit interiors shall provide seated accommodation for 200 passengers on both the AC Only Units and the Dual Voltage Units. This shall be treated as a target value. The seating capacity shall be measured in accordance with 3.33.3.13 and 3.33.6.3.	TTS-701
3.33.3.4	The seated and standing capacity of a 5 vehicle Unit shall be broadly in proportion to that of a 4 vehicle Unit.	TTS-702
3.33.3.5	The Unit interior layouts shall allow for rapid, high volume, bi-directional interchange of passengers at stations.	TTS-703
3.33.3.6	The Unit interior layouts shall allow for a mixture of seated accommodation with combinations of entirely longitudinal seating and combinations of transverse and longitudinal being possible.	TTS-704
3.33.3.7	AC only Units shall be supplied with a seating layout utilising a combination of both transverse and longitudinal seating in all Vehicles. Transverse seats shall account for approximately 1/3rd of the seating capacity.	TTS-705
3.33.3.8	Dual Voltage Units shall be supplied with a seating layout utilising entirely longitudinal seating in all Vehicles.	TTS-706
3.33.3.9	It shall be possible to convert an AC only Unit seating layout to be the same as a Dual Voltage Unit and vice versa, to support future business requirements.	TTS-707
3.33.3.10	To maximise the benefits of the Open Wide Gangways, only longitudinal seating shall be fitted in the passenger saloon areas immediately adjacent to the inter-vehicle gangways.	TTS-708
3.33.3.11	The Unit interior layouts shall not include 3+2 transverse seated configurations.	TTS-709
3.33.3.12	The Unit interior layouts shall not include 2+2 transverse seated configurations, although the Unit design shall permit the adoption of such designs if required by the Purchaser in the future.	TTS-710
3.33.3.13	The interior seated capacity and layout shall be calculated on the following basis: • perch type seats shall be excluded from the seated capacity calculation; • where tip-up seats are provided, they shall not be included in the seated capacity calculation if their deployed space is required to meet the standing capacity requirement; and • where tip-up seats are provided in wheelchair space or open areas, they shall be included in the seated capacity.	TTS-711
3.33.3.14	The interior standing capacity shall be calculated on a nominal basis of 5 passengers per square metre of Usable Standing Area following the guidance of section 5 in BS EN 15663.	TTS-712
3.33.3.15	Each defined standing space (as counted within the standing capacity calculation) shall accommodate passengers from within the defined User Population, and shall provide suitable handholds to allow passengers to	TTS-713

safely stand.

3.33.3.16 The Vehicle interior shall include a system of grab poles, grab rails and handholds which comply with PRM-TSI and are positioned to provide safe and comfortable support to all passengers standing or walking through the Vehicle, whilst not impeding passenger flow or wheelchair movement through the Unit. The grab rails may include the use of strap hangers, to provide safe and comfortable support to standing passengers. TTS-714

3.33.3.17 Strap hanger design(s) shall be subject to agreement with the Purchaser. TTS-715

3.33.3.18 Grab poles and handholds shall be designed and positioned to reduce the risk of injury, particularly head injury, arising from impact during severe deceleration. TTS-716

3.33.4 Flexibility TTS-717

3.33.4.1 The passenger interior components and attachment shall allow alterations in the interior layout during the Vehicle life. This flexibility shall allow, as far as practicable, alterations in the seating numbers, seat types and arrangement without major structural modification to the Vehicle. TTS-718

3.33.4.2 As far as practicable, there shall be no structural features protruding within the passenger interior space that limit the capability to alter the interior layout. TTS-719

3.33.4.3 Unless agreed otherwise with the Purchaser, the saloon floor area shall be kept clear of equipment that could limit interior flexibility or cleaning. TTS-720

3.33.4.4 Toilet facilities shall not be fitted within the Units, however the Unit design shall include passive provision for the future fitment of one UAT facility either on the vehicle with wheelchair spaces or adjacent to but fully accessible from the vehicle with wheelchair spaces. TTS-721

3.33.5 Passenger Doorway Stand Back Areas TTS-722

3.33.5.1 The interior layout shall incorporate appropriate passenger stand back areas adjacent to all passenger doorways. The stand back area design shall ensure that on-board passengers may stand clear of the doorway to assist in the passage of passengers out of and into the Vehicles. TTS-723

3.33.5.2 Draught screens shall minimise draughts into the adjacent seated area from an open doorway, whilst not impeding passenger flows between the seated area and the doorway. TTS-724

3.33.5.3 The vestibule area including the stand back areas shall incorporate suitable handholds for standing passengers, the position design and location of which shall be useable by the User Population. TTS-725

3.33.5.4 The stand back areas shall principally be designed to accommodate standing passengers, however they shall also provide as far as is practical space that may be used by pushchairs and larger items of luggage. TTS-726

3.33.6 Passenger Seats TTS-727

3.33.6.1 Passenger seat cushions and squabs shall be cushioned and shall be finished with a moquette fabric. TTS-728

3.33.6.2 Passenger seat covers and other fabric items shall be straightforward and economical to replace when damaged, soiled or stained. TTS-729

3.33.6.3 The cushioned area of a passenger seat base shall be no less than 450mm TTS-730

wide. The centre to centre spacing between seats shall be no less than 500mm.

3.33.6.4 Passenger seat dimensions and design shall accommodate the defined User Population. TTS-731

3.33.6.5 Passenger seat design and layout shall allow ease of access and egress of the User Population. TTS-732

3.33.6.6 Passenger seats shall meet the requirements of GM/RT2100. TTS-733

3.33.6.7 Transverse passenger seat backs shall be tapered to provide visibility along the Vehicle length. TTS-734

3.33.6.8 Transverse passenger seats shall be fitted with armrests which shall fold where necessary to allow unimpeded access to each seat position. TTS-735

3.33.6.9 Transverse passenger seats shall ensure that the installation with an adjacent seat helps prevent pick pocketing from behind the seats. TTS-736

3.33.6.10 Longitudinal seats shall incorporate a fixed armrest between adjacent seats. The armrests shall be designed and positioned to minimise the risk of injury caused to passengers impacting the armrest during severe deceleration during incidents. TTS-737

3.33.6.11 As far as practicable and where Unit weight is not unduly affected, passenger seats shall be free from fixed components underneath the seat that impede cleaning. TTS-738

3.33.6.12 Tip-up seats shall only be provided in conjunction with wheelchair areas, and the type of 'flexible utility space' areas envisaged by clause 3.33.7. Tip up seats should not be placed immediately adjacent to doorways unless provided in conjunction with wheelchair areas, or used in conjunction with the 'flexible space' areas adjacent to the gangways. TTS-739

3.33.6.13 Tip-up seats shall return without assistance to the stowed position when unoccupied. TTS-740

3.33.6.14 Tip-up seats may be multi-purpose and provide a perch type seat function when in the stowed position. Single purpose perch type seats are not preferred. TTS-741

3.33.7 Flexible Utility Space TTS-742

3.33.7.1 The Unit interior design shall incorporate two flexible utility spaces, in a position to be agreed with the Purchaser. TTS-743

3.33.7.2 The flexible utility space shall not occupy a floor area greater than 3 to 4 longitudinal seats or 4 transverse seats, whichever is the greater. TTS-744

3.33.7.3 The flexible utility space shall provide storage for:

as a minimum, accommodation for the following luggage types shall be provided for: TTS-745

- large cases 850mm x 650mm x 400mm
- three folding or three non-folding bicycles; and
- folded and unfolded pushchairs.

