6.1 Metrorail – 3kV DC EMU Technical Specification

Conceptual Train specifications relevant to the PRASA rolling stock fleet renewal programme

17 March 2011

Contents

Abbreviations

AC	Alternating Current
ATOC	Association of Train Operating Companies
CCTV	Closed Circuit Television
CFA	Call For Aid
dB(A)	Decibel
DC	Direct Current
EMU	Electric Multiple Unit
EN	Euro Norm (European Standard)
ERTMS	European Railway Traffic Management System
FFCCTV	Forward Facing Closed Circuit Television
LED	Light Emitting Diode
MMI	Man Machine Interface
Module	The minimum set of cars capable of independent operation in passenger service (Unit)
MRP	Main Reservoir Pipe
OH&S	Occupational Health and Safety
OTDR	On Train Data Recorder
PIS	Passenger Information System
PRASA	Passenger Rail Agency of South Africa
PRM-TSI	Technical Specification for Interoperability. Persons with Reduced Mobility (an EU Standard applicable for special needs passengers).
RASTI	Rapid Speech Transmission Index
RCD	Residual Current Detector
RTPIS	Real Time Passenger Information System
TCN	Telecommunications Network
TCP/IP	Transmission Control Protocol/Internet Protocol
TMS	Train Management System
UK Railway Group Standard	Standards Applicable in the UK
UV	Ultra Violet
Vehicle	An individual passenger vehicle

1 Introduction

The Passenger Rail Agency of South Africa (PRASA) is to invest in the fleet-wide replacement of its rolling stock and has engaged KPMG and its partners (Arcus Gibb, Interfleet Technology and Edward Nathan Sonnenbergs) to undertake a feasibility study for this programme including a Market Engagement process.

This document details PRASA's Technical Specification - as at Market Engagement - for its largest fleet: the 3kV EMU Metrorail rolling stock. It is to be read in conjunction with the associated User Requirements Specification and the Infrastructure Interface Document. It has been developed as far as possible given the current stage of the Programme. However, it is anticipated that some further detailed refinement will take place following Market Engagement.

The Technical Specification for the replacement of Eastern Cape 25kV EMU/Diesel Multiple Unit fleets and the Shosholoza Meyl fleets are be developed once the key options identified in the User Requirements Specifications for these fleets are concluded.

Variants

The User Requirements for the 3kV EMU Metrorail rolling stock anticipates that a number of variants of the basic train are, or may be, required based on two key market segments:

- Metro – Base specification, no toilets, no air-conditioning, forced ventilation and heating system, longitudinal seating.
- Metro Express – Improved passenger environment, different internal layout with lateral seating, plus some other optional enhancements (see below).

It is expected that the variants will be based, as far as possible, on a common (modular) design platform to minimise the number of different components and designs required.

In addition to the two classes described above, there are other variants envisaged.

These include:

- Some future Modules potentially being built with 160km/h capability.
- Some reduced length Modules being built to facilitate shorter off-peak services and some single trains serving both segments.
- Future Airport and Inter-Regional Service Specifications.

The basic design shall allow such variants to be built using the same common (modular) design platform with the minimum of change.

Options

A number of options are envisaged. These include:

- Provision of CCTV (currently specified as base for all Modules, but priced option for non-fitment is requested)
- Provision of toilets (currently not specified, but priced option for fitment on Metro Express is requested)
- Provision of saloon air-conditioning (currently not specified, but priced options for fitment to Metro Express only or alternatively to both Metro and Metro Express)

2 Standards, Approval and Environment

2.1 Standards and Legislation

2.1.1	The Modules shall comply with the requirements of all applicable South African Standards and Legislation at the time of contract.
2.1.2	The Modules shall comply with other international standards as required by this specification.
2.1.3	Where a manufacturer wishes to propose an alternative standard, full justification shall be provided. The justification shall refer to its applicability and acceptability.
2.1.4	The Module design shall ensure compatibility with the infrastructure over which they are to operate and in order to support reduced whole life cost for the railway system.
2.1.5	All design, construction and commissioning life cycle requirements for engineering and operating systems shall be done in accordance with the National Railway Safety Regulator Act 16 of 2002 (as amended) and relevant standards as well as the Occupational Health and Safety Act 85 of 1996.

2.2 Operating Environment

2.2.1	The Modules shall be capable of continuous operation, including starting up from overnight berthing in the open, within the full range of ambient conditions likely to be encountered within the South African climate.
2.2.2	Each Module and all its constituent parts shall comply with the requirements of climatic zone T1 and altitude range AX as specified in EN50125-1 1999 Railway Applications - Environmental conditions for equipment. The altitude at which the Modules shall operate is up to 2000m above sea level. Roof mounted equipment shall be protected against degradation caused by UV radiation

2.2.3	Each Module shall be resistant to the effects of exposure to salt water spray. Exposure to salt water spray shall not cause excessive corrosion or degradation of exposed surfaces, components and equipment.
2.2.4	The Modules shall be required to operate under all forms of precipitation including severe driving rain and snow without reduced performance.
2.2.5	Each Module shall be resistant to the effects of any fluids (such as graffiti removal or vehicle washing chemicals) or particles likely to be encountered in the railway environment.
2.2.6	Each Module exterior, when all doors and windows are closed, shall prevent the ingress of snow, rain, wash plant spray, draughts, dust and leaves under all environmental conditions. In the vicinity of externally opening windows and doors, all controls, equipment and enclosures shall be designed to ensure continued operation with no adverse effects of local ingress of water, dust, snow and leaves.
2.2.7	The Modules shall be able to operate under their own power at a speed of not less than 8km/h through floodwater up to a depth of 100mm above the top of the running rail, continuously and without detriment to any of the equipment.
2.2.8	The Modules shall be able to withstand any effects caused by the extremely severe electric storms which occur in South Africa. The Modules shall also be able to withstand any effects caused by ice, severe dust, and iron particle laden wind conditions.

3 Module Requirements

3.1 Module Configuration

3.1.1	Modules for the priority corridors will have a length of between 260m and 275m between coupler faces and shall comprise a single Module.
3.1.2	The train design shall be flexible to allow shorter formation Modules to be procured at a later date which are compatible with maximum Module lengths of 160m, 210m and 235m

3.2 Module Capacity

3.2.1	The Module Capacity for the base specification Metro Modules shall be: • Seated: The minimum number of fixed conventional seats shall be 500. Tip up seats may be counted in this calculation, however perch seats (if fitted) may not. • Maximum Service Load: A minimum of 2425 passengers with all seats filled and with a standing passenger density no greater than 6m^2 in aisles and 8m^2 in doorways). Standing area to be calculated in accordance with EN 15663:2009 Railway applications - Definition of vehicle reference masses. The basic design shall be flexible in order that variants can be produced to reflect PRASA's market segment needs. It is anticipated some Modules may be required for Metro Express services. These will include 2+2 seating throughout, catering facilities, toilets etc. and provide a significantly more comfortable travelling environment. The design shall not preclude future variants being fitted with 2+3 seating.
3.2.2	Each Module shall provide maximum usable standing capacity consistent with the required minimum seating capacity.

3.2.3	The base Metro Modules for the priority corridors will not be fitted with toilets. However, the design of the train shall be such that it should be possible for PRASA to procure later variants which are fitted with toilets without significant redesign of the underframe or other equipment. Provision of toilets shall be a priced option on the Metro Express trains procured.

3.3 Module Mass and Loading

3.3.1	The tare mass of each Module shall not be greater than 460 tonnes.
3.3.2	For the purposes of this specification the following mass / loads shall be considered: M1: Tare weight of the vehicle (mass per vehicle with all equipment) M2: Full Load is the tare weight, plus a full load of passengers assuming 80kg per person and a loading of 6 passenger per m^2 in aisles and 8 passengers per m^2 in doorways. The Full Load is to be used for capacity calculations. M3: Crush Load is the tare weight of the vehicle, plus a crush load of passengers assuming 80kg per person and a loading of 12 passengers per m^2 in the available standing area as defined in EN 15663:2009 Railway applications - Definition of vehicle reference masses. The Crush Load is to be used for fatigue and braking calculations etc.

3.4 Floor Height and Headroom

3.4.1	The nominal floor height above the rail at vehicle entry doorways and throughout the Module shall be 1100mm.
3.4.2	The actual static floor height when measured in service under all conditions of load and vehicle state (including wheel wear) shall not exceed 1105mm nor be less than 1080mm.
3.4.3	There shall not be a vertical step between any exterior doorway tread plate and the Module floor.

3.4.4	There shall be a minimum clear headroom of 2,000mm from floor to ceiling, measured 300mm from the interior side of the vehicle. At the centre line of the vehicle, the minimum headroom shall be at least 2,060mm.

3.5 Intercar Gangways

3.5.1	Intercar gangways shall be provided between each vehicle within a Module. There is no requirement for Module end gangways.
3.5.2	Inter-car gangways shall be at least 1350mm wide at floor level and have sufficient width above floor level to allow at least two 95th percentile adult male passengers to pass each other unimpeded.
3.5.3	Inter-car gangways shall be at least 1900mm high throughout.
3.5.4	The inter-car gangway floor shall be level with the main saloon floor, free from step or trip hazards.
3.5.5	The inter-car gangway shall be fitted with the necessary grab rails or other hand holds to allow passengers to safely stand in these areas.
3.5.6	Functional or design solutions shall be implemented as necessary to mitigate any increase in fire risk resulting from the absence of gangway doors.
3.5.7	Each Module shall be fitted with two sets of deployable lockable gangway barriers or partitions to close off sections of the Module for operational purposes, located as far as practical at one third and two thirds positions along the length of the Module.
3.5.8	The gangway partitions shall be deployable by Train Operator staff in service between workings or, in emergency, whilst the train is moving.
3.5.9	In case of emergency, passengers shall be able to access the closed off section of the Module through the deployable lockable gangway barriers.

3.6 Multiple Module Operation

3.6.1	Modules shall be capable of automatic mechanical and pneumatic coupling to a Module of the same type under all loading and wheel wear conditions.

3.6.2	Shorter Modules (if procured) shall be capable of operating in multiple up to the maximum train length of 275m. When formed, the Module shall automatically reconfigure and function as a single Module and shall meet all the requirements of a single Module as described in this specification.
3.6.3	For the purposes of rescue, Modules shall, subject to infrastructure constraints, be capable of operating in multiple up to a train length of 550m (two full length Modules coupled). In such circumstances the rescued Module shall be unpowered.
3.6.4	In this rescue mode, essential functionality for crew to crew and crew to passenger communications shall be available between Modules. Connection between Modules for these essential functions may be via a special electrical jumper cable that is stowed within the cab. In this mode Passenger information functions need not be provided between Modules.
3.6.5	Modules shall be capable of operating in multiple for rescue purposes under the control of a single driver in the healthy Module, with the assistance of a crew member in the defective Module if required.
3.6.6	Modules shall be capable of operating in multiple for rescue purposes, in any combination of operational loading conditions, with the healthy Module pulling or pushing.
3.6.7	Modules shall automatically recognise a change in configuration when coupled or uncoupled.

3.7 Coupling

3.7.1	Each Module shall be fitted with automatic couplers at both ends of the Module.
3.7.2	The coupler shall be fitted with its centreline 895mm above rail level.
3.7.3	The coupler system shall be compatible with the track geometry given in the Network Information and Infrastructure Interface document.
3.7.4	It shall be possible to safely mechanically and pneumatically couple or uncouple Modules without the need for the driver(s) to leave the cab.
3.7.5	The driver shall be provided with an indication that coupling has occurred.
3.7.6	Following uncoupling the un-manned module shall be left in a safe state with brakes fully applied.

3.7.7	Electrical coupling for control and the powering of circuits of Modules in multiple shall be achieved in a simple and reliable manner.
3.7.8	Electrical coupling using the emergency jumper cable in rescue mode shall be possible from either side of the Module when access is restricted to track level or platform level.
3.7.9	The Module coupler need not be compatible with 5M2A and 10M Modules.
3.7.10	Coupling adaptors shall also be supplied to enable Modules to be recovered by a locomotive.
3.7.11	Semi-permanent couplers shall be installed for the coupling of Vehicles within the Module that shall facilitate straightforward separation of Vehicles within a Module for maintenance.

3.8 Rescue

3.8.1	It shall be possible for an unpowered Module to be hauled up to maximum speed provided an air and electrical control or battery supply are available.
3.8.2	The Module shall have sufficient battery life to allow an unpowered Module to be hauled or propelled for a minimum of 60 minutes.
3.8.3	It shall be possible for an unpowered Module to be propelled at a speed of 40km/h provided an air and electrical control or battery supply are available.
3.8.4	It shall be possible to reconfigure the Module to be hauled or propelled unbraked at low speed with barrier vehicles/locomotives at each end providing braking force.
3.8.5	In the event of derailment it shall be possible for the Module to be recovered without consequential damage using wheel skates, rail cranes, jacks and any other tools and equipment considered necessary.

4 Infrastructure Interfaces

4.1 Vehicle Gauge

4.1.1	The body profile swept and kinematic envelopes shall be consistent with the normal operation on all the routes defined in the Network Information and Infrastructure Interface document. This shall include operation with a deflated secondary air suspension. The Vehicle gauge requirement is provided in the Network Information and Infrastructure Interface document.
4.1.2	The Module design shall fully exploit the defined gauge to maximise the internal space.
4.1.3	The Module gauge shall be assessed using an appropriate method (for example, the methods described in UK Railway Group Standards GM/RT2149 Requirements for Defining and Maintaining the Size of Railway Vehicles and GE/RT8073 Requirements for the Application of Standard Vehicle Gauges would be deemed suitable).

4.2 Track

4.2.1	Nominal track gauge is 1065mm. Gauge widening on 120m curve: 20mm. The sharpest turnout is 1:6. For further information on track geometry refer to the Network Information and Infrastructure Interface document.
4.2.2	The Module shall be designed to ensure the safe running on twisted track, taking into account specifically the transition phase between canted and levelled track and cross level deviations. This shall also be achieved with deflated secondary air suspension. The compliance with this requirement shall be verified using an appropriate method (for example, the methods described in UK Railway Group Standard GM/RT2141 Resistance of Railway Vehicles to Derailment and Roll Over would be deemed suitable).
4.2.3	The running dynamic behaviour of the Module shall be assessed using appropriate methods (for example, the methods described in UK Railway Group Standard GM/RT2141 Resistance of Railway Vehicles to Derailment and Roll Over would be deemed suitable).

4.2.4	In order to minimise system whole of life costs the Module design shall be optimised with the infrastructure parameters so as to minimise track and wheel maintenance cost whilst ensuring safe running under all operational conditions. In order to reduce track maintenance costs, the design shall reduce tangential forces and contact patch energy so as to minimise wheel and rail wear and rolling contact fatigue. Suspension and bogie designs shall be configured so as to avoid hunting behaviour, to minimise vibration and noise, and to maximise ride quality.
4.2.5	It is desired that no flange lubrication will need to be fitted. However, provision should be made in the design to allow for the retrofitting of a suitable proprietary system.
4.2.6	The PRASA network generally wheel and rail profiles are included in the Network Information and Infrastructure Interface document. An alternative wheel profile may be proposed by the Supplier providing that the supplier validates that the proposal has no adverse impact on the wear and tear of the rail and does not increase track maintenance requirements. It will be the Supplier's responsibility to verify the wheel rail interface as part of both the design and commissioning processes.
4.2.7	The Maximum axle load in the Crush Laden condition shall not exceed 20 Tonnes. Module mass shall be balanced (as far as practical) over all Module wheelsets to minimise the maximum contact force at the wheel rail interface

4.3 Power Supply

4.3.1	The nominal line voltage shall be assumed to be 3.3kV DC. Under normal conditions this may vary between 2.7kV DC and 3.9kV DC. Performance of the Module shall be guaranteed within this range. Under abnormal conditions voltage may vary between 2.0kV DC and 4.0kv DC. Modules shall continue to operate within this range. Further information on power supply parameters is provided in the Network Information and Infrastructure Interface document.
4.3.2	Each Module shall be capable of regenerative braking providing the overhead line is receptive. The Module shall not cause the line voltage to become greater than 3.75kV DC under regenerative braking.

4.3.3	The pantograph shall be capable of operation without arcing at a contact height of between 4220mm and 6000mm above rail level. The pantograph shall remain in contact with the wire under all combinations of lateral inputs, including dynamic movements, cant deficiency, cant excess, wind loading etc. Maximum design static contact wire stagger is 300mm on either side of the track centreline. Further information is provided in the Network Information and Infrastructure Interface document. Note: Current Modules are fitted with copper head pantographs. PRASA would like to move to carbon pantographs heads if possible, however suppliers are to consider compatibility issues when making their offer.
4.3.4	Protection systems for the safe and reliable operation of the Module shall be provided for all High Voltage equipment. These will include devices to disconnect the supply in the case of overload or short circuit conditions and devices to prevent damage as a result of power surges. Wherever possible, resetting of faults shall be automatic to minimise driver involvement. An auto drop device shall be provided which will lower the pantograph automatically if damage to the carbons, or pantograph overheight occurs.
4.3.5	There shall be a method for remotely raising the pantograph from the cab after all air has leaked from the Module. The main air compressor and the auxiliary electric supply will automatically start up once the pantograph is raised. An emergency pantograph down button shall be provided that will lower the pantograph in an emergency and stop the pantograph raise sequence.

5 Signalling and Train Communications

5.1 Signalling and Control

5.1.1	Each Module shall be capable of operating in the current train management and control environment.
5.1.2	All signalling and telecommunications interfaces supplied on the Modules shall comply with applicable standards, and be completely compatible with existing systems found on the network. Interference with the signal system by the Modules is not permitted. The Modules shall be compatible with signalling and track circuit equipment and standards as defined in the Network Information and Infrastructure Interface document.
5.1.3	Provision shall be made for the future fitment of a new signalling and control system, for example ERTMS. Spare wiring, space in the cab and at least 2kW spare power capacity shall be provided to allow retrofitting of equipment in the future.

5.2 Communications

5.2.1	A Trunk Radio system shall be fitted. Refer to the Network Information and Infrastructure Interface document for further information.

5.3 Track to Train Data Communications

5.3.1	The Module shall be equipped with track to train and train to track data communications equipment; hereafter call the ‘Communications Gateway’.

5.3.2	The 'Communications Gateway' working in conjunction with the ground based communications infrastructure shall support two grades of service, namely 'high bandwidth service' and 'medium bandwidth service'. Typically, 'high bandwidth service' will be supported at critical locations, e.g. depots and major stations using WiFi, or similar. The train supplier shall define the technology and provide infrastructure equipment costs for installation by the operator. The 'medium bandwidth service' would be provided between stations, this will be supported by public mobile networks or private radio system. The bandwidth and coverage shall be commensurate with the objectives of applications defined in this specification. The train supplier shall propose their solution and undertake route surveys to validate their choice of solution.
5.3.3	All protocols used for communications between track and train shall be compatible with TCP/IP communications using industry open standards. Raw data provided by the train and any software (inclusive of license costs for train life) required to convert this data to information shall be provided as part of the train supply contract
5.3.4	The 'Communications Gateway' shall be integrated with an on-board data network supporting the train management system operating to the internationally recognised standard TCN (IEC61375); the TCN network shall additionally support multimedia services such as passenger information system, CCTV, passenger counting with at least 50% spare capacity for future systems.

6 Performance Capabilities

6.1 Running Times

6.1.1	Each Module shall be capable of achieving as a minimum the journey times and duty cycle listed in the Network Information and Infrastructure Interface document.
6.1.2	Journey times and duty cycle shall be achieved, taking account of the traction power supply for the relevant routes.
6.1.3	All performance requirements shall be achieved in Full Load M2 conditions
6.1.4	The performance requirements shall be achieved with all allowable wheel sizes.
6.1.5	The Modules shall incorporate redundancy and as a minimum shall be capable of achieving the performance requirements with one traction subsystem isolated.

6.2 Traction and Braking Performance

6.2.1	Each Module shall be capable of a maximum speed of 120km/h on level tangent track when travelling into a head wind of 60km/h.
6.2.2	The basic Module design shall be such that, should it be required, future variants could be built with a maximum speed of 160km/h with the minimum of re-design.
6.2.3	Each Module shall be able to achieve an acceleration rate sufficient to deliver the running time requirements and no less than $1m/s^2$ up to 55km/h on level track, under all loading conditions up to Full Load M2 subject to line current limitations.
6.2.4	Each Module shall be capable of achieving a full service brake deceleration rate of at $1m/s^2$ under all load conditions, from a speed of 120 km/h.

6.2.5	Each Module shall be capable of achieving an enhanced emergency brake deceleration rate of at least 1.3m/s^2 under all load conditions, from a speed of 120 km/h. The emergency braking command shall have a separate control route to the service brake control and shall be achieved using the friction brake alone.
6.2.6	Each Module shall have a jerk rate under all load conditions of not greater than 0.75m/s^3. Jerk rate shall be adjustable by maintenance staff between 0.5 m/s^3 and 1m/s^3. The jerk rate in emergency braking shall be limited to 2m/s^3.
6.2.7	The adhesion coefficient for design purposes shall be taken as 20% for motoring and 11% for service braking.

6.3 Traction Supply

6.3.1	Modules shall be capable of operating over the 3kV DC electrified systems.
6.3.2	In instances where a route has line current limitations the Module shall automatically adjust power consumption to remain within acceptable limits while maximising performance.

6.4 Operational Routes

6.4.1	Modules shall be capable of operation on all normal and diversionary designated routes. Refer to the Network Information and Infrastructure Interface document for details.
6.4.2	Modules shall be capable of negotiating the minimum horizontal and vertical track curvatures within depots and sidings which may be less than those defined for the designated routes.

6.5 Operational Configuration Times

6.5.1	Each Module shall have an operational set up time of no more than 2 minutes including any time required to configure cab systems such as the passenger information system (PIS).

6.5.2	Each Module shall be capable of reversing at terminating stations and sidings, both involving changing of driving position to the opposite end of the Module, in no more than 2 minutes excluding door open/close times and any walking time between ends.
6.5.3	Resetting of Module control and other systems shall be achievable from the operating cab.
6.5.4	The Module shall be capable of building up sufficient air pressure for normal operation within 20 minutes starting from having all air reservoirs empty.
6.5.5	The driver shall be required to login only once when preparing the train.

6.6 Station Dwell Time

6.6.1	Each Module shall be capable of supporting a 45 second station dwell time.
6.6.2	The available doors fully open time for passenger flow within the 45 second dwell shall be at least 27 seconds under driver control.
6.6.3	Module doorways shall be sufficiently wide to allow passengers to pass through unhindered two abreast, each carrying a briefcase or similar size package.

6.7 Capacities Between Servicing

6.7.1	The capacity of the Module windscreen wash system shall support a minimum of 3 days of service operation between top ups.
6.7.2	Where toilets are specified (a priced option), the fresh water tanks shall have sufficient capacity to allow 3 full days of operation of the toilet including routine use of the hand basin. An external warning indication shall be provided to alert staff when the water tank is approximately 75% empty. The fresh water tank shall be fitted with a level gauge and level indicator that gives a graduated indication to the TMS.

6.7.3	Where toilets are specified (a priced option), the effluent retention tank for each toilet shall have a capacity sufficient to allow 3 full days of operation in between emptying. An external warning indication shall be provided to alert staff when the effluent tank is approximately 75% full. The retention tank shall be fitted with a level gauge and level indicator that gives a graduated indication to the TMS.
6.7.4	Where applicable, levels of clean water, effluent and windscreen wash fluid shall be monitored and reported via the TMS.