3.33.7.4 The flexible utility space shall be provided with tip-up seating to maximise the overall seating capability of the Unit. TTS-746

3.33.8 Passenger Luggage Storage Provision

TTS-747

3.33.8.1 The space underneath longitudinal passenger seats shall permit the storage of items of luggage, including briefcases, laptop bags and small rucksacks. TTS-748

3.33.8.2 Luggage stowed under seats shall be visible to staff walking through the Unit. TTS-749

3.33.8.3 Passive provision for future fitment of overhead luggage racks shall be provided above all seated passenger areas, apart from immediately adjacent to the inter-car gangway areas. TTS-750

3.33.8.4 The passive provision for overhead luggage racks shall permit at a later date the installation of overhead luggage racks capable of accommodating hand luggage. TTS-751

3.33.8.5 The future design of luggage rack shall have storage space maximised as far as practicable having regard to other constraints on the interior design, with the objective of accommodating luggage up to a maximum dimension of 600mm x 550mm x 270mm. As a minimum the luggage racks shall be sized to be capable of securely storing items of a dimension of 560mm x 360mm x 230mm. TTS-752

3.33.8.6 The future design of the overhead luggage racks and ceiling profiles, in combination with the seating layout below shall prevent the risk of injury when passengers are sitting down into or getting up from their seats. TTS-753

3.33.8.7 The future design of the overhead luggage rack, shall as far as is practicable permit luggage stored in the rack to be visible from the seated positions directly below and to the Saloon CCTV. TTS-754

3.33.8.8 The future design of the overhead luggage racks shall be designed to ensure the retention of stowed luggage during normal Vehicle movements. TTS-755

3.33.8.9 The future design of the overhead luggage racks shall incorporate appropriate divisions / compartmentalisation along their length that provide demonstrable resistance to the spread of fire between items of luggage stored in the racks. TTS-756

3.33.9 Interior Flooring and Panelling

TTS-757

3.33.9.1 Passenger floor surfaces shall be level and free of trip hazards or access hatches. A slope of no more than 3 degrees in doorway areas to facilitate the drainage of rainwater is permissible. TTS-758

3.33.9.2 Interior floor covering shall be anti-slip, hard wearing, easy to clean and maintain and suitable for wet and dry conditions. Carpet shall not be used. TTS-759

3.33.9.3 Floor covering in doorway vestibules shall be of a similar material to the general saloon area, but may incorporate grooves locally to assist in the drainage of moisture from incoming passengers' footwear and rain or snow entering through open doors. The doorway floor covering shall be acceptable to the Purchaser. TTS-760

3.33.9.4 Interior floor coverings shall be fitted to prevent the ingress of liquids beneath the covering, into adjacent areas or under floor cavities. TTS-761

3.33.9.5 All passenger area surfaces; walls, partitions, bodyside panels and ceiling panels shall be hard wearing; resistant to physical damage by vandalism, fading, scouring, graffiti and be easy to clean and maintain. TTS-762

3.33.9.6 Visible fixings within the interior shall be avoided. Where fastenings are TTS-763

visible special tooling shall be required that provides a level of tamper resistance.

3.33.9.7 Joints between adjacent internal panels shall be minimised but shall promote an appearance of design modularity. Joints shall present a consistent appearance, both edges being parallel and panel surfaces being level with each other. TTS-764

3.33.9.8 All interior panels, fixtures and fittings shall be designed to eliminate drumming, rattles and squeaks during all Normal Operation modes of the Unit. TTS-765

3.33.9.9 The interior panelling and layout shall be as modular as practicable to minimise the number of individual sub-assemblies required and to facilitate ease of repair. TTS-766

3.33.10 Bodyside Windows and Glazed Surfaces TTS-767

3.33.10.1 Bodyside windows and door glazing shall be provided which are suitably spaced and sized to reflect the envisaged mixture of seated and standing passengers. As far as practicable, the windows shall provide a clear external view to passengers sitting in transverse seating. TTS-768

3.33.10.2 Passenger windows, door glazing and interior glazed surfaces shall incorporate replaceable protective films to mitigate damage as a result of vandalism by etching or scratching. TTS-769

3.33.10.3 Bodyside windows and interior panelling shall be designed to allow swift change-out of the window following damage. The total change time for damaged or defective bodyside windows to allow a Unit to be returned to service shall be less than 3 hours. TTS-770

3.33.10.4 Bodyside windows shall comply with the requirements of GM/RT2100 section 5.3. TTS-771

3.33.10.5 Clause not used. TTS-772

3.33.10.6 The Unit shall allow passenger mobile phones and other similar devices compatible with GSM-P systems to operate without excessive impediment. In particular, such mobile phone network signals passing through the bodyside windows shall not be attenuated by more than 3dB.This requirement is in addition to any Unit based system provided in accordance with 3.47.1.1. TTS-2609

3.33.11 Interior Advertising TTS-773

3.33.11.1 The Unit interior design shall maximise the opportunities for inclusion of advertising systems to display commercial advertising material and shall include, London Underground type advertising cards in frames, back lit LED advertising frames and electronic TFT displays. TTS-774

3.33.11.2 Interior passenger areas shall be provided with frames for the display of London Underground type advertising cards above the bodyside windows. The exact layout of advertising displays shall be acceptable to the Purchaser. TTS-775

3.33.11.3 The frame for the display of the London Underground type advertising cards shall be integrated with the Unit interior panels in a consistent approach to that adopted for the back lit LED advertising frames and electronic TFT displays. TTS-776

3.33.11.4 London Underground type advertising card frames shall ensure the secure TTS-777

retention of advertising cards, and that unskilled staff are able:

- to place advert cards correctly, without the need for adjustment for neatness and regularity; and
- to remove and replace any card within a maximum time of 5 seconds, without repositioning the remainder.

3.33.11.5 Interior passenger areas shall be provided with back lit LED advertising frames, for the display of commercial advertising material of approximately the same size and shape of existing London Underground advertising cards 612mm by 280mm above the bodyside windows. The exact layout of advertising displays shall be acceptable to the Purchaser. TTS-778

3.33.11.6 The back lit LED advertising frames shall be integrated with the Unit interior panels in a consistent approach to that adopted for the London Underground card displays and electronic TFT displays. TTS-779

3.33.11.7 The back lit LED advertising frames shall ensure the secure retention of advertising material, and that unskilled staff are able to remove and replace any material within a maximum time of 60 seconds. TTS-780

3.33.11.8 Interior passenger areas shall be provided with electronic TFT digital display screens of a rectangular shape and approximate display area of 1500cm^2 for the display of commercial advertising media, above the bodyside windows. The exact layout of electronic TFT digital displays screens shall be acceptable to the Purchaser. TTS-781

3.33.11.9 The electronic TFT digital display screens shall be capable of meeting the following requirements:

- displaying a mixture of commercial advertising and general information to passengers;
- varying the display material throughout the day's service depending on time and location; TTS-782
- remote uploading of the display material; and
- real time updating of the information component.

3.33.11.10 The electronic TFT digital displays shall be integrated with the Unit interior panels in a consistent approach to that adopted for the London Underground card displays and back lit LED advertising frames. TTS-783

3.33.11.11 The vehicle interior design shall permit the installation of any of the three types of advertising identified in clause 3.33.11.1 above any saloon bodyside windows. TTS-784

3.33.11.12 The vehicle interior design shall initially include an equal distribution of all three types of advertising identified in clause 3.33.11.1, equally distributed within the vehicle in agreement with the Purchaser. TTS-785

3.33.11.13 The vehicle interior design shall permit future changes in the distribution of the three types of advertising identified in clause 3.33.11.1, allowing the replacement of all London Underground cards, and the inclusion of an equal distribution of back lit LED advertising frames and electronic TFT digital displays. TTS-786

3.33.11.14 The vehicle interior design and associated electrical supply and advertising system network and data capacity shall from the initial construction support the options identified in clause 3.33.11.13. TTS-787

3.33.11.15 The Special Tools, equipment and software provided for the electronic TFT digital displays shall allow the following:

- recording and compiling display material;
- updating / editing the material;
- remotely uploading the material; and
- support the electronic advertising requirements of this specification.

TTS-788

The functionality of the equipment shall be developed by the Manufacturer and be acceptable to the Purchaser.

3.33.12 Route Maps and Signage

TTS-789

3.33.12.1 Route maps shall be displayed in the Unit interior. The location, exact layout and mounting arrangement of the route maps shall be integrated into the interior layout and be acceptable to the Purchaser. TTS-790

3.33.12.2 Emergency and Safety signs shall be fitted in accordance with the requirements of Railway Group Standard GM/RT2130. TTS-791

3.33.12.3 Statutory signage shall be fitted in accordance with Applicable Laws and Standards. TTS-792

3.33.12.4 Non-mandatory signage shall be acceptable to the Purchaser. All signage shall be to a size, design/style and font to be defined by the Purchaser unless otherwise dictated by Applicable Laws and Standards. TTS-793

3.33.12.5 All signage must be, as far as practicable, resistant to forced removal and deliberate defacing activities. TTS-794

3.33.12.6 All signage must be capable of being removed if required without damaging the substrate, using a method specified by the Manufacturer. TTS-795

3.33.12.7 Unique Vehicle and Unit numbers allocated by the Rolling Stock Library shall be displayed externally and internally. Doors shall be identified through signage and numbered sequentially to a numbering system acceptable to the Purchaser. The Size, font and colour of the identification numbers shall be acceptable to the Purchaser. TTS-796

3.33.13 Interior Cleaning and Litter

TTS-797

3.33.13.1 The Unit shall not be fitted with litter bins. TTS-798

3.33.13.2 All areas of the Unit interior shall be capable of being cleaned, using normal railway and industrial cleaning methods, equipment and materials. TTS-799

3.33.13.3 Interior panelling and other surfaces shall be durable, smooth, stain resistant and easy to wipe clean after normal soiling. TTS-800

3.33.13.4 Interior panelling and finishes shall be capable of withstanding the effects of any chemicals used in the cleaning process, including those associated with the removal of graffiti or to kill pathogens. The interior surfaces shall not degrade as a result of persistent cleaning with such agents. TTS-801

3.33.13.5 Interior panelling and items of seating (cushions, covers and squabs) shall be capable of being easily replaced when heavily soiled or damaged. TTS-802

3.33.13.6 Lighting and other interior assemblies shall prevent the ingress and build-up of dust and dirt. TTS-803

3.33.13.7 Heating, ventilation, air-conditioning and extraction ducts and grills shall be designed to prevent the build-up of dust, dirt and detritus. They shall be TTS-804

accessible and cleanable using standard cleaning equipment and tools in order to avoid hygiene problems or build-up of flammable material.