7 Train Wide Functions

7.1 Energy Usage and Efficiency

7.1.1	The Module design shall minimise the net energy drawn from the power supply system, consistent with the operational performance required. A very high proportion of kinetic energy recovery during braking with its re-use both on board the Module and by other trains in the area is a key element in improving energy efficiency.
7.1.2	Suppliers shall consider on board use of regenerated energy including, if appropriate storage system for storing and re-using braking energy that cannot be used by the Module auxiliaries or returned to the traction supply.
7.1.3	Each Module shall achieve an improvement of at least 15% in net energy consumption, over current design rolling stock.
7.1.4	Each Module shall have an intelligent stabling system which minimises energy consumption during periods out of use.
7.1.5	The intelligent stabling system shall ensure that Modules can re-enter service, without delay, when required ensuring that the train crew and passenger environments are reasonably comfortable for immediate entry into service.
7.1.6	The intelligent stabling system shall be capable of being activated and de-activated from the cab.
7.1.7	The intelligent stabling system shall be accessible to servicing staff without the need for a driver's master key.
7.1.8	Energy consumption measurement is required and shall identify the net energy used over a settable time span.
7.1.9	Each Module shall separately measure the energy taken from and regenerated into the network.

7.2 Ride Quality

7.2.1	The Module ride quality shall achieve a mean comfort index of 2 based on the EN 12299:1999 Ride Comfort for Passengers, Refer to the Network Information and Infrastructure Interface document for details of track parameters and quality.
7.2.2	Compliance with the ride comfort requirement shall be assessed using the 95th percentile Simplified Comfort Index in accordance with EN 12299:1999 Ride Comfort for Passengers, Measurement and Evaluation.
7.2.3	The design shall be optimised to ensure that an acceptable level of ride quality is achieved when one or more air springs are deflated.
7.2.4	The Module's ride quality shall not be significantly degraded by wear or ageing of suspension components.
7.2.5	The ride quality requirements shall be demonstrated for both Tare M1 and Full Load M2 conditions over a range of speeds up to the maximum speed of the Module.

7.3 Aerodynamics and Pressure Effects

7.3.1	The Module design and construction shall ensure that passengers and/or staff do not experience significant discomfort due to internal pressure changes when operating over the designated route, including: • In single bore/track tunnels; and • With trains passing in twin track tunnels.
7.3.2	The supplier shall demonstrate resistance of the vehicles to roll over in high winds. For example, a demonstration that the train meets the requirements of UK Railway Group Standard GM/RT2142 Resistance of Railway Vehicles to Roll Over in Gales would be deemed acceptable.

7.4 Noise and Vibration

7.4.1	Each Module shall comply with the requirements of the Noise Technical Standard for Interoperability (NOISE-TSI).

7.4.2	The Module's interior noise levels shall not exceed; 74 dB (A) at the centre of each car at 120km/h in open air with all traction and auxiliary systems operating when measured in accordance with EN ISO 3381:2005 Railway Applications Acoustics measurement of noise inside railbound vehicles. 76 dB (A) above floor level in each vestibule and gangway areas at 120km/h in open air with all traction and auxiliary systems operating when measured in accordance with EN ISO 3381:2005.
7.4.3	Each Module's maximum internal noise levels under stationary condition in open air with all auxiliary systems operating normally shall not exceed 62 dB (A) anywhere along the Module length when measured in accordance with EN ISO 3381:2005.
7.4.4	Modules shall not emit any prominent harmonics or discrete tones in any operating modes or conditions.
7.4.5	Interior fittings and components shall not produce noise at any time through the life of the Module.

7.5 Fire Safety

7.5.1	The Module design shall adequately mitigate the risk of fire and its products of combustion when operating across the whole network.

7.5.2	A Module designed to be fully compliant to BS6853: 1999 Category 1b is considered as achieving the objectives defined above. However it is also recognised that this Specification specifies Modules with an open gangway arrangement and therefore clause for clause compliance to BS6853 Category 2 can not be achieved. In this case additional functional or design solutions will need to be implemented within the Module design to mitigate the increased fire risks presented by the absence of inter-car fire rated partitions. The Supplier shall demonstrate that the Module's design, including open gangway meets the clause fire safety objectives by: • Demonstrating that, with exception of fire rated inter-car doors, the Module design is as a minimum compliant to BS6853:1999 Category 1b; and • Demonstrating that no credible fire event (including arson) will cause the passenger compartment to become untenable within a time period of 8 minutes plus the time required to evacuate train occupants to a place of ultimate safety.
7.5.3	Alternatives to a fire safety strategy based on BS6853 may be offered, however in these cases the Supplier shall use a European rolling stock fire safety standard for the assessment of material fire, smoke and toxicity performance and ensure that the offered fire safety strategy is holistic, and specifically includes: • The design of emergency (eg lighting and passenger communication) and essential (eg braking and traction) train systems such that they continue to function in the event of a developing fire for a duration sufficient to allow the vehicle to reach a place of safety and undertake passenger evacuation; • The design of crew cab to saloon partitions such that an adequate level of fire resistance is provided to enable the Module to be driven to a place of safety for passenger evacuation; • The design of flooring assemblies such that an adequate level of fire resistance is provided from underfloor fire hazards; • The design of the Modules to ensure that vehicle borne ignition scenarios are mitigated to a level as low as is reasonably practicable; • The provision of adequate passenger and crew emergency evacuation measures; and • Demonstrate that the application of the proposed fire safety strategy results in a Module design of an adequate and acceptable level of fire safety and one that is compliant to the objectives defined above.

7.6 Human Factors and Ergonomics

7.6.1	Ergonomic and human factors criteria and techniques shall be applied to the design of passenger and crew areas of the Modules using applicable anthropometric data for passengers, train crew and maintenance personnel.
7.6.2	Each Module shall present a safe, secure, user-friendly and comfortable environment for passengers, crew and maintenance staff with features and interface that are intuitive to users and minimises adverse effects from human errors.

7.7 Security, Anti Social Behaviour and Vandalism

7.7.1	The Module shall be capable of being made secure when stabled without compromising the need to maintain accessibility for emergencies.
7.7.2	The design of the interior bodyside windows and glazed surfaces shall optimise passenger safety in all foreseeable circumstances.
7.7.3	The saloon to cab door shall be secure such that the cab is inaccessible to passengers during normal operation. The door shall be fitted with an air tight seal.
7.7.4	The Module interior shall be sufficiently robust to minimise damage from foreseeable vandalism and misuse.
7.7.5	Tamper-proof fixing arrangements shall be fitted where necessary. Fasteners shall not be visible or accessible to passengers as far as practicable.
7.7.6	All interior bodyside windows and glazed surfaces shall incorporate a means to minimise the damage from vandalism by etching or scratching.
7.7.7	Internal and external finishes shall permit the easy removal of graffiti by trained personnel using proprietary graffiti cleaning chemicals, and the surfaces shall not readily degrade as a result of the removal process.
7.7.8	The Module interior shall be free from gaps and crevices where litter, sharp objects or any other items could be concealed or lodged. Any equipment fitted behind seats shall be adequately designed to eliminate gaps or hidden voids.

7.7.9	Soft furnishings shall be resistant to damage by sharp objects and be designed to be economical and easy to replace when deemed necessary.
7.7.10	All Module interior equipment within the passenger areas including PIS screens shall be resistant to vandalism.
7.7.11	Use of any high value materials (e.g. aluminium) shall be avoided wherever possible.

7.8 Flexibility

7.8.1	The Module interior layout and interior components including the seats, grab poles, draught screens, shall be reconfigurable in an operational depot to allow for changes in capacity ratios.
7.8.2	The saloon floor area shall be kept clear of under seat equipment that could limit interior flexibility.
7.8.3	The interior draught screens and other intermediate partitions shall not be structural.
7.8.4	The Module wiring shall be accessible to maintenance staff without significant disassembly of the interior.
7.8.5	The Module shall also include provision for additional control and communications cabling to be added at a later date with minimal disruption to the interior or underframe equipment.
7.8.6	It is a desirable requirement that the Module architecture is flexible to allow for formation changes, redeployment or route upgrade throughout its life.

7.9 Recyclability

7.9.1	The Module shall be designed for optimal recyclability.

8 General Vehicle Design

8.1 Vehicle Design

8.1.1	The Module shall have a design life of not less than 40 years.
8.1.2	The Module structures and equipment shall be designed for the defined fatigue loadings and service duty cycles under the relevant operating conditions.
8.1.3	The Module design shall provide the driver with the necessary collision survival space requirements in accordance with EN 15227, whilst maximising the saloon space available for passengers.
8.1.4	The Modules shall be designed and manufactured such that they provide a safe environment for the passengers and operating staff in both normal operation, under emergency braking and in the event of abnormal/failure conditions or a collision. The Modules shall be designed, constructed and tested in accordance with internationally recognised standards such as: • EN 15227 2008 Railway Applications - Crashworthiness Requirements for Railway Vehicle Bodies; • EN 12663 2000 Railway Applications - Structural Requirements for Railway Car Bodies; and • GM/RT2100 Requirements for Rail Vehicle Structural Requirements, with particular respect to interior crashworthiness. The structural and interior design of the Modules shall minimise injuries to passengers and operators caused by derailment, collision with other trains, and collision with road vehicles (including heavy goods vehicles such as concrete mixers) at level crossings.
8.1.5	Bogie shall be designed, constructed and tested in accordance with internationally recognised standards such as: • EN 13749 Methods of specifying structural requirements of bogie frames.
8.1.6	Where possible motor and trailer bogies shall be of a similar design.
8.1.7	The design shall prevent body / bogie separation in the event of a derailment.

8.2 Exterior Requirements

8.2.1	Each Module shall have smooth body contours as far as practical to allow efficient automatic or manual washing.
8.2.2	The Module livery shall be agreed with PRASA.
8.2.3	The Module shall be either self-protective metal or painted and be capable of being fitted with vinyl film in addition to the painted finish.
8.2.4	Any paint finish shall be capable of withstanding the effect of any detergents used in the cleaning process.
8.2.5	The external paint and finishes 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.
8.2.6	The number of different window sizes shall be minimised. Aluminium window frames are undesirable because of the levels of theft and vandalism experienced. The offered design shall therefore be resistant to theft and vandalism and will avoid use of high value materials wherever possible.
8.2.7	Except where air conditioning is specified (a priced option), the bodyside windows shall be designed to maximise ventilation whilst preventing passengers from leaning from open windows. Hopper windows are not considered to provide adequate ventilation. Windows shall enable maximum viewing for interior seated and standing passengers. Where air conditioning is specified, sealed windows shall be provided with some emergency ventilation in the event of air conditioning failure.
8.2.8	The Module bodyside windows including door glazing shall use laminated glass in accordance with a recognised international standard. For example, UK Railway Group Standard GM/RT2100 issue 4, Structural Requirements for Railway Vehicles would be deemed acceptable. Where air conditioning is specified (a priced option) double glazed glass shall be provided.
8.2.9	Windows shall incorporate reflective coatings or tints to reduce heat transfer in sunny conditions.
8.2.10	Suppliers shall consider resilience to vandalism as a major factor in choice of window design and material. PRASA have stated a preference for polycarbonate windows, however it is acknowledged this may conflict with the fire requirements in this specification and therefore suppliers are encouraged to offer other solutions.

8.2.11	The front end of the Module shall be functional but feature a strong aesthetic look to demonstrate contrast with existing older vehicles.

8.3 Interior Design

8.3.1	The Module interior fittings shall be robust and minimise damage due to scuffing and abrasion damage from contact with passenger luggage or wheelchairs, etc.
8.3.2	All materials and components shall be resistant to fading and scratching and shall be sufficiently durable to withstand heavy usage for the life of the Module.
8.3.3	All interior panels, fixtures and fitting shall be designed to eliminate drumming, rattles and squeaks.
8.3.4	All glass panels used in the interior shall use laminated glass.
8.3.5	The floor covering shall be compliant with PRM-TSI, anti-slip, suitable for wet and dry conditions and hard wearing. Carpet shall not be used.
8.3.6	The floor covering shall be laid in such a way to prevent liquids seeping beneath the covering.
8.3.7	The floor covering in the vestibules shall be capable of coping with moisture from incoming passengers and rain and snow entering from open doors.
8.3.8	The Module interior design shall include a system of grab poles and grab rails which are compliant with PRM-TSI and intuitively positioned to provide safe and comfortable support to passengers standing and walking through the Module, whilst not impeding passenger flow.
8.3.9	All interior areas of the Module which facilitate standing or walking passengers shall be fitted with appropriate means of support to maximise the safety of passengers in all normal and emergency modes of operation.
8.3.10	The Module interior floor be free from any fixed components that will obstruct, hinder and complicate cleaning.

8.4 Seating Provision

8.4.1	The base Metro Modules shall be provided with longitudinal seating throughout. Seats shall be very robust and easy to clean. Metro class seats do not need to be upholstered. Provision of standbacks around doors is preferred to allow easy passage of passengers on and off the vehicles. Tip up seats and/or perch seats may be used where appropriate providing they can demonstrate they are sufficiently robust for the operating environment and train loadings prevalent on the relevant routes. It is anticipated some Modules may be required for Metro Express services. These will include 2+2 upholstered seating throughout.
8.4.2	Seat types and arrangements shall be appropriate for all users, and the seat construction and installation shall facilitate passenger comfort, maintenance and cleaning.
8.4.3	Priority seats shall be easily discernable to all passengers.
8.4.4	Priority seats shall be designed and configured to maximise the ease of access and egress.
8.4.5	If fitted, tip-up seats shall, without assistance, return to the stowed position when the seat is unoccupied.
8.4.6	If fitted, tip-up seats shall be designed to fulfil the perch seat function when in the stowed position.
8.4.7	Draught screens shall be provided between stand backs and adjacent seating.
8.4.8	The floor area around seats shall be designed to avoid obstruction to passengers' feet.

8.5 Toilets

8.5.1	Toilets will not be fitted to the base Metro Modules. However, the Module design shall be such that variants may be built to include toilets without significant redesign of the underframe or other major components. It is anticipated some Modules may be procured for Metro Express with controlled emission toilets, capable of fully retaining all waste and odour between servicing on all routes and service patterns.

8.5.2	Where toilets are specified (a priced option), they shall incorporate a high level of resistance to becoming blocked due to misuse and overfilling.
8.5.3	Where toilets are specified (a priced option), the Module interior shall be free from toilet odours at all times.
8.5.4	Where toilets are specified (a priced option), toilets and cubicles shall be designed to avoid dirt traps and to allow efficient and effective cleaning.
8.5.5	Where toilets are specified (a priced option), they shall be completely sealed.
8.5.6	Where toilets are specified (a priced option), they shall incorporate appropriate features to prevent fluid leakage into the saloon or vehicle underframe.
8.5.7	Where toilets are specified (a priced option), the toilet module shall be capable of being removed and replaced by seating, or other interior features, without the need for major structural changes.
8.5.8	It is a desirable requirement that the installation of toilets to Modules not fitted shall be possible without the need for major structural changes.
8.5.9	Where toilets are specified (a priced option), toilet waste retention tanks shall be sited to facilitate ease of cleaning.
8.5.10	Where toilets are specified (a priced option), toilet retention tanks shall be capable of being 100% drained during normal servicing.
8.5.11	Where toilets are specified (a priced option), toilet door lock operation shall be clearly perceptible to all passengers and intuitive to the user providing unambiguous feedback as to whether the door is locked or unlocked.
8.5.12	Where toilets are specified (a priced option), toilet doors shall incorporate a device to allow the door to be overridden and opened by Train Operator staff when ‘locked’.
8.5.13	Where toilets are specified (a priced option), the design of the toilet access door unlocking device, intended for staff, shall be sufficient to avoid the device being used or tampered with by passengers.
8.5.14	Where toilets are specified (a priced option), the device shall be designed to ensure that in the event of failure, passengers are not locked in the toilet module.
8.5.15	Where toilets are specified (a priced option), the doors shall incorporate a means for staff to lock the door out of use.

8.5.16	Where toilets are specified (a priced option), a means shall be provided to clearly identify to passengers that the toilet is 'locked out of use'.
8.5.17	Where toilets are specified (a priced option), an illuminated sign shall be provided in each car to inform passengers of the location and status of the nearest toilets.
8.5.18	Where toilets are specified (a priced option), each toilet shall be fitted with the following: • A toilet bowl lid catch that holds up the lid when the train is in motion; • A flush device that is visible when the toilet seat is in the raised position; • A device to freshen the air by the addition of a pleasant fragrance; • A sink and a tap that provides warm water at a temperature suitable for hand washing; • A warm air hand drying facility that effectively dries hands within 15 seconds; • A mirror with tamper proof fixings; • A soap dispenser; • A toilet roll dispenser; • A system for disposal of sanitary towels; • A nappy changing facilities; • Two hooks for coats and bags; • A litter bin; • Support grab handles; and • Suitable lighting.
8.5.19	Where toilets are specified (a priced option), it shall be possible for maintenance staff to remove and replace the toilet bowl and associated equipment within 30 minutes.
8.5.20	Where toilets are specified (a priced option), they shall be provided on every second vehicle in the Module.
8.5.21	Where toilets are specified (a priced option), one universal toilet shall be fitted within each Module, which shall be accessible from all wheelchair spaces within the Module.

8.6 Luggage Stowage

8.6.1	Overhead luggage racks shall, where practicable, be provided above all seated areas of the train.

8.6.2	The design of the luggage rack shall ensure that airline sized hand luggage (560x450x250 mm) can be securely stowed with the longest edge parallel to the direction of travel.
8.6.3	Luggage stowed in the overhead rack shall be visible from seated positions directly below.
8.6.4	Luggage stowed in the overhead rack shall be visible by staff walking through the train.
8.6.5	Luggage stowed in the overhead rack shall be visible by CCTV cameras within the saloon.
8.6.6	All longitudinal overhead luggage racks shall be designed to maximise the retention of passenger luggage during normal conditions as well as during a collision.
8.6.7	Appropriate signage solutions shall be utilised to ensure that luggage is stowed in a safe manner.

8.7 Signage

8.7.1	All non-mandatory signs shall be designed in accordance with general South African standards for safety signage. In addition reference should be made to a suitable rail industry standard, for example ATOC (UK) guidelines for safety signs.
8.7.2	Signage shall be durable and resistant to picking and malicious removal.
8.7.3	Bodyside panelling shall be designed with discrete features to allow for signage to be visible and in consistent locations throughout the Module.
8.7.4	Unique car and Module numbers shall be displayed externally and internally. Door positions shall be identified through signage.

8.8 Catering

8.8.1	In Metro Express trains only, provision shall be made for the storing and powering of refreshment trolleys or cabinets which shall serve hot and cold refreshments as well as snacks.

8.9 Litter

8.9.1	On Metro Express Modules, litter bins shall be conveniently distributed throughout the Module. Litter bins are not required on the Metro Modules.

8.10 Cleanability

8.10.1	Each vehicle shall be fitted with an RCD protected power point for a commercial vacuum cleaner which is compatible with South African domestic supply voltages and connections.
8.10.2	Lighting and other interior assemblies shall be sealed against the ingress of dust and dirt.
8.10.3	Interior panels, covings and lighting shall be simply shaped to allow easy cleaning and have no visible gaps between sections that could act as water or dirt traps.
8.10.4	All interior materials shall be resistant to cleaning chemicals including chemicals required to kill pathogens and remove graffiti.
8.10.5	All heating and ventilation ducts shall be designed to minimise the build up of dust, dirt and combustible detritus, and shall be fitted with suitable covers to both allow easy access for cleaning yet prevent against access by passengers.
8.10.6	It shall be possible to complete the daily standard clean, including the floor in no more than 3 man hours per Module.
8.10.7	It shall be possible to complete a periodical heavy clean in no more than 42 man hours per Module.
8.10.8	The vehicle layout shall allow the use of industrial floor cleaning machines to access all areas of floor. Floor cleaning shall not require the use of secondary sealing products.

8.11 Requirements of Special Needs Passengers

8.11.1	The Modules shall be designed to meet the intent of South African legislation relating to Universal Design and the accessibility of public transport to Special Needs Passengers. As a minimum the Modules design shall comply with the requirements of PRM-TSI.

8.11.2	Wheelchair exterior accessible doorways shall be accessible from the same location(s) on the station platforms, regardless of Module orientation. The wheelchair accessible doorways shall meet the requirements of manually deployed wheelchair ramps to allow for current variation in platform heights. When ramps are deployed, the train brakes must be prevented from being released. If the ramp design prevents closure of the train doors this function may be achieved via the door traction interlock system.
8.11.3	Spaces for wheelchairs shall be accessible from access doors located on each side of the Module.
8.11.4	Tip-up seats shall be fitted where practicable within each wheelchair space for the use of other passengers when the wheelchair space is unoccupied.
8.11.5	Tip-up seats shall not encroach on the dimensional requirements of the wheelchair space when in the stowed position.
8.11.6	The manufacturer will be required to liaise with relevant bodies to ensure the internal layout meets the needs of Special Needs Passenger groups as far as reasonably practicable without compromising other aspects of the design.

8.12 Cab Design

8.12.1	Each Module shall have a fully-functional and identical driving cab at each end.
8.12.2	The driver's field of view from the seated position in the Module cab shall be maximised on both sides of the train and as a minimum be fully compatible with normal position of signals on the relevant network.
8.12.3	Each cab shall have access doors (sliding, sliding plug or inward opening) on each side within the confines of the cab.
8.12.4	The route from the cab to the side access doors shall not be via an adjacent vestibule.
8.12.5	Access and emergency egress via the side access door shall be possible when the Module is electrically dead and the air system is discharged.
8.12.6	It shall be possible for the driver to access and egress the cab, lock, unlock, open and close the side access door, either from platform level or when standing 300mm below rail level.

8.12.7	Steps and handrails shall be provided with suitable non-slip surfaces to permit safe and easy access and egress without strain, symmetrically aligned with the doorway.
8.12.8	Each cab shall be fitted with an airtight door between the driving cab and the saloon which shall be inaccessible to passengers in all circumstances.
8.12.9	The door between the driving cab and the saloon shall be accessible from the cab.
8.12.10	The door between the driving cab and the saloon shall be rapidly accessible by the driver as an escape route to survival space (if required by the design).
8.12.11	Ergonomics and human factors techniques shall be applied to design a cab with minimal hazards and with controls in easy reach. The design features and position of all controls and indicators shall be optimised to enable the driver to operate the Module safely and efficiently.
8.12.12	Design and layout of equipment and controls shall be such to avoid inadvertent damage or activation by the driver, train crew, or maintenance personnel whilst occupying entering, leaving or moving about in the cab.
8.12.13	The cab traction/ brake controller shall be configured for push forward to apply traction and drawn backwards to apply the brake consistent with current rolling stock.
8.12.14	Cab instrumentation and controls shall be integrated to optimise cab layout and minimise cab equipment.
8.12.15	Cab interior surfaces shall be coloured and finished to minimise glare and provide appropriate levels of contrast for controls. Cab lighting shall be dimmable.
8.12.16	The cab design, including driver's seat, second man seat and means of access / egress , shall accommodate a range of drivers from small (5th percentile) females to large (95th percentile) males. Reference shall be made to relevant Anthropometric data for South African people.
8.12.17	The manufacturer will be required to work closely with PRASA in the development of the cab design, layout and functionality to ensure that the cab complies with accepted custom and practice. A mock up will be required.