3.33.13.8 The interior shall incorporate sufficient BS1363 230V AC metal clad socket outlets equipped with RCD protection and associated electrical supplies to enable commercial vacuum cleaners and any other electrical cleaning appliances to be used when the Unit is stabled. TTS-805

3.33.13.9 The power points shall be suitably located or positioned behind covers so as to discourage their use by passengers while the Unit is in passenger service. TTS-806

3.33.13.10 The Unit interior layout shall allow the use of industrial floor cleaning machines to access all areas of the floor. TTS-807

3.33.14 Security, Robustness and Vandalism Resistance

TTS-808

3.33.14.1 The Unit shall include suitable security to prevent unauthorised access. TTS-809

3.33.14.2 The Unit shall be fitted with a suitable range of locks to protect specific areas of the Unit from unauthorised access. It shall be possible to implement a hierarchical key strategy with a range of keys at different levels of security giving access to different areas of the Unit. The strategy and key types shall be acceptable to the Purchaser. TTS-810

3.33.14.3 Unit systems, assemblies and controls located within Vehicles shall be protected from unauthorised access or tampering. Suitable tamper resistant designs and mechanisms shall be incorporated. TTS-811

3.33.14.4 The Unit interior and components shall be robust and resistant to damage from foreseeable vandalism, accidental damage and misuse. TTS-812

3.33.14.5 The Unit interior shall be resistant to scuffing or abrasion damage from contact with wheelchairs, pushchairs, passenger luggage, bicycles or other reasonably foreseeable items. TTS-813

3.33.14.6 Gaps and crevices in the Unit interior where litter, sharp objects such as needles or cigarette ends or any other items could be concealed or lodged shall be minimised. TTS-814

3.33.14.7 Soft furnishings shall, as far as practicable, be resistant to damage by sharp objects and be easy and economical to replace when necessary. TTS-815

3.33.15 Passenger Power Sockets

TTS-2629

3.33.15.1 The Vehicles of AC Only Units shall be fitted with 230V AC power socket outlets to BS1363, accessible to seated passengers, in order to permit them to charge low powered electrical items including laptops, mobile phones and tablet devices. TTS-2630

3.33.15.2 The power sockets shall be labelled to indicate they are only for laptops, tablets and mobile phone charging. TTS-2631

3.33.15.3 A minimum of one power socket shall be provided at each pair of transverse seats. No power sockets are required at longitudinal seats. TTS-2632

3.33.15.4 Power sockets shall be positioned so that: TTS-2633

- they are readily accessible to passengers sat in the transverse seats;
- they can accommodate the normal range of plugs and adapters which passengers might reasonably wish to use; and

- their position minimises the risks associated with trailing cables.

3.33.15.5 The power provided by the sockets shall meet the same standards as those met by a normal UK domestic supply. In particular, careful consideration shall be given to: TTS-2634

- the levels of distortion present in the power supply waveforms; and
- the voltage relationship between the live, neutral and earth under both normal and foreseeable failure conditions of the supply.

3.33.15.6 Sockets shall be powered whilst the train is in service. It is permissible for power to the sockets to be lost whilst traversing 3rd rail gaps of greater than 1 second in duration or neutral sections. TTS-2635

3.33.15.7 The sockets shall be adequately protected against both overcurrent (e.g. through the use of miniature circuit breakers) and live / neutral current imbalance (e.g. through the use of residual current devices) taking into account best practise. TTS-2636

3.33.15.8 The design of the installation shall seek to minimise the effect of the operation of protective devices on the availability of power to passengers, in particular: TTS-2637

- at seat sockets shall be protected by separate devices in each vehicle;
- operation of a single protective device shall not result in the loss of more than one third of the sockets on a Vehicle;
- power sockets protected by the same single protective device shall be installed within the same general area / zone of the Vehicle interior; and
- the operation of a protective device shall be automatically notified to the driver, identifying which Vehicle and which area / zone has been affected.

3.33.15.9 The driver shall be able to reset all overcurrent and live / neutral current imbalance faults described in 3.33.15.7 from within the affected Vehicle by a local reset, suitably secured against misuse and available only to an Authorised Person. TTS-2638

3.33.15.10 The setting of the overcurrent protection shall be appropriate for the expected loadings and the Manufacturer shall confirm and agree the setting with the Purchaser. TTS-2639

3.33.15.11 The Dual Voltage Units shall have the necessary wiring and protection devices installed from day one, but not the actual sockets, to allow compliance with requirements of 3.33.15.1 to 3.33.15.10 should the Purchaser require it in the future. TTS-2640

3.34 Passenger Loadweigh Monitoring Systems TTS-818

3.34.1 Passenger Counting TTS-819

3.34.1.1 A quarter (25%) of the AC Only Units and a quarter (25%) of the Dual Voltage Units shall be installed with a passenger counting system that automatically counts and records the number of passengers boarding and alighting through each doorway. TTS-820

3.34.1.2 The passenger counting system shall record the individual journey, location, time and date for which the recorded information applies. TTS-821

3.34.1.3 The passenger counting system shall provide data which shows:

- the number of passengers which alight the Unit at each station; and TTS-822
- the number of passengers which board the Unit at each station.

3.34.1.4 The passenger counting system shall be capable of recording the passenger numbers to within 5% of the actual number of people boarding and alighting the Unit at each station stop. TTS-823

3.34.1.5 Passenger counting recorded data for the Unit shall be downloadable while the Unit is in motion. TTS-824

3.34.1.6 Passenger counting recorded data for the Unit shall be downloadable while the Unit is at the maintenance depot or any of the identified sidings. TTS-825

3.34.1.7 All passenger count data shall be accessible remotely and in real time from the Wayside. TTS-826

3.34.2 Passenger Loadweigh Monitoring TTS-827

3.34.2.1 All Units shall have a loadweigh monitoring system that automatically monitors passenger load in order to estimate the number of passengers on board. TTS-828

3.34.2.2 The loadweigh system shall record the passenger loading to an accuracy of 10 passengers per vehicle. TTS-829

3.34.2.3 The loadweigh system shall have the capability to categorise for each Vehicle the loading as follows:

- empty to 50% seated;
- 50% seated to fully seated; TTS-830
- fully seated to Normal Payload; and
- Normal Payload to Exceptional Payload.

3.34.2.4 The passenger loadweigh monitoring system shall record the individual journey, location, time and date for which the recorded information applies. TTS-831

3.34.2.5 The passenger loadweigh monitoring system shall provide data which shows the number of passengers on board the Unit on departure from each station. TTS-832

3.34.2.6 Passenger loadweigh monitoring data for the Unit shall be downloadable and accessible to the Wayside in real time while the Unit is in motion using the permissible bearers defined in Appendix B. The data shall be presented in a format acceptable to the Purchaser. TTS-833

3.34.2.7 Passenger loadweigh recorded data for the Unit shall be downloadable while the Unit is at the maintenance depot using the permissible bearers as defined in Appendix B. The data shall be presented in a format acceptable to the Purchaser. TTS-834

3.34.2.8 The passenger loadweigh monitoring system shall utilise periods where the Unit Vehicles are out of operational service to calibrate the system. TTS-835

3.35 Interior Lighting TTS-836

3.35.1.1 The interior lighting within passenger and crew areas shall provide TTS-837

illumination that presents a safe, secure and pleasant glare free environment.