8.12.18	All rolling stock forward facing windows (windscreens) must comply with the requirements defined in EN 15152 Railway applications - Front windscreens for train cabs.
8.12.19	The cab controls shall provide a system such that a driver's key, smart card or other device is used to identify the driver and allow access to all necessary train controls. It shall be possible to provide other levels of enhanced or restricted access to control systems for maintenance staff, other traincrew and train cleaners as appropriate. It shall incorporate a cleaning/stable mode.
8.12.20	The driver's cab shall be fitted with a robust spring loaded, retractable roller blind for shielding against direct sun rays. The retracting process shall be damped to prevent damage to the roller blind, when the retracting catch is released.

8.13 Cowcatchers

8.13.1	At each driving end of the Module a cowcatcher shall be fitted to provide protection of underframe mounted equipment. Under all conditions of permitted wheel size and air suspension inflation, the clearance above rail level shall be minimised, but will not be more than the clearance above rail level of any underframe equipment. The cowcatcher shall comply with Vehicle gauge restrictions and will not interfere with emergency coupling and operation with other Vehicles. The cowcatcher shall be removable and have variable height adjustment. The cowcatcher shall blend in and appear as an integral part of the Module.

9 System Functions

9.1 Regenerative / Rheostatic Braking

9.1.1	Each Module shall be fitted with a traction and regenerative braking system which is designed to support achievement of the energy efficiency objectives of this Specification and optimised to deliver maximum benefit for the duty cycle that the average Module will encounter in service.
9.1.2	Where the regenerated energy is unable to be absorbed by the power supply system or used by the train auxiliaries the system shall default to rheostatic mode.
9.1.3	The blending of pneumatic, regenerative and rheostatic braking shall be fully automatic.

9.2 Auxiliary Power Supply

9.2.1	Each Module's auxiliary power supply capacity shall be continuously rated at 10% over the calculated design loading so that additional features can be fitted during the life of the Module.
9.2.2	The Module's batteries shall maintain essential and emergency systems, for at least 120 minutes, for the full range of environmental conditions experienced by the Module in the event of external power failure.
9.2.3	The Module's essential and emergency systems shall include, but not be limited to: • Emergency lighting (for cab, saloon and emergency egress); • Ventilation fans; • Tail and marker lamps; • Internal emergency signage; • Public address systems; • Communications systems; • Train control systems; • Door control system; • Traction and braking control; • Windscreen wipers; and • Forward facing CCTV systems.

9.2.4	In the event of a short term power interruption of 30 seconds or less, all systems that may be sustained by battery power shall remain powered.
9.2.5	All Modules shall include battery charging receptacles that enable an external battery charging supply to be connected.
9.2.6	All electrical equipment shall be protected from overload. All high voltage equipment shall be enclosed and interlocked to ensure safety of passengers, and operating and maintenance staff. A means of isolation shall be provided for all electrical equipment to allow maintenance activities to be safely carried out.

9.3 Braking Systems

9.3.1	The Module must be capable of holding and safe starting on gradients without rolling back on the maximum gradient of 1:40
9.3.2	The Module parking brakes shall automatically apply when the Module is stabled. The parking brake shall apply when the driver's controls are isolated. The parking brake shall be released when the cab is activated, the pantograph is raised and there is enough air in the brake system to hold the Module at a stand.
9.3.3	The parking brake shall be capable of holding the Module on a maximum gradient of 1:40 for an indefinite time period and for all operating and environmental conditions. The interaction of the parking brake and service brakes shall be such that during any transitional phase between parking brake and service brake, adequate holding force is maintained to meet the requirements above and prevent roll back of the Module.
9.3.4	It shall be possible to release the parking brakes manually from the side of the train.
9.3.5	A fail safe friction braking system is required which is capable of stopping the train under an emergency brake application from full speed in all load conditions. A tread brake or disc brake system may be offered. In addition to the friction brake system a fully blended, electric regenerative/rheostatic brake shall be provided. If the dynamic brake is disabled it shall be permissible for the train to continue in service at normal operating speed until the end of its journey.
9.3.6	A fully variable brake control or one with at least 64 steps in application and release shall be provided.

9.4 Wheel Slip and Slide Control

9.4.1	Each Module shall include a proven slip / slide control system that shall operate effectively and efficiently.
9.4.2	The wheel slip / slide control shall maximise the use of available adhesion under both traction and braking conditions in all reasonably foreseeable wheel rail conditions encountered in South Africa. PRASA's preference is for no sanding equipment to be fitted.

9.5 Vigilance System

9.5.1	A deadman device and vigilance system shall be provided. Control systems shall incorporate interlocking, redundancy and safeguards to ensure the safe operation in all consist configurations. All systems and components shall be configured such that a failure will not compromise the safety of the Module.
9.5.2	The power/brake controller shall incorporate a deadman's device. The driver is required to depress the deadman's device under all normal driving modes. It shall incorporate a reset device requiring the driver to release and depress the trigger whenever the controller is returned to the off position. An audible warning will indicate a reset is required. The deadman's device will be tamper-proof.

9.6 Door System

9.6.1	The base design shall have three double leaf passenger doors on each side of each vehicle. On Metro Express trains it is anticipated that only two doors are required.
9.6.2	Due to the levels of vandalism on the network, PRASA's experience indicates exterior sliding doors are preferable. However, suppliers may offer an alternative if they can demonstrate its reliability and resistance to vandalism and abuse.
9.6.3	The door control system shall permit the Driver to operate the doors from the front Cab or the Guard to operate the doors from the rear cab of the train.

9.6.4	The Driver or Guard will open and close all the doors on the train remotely from controls located in the cab. The location of crew door controls is to be agreed with PRASA during the design review and mock up process. Individual door open / close pushbuttons on each door are not required.
9.6.5	Door auto close (after a time delay) is not required.
9.6.6	The door system shall provide an optimised method of obstruction detection that ensures the safety of boarding and alighting passengers.
9.6.7	The door system shall minimise the impact of obstruction detection on the station dwell time.
9.6.8	When an obstruction is detected the door system shall provide appropriate information to the driver and passengers to assist in reducing the impact of obstruction detection on the station dwell time.
9.6.9	It shall be possible to isolate and lock out of service any individual door.
9.6.10	A traction interlocking system shall be provided such that the brakes are applied and traction power may not be taken if any door is open. A manual override must be provided to allow the train to be operated without traction interlock.
9.6.11	A door emergency egress device shall be fitted to each door. This will allow the passengers to release the doors in an emergency if the train speed is less than 5km/h. On activation, an indication shall be given to the driver that an emergency door release has been initiated. At speeds greater than 5km/h the emergency egress device shall first initiate an emergency brake application, allowing door release only after the speed has dropped below 5km/h.

9.7 Heating Ventilation and Cooling

9.7.1	An independent cab heating, ventilating and cooling system shall be provided which is capable of maintaining a temperature range within the cab of 18℃ to 26℃ in all South African ambient we ather conditions and provide a mix of fresh and return air in all operating modes for a safe and comfortable working environment for the driver.
9.7.2	The cab system shall be designed to take account of the requirement to minimise the economic and environmental impact of its operation.

9.7.3	In the event of failure of the cab heating ventilating and cooling system there shall be an independent fresh air forced ventilation system with variable volume and direction control. When not in use this system shall not cause draughts.
9.7.4	The cab system shall include a standby mode that allows the chosen temperature set point to be altered to reduce energy consumption when the Modules are not in normal operational service. Cab standby mode must be deactivated to off mode 15 minutes after a cab has been deactivated by either the driver or the guard.
9.7.5	The driver shall have control of the cab temperature by an adjustable thermostat
9.7.6	It shall be possible to switch on and off the cab system by means of a switch in the cab.
9.7.7	The cab standby mode temperature range shall be 16°C to 22℃ with the set point adjustable by maintenance staff.
9.7.8	The base design of Metro vehicles will be fitted with a forced pressure ventilation system for the passenger saloons. A heating system shall be provided which is thermostatically controlled and capable of maintaining an average inside temperature of 21℃ when the exterio r temperature is -10℃, assuming all windows and doors are closed. An even temperature shall be maintained in the saloon. Draughts and colds spots are unacceptable. The thermostat shall be adjustable between 15℃ and 25℃ by maintenance staff but not passengers. Provision of a full air conditioning system shall be priced as an option both for all Modules and for just Metro Express Modules.
9.7.9	Where air conditioning is specified (a priced option), the Module shall be fitted with a heating, ventilation and cooling system which is compliant to EN14750-1 2006 Railway Applications, Air Conditioning for Urban and Suburban Rolling Stock for a category A vehicle.
9.7.10	Where air conditioning is specified (a priced option), the system shall deliver a comfortable environment and be capable of regulating the temperature of all passenger saloons, vestibules, toilets and open wide gangways in a uniform manner.
9.7.11	Where air conditioning is specified (a priced option), the interior set point temperature shall be adjustable by maintenance staff over the range 20℃ to 25℃.

9.7.12	Where air conditioning is specified (a priced option), the interior temperature regulation shall be in accordance with the regulation curve defined in EN14750.
9.7.13	Where air conditioning is specified (a priced option), the system shall provide emergency ventilation in the event of failure.
9.7.14	Where air conditioning is specified (a priced option), the emergency ventilation shall include smoke detection to provide control of air flow to minimise the effects of smoke.
9.7.15	Where air conditioning is specified (a priced option), the heating, ventilating and cooling system shall be designed to minimise mass and energy consumption.
9.7.16	Where air conditioning is specified (a priced option), the system shall be capable of maintaining a comfortable passenger environment in all likely South African ambient weather conditions and operating altitudes.
9.7.17	Where air conditioning is specified (a priced option), the system shall minimise temperature changes within the car when the doors are opened.
9.7.18	Where air conditioning is specified (a priced option), the system shall vary the volume of air which is moved within the car according to passenger load. (e.g. When few passengers are on board the air flow should be the minimum).

9.8 Warning Hooters

9.8.1	Each driving end of the Module shall be provided with one foot operated set of dual tone warning hooters. Each hooter shall have a sound output level of 120-125dB(A) measured at 5m on the axis of the hooter. The frequency of operation shall be: • Tone 1 : 370±10 Hz • Tone 2 : 660±15 Hz

9.9 Exterior Lights

9.9.1	A twin headlight shall be fitted in the centre of the cab front at Cantrail level. The headlight shall have three settings ‘off’, ‘dim’ and ‘normal’ which are selectable by the driver.

9.9.2	Dual Auxiliary (Platform) headlights shall be provided and mounted below the driver's windscreen. The headlight shall have two settings 'off' and 'on' which are selectable by the driver.
9.9.3	Side lights shall be provided at Cantrail level in both corners of the cab front. The side light has a dual function – a red light when viewed from the rear, and a white light when viewed from the front of the train. A red tail light shall be provided on the cab front below the driver's windscreen. Side and tail lights shall be controllable by the driver and guard.
9.9.4	A tail lamp bracket shall be fitted near the tail light below the driver's window.

9.10 Interior Lighting

9.10.1	Each Module shall use high efficiency lighting which is arranged to create a safe, secure and pleasant environment. Light shall be thrown onto and across the ceiling including the luggage racks.
9.10.2	The lighting for passenger areas shall comply with the requirements of EN 13272:2001 "Railway Applications - Electrical Lighting for Rolling Stock in Public Transport Systems" for mass transit vehicles.
9.10.3	Lamp housings and fitments required for the illumination of doorway steps and the edge of platforms, especially for emergency evacuation shall be secure and permit easy access for lamp replacement and maintenance.
9.10.4	The Modules doorways used for evacuation shall be illuminated in accordance with applicable standards.
9.10.5	The Modules shall include two main and one emergency lighting circuit in each vehicle. In the event of a single auxiliary power supply failure at least one main and the emergency lighting circuits shall remain energised. Under normal conditions the emergency lighting and main lighting system shall operate together and there shall be no visible difference between the appearance of the main and emergency lighting. In emergency conditions, the Modules emergency lighting system shall operate for a minimum of 120 minutes.
9.10.6	Lighting enclosures shall be tamper proof, prevent the ingress of dust and be sealed to IP54 as defined by EN 60529 Specification for Degrees of Protection Provided by Enclosures.

9.10.7	The interior lighting system shall be fully compatible with the requirements of the saloon CCTV system.
9.10.8	The interior lighting system shall fully complement the passenger information system and interior signage such that there is no adverse glare or reflections from any part of the Module during any ambient light conditions.
9.10.9	The interior lighting shall be controllable by train crew.
9.10.10	The interior lighting shall include energy saving features, including where practicable to automatically reduce or switch off lighting in unoccupied areas. Unoccupied areas should include areas closed off to public use, but may also include cars or sections of cars that are not currently occupied by passengers.

9.11 Passenger Information and Communications

9.11.1	The PIS shall provide all necessary information to meet legislative requirements and the requirements of PRM-TSI.
9.11.2	The PIS shall enable passengers to position themselves for alighting at the next station by indicating in advance which side the doors will open.
9.11.3	The PIS shall provide destination and next station information for the Module, presented in both audio and visual format. Additional information such as the route, via stations and calling points shall be configurable for delivery as determined by the operator.
9.11.4	Visually presented destination and stopping pattern information shall be capable of being instantly assimilated by every passenger on entering the train.
9.11.5	The PIS shall provide several categories of driver controlled messages under the following headings: Advisory, Safety, Emergency, Delays and Diversions. The driver shall have the facility to select emergency or other announcements to meet the requirements of standards, legislation, customer service and good practice in a logical and timely manner. In total the system shall allow up to 99 pre-configured audio/visual messages to be stored. The message may be addressed to any of the visual displays (including external) and the system shall make provision for managing priority with automatic PIS. Provision shall be made for non-service conditions, i.e. display 'Not in Service' etc.

9.11.6	The PIS shall provide real time passenger information (RTPIS) to passengers on delays and the service status of the railway network. The system shall accept and process information downloaded from the infrastructure allowing passengers to make informed choices about their journey both normally and during times of disruption. This information shall be derived from ground based information system and delivered to the train using the 'medium bandwidth service'. RTPIS may include instructions for the on-board PIS to add or delete schedule station stops. The RTPIS shall support the delivery of freeform visual messages from the ground system to the train and delivery of freeform audio announcements or construction of announcements using phrases and words stored on the train. The PIS shall manage delivery of RTPIS to ensure compliance with PRM-TSI and priority of the relevant automatic PIS or RTPIS information.
9.11.7	The PIS shall provide adequate visual information to all passengers, including those with disabilities and have the functionality to display graphical symbols. The supplier shall consider human factors to maintain optimum colour, colour contrast and use of clear distinctive graphics.
9.11.8	The PIS shall be capable of displaying PRM-TSI compliant information and delivering interchange information, departure information for connections (including platforms and time), and deliver other information such as corporate announcements. In order to satisfy this objective, the display shall comprise a minimum dot matrix resolution of 16 high by 220 wide and shall support static text with transitional change effects, also vertical rolling and horizontal scrolling text. The display shall also have the capability to display current time when configured to do so and door side in the station approach phase until doors are opened. It shall be possible to show door left, door right or both doors using a graphical 'arrow'. At other times, when door side arrows are not required the full horizontal width of the display matrix shall be available for textual messages. Internal displays shall be monochrome; yellow text with dark/black background is preferred. The door side indication shall be supplemented by 75mm high matching dot matrix '<>' on the door header panels, to be illuminated on the side that the door/s that will open.
9.11.9	External displays shall be readable in sunlight and include ambient light level adjustment. Body side displays shall be operable between approach and departure from stations but shall be blank between stations to reduce power and temperature rise and therefore improve reliability. Front of train displays associated to coupled intermediate cabs shall be blank; front and rear displays of the train shall be operated at all times whilst the train is in passenger service. Passenger service is deemed to end 90 seconds after arrival at the destination and begin when the driver or train crew in another cab set up the train to enable PIS.

9.11.10	Front displays shall have sufficient resolution and size to display the textual destination on the top line in larger text with a second line (70mm capital, minimum) for the 'via' station; additionally a line/route graphical symbol or two character train number that occupies both lines vertically. The display shall provide an option to show alternative language variants of the textual information in phases, each shown for two seconds minimum (configurable). Front displays may be monochrome; yellow text with dark/black background is preferred. Consideration shall be given to the use of shutters/shade on LED technology displays to improve contrast in bright sunlight and reduce solar thermal gain within the display.
9.11.11	Bodyside displays shall have sufficient resolution and size to display the textual destination on the top line in larger text with a second line (35mm capital, minimum) for the 'via' station; additionally a line/route graphical symbol or two character train number that occupies both lines vertically. It shall be possible to configure the display to scroll horizontally the 'calling at' station names. The display shall provide an option to show alternative language variants of the textual information in phases, each shown for two seconds minimum (configurable). Four displays shall be provided on each vehicle, two per side installed from within the vehicle, positioned at 'eye level' for persons stood on the platform. Side displays may be monochrome; yellow text with dark/black background is preferred.
9.11.12	The Module shall present to passengers only that information that is most relevant to the current location in the current journey.
9.11.13	The internal visual displays shall be situated such that the information is, as far as possible, visible to all seated and standing passengers. Door side and exit direction indicators may be repeated or separate from the internal displays to satisfy this objective and maximise the wayfinding benefit for passengers stood within the vehicle as well as passengers stood in the vestibule close to the doors that will open at the next station.
9.11.14	The system shall provide public address facilities from the cabs, automatic announcer and signaller via the train radio, that gives a high quality intelligible output of RASTI > 0.7 with volume levels automatically adjusted for the background noise level.
9.11.15	The PA system priorities (high to low) are: train radio (with 2 min timeout until reselected), driver PA, PA from other cabs then auto-announcer. The driver shall have full control over selection of operating modes: PA, cab to cab communication and driver to passenger communication. The auto-announcer may be simultaneously operating at the same time as cab to cab and passenger to driver communications, but will be muted in the vicinity / vehicle where driver to passenger communication is taking place.

9.11.16	The system shall provide full duplex communications between cabs including the cabs of coupled Modules.
9.11.17	The system shall provide passenger emergency alarm facilities that support discrete two-way voice communication between the driver and the passenger at that alarm location. Passenger alarm units shall be located adjacent to each door. When a passenger alarm is operated a distinctive warning shall be generated in the cab. If the train is departing from a station, operation of an alarm shall cause immediate emergency brake application. When the train is beyond the station platform, as determined by distance, operation of the alarm shall be delayed (typically 5 seconds, but configurable) and the driver may override brake application allowing the train to proceed to a place of safety. The driver shall have the facility to reset passenger alarms from the cab but only following operation of the talkback facility to that particular alarm. Talkback shall be full duplex but the driver's handset Press to Talk button shall be operated to enable driver speech to the passenger. The passenger alarm shall include an indicator to show when the alarm has been activated and another indicator to show when the passenger should speak. The passenger alarm and its interface to the brake system are safety related functions and shall be designed to fail safe. All individual events and faults shall be logged to the TMS, and a single channel of passenger alarm operation shall be stored on OTDR.
9.11.18	The passenger emergency alarm units shall be designed as far as practicable to deter malicious or accidental operation.

9.11.19	Where provision is made for wheelchair users and in toilets (when fitted) with facilities for wheelchair users then Call for Aid (CFA) units shall be provided. The CFA units shall be installed in accordance with PRM-TSI. The CFA talkback facility shall be integrated with the Passenger Alarm talkback facility, the two systems shall be similar with the following exceptions: • CFA calls provide a different alert tone in the cab; • CFA calls do not affect the train braking system; • CFA and Passenger Alarm calls are distinct and identified by location text on the drivers MMI; • CFA units shall be positioned to allow easy access by wheelchair user; also designed so that persons with disabilities of the hands may operate the facility with minimal difficulty; • CFA and Passenger alarms are placed in a queue for the driver to communicate with; the driver will deal with the queue in the order that calls arrive. The driver shall have the facility to use other forms of communication (PA, intercom, train radio) between speaking to passengers in the queue. The driver shall have the facility to return to a caller already communicated with but remaining in the queue; and • Passenger Alarm and CFA calls may be reset and deleted from the queue once the individual unit has been communicated with. Resetting will require individual selection and confirmation, this action shall be logged by the TMS.
9.11.20	The operation control centre shall be able to broadcast announcements within the Module if required.
9.11.21	All necessary off train software and equipment required to import timetables, interface with ground system RTPIS information sources, send, receive, process, configure, print and interpret PIS data shall be provided.
9.11.22	PIS databases and auto-announcer files/ data shall be transferred using the 'high bandwidth service' and additionally via direct connection to an Ethernet M12 upload connector on board the train.
9.11.23	The PIS shall be capable of delivering short messages in up to three alternative languages prior to selected stops.

9.12 Storage of Investigative Data

9.12.1	Each Module shall be equipped with an On Train Data Recorder (OTDR) that complies with applicable standards.

9.12.2	In addition to any mandatory requirements, the OTDR shall monitor and record cab status, traction application, brake control status, train speed, deadman/vigilance status, WSP status, door status, leading bogie brake cylinder pressure, hooter operation, passenger emergency alarms etc.
9.12.3	It shall be possible to download data from the OTDR remotely using both the 'medium bandwidth service' for short duration requests and the 'high bandwidth service' for longer term requests. A facility to locally download shall also be provided; either by connection of a download lead using a computer or by way of removing a non-volatile storage medium.
9.12.4	All necessary off train software and equipment required to receive, process, print and interpret OTDR data shall be provided. The software shall ensure that the records are continuous and coherent and shall support a regime of archiving all data from train OTDR to a ground based server.
9.12.5	The OTDR software supplied shall allow access to raw OTDR data and its conversion to real information in such a way that the operator or third party software developer may analyse the data.
9.12.6	The operational control centre shall have the capability to request short duration OTDR extracts in near real time.

9.13 Train Management System

9.13.1	Each Module shall be equipped with a train management system (TMS) which shall include a Man Machine Interface (MMI) using a sunlight legible screen of at least 15" diagonal dimension.
9.13.2	The TMS shall be capable of generating, receiving and storing information on the train status and location.
9.13.3	The TMS shall be capable of managing failure of a Module subsystem with the objective of minimising service disruption by providing advisory information on remedial actions to be taken by the driver in case of failures.
9.13.4	The TMS shall be capable of identifying failures of both service affecting and passenger facing equipment to the maintenance centre so that repair and maintenance work can be planned.
9.13.5	The TMS shall be capable of recording mileages, identifying repair and maintenance work.
9.13.6	The TMS shall provide a common source of time, date and train location information for all subsystems that require it. Time shall be accurate to +/- 5 seconds but the time used by individual subsystems on board the same train shall be consistent to +/- 0.1 second.
9.13.7	The TMS shall be capable of transmitting selected information on train location and status at least every 30 seconds to the operational control centre using the 'medium bandwidth service', assuming infrastructure communications are supported.
9.13.8	The TMS shall record energy consumption data provided by the onboard energy measurement system.
9.13.9	The TMS shall monitor and record driving performance and timing data.
9.13.10	The TMS shall monitor and display relevant information to the driver in the cab on the MMI.

9.13.11	The TMS shall provide a method for maintenance staff to monitor Module status information in the driving cab without interfering with the normal driving displays. Should the proposed solution rely on an interface to a maintenance PC, the method of connecting the PC must be robust and connection must be possible at any time without affecting the operation or functionality of the on-train systems. An Ethernet interface using M12 connector shall then be used. The maintenance PC must be capable of displaying real time information as would be available via the cab TMS MMI as well as taking downloads.
9.13.12	The TMS shall provide a simple data download capability without the need for specialist software. Raw data and the means of decoding raw data to information shall be provided to the operator.
9.13.13	The TMS shall send and receive selected information (to be defined during the design review process) in real time to and from the operational control centre and maintenance depot.
9.13.14	All necessary off train software and equipment required to receive, process, print and interpret TMS data shall be provided.