3.35.1.2 The interior lighting shall be integrated with the interior design. TTS-838

3.35.1.3 The Unit shall be fitted with high efficiency interior lighting that provides illumination in accordance with Applicable Laws and Standards. The interior lighting system shall comply with the requirements of BS EN 13272:2012 and where clauses differentiate between rolling stock types the requirements for 'conventional trains' shall apply. TTS-839

3.35.1.4 In addition to complying with the requirements of BS EN 13272:2012, the Unit shall be fitted with an emergency lighting system (as defined in BS EN 13272:2012) that meets the requirements of Railway Group Standard GM/RT2130. TTS-840

3.35.1.5 The interior lighting system shall be fully compatible with the requirements of the Saloon CCTV system. TTS-841

3.35.1.6 The interior lighting system shall be compatible with the passenger information system, interior signage and advertising systems. This shall ensure that there shall be no adverse glare or reflections caused by the lighting system during any ambient light conditions. TTS-842

3.35.1.7 The interior lighting system shall include energy saving features, including where practicable to automatically reduce lighting use when Units are in service in high ambient light levels, or unoccupied and stabled out of service. TTS-843

3.35.1.8 The interior lighting and the associated controls shall be configured to facilitate light cleaning activity (e.g. removal of loose litter and newspapers) by cleaning staff without the need to activate a driving cab or energise other Unit systems. TTS-844

3.36 Heating, Ventilation and Air Conditioning System TTS-845

3.36.1 Passenger HVAC TTS-846

3.36.1.1 The passenger saloon of each Vehicle shall be fitted with an HVAC system which is independent of the cab HVAC system and which shall conform to the requirements of BS EN 14750-1:2006. The HVAC system shall include a heating and cooling function in conformance with BS EN 14750-1:2006 and an emergency ventilation system. TTS-847

3.36.1.2 Vehicles shall be considered to be 'Category B' Vehicles in accordance with the definition and requirements defined within BS EN 14750-1:2006. TTS-848

3.36.1.3 The passenger HVAC system shall adopt control functions that allow for a high degree of flexibility to optimise the passenger environment. This shall include optimising controls taking account of changes in the passenger load on a Vehicle and providing specific seasonal functionality. TTS-2613

3.36.1.4 To provide normal and specific seasonal controls the passenger HVAC system shall as a minimum have three modes of operation. These modes shall be: TTS-849

- a normal default mode as defined by clause 3.36.1.5;
- a winter mode; and
- a summer mode.

It shall be possible for Authorised Persons to select the operating mode via

a method acceptable to the Purchaser. If no mode has been selected the normal default mode shall apply.

3.36.1.5 The passenger HVAC system shall be capable of regulating the passenger saloon temperature to the recommended curve (Figure A.2, curve 1) defined within BS EN 14750-1:2006 when the Unit is under all passenger load conditions up to and including Normal Payload. TTS-850

3.36.1.6 The passenger HVAC system shall be able to operate under the extreme external temperature requirements defined by clause 6.2 of BS EN 14750-1:2006. The normal exterior temperature range that shall be used as the basis to calculate the extreme temperature range shall be -10°C to +40°C. TTS-851

3.36.1.7 The interior set point temperature of the passenger HVAC system shall initially be set as follows for the winter and summer modes under all passenger load conditions up to and including Normal Payload:-

- In the winter mode regulating to a curve that follows the upper limit of the permitted area in Figure A.2 of BS EN 14750-1:2006 from an external ambient temperature of -40°C until this upper limit intersects with the recommended regulation curve, above which the recommended regulation curve shall apply; TTS-852
- In the summer mode regulating to a curve that follows the lower limit of the permitted area in Figure A.2 of BS EN 14750-1: 2006 from an external ambient temperature of +40°C to +10°C, below which the recommended regulation curve shall apply.

3.36.1.8 In order to ensure a comfortable passenger environment is achieved the passenger HVAC system design and validation processes shall optimise and where appropriate amend:

- the normal default mode settings;
- the winter and summer mode settings; and TTS-2614
- the system controls adopted to account for quickly changing passenger loads.

The process and amendments to the controls to achieve this optimisation shall be agreed with the Purchaser.

3.36.1.9 With due consideration to the required adoption of OWG between all Vehicles, the passenger HVAC system on a Vehicle shall be capable of continued operation irrespective of the condition of the air conditioning system on the adjacent Vehicle(s). TTS-853

3.36.1.10 The HVAC system shall incorporate energy saving functionality. This shall include, as a minimum, the facility to limit fresh air intake when the Unit is not in traffic or is lightly loaded, and modes which vary the target temperature when the Unit is not in traffic. The control modes when the Unit is not in traffic may include: TTS-854

- differences in target set point between heating and cooling modes, acceptable to the Purchaser; and
- the ability to remotely activate HVAC systems prior to the Unit entering service, acceptable to the Purchaser.

3.36.1.11 The Unit shall incorporate smoke detection functionality which on detection of smoke within the HVAC system shall respond accordingly to minimise the risks associated with drawing smoke into the Vehicle saloon or circulating TTS-855

smoke within the HVAC system.

3.36.1.12 The passenger HVAC system shall have a manual override system which can be activated by the driver under emergency conditions. The manual override shall prevent the drawing in of smoke from outside of the Unit. TTS-856

3.36.1.13 The passenger HVAC system shall have the capability to allow Resetting of appropriate faults by the driver, as far as reasonably practicable from within the cab. TTS-857

3.36.1.14 The Unit shall incorporate an emergency ventilation capability to ensure that, in the event of failure or loss of the normal HVAC function, the internal air quality requirements of the CR-TSI are maintained for a minimum duration of 60 minutes following loss of the normal function. TTS-858

3.36.1.15 The air inlets and outlets of the passenger HVAC system in the saloon shall be designed and located to minimise the likelihood of being covered by passengers or their possessions, particularly in consideration of the use of longitudinal seating and luggage stowed under the seats. TTS-859

3.36.2 Cab HVAC TTS-860

3.36.2.1 Each drivers cab shall be fitted with an HVAC system which is independent of the passenger saloon HVAC system and which shall conform to the requirements of BS EN 14813-1:2006 + A1:2010. This system shall include a heating and cooling function in conformance with BS EN 14813-1:2006 + A1:2010. TTS-861

3.36.2.2 The driving cab shall be considered to be 'Category A' in accordance with the definition and requirements defined within BS EN 14813-1:2006. TTS-862

3.36.2.3 The cab HVAC system shall allow the driver to select the following:

- the cab interior set-point temperature (between +18°C to +26°C in accordance with BS EN 14813-1:2006 +A1:2010);
- the fan speed (high or low in accordance with BS EN 14813-1:2006 + A1:2010); TTS-863
- operate in fresh air ventilation mode drawing air into the cab from outside of the Unit; and
- turn off the cab HVAC system.

3.36.2.4 The cab HVAC system shall achieve the desired set temperature within 20 minutes of the cab being opened up for use when all cab doors and windows are fully closed, for the full range of ambient temperature limits defined within BS EN 14813-1:2006. TTS-864

3.36.2.5 The cab HVAC system shall permit appropriate adjustment of air flow and direction and shall avoid the generation of draughts which may cause discomfort or distraction to the driver. TTS-865

3.37 Passenger Information System TTS-866

3.37.1 General TTS-867

3.37.1.1 The Unit shall be equipped with a Passenger Information System (PIS) which provides the following functions on all parts of the LO Infrastructure: TTS-868

- crew audio communication;
- public address audio (compliant with PRM-TSI requirements);

- automated passenger audio and visual broadcasts (compliant with PRM-TSI requirements);
- Service Information audio and visual broadcasts;
- passenger alarm communication (compliant with CR-TSI requirements); and
- passenger Call For Aid communication (compliant with PRM-TSI requirements).

3.37.1.2 The failure of one or more of the PIS functions shall not affect the operation of the other PIS functions. TTS-869

3.37.1.3 The PIS functions shall be prioritised according to a hierarchy acceptable to the Purchaser such that display, broadcast and communication of important information always takes precedence over lower priority functions. TTS-870

3.37.1.4 Visual messages displayed shall be clear, legible and free of reflection and glare under all lighting conditions. TTS-871

3.37.1.5 All audio announcements shall be free of echoes, reverberations and feedback and shall provide a high quality output which is clearly audible throughout the Unit, with a RASTI of 0.65 or greater. Volume levels shall be automatically adjusted for the background noise level. TTS-872

3.37.1.6 The PIS shall integrate audio announcements and visual display functions so that they are consistent with each other throughout the Unit's journey. TTS-873

3.37.1.7 The number, content, timing and duration of automatic and service audio announcements and visual messages shall be acceptable to the Purchaser and installed on the Unit prior to delivery by the Manufacturer. TTS-874

3.37.1.8 It shall be possible to configure the PIS according to the Unit Reporting Number input by the driver. TTS-875

3.37.1.9 It shall be possible to configure any passenger information or electronic advertising display on the Unit to display, continuously or intermittently, the time of day in 24-hour clock format (hh:mm) synchronised to the time displayed in driving cabs in accordance with 3.38.1.9. TTS-876

3.37.2 Crew Audio Communications TTS-877

3.37.2.1 The crew audio communications function shall include secure, Full Duplex crew communications which shall permit the discreet communication between driver and Authorised Persons in the rear cab. TTS-878

3.37.2.2 Driver to crew communication shall not interfere with the normal automatic announcements being made by the PIS or be interrupted by any other PIS function. TTS-879

3.37.3 Public Address Audio TTS-880

3.37.3.1 The PIS shall include a PRM-TSI compliant public address audio function which shall permit the driver or second crew member from any Occupied Cab or Non-occupied Cab to make manual audio announcements to all passenger areas. TTS-881

3.37.3.2 Public address audio announcements shall override any other audio announcements in progress. TTS-882

3.37.3.3 The PIS shall allow remote direct addressing of the Unit's public address audio by the signaller through the GSM-R radio system as defined by TTS-883

GK/RT 0094. This shall permit the signaller to address the passengers via the public address system on demand.