9.14 Passenger Counting System

9.14.1	Each Module shall include a system to measure and record passenger loadings in each vehicle to an accuracy of +/-5% at full seated occupancy based on an average weight of 80kg per person. It shall be possible for the operator to recalibrate the system for changes to average weight per person.
9.14.2	The system shall record the reporting number of the train and passenger loading against individual journey, time, location and date for which the information applies. Information shall relate to the journey leg between two stations resolved to individual vehicle identification.
9.14.3	Vehicle loading information shall be available for transmission in real time less than 30 seconds after station departure) to the operational control centre.
9.14.4	Intelligent vehicle loading information shall be generated on-board the Module, taking data from the passenger loading system. The operator shall therefore have access to data. For example, data may be presented to station platform customer information systems at the next station to guide passengers to position themselves with vehicles with lighter loadings of the next train to arrive.

9.14.5	Vehicle loading information over a 7 day period shall be accessible via a remote download system capable of operation using either the medium or high bandwidth services as appropriate.

9.15 Forward and Rear Facing CCTV

9.15.1	It is intended that each Module shall be fitted with a forward and rear facing CCTV system that is optimised to identify track, signals and any approaching features of interest on the track. However, prices shall be provided both with and without FFCCTV equipment.
9.15.2	The preferred resolution shall be 1280 x 720 or better using progressive scanning; the minimum acceptable resolution is 576p. The camera shall be sealed to the cab window to prevent the ingress of dust and to damp any vibrations, the relationship of lens to window shall be optically optimised; the camera shall benefit from the sweep of the windscreen wiper.
9.15.3	The FFCCTV camera shall record in colour during day time. The camera technology shall be optimised for wide dynamic range, for example a technology such as PIXIM or alternatives with similar dynamic performance shall be offered.
9.15.4	The FFCCTV camera shall record in black and white at night time where images shall fully be resolved down to 0.1 Lux. If necessary to achieve full day and night performance, two cameras shall be fitted, preferably in a common housing.
9.15.5	The lens size, viewing angle, depth of field and point of prime focus shall match the driver's normal area of interest. The frame rate and depth of field shall be chosen to ensure continual in focus images matched to the speed of the train with a minimum frame rate 4 fps. Typically, at 120km/h frame rate is expected to approach 25 fps.
9.15.6	The driver shall be provided with an event button. Up to twenty events may be archived with 30 seconds pre-event and 30 seconds post event (2 minutes for each event).
9.15.7	When a driver operates the event button, several still images (typical three pre-event, three post event, still images at one second intervals) will be sent to the operational control centre. Operation of the event button will create an alert on the OCC Fleet status screen, access to the images will be provided once downloaded by a mouse selected link from the screen.
9.15.8	The rear CCTV camera is operational at all times but intermediate coupled cab cameras are not activated.

9.15.9	Non volatile storage shall support 72 hours recording plus the requirements of the event archive. The storage media shall be magnetic hard drive or solid state based upon the technology that can be demonstrated to provide lowest life cycle cost
9.15.10	All recordings shall be date, time and location stamped.
9.15.11	The full range of tools to extract, download, analyse and publish video file shall be provided.

9.16 Internal Saloon CCTV

9.16.1	It is envisaged that each passenger saloon shall be fitted with a full colour CCTV system with an image resolution of at least 640 x 480. However, prices shall be provided both with and without CCTV equipment.
9.16.2	The CCTV system shall have sufficient cameras to give full coverage of the Module interior (except toilets if specified), including gangways, passenger alarm and call for aid devices.
9.16.3	The cameras shall minimise the view outside the train where possible to prevent fast changing scene and light conditions.
9.16.4	The cameras shall be located in such a way that each camera is viewed by at least one other. Cameras shall be positioned such that facial recognition to 50% image height is achieved at some point when each passenger boards and alights.
9.16.5	Images from the CCTV system throughout a Module shall be available in the driving and rear cabs for review by the driver or guard or the police on site, subject to suitable security safeguards. Provision shall be made to blank the images in a driving cab whilst the train is in motion
9.16.6	For the normal recording rate the system shall record images in the specified areas, at the frame rates specified below as a minimum. • Carriage entrances and exits: 8-12 fps • All other passenger areas: 5-7 fps
9.16.7	In the event of a CCTV trigger event (e.g. operation of a passenger emergency alarm, fire/ smoke detection), the system shall operate at a higher recording rate 12 fps where all images shall be recorded at a higher frame rate than for normal service suitable for detailed analysis of the incident.

9.16.8	In the event of passenger emergency alarm, CFA or fire/smoke detection the internal CCTV feed shall be capable of being shown to the driver for the area of activation. When the driver selects talkback, CCTV images shall follow the talkback selection.
9.16.9	This higher recording rate shall be for 10 minutes before and 30 minutes after the event. There shall be up to 20 events stored in archive.
9.16.10	The CCTV system shall provide a minimum of two weeks of recording capacity for the normal recording rate based on normal train service requirements and assuming 1 CCTV trigger event requiring the higher recording rate during this period. Alternatively, the CCTV images shall be securely and automatically downloaded every 24 hours to a central database that has a six month storage capacity for the fleet of Modules.
9.16.11	The output produced by the CCTV system at both normal and high recording rates shall be capable of being admissible in any South African court of law.
9.16.12	The CCTV system recording and retrieval functions shall give a secure auditable trail of data that satisfies the requirements of data protection, data security, data integrity and evidential continuity to prove that the data has not been tampered with in any way to the satisfaction of standards required for juridical evidence in a South African court of law.
9.16.13	All necessary off train software and equipment required to extract, view, print and interpret CCTV images shall be provided.
9.16.14	It shall be possible to view any of the recorded images on a Module via a single Ethernet M12 diagnostic port.
9.16.15	It shall be possible to view a minimum of 4 simultaneous cameras feeds from the same diagnostic port.
9.16.16	The CCTV system shall be linked to the fire detection system, so that in the event of fire detection images from the location of the detection are available in the driving and rear cabs.
9.16.17	The physical on-train storage device shall be located such that it is easily accessible by the Operator's staff; however, it shall not be identifiable to passengers. The device's location shall be secure to prevent unauthorised access.
9.16.18	It shall be possible to quickly remove the storage device and replace with another .

9.16.19	It shall be possible to extract CCTV data by downloading via the diagnostic port or by removal of the non volatile storage media for replay and analysis on a ground / wayside reading system. Extracted data or media from every CCTV recorder on a train shall be playable on the reading system where it shall be possible to track a person moving through the entire length of the train. The reading system shall then support the export of selected camera and timeline video sequences onto common media (SD card, DVD etc) in a format that does not allow subsequent changes but may be played on a standard PC without the use of additional software. The supporting video player software may be included on the common media.

9.17 Fire Detection Systems

9.17.1	Each Module shall be equipped with a fire and smoke detection system.
9.17.2	On detection of fire or smoke, the information, including the location within the Module shall be provided to the driver in real time.
9.17.3	On detection of fire or smoke, the information, including the location within the Module shall be provided to the operational control centre in real time.

9.18 Fire Extinguishers

9.18.1	The design of the coaches shall incorporate provision for the operator to mount fire extinguishing equipment in each coach. The type and accessibility of this equipment shall be risk assessed taking into account the propensity for misuse and any impacts/hazards this may present.

9.19 Traction Control

9.19.1	The Module shall be equipped with a hill start function.
9.19.2	The Module shall be equipped with a slow speed shunting mode that controls the speed in stepped increments of 1km/h +/- 0.5km/h up to a maximum 10km/h for operation in sidings and wash plants. The slow speed shunting controls in the cab shall be independent from the service traction controller, and capable of being used up to 10km/h in the event of failure of the traction controller in service.

9.19.3	The Module shall be capable of reverse operation at speeds of up to 25km/h using forward facing CCTV, driving from the rear cab.

9.20 Windscreen Wiper System

9.20.1	The Module shall be fitted with a wiper system in accordance with applicable standards. The windscreen wiper system shall include an intermittent wipe facility.

9.21 Mobile Communications

9.21.1	The Module design shall ensure that mobile telephones and personal devices operating in the range 850MHz to 2400MHz do not suffer degraded performance by the design of the vehicle. For example, through window treatment (solar treatment, metallisation etc) or through window dimensions.
9.21.2	Should the Module design cause degradation to mobile/personal communications the supplier shall provide a system to restore performance to a level equivalent to that available to a train roof antenna, e.g. a cell enhancer, but the cell enhancer shall be configurable to support the individual frequency spectrum allocated to each mobile operator in South Africa. The supplier shall undertake management of the technical and commercial interfaces with the individual mobile operator to ensure the system operates legally within the existing spectrum licensing regime.

10 Reliability

10.1 General

10.1.1	The Module must be designed to achieve a high level of reliability in general service, as demonstrated by the mean distance between service affecting failures.
10.1.2	The Modules shall be designed to achieve an extremely low level of mission failures.
10.1.3	Reliability assurance shall be controlled through the EN50126-1:1999 The Specification and Demonstration of Reliability, Availability, Maintainability and Safety or an equivalent approved framework from tendering through the design, manufacture, testing, integration and introduction into service phases and through their entire life.

10.2 Mean Distance Between Failures

10.2.1	Each Module shall achieve a mean distance between service affecting failures of 100,000 km in general service where service affecting is taken as any delay greater than 2 minutes.
10.2.2	Failure between stations, requiring detrainment and evacuation of passengers, shall not occur more than once every 100,000,000 km
10.2.3	Failure causing a delay exceeding 60 minutes and / or requiring detrainment at a station shall not occur more than once every 25,000,000 km

10.3 Technical Delays

10.3.1	The Module shall be designed with the necessary functionality in both normal and degraded modes to recover from or mitigate for technical failures, malfunction and reduced performance so that technical delays are minimised. Rapid recovery shall be provided for all potential failure modes, with minimal interaction by the driver, and avoids the need for the driver to leave the cab.

10.3.2	Targets for such technical delays shall be established which are consistent with the aims of the performance regime.

10.4 Design for Reliability

10.4.1	The design of the Module shall include a fast boot up facility for all systems.
10.4.2	The design of the Module shall include an automatic resetting facility.
10.4.3	The design of the Module shall include remote subsystem isolation which allows the driver to manage failures with the minimum of delay.
10.4.4	The above shall be achieved without the driver leaving the cab.
10.4.5	Each Module shall have the ability to move with an onboard failure under its own power to the next station where passengers can be detrained except where the failure is of a major mechanical component. This ability shall be available in all circumstances except a failure of the traction supply or a physical obstruction of the track.
10.4.6	Each Module shall be fitted with self monitoring and predictive diagnostic equipment that will advise the driver and ground based operations and maintenance staff on failures of any train subsystem likely to affect the ability to achieve the specified levels of performance and service reliability.
10.4.7	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.
10.4.8	The Module traction system shall redistribute the available power amongst the remaining operational traction sub systems, within the system limits, in the event of one or more traction subsystem failures, so that the impact on performance and energy efficiency is minimised.
10.4.9	The Module design shall minimise the risk of complete Module failure due to loss or lack of air. In particular vulnerable air pipes, valves, cocks and other equipment shall be protected from trackside damage and isolation cocks shall be strategically located to allow isolation of leaking sections to prevent complete failure of the Module.
10.4.10	To overcome a potential single point failure, the Module shall provide a secondary means of speed display in the cab of sufficient accuracy for the Module to continue in service until it can conveniently be removed.

11 Maintenance and Operations

11.1 Module Maintenance

11.1.1	The design philosophy shall be to minimise the life cycle cost of the Modules. This shall be achieved by: • Minimising maintenance requirements and Vehicle downtimes; • Maximising availability and reliability; • Minimising energy consumption; and • Minimising initial cost.
11.1.2	Each Module shall be designed for ease of maintenance, servicing, cleaning and reparability, this shall include the design of interior panelling and other items prone to vandalism.
11.1.3	The Module design shall incorporate features which enable maintenance and repairs to be carried out quickly and effectively.
11.1.4	The Module design shall be such that the length of time Modules are out of service for maintenance, overhaul and repair is minimised and so that routine maintenance can be accommodated in times that are outside of the peak service requirement.
11.1.5	The modules shall be designed to be capable of running without attention from maintenance staff for a distance of not less than 20,000 km or a period of two months, whichever comes first
11.1.6	The Module shall require much less maintenance than current generation vehicles.
11.1.7	The Module shall incorporate simple to change modular equipment with simple to manage train diagnostics, condition monitoring and train data systems.
11.1.8	Each Module design shall ensure the long term availability and quality of all spare parts and consumables for the life of the Module.
11.1.9	All Module component and sub system parts including interior panelling and exterior trim shall be uniquely coded and labelled so that replacement parts can be easily identified.
11.1.10	All interior cupboard doors and panels shall incorporate retention devices as appropriate to minimise the risk of injury to passengers or to staff.

11.1.11	Suitable test and condition monitoring software and equipment to allow testing, fault diagnosis and repair of all Module sub systems shall be provided.
11.1.12	All necessary off train software and equipment required to send, receive, process, configure, print and interpret Module sub system data shall be provided.
11.1.13	All necessary special tools and equipment required to maintain and repair Module equipment and sub system shall be provided.
11.1.14	Module external service connection points shall be located to ensure that only a minimum of trackside servicing points are required regardless of the orientation and/or formation of the Module. Connection points shall be safe, durable, simple and quick to use and capable of repeated use in the harsh conditions to be expected at servicing locations. They shall be capable of being changed easily and quickly, in the event of failure.
11.1.15	All equipment locations must be marked to identify the function, type and model of equipment installed. Major components must be marked with the year and month of manufacture and fitted with an equipment identification plate that shows the manufacturers name, equipment designation, revision code, serial number and a bar code to allow tracking of components. All separable items of equipment must be clearly and permanently labelled in English in a suitable location that is clearly visible and legible when the equipment is installed. Nameplates for equipment must be securely and permanently attached to a non-removable part of the component or major sub-assembly. Nameplates and markings must be indelible and vandal resistant. They must not be adversely affected by cleaning agents, graffiti or graffiti removal chemicals.
11.1.16	It must be safe to work on any electrical equipment within 30 seconds after it has been isolated from its supply. Energy storage devices such as capacitors must be discharged.
11.1.17	Pneumatic components must vent outside the passenger area. Exhausts from vented components must not present an OH&S hazard to maintenance staff.
11.1.18	The rolling stock must be designed with ease of maintenance in mind. All equipment that has a maintenance requirement must be readily accessible and clearly labelled in English. All covers within the passenger area that are required to be opened during routine maintenance must be fitted with security locks that visually indicate their locked status

11.1.19	All lifting and jacking points must be clearly marked and accessible without the need to remove other equipment.

11.2 Module Repairs

11.2.1	Each Module shall be designed and constructed so that the time required to repair exterior collision damage is minimised, this is particularly important for front end damage.
11.2.2	Each Module shall be designed and constructed so that the time to repair vandalism and to replace damaged interior components is minimised.
11.2.3	Each Module shall be designed and constructed so that the windscreen shall be exchangeable within 4 hours, including any curing time.
11.2.4	Each Module shall be designed and constructed so that bodyside windows shall be exchangeable within 3 hours, including any curing time.
11.2.5	Each Module shall be designed and constructed so that bodyside door windows shall be exchangeable within 4 hours, including any curing time.
11.2.6	Where failed exterior lamps cannot be replaced in 15 minutes they shall be of a suitable LED technology designed with a lifetime similar to the Module.
11.2.7	The time required to replace all major components shall be minimised.
11.2.8	There shall be a system for the operator's staff to fix a temporary window or cover to a broken or cracked bodyside window, to allow the Module to continue in service to the end of the day.

11.3 Documentation

11.3.1	The Module manufacturer shall provide comprehensive maintenance documentation covering the maintenance and overhaul requirements for the life of the vehicles, repair procedures, test procedures and fault-finding procedures.
11.3.2	The Module manufacturer shall provide comprehensive overhaul documentation covering the maintenance and overhaul requirements for the life of the vehicles.
11.3.3	The Module manufacturer shall provide comprehensive parts information, including an illustrated parts catalogue showing all parts, their description, part numbers, ordering details etc.
11.3.4	The Module manufacturer shall provide all drawings related to the construction and maintenance of the Modules, including circuit diagrams , wiring diagrams, structural drawings, general arrangements etc.
11.3.5	The Module manufacturer shall provide detailed technical descriptions of the Module and its operation.
11.3.6	The Module manufacturer shall provide easy to read fault finding guides for drivers.
11.3.7	The above documentation shall be provided in hard copy and in an agreed electronic format.
11.3.8	The electronic information shall include comprehensive cross-referencing (enabling easy navigation between documents and parts of the same document).
11.3.9	Electronic information shall be readily accessible by the customer operator to enable updating.
11.3.10	The manufacturer shall be responsible for all training and assessment/certification of the maintenance staff who will undertake the maintenance of the trains.

12 Mock Ups

12.1 General

12.1.1	Mock ups will be used by PRASA to evaluate the Module interior against operator requirements and gain acceptance with relevant stakeholders and user groups. The mock ups will also be used and modified during the design phase for ergonomic and human factors evaluation before refinement of the final design features and delivery as the final mock-ups. The Module manufacturer shall construct any additional breadboard mock-ups, prototypes, models and 3D visualisations that are necessary for ergonomic and human factors evaluation, including assessment of maintainability.
12.1.2	The final mock ups shall be delivered and stored at an agreed location in South Africa.

12.2 Cab Mock Up

12.2.1	A full size representative cab internal mock up shall be provided.

12.3 Saloon Mock Up

12.3.1	A transportable full size interior saloon mock up shall be provided incorporating the floor, bodyside and ceiling section for a length of seats equivalent to one end bay up to and including the vestibule and doorway. The mock up shall include seats, luggage racks, utility modules, grab poles and draught screens, and showing the location and form of PIS displays and signage.
12.3.2	The mock up shall also include the wheelchair areas and where applicable toilets.
12.3.3	The mock up shall also include a vestibule area with full width floor area and ceiling structure to show grab pole arrangements.
12.3.4	The lighting and seat comfort shall be as per the finished build.

13 Driver Simulator

13.1 General

13.1.1	As a priced option the Manufacturer shall provide a driver training simulator.
13.1.2	The driver training simulator shall consist of a computer controlled video based system showing the track ahead, interfaced with the driver's controls with all relevant audible effects.
13.1.3	The simulator shall include: • A driver's cab mock-up with a fully functional driver's desk; and • An instructor's console for inputting information and monitoring the driver's actions together with recording and printing facilities.
13.1.4	The driver training simulator shall realistically model the Module's performance over the specified routes in this agreement under all passenger loading conditions.
13.1.5	The simulator shall not simulate the dynamic movement of the driving cab.
13.1.6	A synchronised progressive information monitor shall be included to show details of the route ahead.
13.1.7	The driver training simulator shall accurately synchronise all recorded audible effects with their position on the track image seen by the driver.
13.1.8	The simulator shall be capable of recording and playing back through the monitor on the instructors console all driver actions.

13.2 Cab

13.2.1	The interior of the simulator cab shall be a full size replica of the Module's driving cab interior.
13.2.2	The simulated cab shall be fitted with a video camera to which all drivers controls will be visible.

13.3 Instructors Control Console

13.3.1	The instructors control console shall be fitted with all of the equipment required to control the operation of the simulator and monitor the driver's performance.
13.3.2	This instructors control console shall include repeater monitors displaying: • The driver's forward view; • The track information monitor; and • Cab camera view.
13.3.3	The instructor's console shall: • Provide a display for continuous monitoring of the driver's actions throughout the training run; • Record all of the driver's actions; • Replay the recording of the exercise and driver's actions; and • Enable quick access to any portion of the training run for replay purposes.
13.3.4	The instructor's console shall enable the instructor to memory mark any position on the training run which he may wish to identify for quick reference.
13.3.5	The instructor's console shall enable hard copy reports to be produced.
13.3.6	The instructor's console shall provide a suitable display for continuous computer log monitoring of a maintenance technician's actions throughout a fault-finding training exercise. All actions shall be recorded. It shall be possible to replay the recording of the exercise and the technician's actions. The instructor shall have quick access to any portion of the exercise for replay purposes.
13.3.7	The instructors console and the positioning of monitors, handsets controls and other equipment. shall be designed to a high ergonomic standard. All monitors, handsets, controls, and push buttons shall be identified with a label. Where appropriate the label shall correspond to that fitted in the cab.

13.4 Computer System

13.4.1	The Simulator computer programs shall be written in a recognised high level language, and be supported by the computer manufacturer.
13.4.2	The system design shall be as simple as practicable and shall not require the instructor to be computer literate to operate it satisfactorily.

13.4.3	The input of instructions, parameters and other data into the computer by the instructor shall be via a mouse or touch screen as far as possible. The system shall be programmed to avoid the need to use keyboard only interfaces.
13.4.4	The computer programmes shall not be damaged nor shall the memories be affected in any way by the sudden loss of the electrical supply.
13.4.5	On loss of power the system shall revert to a standby mode. The system will require an action from the instructor to re-initiate the system once power is restored.

13.5 Computer Interfaces

13.5.1	The following pre-programmed functions shall be interfaced with the simulator's computer: • Track gradients and curves; • The Module's resistance to motion; • Signals; • Any other functions that the Manufacturer considers necessary for an accurate simulation.
13.5.2	The simulator shall enable the instructor to program or control the following functions: • Vary the wheel/rail adhesion level during the simulated run. The adhesion level for each set of assumed rail conditions shall include an element of random variation to give a realistic representation of poor adhesion conditions; • Simulate wheel slip or slide as determined by the appropriate track conditions, brake notch and power notch positions; • Determine the status of all colour aspect signals throughout the simulated run; • Introduce a temporary speed restriction or emergency indication into the simulation; • Allow the instructor to contact the driver via simulated Module to control centre radio equipment; • Allow the instructor to act as a passenger contacting the driver via the passenger emergency alarm system; and • Vary the passenger loading, at simulated station stops.

13.5.3	During a simulated run the simulator shall allow the instructor to be able to input the following faults and conditions at any point. The simulator shall accurately model all the faults and conditions and their effect on the operation of the train: • Isolation of the pneumatic brake on one trailer bogie or one powered bogie; • Sudden loss of main reservoir pipe pressure; • Failure of brakes to release; • Loss of dynamic braking; • Loss of regenerative brake; • Operation of passenger alarm device; • Loss of traction power; • Pantograph defect; • Failure of Deadman / Vigilance system; • Tripping of circuit breakers; • Failure of communications systems; and • Diagnostic and Fault Indicating System faults.

13.6 Simulated Sounds

13.6.1	The simulator shall replicate as a minimum the following sounds at the appropriate time in relation to the operation of the train: • Wheel/rail sounds on continuous welded rail, switches and crossovers, wheel squeal and flange noises; • Passing sounds for signal posts, platforms, other trains, bridges, tunnels; • Wheelslip / slide prevention activity; • Wheels sliding under low adhesion conditions; • Traction motor noises whilst under traction, under braking or coasting; • Friction brake noises; and • The warning horn.

13.7 Hard Copy Reports

13.7.1	The simulator shall be capable of printing out a report at the end of a training run containing the following details: • Instructor's name; • Driver's name; • Date; • Start and finish time of the training run; • Special conditions. This shall refer to any conditions faults etc. that have been inserted into the simulated journey, and at what locations; • Average journey speed; • Theoretical maximum journey speed; • Time of arrival and departure from stations, compared against programmed arrival and departure times; • Malfunction of controls; • Misuse of controls; • Failure to respond to simulated faults and conditions; • Failure to respond to a signal correctly; • Number of times wheel slip occurred; and • Number of times wheel slide occurred.