3.37.3.4 The driver's ability to communicate over the Unit's public address audio shall take precedence over communication with individual CFA or PEA points. The driver shall have the capability to communicate with all passengers at any time. TTS-884

3.37.4 Automated PRM-TSI compliant Passenger Audio and Visual Broadcasts TTS-885

3.37.4.1 The PIS shall include a PRM-TSI compliant automatic passenger audio and visual broadcast function. TTS-886

3.37.4.2 The PIS shall provide audio announcements as follows:

- prior to each station stop - The Approach Announcement; and
- on arrival at the station stop - The Arrival Announcement; and TTS-887
- following the Arrival Announcement and before departure from each station - The Departure Announcement.

3.37.4.3 The PRM-TSI compliant visual displays shall be integrated into the vehicle interior design and be located to provide the best practicable view to seated and standing passengers. TTS-888

3.37.4.4 The PRM-TSI compliant visual displays shall use thin film transistor (TFT) colour display technology. TTS-889

3.37.4.5 The PIS shall provide visual information as follows:

- prior to each station stop - The Approach Message;
- during the station stop - The Arrival Message; and TTS-890
- following the display of the Arrival Message and before departure from each station - The Departure Message.

Each message shall be displayed until over written by the next.

3.37.4.6 The PRM-TSI compliant visual messages shall not be split between adjacent displays, and the displays shall be sized to minimise the scrolling of text. TTS-891

3.37.4.7 The PIS shall allow the driver to:

- suppress automated audio announcements and visual messages; and TTS-892
- initiate standard pre-programmed automated audio announcements and visual messages for particular situations on demand.

3.37.4.8 The PIS shall provide external visual displays at the front of each Driving Vehicle displaying the final destination. TTS-893

3.37.4.9 The PIS shall provide external visual displays on both sides of each Vehicle. The displays shall show the following information:

- final destination; and
- Unit Reporting Number. TTS-894

The displays shall also be capable of simultaneously showing the following information:

- Vehicle identification; and

- next station stop.

3.37.4.10 The external Vehicle displays shall be designed such that they can be easily read by the User Population waiting on platforms in a variety of lighting environments likely to be encountered on the LO Infrastructure. The displays shall be sized to minimise the scrolling of text. TTS-895

TTS-896

3.37.5 Service Information Audio and Visual Broadcasts

3.37.5.1 The PIS shall provide a Service Information audio and visual broadcast function. TTS-897

3.37.5.2 The Service Information audio and video broadcasts can take the form of either pre-programmed routine broadcasts or broadcasts triggered from the Wayside in response to specific real time events. TTS-898

3.37.5.3 The PIS shall provide Service Information audio announcements in a manner which is consistent with the PRM-TSI compliant automated announcements as follows:

immediately following the Approach Announcement:

- specific restrictions relating to the next stop pertinent to a specific Vehicle, e.g. ASDO door opening restrictions (these announcements shall be made only on the Vehicle(s) to which the restriction applies);
- specific restrictions relating to the next stop e.g. lift out of Service Information; and
- specific details relating to the next stop providing information about local landmarks, tourist attractions and other places of interest (these announcements shall be filtered by day of the week and time of day). TTS-899

on demand in response to a triggering signal sent from the Wayside to assist managing real time events:

- specific announcements from a predetermined list programmed into the Unit PIS, filtered such that only information applicable to the Unit's diagram and location is broadcast. These announcements include, but are not limited to, station closures, Unit diversions, service delays, service suspensions or service terminations.

The content and extent of Service Information audio announcements shall be agreed with the Purchaser.

3.37.5.4 The Service Information internal visual displays shall allow the display of text messages, pictograms and high quality video information such as the TfL Live Service Update Board. TTS-900

3.37.5.5 The Service Information internal visual displays shall use thin film transistor (TFT) colour display technology. TTS-901

3.37.5.6 The arrangement of Service Information internal displays shall be such that Service Information messages do not interrupt or confuse mandatory PRM-TSI messages. TTS-902

3.37.5.7 The PIS shall provide Service Information visual messages to be displayed as follows:

throughout the journey: TTS-903

- the local Vehicle identification;

immediately following the Approach Message:

- specific restrictions relating to the next stop pertinent to a specific Vehicle, e.g. ASDO door opening restrictions (these visual messages shall be displayed only on the Vehicle(s) to which the restriction applies);
- specific restrictions relating to the next stop e.g. lift out of Service Information; and
- specific details relating to the next stop providing information about local landmarks, tourist attractions and other places of interest (these announcements shall be filtered by day of the week and time of day).

on demand in response to a triggering signal sent from the Wayside to assist managing real time events :

- specific visual messages from a predetermined list programmed into the Unit PIS, filtered such that only information applicable to the Unit's diagram and location is broadcast. These visual messages include, but are not limited to, station closures, Unit diversions, service delays, service suspensions or service terminations.

The content and extent of Service Information visual messages shall be agreed with the Purchaser.

3.37.5.8 The Service Information internal visual displays shall allow the display of freeform text visual messages sent from the Wayside. TTS-904

TTS-905

3.37.6 Passenger Emergency Alarms

3.37.6.1 The PIS shall be provided with PEA devices compliant with the requirements of the CR-TSI (section 4.2.5.3(b) applies). TTS-906

3.37.6.2 The PEA devices shall be integrated into the vehicle interior design yet be prominent, positioned and designed, so far as is practicable to deter malicious or accidental operation. The location and design of the PEA devices shall be acceptable to the Purchaser. TTS-907

3.37.6.3 It shall be possible for PEA devices to be Reset by the driver without leaving the driving cab. TTS-908

TTS-909

3.37.7 Call For Aid

3.37.7.1 The PIS shall be provided with CFA devices, compliant with the requirements of the CR-TSI and PRM-TSI at all designated wheelchair spaces. TTS-910

3.37.7.2 The CFA devices shall be clearly distinguishable from PEA devices and shall include appropriate signage (acceptable to the Purchaser) to advise users how to contact the driver in the event that assistance is required. TTS-911

3.37.7.3 The activation of a CFA, and its location on the Unit, shall be immediately indicated to the driver in a way that is clearly distinguishable from activation of a PEA. TTS-912

3.37.7.4 The activation of a CFA shall be clearly indicated to the user. TTS-913

3.37.7.5 The CFA units shall be integrated into the Vehicle interior design yet be prominent, and as far as is reasonably practicable within the constraints of Applicable Laws and Standards be protected from accidental operation. The location and design of the CFA units shall be acceptable to the Purchaser. TTS-914

3.37.7.6 It shall be possible for CFA units to be Reset by the driver without leaving the driving cab. TTS-915

3.37.8 System Updates and Capacity TTS-916

3.37.8.1 The PIS shall allow updates of the number, content, timing and duration of automated and service audio announcements and visual messages by the Purchaser in accordance with ongoing operational requirements e.g. timetable changes, using hardware and software provided by the Manufacturer. TTS-917

3.37.8.2 PIS updates, including audio and visual databases, shall be achievable by a Wayside PIS remote download system initiated by the Purchaser when the Unit is not in service. TTS-918

3.37.8.3 The PIS shall permit updates, including full timetable changes and short term timetable changes (for engineering work, special events, etc.), to be implemented overnight across all Unit's ready for the following day's service. TTS-919

3.37.8.4 Where the PIS updates defined in clauses 3.37.8.1 to 3.37.8.3 cannot be implemented across all Units, due to a Unit or Units being powered down or not having communication network coverage, the remote download system shall report to the user which Unit or Units have been successfully updated and which has not. TTS-920

3.37.8.5 To manage the partial fleet updates defined in clause 3.37.8.4, the PIS remote download system shall have the functionality to allow a user to apply the PIS updates not only to all Unit's but also to a Unit or a selectable subset of Unit's. TTS-921

3.37.8.6 The PIS shall have a Unit diagnostic port that shall allow PIS audio and visual database updates on a specific Unit when the Unit is not in service. TTS-922

3.37.8.7 The PIS shall have sufficient capacity to store the audio announcements and visual messages required for operation on the LO Infrastructure. TTS-923

3.37.8.8 Special tools, equipment and software provided for the PIS shall allow the following:

- recording and compiling all audio and visual messages;
- updating / editing the databases;
- remotely uploading the databases from the Wayside; TTS-924
- uploading the databases via the Unit diagnostic port; and
- support the PIS requirements of this specification.

The functionality of the equipment shall be developed by the Manufacturer and be acceptable to the Purchaser.

3.38 Driving Cab TTS-925

3.38.1 Driving Cabs General TTS-926

3.38.1.1 Identical driving cabs shall be provided at both ends of the Unit to permit operation of the Unit in either direction. TTS-927

3.38.1.2 The driver's cab shall ensure that drivers ranging from 5th percentile adult UK female to the 95th percentile adult UK male shall be able to undertake all driving tasks safely and efficiently from the seated position, including: TTS-928

- driving the Unit;

- controlling the door systems;
- using the passenger information system;
- communicating with the signaller using the train radio(s);
- interfacing with the Train Management System;
- viewing the DOO CCTV; and
- viewing the Saloon CCTV.

3.38.1.3 Forward sightlines from the driving position (calculated in accordance with GM/RT2161) shall be maximised as far as practicable within the constraints imposed by crashworthiness and other necessary considerations. TTS-929

The Units will be required to couple frequently in normal service, the sightlines shall give a view of the track (at rail height) at 5 m beyond the vehicle BED as specified in GM/RT2161 clause 6.1.1 case (a).

3.38.1.4 The driving cab design shall adopt either a left hand side or central driving position of the cab, and shall achieve sightlines compatible with operating on the LO Infrastructure. TTS-930

3.38.1.5 The driver's combined traction power and brake controller shall have the following positively notched positions:

- brake control with three equally distributed levels of service brake application and one emergency brake application position; TTS-931
- release position; and
- traction control with four equally distributed levels of traction power.

3.38.1.6 The driver's combined traction power and brake controller shall adopt standard UK practice for direction of application of traction and braking. TTS-932

3.38.1.7 The driving cabs shall provide a second seated position for a Second Person. TTS-933

3.38.1.8 The driver's cab shall ensure that Second Persons ranging from 5th percentile adult UK female to the 95th percentile adult UK male shall be able to undertake all tasks safely and efficiently from the seated position, including:

- viewing the line ahead for the purposes of driver instruction; TTS-934
- monitoring the behaviour and performance of the driver;
- providing verbal instruction and advice to the driver; and
- operating an emergency brake control.

3.38.1.9 The driver's cab desk shall include a digital clock display, in a prominent position viewable from the driver's seated position, formatted hh:mm:ss. The time shall be maintained from the TMS synchronised on board clock. TTS-935

3.38.1.10 Interior surface finishes and colours shall be designed to minimise glare and reflection and appropriate contrasts shall be included to ensure clear visibility of displays and controls. Electronic displays shall be positioned or shielded to ensure that visibility is not impaired by incident sunlight. TTS-936

3.38.1.11 The cab environment shall provide a modern-appearance and easy to clean working environment for staff, follow demonstrably good ergonomic design principles and be subjected to a comprehensive human factors study. The design, materials and equipment shall be suitably robust for a heavily used cab environment and shall as a minimum meet the standards prescribed in TTS-937

this specification for the passenger saloons for, inter alia, cleanability, damage resistance, repair, maintainability and panel fit.

3.38.1.12 The driver's cab shall meet the structural requirements of GM/RT2100. TTS-938

3.38.1.13 The components within the cab shall resist damage from robust usage, vandalism and deliberate attempts to misuse. TTS-939

3.38.1.14 All surfaces surrounding controls and instruments shall be designed and constructed to prevent cups, flasks or bottles being balanced on them. TTS-940

3.38.1.15 Equipment within the cab shall be protected from inadvertent actuation or damage for example by persons accessing or leaving the driver's position or when the driver's seat is being adjusted. TTS-941

3.38.1.16 The driver's cab shall be sealed against draughts with all doors and windows closed. TTS-942

3.38.1.17 While one cab within the Unit is active it shall not be possible for the other cab to be activated to take control of the Unit. Specific functionality shall be allowed from the non-active cab as defined within this specification. TTS-943

3.38.1.18 The cab back wall shall constitute a fire barrier in accordance with Applicable Laws and Standards and shall in addition provide, as far as reasonably practicable, a secure barrier against penetration due to explosion or terrorist act in the adjoining passenger saloon that might disable the driver. In particular, the cab back wall shall be secured directly to the main framework of the vehicle and be fully compliant with the requirements of GM/RT2100. TTS-944

3.38.2 Cab Access and Egress TTS-945

3.38.2.1 Each driver's cab shall be equipped with an exterior door on each side, which shall not be available for passenger use. TTS-946

3.38.2.2 The driver's cab exterior doors shall provide direct access between the cab interior and Vehicle exterior without passing through a vestibule. TTS-947

3.38.2.3 Each cab shall be equipped with a cab to saloon door to provide access to the passenger saloon area. TTS-948

3.38.2.4 The cabs shall be suitably secured to permit only authorised entry in accordance with the hierarchical key strategy requirements acceptable to the Purchaser. TTS-949

3.38.2.5 The cab to saloon door shall be an unglazed, solid and robust door with a 'spy hole' device for viewing into the passenger saloon from the driving cab. TTS-950

3.38.2.6 The cab to saloon door shall be secured against unauthorised access into the cab from the passenger saloon, but shall allow the driver to exit the cab into the passenger saloon without using any tool or key. TTS-951

3.38.2.7 The driver's cab doors and doorways shall be designed to accommodate the full range of the User Population. TTS-952

3.38.2.8 The status of all cab doors shall be reported to the driver via the TMS. The cab bodyside doors shall be interlocked to the traction system to prevent movement of the Unit when the door is not proven closed. TTS-953

3.38.3 Cab Storage and Other Facilities TTS-954

3.38.3.1 The driver's cab shall be provided with the following facilities: TTS-955

- two coat hooks;
- small waste bin;
- two cup holders (one per driver's and Second Person's side);
- illuminated A4 size clipboard for notices;
- bag storage for a small sized rucksack or bag (size as defined in CR-TSI); and
- two BS1363 type socket outlets (one per driver's and Second Person's side) for charging equipment including mobile phones, to be available for use whenever the Unit is powered.

3.38.4 Cab Windscreen and Windscreen Systems. TTS-956

3.38.4.1 A cab windscreen shall be provided that provides forward visibility as required by 3.38.1.3 and complies with the Applicable Laws and Standards for strength and optical properties. TTS-957

3.38.4.2 The Unit shall be fitted with a windscreen wiper and washer system in accordance with Applicable Laws and Standards, and shall include an intermittent wipe facility. TTS-958

3.38.4.3 The windscreen wipers and washers shall be of a robust construction and be resistant to damage caused by impact with projectiles and objects that may reasonably be assumed (for example bird strikes and wash plant brushes). TTS-959

3.38.4.4 The windscreen wipers shall not suffer from adverse aerodynamic effects and shall retain full contact with the windscreen and full coverage of the required sight line area under all conditions up to the maximum operating speed of the Units. TTS-960

3.38.4.5 Windscreen de-icing and de-misting equipment shall be provided together with fully adjustable sun visors in accordance with Applicable Laws and Standards. TTS-961

3.38.4.6 The windscreen shall be designed to allow swift change-out following damage. The total change time for a damaged or defective windscreen to allow a Unit to be returned to service shall be less than 4 hours. TTS-962

3.38.5 Cab Side Windows TTS-963

3.38.5.1 The driving cabs shall be provided with openable cab side windows, suitably sized and located to permit the driver to view platform mounted stop boards from the seated driving position. TTS-964

3.38.5.2 If the cab side window on the driver's side is located adjacent to the driver's seat and desk, it shall be provided with an adjustable sun visor to minimise glare and reflections. TTS-965

3.38.5.3 Where clearances cannot be maintained in accordance with the requirements of GC/RT5212 for opening windows, the Unit design shall ensure that credible risk to train crew from the side window being open when the Unit is in motion is prevented. TTS-966

3.38.6 Emergency and Safety Equipment TTS-967

3.38.6.1 The Unit shall be equipped with emergency and safety equipment which comply with the requirements of GM/RT2130 and GM/RC2532. TTS-968

Certain equipment shall be located within the cab in accordance with Appendix D; other equipment shall be located elsewhere on the Unit in accordance with Appendix D.

The final location of all emergency and safety equipment shall be agreed with the Purchaser.

3.38.6.2 Access to the emergency and safety equipment enclosures shall be by means of a robust and protected mechanism. It shall be easy for maintenance and operations personnel to identify if the protection has been breached and the mechanism has been operated to gain access to the equipment. TTS-2615

3.39 Train Management System TTS-969

3.39.1 General TTS-970

3.39.1.1 The Unit shall be equipped with a TMS which shall support the driver, train crew, train operator and maintainer with the information necessary to achieve the required Unit service performance and manage disruptions with the minimum impact on the service. TTS-971

3.39.1.2 The TMS shall provide a comprehensive interface between Unit Subsystems and the driver, maintenance and operational staff. TTS-972

3.39.1.3 The TMS shall monitor Unit status and advise the driver and Wayside of the current status of the Unit to:

- assist in operating the Unit in an effective manner;
- manage faults and failures of Unit Subsystems so as to minimise the impact on service;
- support the Purchaser in the implementation of processes to manage the operational capability of the Unit; TTS-973
- provide guidance to drivers on appropriate responses to fault situations; and
- assist the maintenance of the Unit.

3.39.1.4 Where the Unit status requires intervention by the driver or maintenance staff then the TMS shall raise an appropriate alarm.

Three levels of alarm shall be generated:

- Category A - Those requiring immediate action by the driver. These shall be displayed to the driver and transmitted to the Wayside immediately;
- Category B - Those requiring action by technical staff or the driver during the turn of duty, whilst the Unit is in service. These shall be displayed to the driver only when it is appropriate to do so, and transmitted to the Wayside within 30 minutes of occurrence; and TTS-974
- Category C - Those requiring action by maintenance staff when the Unit returns to the depot. These shall not be displayed to the driver but shall be transmitted in a timely manner to the Wayside to facilitate appropriate corrective action or maintenance activity.

3.39.1.5 For each alarm the following information shall be provided: TTS-975

- a clear explanation of the meaning of the alarm;
- the source of the alarm, including where factors external to the Unit (e.g. fluctuations in supply voltage) have initiated an alarm; and
- the recommended action to be taken to address the cause of the alarm.

3.39.1.6 The TMS shall report an alarm relating to the primary cause, and shall not raise alarms for consequential effects of the primary cause.

For example, where a fault with the Unit's auxiliaries occurs an alarm shall be raised for that fault, without raising 'loss of power' alarms for all the Subsystems that operate off the auxiliary supply. TTS-976

3.39.1.7 The TMS shall monitor status event information for the Unit. All status event information shall be available to maintenance staff and operations staff. A sub-set of the full status events shall be available to the driver. TTS-977

3.39.1.8 The TMS shall record Unit alarm and status events for investigative purposes on or off the Unit. All recorded alarms and status events shall be time and position stamped such that it is possible to accurately reconstruct a sequence of events and actions. TTS-978

3.39.1.9 The TMS shall operate in accordance with a defined alarm and status events strategy for the Unit, which shall be acceptable to the Purchaser. This strategy shall include:

- Unit functions requiring alarms and status events;
- the initiating condition for each alarm;
- the category of each alarm; TTS-979
- the method to alert the driver of each alarm;
- the text for each alarm and status event, the source information and where appropriate the action message; and
- demonstration that the alarms, status events and associated information is clear, concise and appropriate to the actions required.

3.39.1.10 The TMS shall allow the alarm category, message text and supporting information to be modified by the Purchaser throughout the operational life of the Unit. TTS-980

3.39.1.11 The TMS shall maintain a synchronised on board clock across all Unit Subsystems which shall itself be synchronised to a recognised external time source.

This shall provide for the following:

- digital time display to the driver, formatted hh:mm:ss;
- use by the PIS Subsystem; TTS-981
- time stamping of alarms and status events;
- time stamping of recorded DOO CCTV, Saloon CCTV and FFCCTV (including pantograph monitoring CCTV) images; and
- time stamping of Unit Subsystem event logs.

This clock shall be consistent with the times held in the OTMR and, if the passive provision for ETCS is exercised, the Juridical Recorder.

3.39.1.12 The TMS shall record events detected by on-board systems that may TTS-982

indicate faults with the infrastructure, or provide information relating to the improved working of the Unit/infrastructure interface. Such events shall include (subject to the functionality of on-board systems), but not be limited to:

- loss of Traction Power Supply, or fluctuation outside voltage or operational limits;
- activation of the pantograph automatic dropping system;
- sanding activity; and
- areas of low adhesion conditions.

The threshold levels and logical conditions for reporting these events shall be acceptable to the Purchaser.

For each event the location, time and duration shall be recorded. The recorded data to support each event shall be retained by the Unit for a period of no less than 3 days.

3.39.1.13 The level of accuracy to which on-board and infrastructure monitoring events are time and location stamped shall be appropriate to the event being recorded and shall be acceptable to the Purchaser. TTS-983

3.39.1.14 The alarms, status events and measurements monitored by and recorded within the TMS shall be readily accessible to the Purchaser and shall be presented in a format agreed with and acceptable to the Purchaser. Refer also to clause 3.39.4 and section 3.40. TTS-984

3.39.2 Driver Interface to the TMS

TTS-985

3.39.2.1 The driver interface to the TMS shall be via an HMI screen in the driver's cab. TTS-986

3.39.2.2 The TMS HMI shall provide a common HMI based data entry and driver login function for Unit Subsystems to prevent the need for double entry of data. TTS-987

3.39.2.3 The TMS HMI shall not distract the driver while the Unit is in motion unless a Category A alarm is active. TTS-988

3.39.2.4 The information displayed to the driver by the TMS shall be presented using a consistent format, language and terminology. TTS-989

3.39.2.5 The TMS shall have a facility for the driver to enter 'defect log' information via a simple, intuitive interface. Logged reports shall include time, date, Unit and driver identity cross references. It shall be possible to recover TMS defect log information remotely or via routine TMS fault log downloads. The defect log facility functionality shall be acceptable to the Purchaser. TTS-990

3.39.2.6 Where the TMS requires the operation of soft pushbuttons by the driver when the Unit is in service, this shall not be by scrolling through screens to access the required function. The TMS soft pushbutton arrangement shall be subject to human factors assessment by the Manufacturer and acceptable to the Purchaser. TTS-991

3.39.3 Subsystem Interfaces

TTS-992

3.39.3.1 The TMS shall provide the principal interface to enable on board Subsystems to be interrogated, downloaded and updated, such Subsystems shall include: TTS-993

- CCTV systems;
- PIS;
- OTMR;
- Traction System;
- auxiliary power supply and battery charging system;
- brake and air system;
- de-icing system;
- cab and saloon HVAC;
- doors systems;
- passenger loadweigh systems; and
- train control and protection systems.

3.39.4 Operator and Maintainer Interfaces

TTS-994

3.39.4.1 In order to assist maintenance staff and operations staff investigating incidents, the TMS shall be the principal interface for TMS alarms and status events and the retrieval of system status data associated with all Unit Subsystems. TTS-995

3.39.4.2 The TMS shall collate TMS alarms and status events and Subsystem status data, both current and historical. It shall provide access to all data via:

- remote download capability with the Wayside; TTS-996
- the driver TMS HMI; and
- through a single Unit diagnostic port providing a laptop connection.

3.39.4.3 TMS alarms and event status data and Subsystem status data shall be clear and unambiguous to assist maintenance technicians undertaking maintenance diagnostic activity. TTS-997

3.39.4.4 The TMS shall monitor and record Unit mileage for the purposes of operational and maintenance planning. Two levels of mileage recording shall be provided:

- total accumulated mileage from service introduction; and TTS-998
- accumulated mileage since last scheduled maintenance inspection.

The mileage recording, accessing and Resetting functionality shall be acceptable to the Purchaser.

3.39.4.5 Special tools, equipment and software required for the retrieval, processing and analysis of the TMS data shall allow the following:

- wayside retrieval of data for off-board review and/or storage on secure digital media; and
- laptop retrieval of data using the on-board diagnostic port, for off-board review and/or storage on secure digital media. TTS-999

Both of these retrieval mechanisms shall permit:

- searching and viewing data by the input of specific date, time or Event Trigger criteria;
- scrolling through data;

- editing alarm message and system status event text;
- uploading of revised alarm and system status event text to the Unit; and
- interrogating, downloading and updating Subsystem data.

The functionality of the equipment and the format of the data shall be developed by the Manufacturer to a specification acceptable to the Purchaser.

3.39.5 Performance Regime Monitoring

TTS-1000

3.39.5.1 The TMS shall continuously monitor and record the health of Unit systems as listed in the TSA to provide the data needed to support the operation of the Performance Regime. TTS-1001

3.39.5.2 The TMS shall record data to assist with verifying that the Unit has performed a station stop; this shall consist of recording time and location for the following events:

- Unit stopping at a platform;
- door release;
- door closing; TTS-1002
- Unit door interlock being achieved; and
- Unit departing a platform.

The recorded data shall be marked with the driver identification, Unit identification and Unit Reporting Number.

3.40 Data Communication System

TTS-1003

3.40.1.1 The Unit shall have a Unit to Wayside data communications system to enable the timely transmission of data between the Unit and the Wayside. TTS-1004

3.40.1.2 The data communication system shall transmit or receive data from the Unit, using GSM-R where mandated and the permissible bearers defined by the Manufacturer as specified in Appendix B, in order to provide the maximum coverage. TTS-1005

3.40.1.3 In order to ensure compatibility with the Purchaser' s operational strategy the specific Wayside location(s) to which each item of data defined within this specification is sent shall be configurable and agreed with the Purchaser. TTS-1007

3.40.1.4 The design of data communication systems shall take account of the guidance contained in Railway Group Guidance Note GE/GN8579. TTS-1008

3.40.1.5 The Unit's data communication system shall be capable of being updated to take advantage of future technological development of technology and to prevent obsolescence within the data communication system. TTS-1009

3.40.1.6 The Unit shall transmit or receive data using the optimal transmission method dependent on the bandwidth availability of each wireless service. It shall be possible to change and reassign the allocation of datasets to particular communication transmission methods in the event of service experience or availability of transmission method. TTS-1010

3.40.1.7 The data communication system shall as a minimum exchange the data defined in Appendix B. TTS-1011

3.40.1.8 In order to manage the available bandwidth, particularly demands on low bandwidth data networks, communication shall be prioritised and transmitted according to operational priorities. TTS-1012

3.40.1.9 The Unit data communication equipment shall be compatible with the Wayside equipment required to receive, send, process, review, interpret and distribute the applicable system data. All Wayside equipment to permit the above shall be provided by the Manufacturer. TTS-1013

TTS-1014

3.41 Reliability and Resilience

TTS-1015

3.41.1 General Reliability Requirements

3.41.1.1 All aspects of the design and manufacture of the Unit and its Subsystems shall be demonstrably undertaken in a way that delivers the required reliability performance. TTS-1016

The design shall ensure that effective maintenance can contribute to the achievement of the required level of reliability.

3.41.1.2 The Unit shall be designed to achieve a Mean Distance Between Service Affecting Failures (MDBSAF) of no less than 50,000 miles. TTS-1017

3.41.1.3 The Unit shall be designed with the necessary functionality to recover from or mitigate for technical failures, so that delays are minimised. Rapid recovery shall be provided for all credible failure modes, with minimal intervention by the driver. TTS-1018

3.41.1.4 Excluding only failures arising from mechanical defect or damage to running gear that makes it physically unsafe to move the Unit without immediate technical attention, it shall be possible for the Unit to be moved under its own power within ten minutes of the Unit becoming immobilised by a fault condition. Such movement may be at reduced speed but shall be of sufficient distance and duration for passengers to be taken forward to the next station and for the Unit to proceed to a maintenance depot, stabling point or terminus station. TTS-1019

3.41.1.5 The following Subsystems are considered key in delivering the required overall reliability:

- passenger bodyside door system;
- Traction System;
- auxiliary power supply system;
- DOO CCTV system; TTS-1020
- TMS system; and
- braking systems.

The Subsystems shall be of a design that has been proven to be reliable when operating in similar conditions. Where appropriate, for example within the Traction System and auxiliary power supply systems, the design shall incorporate redundancy in order to minimise the operational impact of component failures.

3.41.1.6 The design of the Unit shall, as far as is practicable and where not compromising reliability or safety, include the ability for the driver to both Reset systems and where necessary isolate defective Unit systems from within the cab. TTS-1021

3.41.1.7 The design of the Unit and its Subsystems shall, where not compromising performance, reliability or safety, include a capability for the Unit or Subsystem to automatically Reset without the need for driver or train crew intervention. TTS-1022

3.41.1.8 Where systems within the Unit have the functionality to be Reset or automatically Reset, the Unit shall be capable of forward movement within ten minutes of the Unit becoming immobilised by a fault condition. The information displayed to the driver by the TMS in accordance with clause 3.39.1.3 shall facilitate the timely and expeditious use of Reset capability. TTS-1023

3.41.1.9 The Unit shall be able to move under its own power to the next station on any part of the LO Infrastructure, following the occurrence of credible failures. It is permissible for this movement to be at reduced speed and with affected systems isolated if required.

Credible failures are considered to include, but not be limited to: TTS-1024

- traction system faults;
- pneumatic and brake system faults;
- train protection systems faults;
- door interlock systems faults; and
- train control system faults.

3.41.1.10 The Unit shall be able to be rescued or recovered from any part of the LO Infrastructure, following the occurrence of credible failures. TTS-1025

3.41.1.11 In the event of derailment or catastrophic mechanical failure it shall be possible for the Unit to be recovered without consequential damage by methods in accordance with defined procedures and The Rule Book GE/RT8000, aided by wheel skates, rail cranes, jacks and any other tools and equipment considered necessary. TTS-1026

3.41.1.12 The traction system shall be configured in so far as is possible such that a fault on one part of the system does not disable the entire Unit. TTS-1027

3.41.1.13 The traction system shall be resilient against transient supply voltage fluctuations, icing of the OHL conductor wire and DC conductor rail, harmonic interference or any other external factors. Such resilience (i.e. the ability of the Unit to continue its journey) may be achieved by the Reset capability specified above. TTS-1028

3.41.1.14 Where the system design incorporates component redundancy as the method of reducing the consequences of single point failure, such redundancy shall not allow hidden faults to remain undetected. TTS-1029

3.41.1.15 The Unit design shall minimise the risk of complete Unit failure due to loss or lack of air. In particular vulnerable air pipes, valves, cocks and other pneumatic system equipment shall be protected from trackside damage. Isolation cocks shall be strategically located and accessible to Authorised Persons to allow isolation of leaking sections and prevent complete failure of the Unit. TTS-1030

3.41.1.16 The Unit shall include a minimum of two air compressors, which are independently powered and controlled. The output of any one compressor shall be sufficient for the Unit to complete its journey. TTS-1031

3.41.2 Isolation Capability

TTS-1032

3.41.2.1 The Unit shall incorporate controls and isolation devices to facilitate timely recovery and continued operation following the occurrence of Unit faults. TTS-1033

3.41.2.2 The location, form and function of controls and isolation devices shall be in accordance with human factors and safety requirements, and shall be acceptable to the Purchaser. TTS-1034

3.41.2.3 Where the driver needs to access controls and isolation devices, they shall be safely and readily accessible at any location on LO Infrastructure. Particular consideration shall be given for tunnel operation. TTS-1035

3.41.2.4 As far as practicable all controls and isolation devices which the driver may need to access shall be within the active driving cab. TTS-1036

3.41.2.5 Where controls and isolation devices are not located within the driving cab, they shall as far as practicable, be accessible within Vehicle saloons and secured against misuse. TTS-1037

3.41.2.6 Where controls and isolation devices are not located within a Vehicle, they shall be accessible from rail level and secured against misuse. TTS-1038

3.41.3 Cyber Security

TTS-1039

3.41.3.1 Train Control Systems shall be protected from malicious corruption of software, data tables and other information technology applications by persons remote from the Unit, or by passengers, that could result in malfunction of braking, traction, door, on-board signalling and other safety critical and safety related systems in a way that would cause danger to passengers, staff or others, or reduce the overall reliability of the Unit. TTS-1040

3.41.3.2 Data Communication systems shall be protected from malicious interference to transmission of data defined in Appendix B. In particular such protection shall prevent the display of misleading or inappropriate material on passenger information systems and advertising screens, the loss or corruption of data from the Train Management System and the loss or corruption of data from Infrastructure Monitoring Equipment. TTS-1041

3.41.3.3 Data Communication systems shall be configured so that, as far as reasonably practicable, data from on-board systems cannot be remotely accessed and interrogated by unauthorised persons. TTS-1042

3.42 Human Factors

TTS-1043

3.42.1.1 The Unit shall present a safe, secure and comfortable environment for the User Population. TTS-1044

3.42.1.2 Controls for use by the driver or train crew shall be designed so that they are intuitive to use considering the associated layout. Particular regard shall be given to reducing the likelihood of human error. As a minimum the Unit shall be designed according to the results of ergonomic and human factors studies carried out by the Manufacturer. The driver and train crew control designs shall be acceptable to the Purchaser. TTS-1045

3.42.1.3 The Unit, including Subsystems shall be designed taking into account as a minimum the following factors which might affect the ergonomic interface between the User Population and the Unit: TTS-1046

- the range of variability in the User Population;